The contribution of universities to regional innovation in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA)

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Abstract

This thesis explores the contribution of universities to regional innovation by conducting a nested case study of a comprehensive Double First-Class university in the Guangdong-Hong Kong-Macao-Greater Bay Area (GBA) of China, a critical site envisioned to strengthen regional synergy and establish globally influential innovation systems. An single nested case study was conducted with integrating analyses of national and local policies on science, technology, innovation and education, institutional documents, and 88 interviews with stakeholders from the university, industry and government. With Sun-Yet-Sen University (SYSU) and its collaboration partnerships within the GBA as the case, the research sheds light on the important features as the institution of innovation, and critical nodes of multisectoral innovation networks within local innovation systems.

Moving beyond simplified conceptualisations of university–industry–government–society relations rooted predominantly in Western contexts, this research advances a context-sensitive and dynamic approach to understanding innovation, the configurations of Triple/Quadruple Helix systems and universities' roles therein. Unlike a static statist model, roles within Triple Helix are dynamic, varying across innovation sub-systems and the networks of organisations, projects and individuals, influenced by factors such as geopolitical environments, central party-state apparatus, local innovation system configurations, university structures and strategies, disciplinary focuses, and individual enterprising attributes.

State entrepreneurialism, through the interplay of top-down steering and bottom-up initiatives, remains a defining feature of China's and the GBA that drives multi-scalar innovation capacity-building. China's innovation strategy concentrates on strengthening endogenous innovation capability and global innovation leadership through productive cross-scale intersections of innovation, national system thinking and synergistic instruments for deployment and implementation. Global connectivity and international collaboration are conditioned by overarching national priorities and interests, an ongoing balance between openness and closure. By examining the GBA's strategic role as a local-global nexus, the study highlights that innovation network-building, collective learning, and diffusion of innovation practices, though originating in a specific location and are largely policy-driven, often transcend local, regional, and national boundaries.

The GBA innovation system has evolved into a dynamic, multi-actor configuration marked by heterogeneity and emergent balance. As integration deepens across Hong Kong, Macau, and Guangdong, institutional innovation is increasingly characterised by two-way empowerment: top-down strategic design from the central government and bottom-up feedback from cross-border innovation practices. The integration of HK and Macau's international regulatory experience with Guangdong's experimental policy capacity is fostering a hybrid governance paradigm that is both internationally oriented and distinctively Chinese.

Universities' enterprising efforts represent a confluence of policy-driven, market-oriented, and higher education-specific rationales. Embedded in national and local policy agendas, universities align pursuit of academic excellence and institutional prestige with governmental STI objectives and broader societal expectations. They organise innovation practices through large-scale infrastructures, mega-projects, mission-driven team-building, interdisciplinary research, and the coordinated integration of innovation, industrial, capital, and talent chains. Through multi-campus configurations and expanded multidisciplinary profiles across Guangzhou, Zhuhai, and Shenzhen, universities play increasingly enterprising roles in regional innovation governance. These expansions align with internal logics of enrollment growth, prestige accumulation, and resource acquisition.

SYSU exemplifies this dynamic, building an enterprising multiversity model with a strong academic core while strategically leveraging the GBA's political momentum and geographical advantages. Its co-developed innovation platforms with local governments and industries have enabled sustainable spatial expansion, diversified funding, and fostered hybrid organisational forms, enhancing institutional capacity and responsiveness to external demands. The broadening "developmental periphery" (Clark, 2001)—through innovation parks, joint research centres, and incubator programs—enable universities to broaden student markets, research funding, and public and private investment, reinforcing their dual identities as educational and entrepreneurial actors. Some even embarked on experiment of institutional innovation. The emergence of "neo-type research universities" such as HKUST(GZ) and CUHK(SZ), exemplifies how institutions simultaneously position themselves within global academic hierarchies while embedding more deeplu in the GBA's innovation system.

These expansions of multiversities is also underpinned by the capital logic of urban economic expansion, in which they are positioned and position themselves as regional growth machines, attracting high-skilled talent, foreign investment, and emerging industries. The integration of university-led innovation ecosystems into urban planning strategies reflects a broader entrepreneurial turn in higher education, whereby universities become instruments of land valorisation, technology commercialisation, regional economic upgrading, and navigation of demand-supply equilibrium amid changing geopolitical innovationscape.

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List of Acronyms and Abbreviations

ASEAN	Association of Southeast Asian Nations
CAS	Chinese Academy of Science
CRO	Contract Research Organisation
CS	Civil society
CUHK-SZ	Chinese University of Hong Kong, Shenzhen
DFC	Double-First Class initiative
DoIIT	Department of Industry and Information Technology
DoSTI	Department of Science, Technology and Innovation
DRC	Development and Reform Commission
ECR	Early-career researchers
FDA	Food and Drug Administration
GBA	Guangdong-Hong Kong-Macau Greater Bay Area
HEI	Higher education institutions
HKPU	Hong Kong Polytechnic University
HKUST (GZ)	Hong Kong University of Science and Technology, Guangzhou
I&E	Innovation & Entrepreneurship
IO	Innovation organiser
IPR	Intellectual Property Right
JNU	Jinan University
KPI	Key performance indicator
LE	Large enterprises
MOE	Ministry of Education
MOST	Ministry of Science and Technology
MU	Macau University
NIS	Nation innovation system
NMPA	National Medical Products Administration
NNSFC	National Natural Science Foundation of China
RI	Research institutes
PI	Principal Investigator
SAR	Special Adminstrative Regions
SCUT	South China University of Technology
SEZ	Special Economic Zones
SME	Small and medium enterprise
SOE	State-owned enterprise
STEM	Science, technology, engineering, and mathematics
STI	Science, technology, and innovation
SSHA	Social Sciences, humanities and arts
SYSU	Sun Yet-Sen University
SUST	Southern University of Science and Technology
TTO	Technology Transfer Office
UGC	University Grant Committee
WCU	World-Class Universities
ZHI	Zhuhai Science & Technology Research Institute

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Chapter 1 Introduction

This chapter introduces the contextualisation, objectives, methodology, and layout of the thesis. Section 1.1. outlines the broader contexts where higher education worldwide has been strategised as the engine for innovation-driven development in the knowledge economy, as discussed in influential literature such as national innovation system, triple helix, and entrepreneurial university. Section 1.2. then discusses the Chinese policy contexts that influence the university research and innovation capacity in the GBA, including the World-Class University (WCU) agenda and Double First-Class (DFC) initiative. Section 1.3 introduces the regional context, where the Guangdong-Hong Kong-Macau Greater Bay Are (GBA) initiative was launched with ambition to leverage higher education as the engine for a world-class innovation hub. Section 1.4 outlines the study's objectives and methodology, followed by a summary of thesis layout in section 1.5.

1.1. Higher Education and innovation

Higher education increasingly becomes the driver of innovation and development in post-industrial, knowledge economy, not only by generating fundamental scientific insights but also by orchestrating multi-actor networks and collaborative outcomes that underpin national and regional innovation systems (OECD, 1999; Reichert, 2019). Over the past three decades, this role has been theorised successively by the National Innovation Systems approach (Lundvall, 1992; Nelson, 1993; Freeman, 2002; Edquist, 2013), which emphasises knowledge spillovers from academia, and by Triple Helix model, in which universities, industry, and government collaborate via hybrid organisations such as science parks and incubators to stimulate economic and social development (Etzkowitz & Leydesdorff, 1999; Etzkowitz, 2002). These frameworks have produced an epistemic community consisting of governments and stakeholders in designing systemic approaches and policies to affect the innovation process (Sharif, 2006).

Emerging models as the entrepreneurial (Clark, 2001), enterprise (Marginson & & Considine, 2000), and engaged university (Chatterton & Goddard, 2000; Holland, 2001), extend the conceptualisations of universities' roles to teaching, research and the undertaking of "third missions" within national and regional innovation systems. Amid the global movements towards increasing societal engagement and entrepreneurial opportunities, universities of various types (e.g., polytechnics, research universities) enjoy a stronger degree of autonomy in setting their strategic agenda and partaking innovation activities across institutional spheres. Academic freedom and scholarly inquiry are explored beyond the traditional boundaries, notably in the form of academic entrepreneurship. The tensions between new roles and that of teaching and research feed back into each other (Etzkowitz, 2013). The universities' increased entrepreneurial activities in relation to the capitalisation of knowledge result in the concurrence of partnership and competition with existing industry (Etzkowitz & Zhou, 2017).

Besides cultivating innovative talent and a skilled workforce, universities are increasingly expected to lead upstream in the innovation chain by producing new ideas, technologies, and approaches through basic and application-inspired research; to contribute downstream by supporting the development, testing, and commercialisation of innovations and informing the creation of new business models, organisational strategies, and practices; to spawn spin-outs, graduate start-ups, and employment; and to contribute to regional leadership and an innovative culture (Gunasekara, 2006; Uyarra, 2010; Etzkowitz, 2013; Benneworth, Pinheiro & Karlsen, 2017; Etzkowitz & Zhou, 2017; Coates-Ulrichsen, 2023).

1.2. WCU agenda and DFC initiative

Building on Project 211 and 985, China launched the Double First-Class (DFC) initiative in 2015 to overhaul university disciplines and governance, with a 2050 target of becoming a global higher-education leader (Liu, 2018). Its first phase ran from 2017 to 2021. In 2022, its second phrase expanded to include more universities, drop category labels, flag 'non-eligible' disciplines, and prioritise interdisciplinary research (Xiong, 2022; Wang & Lin, 2022). It has overall included a growing number of institutions: all 39 former 985 universities plus 77 additional 211 institutions (MOE, 2022a).

DFC membership secures a steady stream of funding and support for raising global rankings while conferring greater economic and academic prestige, along with closer coordination with central government officials than 'non-member institutions' (Wei, 2020). However, scholars critique DFC as a top-down mechanism that channels intensive national and local funding to a narrow list of elite universities, strengthens performative and audit pressures, and entrenches bureaucratic control over resource allocation (Kim et al., 2018; Liu, 2018). Its narrow 'world-class' criteria, unequal resource distribution, and state-led quality assessments create tensions between compliance and autonomy.

Notwithstanding that the DFC ostensibly aimed to diversify Chinese HEIs by emphasising varied disciplines and programmes, Han, Zha, and Xie's (2023) social network analysis of 86 "first-class discipline" universities' strategic plans, alongside a supporting case study, revealed notably homogeneous structures, objectives and tactics towards developing research-intensive comprehensive universities. Despite the stipulated goal for building WCUs, the DFC may have prompted universities to prioritise national imperatives and the Chinese characteristics over an international focus (Huang, 2015; Yang et al., 2021).

1.3. The GBA as a "higher education highland" and "globally influential international science and innovation hub"

Facing domestic bottlenecks in industrial upgrading and external headwinds from U.S. tariffs and trade barriers, China is also seeking new engines for its economic development and invested substantially in higher education research, innovation, and creative industries to drive innovation-driven transformation (Berlie & Hung, 2020; Mok, 2020; MOE, 2025). Both central and local governments have identified the strategic role of higher education in transforming the manufacturing model in China into one driven by science, technology and innovation (Chow, Hua & Hung, 2019).

Against these contexts, the GBA was launched in the *Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area* issued by the Chinese central government in 2019. The GBA consists of '9+2' cities, including nine from Guangdong Province (Guangzhou, Foshan, Zhaoqing, Shenzhen, Dongguan, Huizhou, Zhuhai, Zhongshan, Jiangmen) and two Special Administrative Regions (Hong Kong SAR and Macao SAR), with a vision to strengthen regional cooperation and establish a "higher education highland", "globally influential international science and innovation hub" and "world-class city cluster" (State Council, 2019). The strategic vision for higher education is stipulated as:

> "By 2035, the GBA will have established several WCUs, nurtured strategic cohorts of scientists possessing strong innovation foresight and an international outlook, produced serial original scientific breakthroughs of major significance to global science and the advancement of human civilisation, becoming a leading exemplar of international higher education cooperation and innovative development". (State Council, 2019)

The GBA features diversity in legal, economic and political systems, with mainland China adopting socialism with Chinese characteristics system and the two SARs keeping the capitalist systems. Despite the "one country, two systems", "three customs territories" and "three legal systems" and "three tariff zones" distinctions among Guangdong province, Hong Kong and Macau, the GBA initiative aims to promote cross-border collaboration and regional synergies of these city-regions, leveraging their strengths to support China's "going global" strategy (Xu & Huang, 2019; Lo et al., 2022). As the gateway of China's market reform and opening-up policy, the area has favorable geography for innovative industries and internationalisation.

Figure 1.1 '9+2' city-regions in the GBA

Source: Gov HK (2021)

1.3.1. Guangdong higher education: under-supply and progressive capacity-building

Despite the ambition to forging an "education highland" (National Development and Reform Commission, 2021), higher education in Guangdong remains incommensurate with its demand for innovation and economic development. Although the sector has expanded rapidly, the quantity and calibre of its universities remain lower than that in other leading metropolises such as Beijing and Shanghai (Table 1.1). Before the DFC program, only two "985" universities in Guangdong—Sun Yat-Sen University and South China University of Technology—were designated as 'First-Class universities' in 2017. In the inaugural DFC cycle, three more Guangzhou-based institutions—South China Normal University, Jinan University, and Guangzhou University of Chinese Medicine, were promoted to 'First-Class discipline' status. The second DFC round in 2022 added three more universities: South China Agricultural University, Guangzhou Medical University, and Southern University of Science and Technology (Guangdong Provincial Government, 2022).

Table 1.1 Number of DFC universities and disciplines in Guangzhou, Shanghai and Beijing

	2017		2022	
	FC universities	FC disciplines	FC universities	FC disciplines
Beijing	34	102	34	120
Shanghai	14	64	15	77
Guangzhou	5	18	8	25

Source: compiled by the author based on MOE (2017, 2022a)

While Guangzhou hosts the vast majority of top universities in Guangdong, Shenzhen's higher education developed later and on a smaller scale (Li, 2021). To meet its high-tech ambitions, Shenzhen University (est. 1983) and Southern University of Science and Technology (est. 2012) were founded with a "compressed development" mandate focused on science and technology (Mok, Welch & Kang, 2020). However, neither institution alone could supply sufficient mature talent or cutting-edge research for the city's needs. Each took over twenty years to meet the Ministry of Education (MOE)'s *Interim Measures for the Review of the Right to Grant Doctoral Degrees* in order to secure doctoral-granting status (MOE, 2000).

To address the shortfall of intellectual supply, Shenzhen has since introduced a diverse array of institutions—local, vocational, private, SARs/Sino-foreign cooperative, and trans-provincial universities—to broaden its higher education system and enable leapfrog development of graduate and doctoral education in joint programs (Xu & Lu, 2019). Despite these efforts, the distribution of education resources in Guangdong remains notably uneven, with the level of development varying notably across city-regions, particularly between the subcentres (Guangzhou, Shenzhen) and the remainders (Zhang & Cai, 2021).

1.3.2. Subnational regionalisation and cross-border collaboration in higher education

Despite the advantages in internationalisation, research capability and teaching quality, higher education in HK and Macau is also constrained by small population and land capacity (Li & Liu, 2018). Based on the common need to improve higher education and its contribution to socioeconomic growth, as well as the geographical, cultural and language proximity among Guangdong province, HK and Macau, governments have been encouraging the establishment of co-research institutes, joint training programmes, and branch campuses; and promoting cross-border mobility of resources and talents (Sharma, 2021). In collaboration, the GBA is expected to assimilate western know-how and British modern management through HK while establishing links with the Lusophone countries through Macau (Berlie & Hung, 2020), gradually improving its knowledge, consensus and innovation bases.

It is against these policy contexts that the Chinese government seeks to promote a policy environment contributive to research, innovation and university-industry collaboration in the GBA, particularly an employment base for young people from HK and Macau (Mok, Welch & Kang, 2020). Government, industry and academia in the GBA shared the visions that universities take on a leading role in creating an entrepreneurial culture conducive to regional integration besides normalised roles in talent cultivation and knowledge creation (Xu & Huang, 2020).

Since 2005, over ten university-affiliated research institutes, hospitals, and joint universities have been established in Shenzhen, Guangzhou, and Zhuhai, key cities identified as international platforms for innovation and regional integration (State Council, 2019). Jinan University, and Sun Yat-Sen University, originally based in Guangzhou, have opened new campuses in Shenzhen and Zhuhai. Such university expansion has been further encouraged by the *Plan for Advancing Collaborative Development of Higher Education in the Guangdong-Hong Kong-Macao Greater Bay Area* and municipality-university collaborations.

According to the latest report from Guangdong government (2024), postdoctoral stations have been set up by Chinese University of Hong Kong (Shenzhen) and the BNUB-HKBU United International College. Additional support has been granted for Sun Yat-Sen University's Hong Kong Advanced Research Institute and South China Normal University's GBA Teacher Education Institute. It has also pioneered mutual recognition of sub-degree qualifications with SARs, opened large-scale research facilities (e.g. SYSU's Guangzhou Supercomputing Centre and Precision Medicine Centre) to SAR partners, and launched 31 GBA joint laboratories, 22 of which are housed by Guangdong universities. To support these initiatives, the province has invested substantial funding—land grants and annual allowances for joint campuses (e.g. BNUB–HKBU in Zhuhai), inclusion in the 2021–2025 "First-Class, Fill Shortfalls, Strengthen Features" plan with 10 million RMB per year. Guangdong hosts over 15,000 SAR students, the largest cohort nationwide, and has already established six Sino-foreign and Mainland-SARs joint universities, accounting for over half of such institutions in China.

Despite recent progress, significant opportunities and challenges are ahead for achieving subnational regionalisation through the GBA, given its legal, institutional, and social, and economic heterogeneity (Xu & Lu, 2019). As a blend of centrally driven top-down deployment and local bottom-up initiatives, the GBA, designated as a national pilot demonstration zone, is a unique arena to experiment with institutional, economic, and social innovations distinct from those in other world-renowned city-regions and bay areas. However, the realisation of these strategic ambitions is subject to multi-scalar local interpretations and implementations (Han, 2017). Strategic and operational challenges persist.

For example, top universities in the GBA generate less income from knowledge transfer compared to their counterparts in other major bay areas (Chow, Hua & Hung, 2019). The innovation-driven strategy and aspirations for leapfrog development are largely anchored in STEM fields and enhanced performance in global science (Marginson, 2022a, 2022b, 2022c). STEM-focused institutions in the GBA display a marked imbalance between STEM and the social sciences, humanities, and arts (SSHA). The under-representation of SSHA might constrain long-term innovation capacity-building and development (Xie, Huang & Jung, 2022). These phenomena, however, are not necessarily unique to the GBA or China.

1.4. Research aims

All these global, national, and local quests for excellence and higher education playing strategic roles are occurring at a time when China has shifted from a high-speed growth to a high-quality development phase, with innovation as the driving force (MOE, 2022a). Responding to heightening national strategic demands for cutting-edge research, innovation, and talent cultivation, higher education institutions (HEIs) are increasingly urged to proactively engage and align their efforts with national development (MOE, 2022b, 2022c, 2025).

Under the Dual Circulation Strategy[1], HEIs are further expected to align research and innovation activities with national and local priorities while strengthening international engagement to showcase China's scientific, technological, and indigenous knowledge contributions. The resulting tensions at the interface of balancing local, regional, national, and global imperatives merit closer study (Zheng & Li, 2024), especially in the GBA, where higher education's innovation-centric regionalisation strategy takes a demonstration role, generating locally rooted initiatives that inform national policy while serving as conduits for China's integration into global innovation governance. Significant gaps remain in understanding both the actual and potential roles of universities.

Hence, this thesis aims to understand the roles of universities in the GBA innovation system, with particular attention to the subnational regionalisation of higher education, WCU agenda, and the encounter with the enterprise/entrepreneurial university movements in contexts beyond and arguably distinctive from the predominantly Western conceptualisations. The study employs a single nested case study design, taking SYSU and its collaborative partnerships within the GBA as units of analysis to explore universities as both innovation institutions and the nodes of multisectoral innovation networks in local innovation systems. The study seeks to explore specifically:

RQ1: How do stakeholders (academic, industry, government) understand innovation?

RQ2: How do stakeholders (academic, industry, government) understand the roles of each other in the regional innovation system?

RQ3 How do universities in the GBA engage in innovation-oriented collaborations with government, industry and civil society?

RQ4: What are the key influencing factors shaping the GBA's innovation system?

The research is of theoretical, methodological and practical significance. It offers an opportunity to problematise the western ideas around research and innovation by incorporating social networks and "glonacal" scales to the unique context of the GBA—a nested conceptual approach that would also advance the understanding of innovative regions globally. In an increasingly multi-polar academic world, the rise of

[1] The strategy was proposed by President Xi in 2020. The central principle is to to establish a new development paradigm centred on domestic circulation while mutually reinforcing domestic and international flows, leveraging both supply and demand to achieve a higher-level equilibrium, where demand drives supply and supply creates demand, thereby securing a proactive position through openness (NDRC,2023).

emerging countries has led to the reconsideration of hegemonic development pathways and traditions (Yang, 2002). An empirical, context-sensitive study grounded in an "open ontology"—one that avoids both methodological globalism (which envisions a de-territorialised global that replaces the national) and methodological nationalism (which confines analysis to nation-states)—is therefore essential (Marginson, 2022d).

Exploring the Chinese characteristics of universities in a regional context not only enables a more equal and inclusive global dialogue of world civilisations, but also provides insights into how globally influential forces—toward innovation system-building, enterprise, and the WCU model are locally perceived and practised. The GBA deserves attention for their dynamic presence in the GBA and arguably special/strategic status relative to the PRC. Its development can lead the way for other rapidly developing city-regions and economic zones in China (e.g. the Yangtze River Delta) and beyond. This will advances state-of-the-art forward by retheorising university–society–state–industry relations within a distinct social framing with capacity for building more coordinated, multi-scalar systems.

1.5. Layout of the thesis

This thesis comprises ten chapters. **Chapter 1** introduces the context, rationale, research design and thesis layout. It begins with the broader contexts casting higher education as the strategic engines of innovation and regional development before outlining the policy context of the GBA in steering cross-border collaboration and subnational regionalisation of higher education among Guangdong, HK, and Macau. Then key Chinese policies and initiatives shaping GBA research and innovation capacity are also discussed.The section concludes by summarising the layout of this thesis.

Chapter 2 is the Literature review. It synthesises key innovation frameworks—glonacal heuristics, national innovation systems, Triple Helix, and the entrepreneurial/enterprise university—into an integrated framework for understanding innovation practices and university engagement across global, national, and regional scales. The chapter then reviews existing research regarding higher education and innovation system in Guangdong, HK and Macau and concludes with the summary of research questions.

Chapter 3 outlines the research design, presenting the research design, explaining the choice of a single-case study, sampling criteria, and data collection methods—semi-structured interviews with faculty, industry, and government stakeholders, alongside policy and institutional documents.

Chapter 4-8 report findings from the empirical study. **Chapter 4** explores the conceptualisations of innovation (RQ1) in policy documents and among interviewees, followed by a comparison of the two datasets. Policy analysis reveals a multi-scalar focus on strengthening China's indigenous innovation capability and global innovation leadership with productive cross-scale intersections, synergistic construction of national innovation system with "foresight", "advanced strategic deployment" and "demonstration". Policies establish a spectrum of evaluation indicators such as "value", "originality", "quality" and "contribution" to direct, incentivise and institutionalise preferable ways of producing innovation.

Interviewees register a variety of initial reactions to "innovation" and approach it with lexical and operational definitions. The connotations of "novelty", as the overarching feature, are thoroughly examined, coupled with the aims of producing "value" through "problem-solving", "usefulness" and "meaningfulness". Discussion covers innovation as a process with distinct stages; activities with varying priorities across research, teaching, university-industry collaboration and production; and outcomes of diverse nature and dimensions.

Chapter 5 addresses RQ2 and RQ3, exploring the contribution of universities within the GBA's innovation system. Section 1-3 compares the perceptions of interviewees regarding the university's innovation activities and expected roles in the GBA. Section 4 examines SYSU's intended and actual role in the GBA by integrating interview data and institutional documents to explore the university's vision for innovation and capacity-building in relation to the perspectives of its staff and external partners/stakeholders. Universities are generally perceived as curiosity-driven institutions with core responsibilities in talent cultivation and original research, with applied and entrepreneurial activities seen as secondary yet increasingly intertwined with its core missions amid growing expectations for societal and economic contributions.

In response to RQ2, **Chapter 6** examines the roles of the industry and government in the GBA's innovation system. Interviewees highlight the principal role of industry in redistributing production materials and resources and innovating business models in line with market demands. Major innovation activities centre on production, commercialisation, and R&D in certain large enterprises or high-tech SMEs. The government's major roles involve macro-level systematic planning, strategic deployment of key innovation domains, and establishment of corresponding goals, timelines, and policy support to enhance national innovation capacity.

While policies and government interviewees identify the industry as the principal actor in advanced research and technological innovation, university interviewees regard universities as the principal innovators. They perceive the industry as profit-driven, risk-averse and utilitarian, focusing on minimising costs and seeking quick returns. Consequently, with innovation being merely one of the means to serve these ends, industrial innovation is often incremental and of lower novelty. Although imitation and absorption of imported technologies are justified as innovation in policies and by government and industrial interviewees, university interviewees argue that many of these lack substantive innovation.

Chapter 7 addresses RQ3 by illuminating how universities and academics engaged in different innovation activities and collaborations with industry, government, and civil society across the GBA's subsystems (Guangdong, HK, Macau) and the domains of business and entrepreneurship, power and energy, medical and pharmaceutical sciences. Unlike the static statist model, the primary role of each helix varies across collaborations, leading in some cases and coordinating in others. Analyses are backed by successful cases from interviewees and validated with data from institutional documents.

Chapter 8 examines the multi-level factors shaping the GBA's innovation system (RQ4). At the macro level, it analyzes the geopolitical landscape, central party-state apparatus, national policies (e.g., DFC, GBA initiative), funding mechanisms, and the regional environment favoring innovation. At the meso level, it explores system characteristics, including academia-industry-government relations, industrial absorptive capacity, bureaucracy, university governance, institutional structures and traditions, and hybrid organisations. At the micro level, it discusses collaboration features, agentic network-building, strategic autonomy, enterprising attributes, and conceptualizations of innovation. The chapter concludes by synthesising these into an integrated innovation factor-framework.

Chapter 9-10 present the discussion and conclusion of the doctoral study. **Chapter 9** integrates all evidence of this study to produce a unified understanding of the case, namely SYSU by its mission priorities, institutional structures, cultures, and characters of social engagement. At the sub-system level, evidence is also synthesised to discuss the divisional roles and interaction dynamics of Triple Helix, drawing on the collaborative networks of SYSU. The chapter then locates these findings within the broader debates of innovation across higher education, business management and innovation studies.

Chapter 10 concludes by highlighting the contributions of this thesis in providing an exemplar of researching innovation with a multi-method qualitative approach and empirical evidence on how innovation is conceptualised and practised in the day-to-day realities of higher education within the GBA. The chapter discusses the implications of these for strengthening universities' innovation, interactions with stakeholders and contributions to local innovative development amid strategic manoeuvring of WCU as well as national and local innovation initiatives. It throws light on the possibility of developing institutional models that are conducive to the social and economic innovation of the GBA notwithstanding institutional, operational and practical challenges. Finally, the chapter states the limitations of the study and offers suggestions for future research.

Chapter 2 Literature Review

This chapter outlines the state-of-art in the literature concerning higher education, innovation and also the GBA, identifying the research gaps that the study addresses. Specifically, the frameworks- National Innovation System, Triple Helix and the Entrepreneurial and Enterprising University are presented to conceptualise the diverse contributions universities can make to innovation systems at the national and regional levels. Second, this chapter looks specifically at the roles of universities in fostering innovation-oriented activities and collaboration with government and industrial actors in the GBA, by reviewing the innovation environments, policies and higher education in Guangdong, HK and Macau, the three most important nexuses of the region. Finally, the challenges in universities' contributing to the regional innovation system will be discussed in relation to the WCU movement, the GBA initiative and taking-up of enterprise roles.

2.1. National Innovation System (NIS)

The NIS approach has gained currency as a result of the enhancing understanding of economic role of knowledge and innovation, the complexity of their formation and the growing number of institutions involved in knowledge production. Sharif (2006) also noted that the system approach is a response to the increasing globalisation, international competition and the strategic focus on knowledge economy. The growing complexity of global economic and geopolitical condition induces a transition from a linear development model to one that is more systemic and discursive.

NIS is broadly defined as "a set of institutions whose interactions determine the innovative performance of national firms" (Nelson, 1993), which contributes to the generation, diffusion and application of new technologies (Freeman, 2002) and "economically useful knowledge" and skills (Lundvall, 1992). It provides a framework for governments to formulate and implement policies that affect the innovation process (Sharif, 2006). Despite the variety of definitions, this approach advances the understanding of the connections among innovation actors in government, private enterprises, universities and public research institutes as well as their collective system of knowledge production and technology performance, which are key to enhancing the growth and productivity of economy (OECD, 1999).

Universities and research institutes serve as the core contributors of basic research for industry, an indirect source of knowledge. The time-lags in adapting basic research to industrial practices limit their direct linkages. However, when more direct connections are established, the industry will benefit from the tacit knowledge brought by personnel mobility of and the informal networks with researchers through occasions such as professional associations and conferences. This includes not only the transfer of specified knowledge from basic research, but also the general approach to innovative problem-solving, all of which becomes valuable knowledge assets for firms (OECD, 1999).

NIS has been pronounced for its conceptual innovation. Despite the increasing openness of national innovation systems to multiple forms of knowledge flows and linkages worldwide (e.g. cross-border technical alliances, international co-authorship), innovation capacity remains largely determined at the national level and contributed by sub-national systems (OECD, 1999). However, it remains difficult to apply existing methods and indicators to measure the system empirically, which also leads to the question of its operational value and implement possibility (Godin, 2009). In response, OECD (1999) attempted to substantiate the framework with a more 'operationable' set of methods and indicators by mapping out four types of innovation activities: institutional connections, innovative firms, human resource flows and industrial clusters (Table 2.1).

For the purpose of increasing the comparability of innovation systems across countries and regions, these proposed methods and indicators are mostly quantitative and descriptive. It is acknowledged that the extant science and technology indicators (e.g., number of graduates, patents, publications or R&D expense) are insufficient in mapping out the full landscape of knowledge distribution and innovation dynamics (OECD, 1995). A new generation of approaches needs to be developed in order to understand *why* and *how* interaction takes place among innovation actors in different institutional spheres. This would require concerted efforts from multiple levels, ranging from pan-national states to influential individuals.

Table 2.1 Mapping of major innovation activities, suggested research methods and indicators

Types of innovation activities and knowledge flows	Research Methods	Indicators
Institutional connections	Documentary/archive analysis	Reviews of news, websites, industrial directories, existing evaluation database, policy documents, company and media reports that document any innovation-oriented collaboration (e.g. joint R&D)
	Bibliometric analysis	Co-publication, co-patent and citation network
Innovative firms	Institution survey (e.g. PACE survey funded by EU Commission)	Knowledge source, input and output relevant to innovation; personnel mobility, alliances and informal ties conducive to innovation
	Documentary/archive analysis	The input and output matrices for innovation activities (e.g. R&D expense) available in company reports or any publicly disclosed

		evaluation database
Human resource flows	Labour market statistical analysis	Labour market statistics (e.g. Labor Force Survey); public database relevant to migration and cross-border mobility (e.g. National Science Foundation); university or organisational reports
Industrial clusters	Cluster analysis	Cluster identification (categorising dimensions; inclusion and exclusion criteria
		Cluster mapping of external environment, economic performance (e.g., exports, imports, labour cost, production and value added), industrial profiling and evolution (e.g. firm strategy, structure and competitive landscape)
		Innovation patterns analysis such as the flows of embodied technology (product purchase), personnel base, innovative interactions (joint-research, co-patenting, co-publication and citation), innovation outcomes, the degree of integration of different industries in the cluster and the type of actors and their relevance to the whole cluster
		Cluster policy analysis (i.e., policy cycles, characteristics and its compatibility with the needs of extant industries and firms)

Source: adapted from OECD' s (1999, 2001a, 2001b) reports on NIS by the author

The complexity of national innovation systems, the variance across regions and countries, the relative significance of the public research sector as a knowledge source for industry (OECD, 1997), and the mixed roles of government at different levels, all make it difficult to assess the overall impact of innovation systems (Wang, 2018). Alignment in goals and capabilities among networks of actors is essential to the fabrication of national innovation systems (Kruss et al., 2015). While underlying the importance of learning and knowledge production, the innovation system literature has limited engagement with literature on higher education and skill formation, but primarily focused on higher education's role in enterprise learning (Kruss et al., 2015). The premise that prototypes and ideas are initially generated by public research organisations and later commercialised by firms still reflects a linear innovation model that the NIS sought to move beyond (Datta et al., 2019).

2.2. Triple Helix

Triple Helix specifies the System approach with functional divisions of labour among innovation actors (Etzkowitz & Dzisah, 2008). As an institutional framework, Triple Helix is a platform for innovation-conducive organisational formats, with governments setting stage for university–industry interactions through provision of research grants (i.e. public venture capital) for start-ups and adjustments in the patent law (Etzkowitz & Zhou, 2017). Within this helix, science-based industry and startups generated from academic research situate adjacent to universities, forming a self-perpetuating ecosystem for innovation (Etzkowitz et al., 2000). The regular entry and graduation of students of "entrepreneurial universities" perennially brings in new ideas and academic scientists who create start-ups from research in collaboration with the industry. Entrepreneurship is integrated with teaching and research as the "third mission", forging commercialisation of knowledge (Shore & McLauchlan, 2012, p.267).

Knowledge-based economies have enabled the fractal structure of the Triple Helix to produce "*self-similar* patterns in innovation systems at different scales", performing upwards and downwards by the three co-evolving actors (Ivanova & Leydesdorff， 2014, p.4). Innovation activities take place across the global, regional, sectorial and technological systems, and the dimensions of separate enterprises and projects. Triple Helix as a communicative framework serves as selection environments and mechanisms that bridge institutional communications and create innovation environments to ensure the reproduction of the system, consisting of components[2], relationships (collaboration, conflict moderation, substitution) and functions (the production, diffusion and application of technology) fulfilled in the Knowledge, Innovation and Consensus spaces (Etzkowitz & Ranga, 2010).

As Etzkowitz and Ranga (2013) postulated, the initial stage oftentimes begins with the generation of the Knowledge Space, the prime venue of R&D activities located in universities, public research institutions, government labs, firms and other functional equivalents in arts that also produce discoveries. Forwarding the knowledge space to further use, the Consensus Space is a combination of top-down and bottom-up processes that create leadership through collaboration. With government playing a prevailing role, the space is comprised of virtual framework, assembling platform and physical space where actors brainstorm innovative ideas. Following the goals articulated in the Consensus Space, the Innovation Space, the realm where extant and new organisational models are recombined to create better ways for innovation, is

[2] Components can be defined by geographical or administrative units such as spatially-bounded systems (regional, national innovation systems), spatially open systems (e.g., technology innovation systems, sectoral innovation systems) or by economic sectors or technologies (Ranga & Etzkowitz, 2015).

bound together with the Knowledge Space. The innovation activities and possible trajectories to create these three spaces are presented in Table 2.2.

Table 3.1 Developmental stages of the Triple Helix spaces

Triple Helix Spaces	Innovation activities	Possible creation trajectories
Knowledge Space	**R&D activities** located in universities, public research institutions, government labs, firms and other functional equivalents in arts that also produce discoveries; **Non-R&D activities** such as organisational transformation and technology adoption.	1) Decentralisation of national public research institutions; 2) Foundation of science-oriented universities; 3) Government-led/mediated aggregation of innovation actors; 4) Urban renewal with creative/artistic clusters; **5)** University and industry alliances
Consensus Space	Actors from varying spheres convene to brainstorm, discuss and assess proposals oriented towards knowledge-based innovation	Create virtual framework, assembling platform and physical space (e.g., regional development forum and council) for collaboration
Innovation Space	Aggregate resources to generate new organisational format; place people on new conceptualised roles; and create legitimate themes for inter-organisational cooperation that combine old and new social goals	1) Create hybrid organisations for technology transfer, business and financial support; 2) Implement policies that support collaborative partnerships, intellectual property rights and finance R&D; 3) Creation universities

Source: Etzkowitz & Zhou (2017)

2.2.1. University

2.2.1.1. Entrepreneurial and enterprise universities

According to Etzkowitz (2004, 2016), entrepreneurial universities embedded in Triple Helix sit at the epicentre of innovation. Albeit in the absence of an agreed definition, entrepreneurial universities are expected to excel in technology transfer, firm-incubation and leading regional innovation (Etzkowitz, 2013).

Amid a global movement towards the entrepreneurial model, universities of various types (e.g., polytechnics, research universities) enjoy a stronger degree of autonomy in setting their strategic agenda and partaking innovation activities across institutional spheres. Academic freedom and inquiry inherent in the Humboldtian tradition are explored beyond the traditional boundaries, increasingly through academic entrepreneurship. Increased entrepreneurial activities in relation to the capitalisation of knowledge result in the concurrence of partnership and competition with existing industry (Etzkowitz & Zhou, 2017). The tensions between new roles and that of teaching and research feed back into each other (Etzkowitz, 2013).

Nevertheless, the term "entrepreneurial university" was initially coined by Clark (1998), referring to universities with five common elements: 1) A strengthened steering core comprised by academic units and central management; 2) The stimulated academic heartland; 3) The expanded developmental periphery (i.e., interdisciplinary research centres, technology transfer office, consulting/service organisations, incubator, science parks); 4) The diversified funding base sourcing from government ministries, research councils, income from industry, foundations, student fees and alike; 5) The unified entrepreneurial culture that embraces innovation, risk-taking and adaption to changes. Both entrepreneurial models give expression to the university's imaginary of itself as an "academic enterprise" taking on more of the character of a public corporation and normalising its purposes with strong executive control (Marginson & Considine, 2000, p. 12).

Etzkowitz's model largely rests on entrepreneurship in a business sense where universities commercialise themselves as corporations and traditional functions such as public critique are left to students and a minority of faculties (Etzkowitz & Zhou, 2017). Clark (2001)'s model is more akin to the "enterprise university", whose innovation endeavours are equally concerned with generating income and institutional prestige. Instead of conforming to the best corporate practices, the enterprise universities vary by and thrive on their distinctive geographies, characters and heritages. Academic agency and collegiality are not seen as obstacles but the very heartland to forward thrust and innovation. In academic-managerial synergy, enterprise universities preserve and renovate old fields of study by virtue of heritage; reinvent roles and identities in regional, national, and global arenas through differentiation, potentially conducing to the diversity, competitiveness, openness, and adaptiveness of higher education systems.

The "enterprise university" has been a more encompassing concept than the "entrepreneurial university" in capturing both the academic and economic dimensions. While the latter is levered to highlight a move away from traditional universities constrained by homogenising state planning and rigidified practices, the former makes distinct the university's ultimate ends in gaining resources, prestige and social weights instead of profit-seeking in corporations. Nonetheless, the enterprise university model comes with limitations. As Clark (2001) noted, the "bottom heaviness" and collegiality of academics are in part conservative and resistant to change (p.22). Diversifying income brings different problems and degrees of expense discretion, influencing the actual agency academics and management can play out. For instance, governmental funding can be relatively generous and unearmarked while requiring tight accounting and incremental budgeting.

Based on empirical studies of Australian universities, Marginson and Considine (2000) noted that the formation of institutional culture featuring a stronger steering core, extended developmental periphery, and diversified funding base did not appear to stimulate the academic heartland as Clark prescribed. Centrally driven integration is based more on the inadequacy of academic cultures than their strength. The academic-managerial synergy is precisely the missing link for the transition to the enterprise model. Oftentimes, the managerial leadership operates in detachment from the academic heartland. Performative control based on general management tools and ideal university models is extended at the cost of dynamic academic cultures, which tends to undermine collegiality and institutional identity. Even more so, the imitation of ideal university or business models risks obscuring the diversity of universities and their distinctive contributions. In particular, the overwhelming focus on serving the university's own end precariously thins out the larger purposes of higher education, particularly the ones closely associated with the public good and thus public support.

2.2.1.2. WCUs: converging enterprising endeavors towards multiversities

Intertwined with the enterprise imaginary is the "academic hype" towards WCUs that influences the reinvention of universities (Deem, Mok & Lucas, 2008, p.84). WCUs are increasingly seen as the game-changers in boosting national and regional socioeconomic development (Kim & Nam, 2007; Smolentseva, 2010; Liu et al., 2011; Mok, 2016). They are largely characterised as "multiversities, conglomerate universities with global vision, abundant resources (i.e., funding, facilities, talents) and commitment to multiple purposes and multi-disciplinary research (Kerr, 2001). They in part carry some elements of the enterprise university such as the capability of technology transfer and favorable governance that supports strategic vision, academic freedom, and innovation (Altbach, 2003; Salmi & Froumin, 2013). These imaginaries have driven a worldwide craze for benchmarking academic excellence. To lift positions in global rankings, emerging economies seek to emulate WCU models that have taken root in metropolitan countries (David & Motala, 2017), some of which overlap with the enterprise mimic-ideals such as Stanford and MIT.

In pursuit of leapfrog development, there is often pressure to act quickly, to deploy well-known mechanisms such as the creation of university science park. The resource consensus with the nation-state in facilitating global standing may support universities to become more enterprising as both effective local and national players and outstanding global players. However, the competition at "glonacal" levels (Marginson, 2022d) in tandem risks placing universities in a more vulnerable position to the emulate/pander-or-perish dilemma. The academic heartland might also be weakened by the conforming pressure to the methodologies of the main English-medium journals, and thus the norms and values of English-speaking countries. The one-size-fits-all nature of WCUs based on American and European research universities and the homogenising effect of such emulation in part jeopardise the very sought-after distinctiveness and diversity within and among universities in the enterprise model (Rodriguez-Pomeda & Casani, 2016).

2.2.1.3. Enterprising universities in China

China is one of the states ambitiously in quest for WCUs and their contributions to generating innovation ecosystems (Song, 2018; Zong & Zhang, 2019; Wei & Johnstone, 2020). WCUs speak to the national ambition to revitalise academic quality and compete in higher-value industries with research, knowledge and an educated workforce (Wang, Wang & Liu, 2011). As Li (2012) described, the unfolding of policy is a dynamic and interactive process in China, a central feature of the "Chiniversity", within which "self-mastery" and "intellectual freedom"[3] are embedded in national and provincial bureaucracies (p.12). The strong nation-state forging of structures, funding, and priorities remains a feature of the Confucian model (Marginson, 2011). However, there are tensions between the rationales of economic planning and rationales shaped by "glonacal" forces. Cultures of excellence take longer to build, while the stratification of institutional identity is difficult to challenge. This reproductive character of the WCU renders it difficult to secure horizontal diversity.

Amid the intra-organisational competition intensified by WCU agenda, some Chinese universities seek to differentiate themselves by modelling after the enterprising universities taken root in the Silicon Valley. Fuzhou University and Nanjing University of Technology[4], for instance, are the pioneers that respectively institutionalised the mimic-model of Stanford in 2008 and 2010 (Fu, 2015). Transition turns out to be strenuous due to the inertial reliance on central planning. Bureaucracy can hinder bottom-up innovation. Knowledge transfer from university research to industry has not been a tradition in China due to the insulation of research and production (Chow, Hua, & Hung, 2019).

There are a few attempts to explore a Chinese path to enterprising universities and leverage this innovation model in WCU initiatives. Fu and Xuan (2019) posited that creation of Chinese enterprise university should base on existing applied universities, using DFC to enhance research capacity and innovate the governance structures of provincial universities. Wu, Weng and Wang (2015) advocated building enterprise universities through internationalisation taking root in Asia, with Singapore being an ideal role model and partner. Liang (2019) clarified that the entrepreneurial university (创业型大学) reveals a shifting focus on the social contribution whereas enterprise university (创新型大学) highlights creativity in traditional models, which long

[3] In comparison to the concepts of"autonomy" and "academic freedom" in European university.
[4] Both belong to the 211 category.

existed in historically-established universities such as Berlin University. Both help nurture entrepreneurial culture and modernise university operations, though Xiong and Cai (2019) considered the latter a more appropriate hybridity to invigorate extant research universities.

2.2.1.3. Diversity of enterprising models to innovation system vitality

The solution to these maladies, as Marginson and Considine (2000) suggested, is to reinvent the university' identity, culture and capacity beyond either the entrepreneurial or enterprise model. This would need system-wide support for instance, in effective mobilisation of the academic core, formation of university community and loyalty, and development of reflexive networked governance structures. Independence and diversity of values, purposes, personalities and heritage are important for universities. The enterprise model varies by the roles of universities societies have ascribed to (Etzkowitz & Zhou, 2017). In the case of facilitating Triple Helix and regional development, innovation also requires varying types of processes whereby universities pursue different development models and specialise in different innovation-related activities.

Taking this further, Datta et al. (2019) elucidated that diversity enables universities to forge distinct niches and strategic knowledge-based clusters in national and regional innovation systems. Ideally, a balanced diversity of universities, each contributing to different parts of the innovation landscape, enhances system-wide development. While further empirical research is needed to confirm this link, examining the potential of diverse university models remains valuable. Although many external factors will continue to shape their futures, universities' ability to sustain effective action remains crucial (Marginson & Considine, 2000).

2.2.2. Government actors

Government is one of the decisive actors in developing innovation capacity for both the national innovation system (Nelson, 1993) and the regional Triple Helix (Etzkowitz & Leydesdorff, 2000). However, the role of government and the way in which it engages in innovation is contestable given the compounding presence of factors that influence innovation activity and performance (Wang, 2018).

Etzkowitz and Zhou (2017) noted that the trajectory and visibility of a Triple Helix are mediated by different state capacities. Government serves as the innovation organiser (IO) in a statist regime (Figure 2.1). In the absence of mediating organisations, the academic and industrial spheres interact modestly under government steering and oftentimes encounter conflicts of interest. In "low-state" societies, laissez-faire government draws on the productive force of industry and market. Government and university respectively play auxiliary roles in addressing market failure and supplying skilled labour and knowledge (Figure 2.2). The optimum is an interactive Triple Helix Field balanced between the two models. Amid the circulation of personnel, information and innovation output across the helices, distinct institutional identity remains while the imbalanced contribution among stimulates more efforts from one another (Figure 2.3). Etzkowitz and Zhou argued that fully developed Triple Helix systems are most likely to emerge in democratic societies, where initiatives can be freely generated, while those under authoritarian regimes remain limited in both the scope and potential for regenerative innovation.

Figure 2.1. The statist model

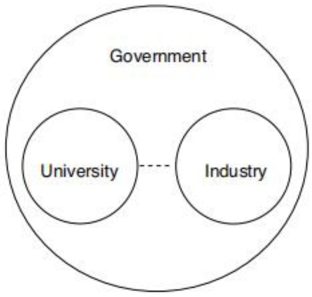


Figure 2.2. The laissez-faire model: from distinct institutional boundaries to voluntary associations

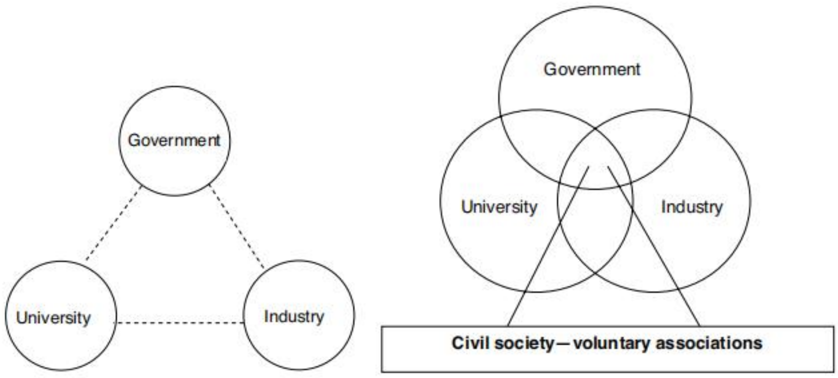
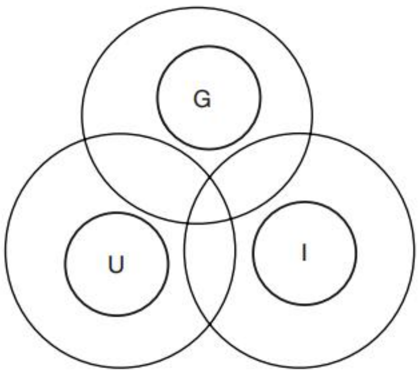


Figure 2.3. Triple Helix Field Model



Source: Etzkowitz and Zhou (2017), pp.12-19

2.2.3. Industrial actors

In Etzkowitz and Zhou (2017)'s discussion, the analysis of industry takes firms as the basic unit. The trajectory of innovative collaboration varies by the type of firms. Traditional firms tend to initially partner with similar entities, particularly those within the same value chain, before collaborating with research institutes, universities and government agencies. Some of the larger firms will even move units to science parks to collaborate closely with academic research groups. Comparatively, spin-offs emanating from universities and incubators usually stay closely connected with their origins, which provides not only facilities, but credibility, intellectual and network resources. In turn, such connection possibly leads to "an industrial penumbra surrounding the university" (p. 44). Firm-formation remains the centerpiece of driving product, technological and organisational innovation in Triple Helix.

From a more system-level lens, Vallance et al. (2018) found that the industrial profile of a region influences the major knowledge bases and mode of innovation in economy. The channels and patterns of university-industry interaction vary by both the specialisation of industries and universities available for innovation-oriented collaboration (Lester, 2007). For instance, a nascent science-based industry may need universities to help establish new firms and upgrade existing industries through innovative activities such as consultancy, joint R&D or the creation of spin-outs. In regions with less technology-intensive industries, the education function of universities appear more important to local employers (Isaksen & Karlsen, 2010).

2.2.4. Organisational and individual actors as nodes of innovation networks

According to Ranga and Etzkowitz (2015), the high credence that Triple Helix literature entitles to institutional spheres leaves little visibility to individual innovators. These individual roles are accommodated through concepts such as the "innovation organiser" and "entrepreneurial scientist" that provide a phenomenology of behavioural types (Schutz, 1964), highlighting ways in which individual and institutional innovation initiate and reinforce each other. For instance, entrepreneur scientists may (a) take a direct interest in leading and forming spin-off firms; (b) hand over innovation to technology transfer offices for disposition; (c) play a supportive role, typically being the members of a Scientific Advisory Board; and (d) take no interest in entrepreneurship, but help to develop technology required to advance basic research goals during firm formation.

Burt's (1992) social network theory offers a valuable lens for understanding how innovation networks form across individual and (supra-)organisational levels. Actors from government, industry, and academia operate within their own institutional logics while engaging in cross-network interactions mediated by key nodes. Universities and their faculties serve as boundary-spanning agents and "network brokers", bridging structural holes (Burt, 2000) across sectors and scales through collaborations in teaching, research, and knowledge exchange. In doing so, they enable collaborative agenda-setting, knowledge production, and institutional innovation, while enhancing their ability to integrate diverse priorities, practices, and tacit knowledge across groups (Burt, 2021). Similarly, key-node organisations and individuals in industry and government also synthesise institutional priorities and capacities when taking on cross-sectoral roles, such as industrial actors and officials involved in research and mentorship. They serve as key nodes within "closure networks" characterised by established trust and resource mobilisation capacity and across "brokerage networks" rich in structural holes.

2.3. The System approach and Triple Helix: limitations and heuristic strengths

2.3.1. Similarities and differences

The System approach and Triple Helix both serve as policy norms to facilitate science and technology in a knowledge-based economy, recognising academia as central to innovation, though with differing emphases.The System approach views universities as co-producers of research and ideas for industry whereas Triple Helix assigns them an active role throughout knowledge production, dissemination and commercialisation of knowledge. Ivanova and Leydesdorff (2014) argued that the System approach can create the conditions for building innovation clusters resembling the structures of normative control, knowledge and wealth generation in the Triple Helix. The three institutional spheres serve as selection environments and communicative frameworks that make possible the cloning of Triple Helix structures in different scales.

Despite these similarities, Triple Helix appears more normative than the System approach in prescribing a model of interaction advocating a balanced contribution of innovation actors. In light of Etzkowitz (2004, 2016), the entrepreneurial university remains the ideal model to facilitate interaction and eventually the development of an innovation ecosystem. The main distinction between the two approaches lies in their attribution of leadership in the innovation processes: the System approach centres on firms (production sphere) and the Triple Helix emphasises universities (knowledge sphere) (Datta et al., 2019). However, in China, the leading role is held by the party-state.

2.3.2. Limitations

Given the historically different techniques used to evaluate the three institutional spheres, the effectiveness of Triple Helix innovation system remains difficult to quantify, a task which is also complicated by the fact that the interactions instead of the separate spheres constitute the principal elements of innovation (Ivanova & Leydesdorff, 2014). The blurred lines between the wide range of innovation activities such as enterprise activities, consultancy and contracted academic research (Meyer et al., 2014) further complicate the discussion and assessment of these activities.

Besides operational challenges, Triple Helix remains a normative prescription and simplistic account of the diverse workings of the society, the undertakings of innovation and the complexity of interactions (Amir & Nugroho, 2013). In addition to supportive policies and incentives for academic entrepreneurship, academia-industry collaboration is also subject to the influences of the researcher's strategic positioning, publications and research budget; the university's location, specialisation and risk-taking culture; the set-up of strategic networks; the costs of producing transferrable knowledge (Belkhodja & Landry, 2007); the absorptive capacity of the collaborating firms; and the regional industrial profile (Vallance et al., 2018). Although Triple Helix was considered to rest largely on "phenomenological case-studies" (Ivanova & Leydesdorff, 2014, p.3), Meyer et al. (2014)'s bibliometric analysis of the literature on Triple Helix indicators suggested that many contributions still focused on identifying and measuring the triad relations in a descriptive approach.

Finally, Triple Helix's excessive focus on performance evaluation focused on maximising economic and technological opportunities in part limits the system's scope and capacity to generate multi-scalar activities and interactions. As Amir and Nugroho (2013) indicated, the wider political, social, cultural and environmental problems emerging from research, innovation and collaboration tend to escape the attention of the framework. The emphasis placed on raising or commercialising research may pressure universities to prioritise certain fields of study to cater to external stakeholders, which risks undermining the long-term strategic research agenda. However, as Vallance et al. (2018) argued, innovation capacity, rather than stand-alone research or commercialisation capacity, is overarching to the successful implementation of regional innovation policy. This includes human capital and components of institution, knowledge and absorptive capacity. Universities conduce to this capacity by optimally integrating their functions such as education, research or enhancing the governance and networking abilities, and accommodating their profiles and activities to the benefit of regional development.

Furthermore, scientific knowledge and technological systems are generated in a cultural environment confined by technological determinism and a narrow definition of knowledge primarily based on Western developed contexts. In non-Western contexts, innovation policies and activities sometimes, if not oftentimes, do not stay attuned to what prescribed in Triple Helix. For instance, in Korea, Park and Leydesdorff (2010) found that the science and technology policies attempting to replicate a Triple Helix model exerted limited impacts on inter-institutional collaboration in effect. Academia remains predominantly focused on the numbers of publication, with scientific co-publication being the dominant type of academic-industry collaboration. In Japan, as a result of stringent regulations on universities, industry-government collaborations supported by widespread public research laboratories lead the way in building a Triple Helix. Instead of going through statist, laissez-faire, and balanced models, Japan is transitioning from a statist to a government-led model in building the national innovation system (Yoda & Kuwashima, 2020). This transition, which features strong government steering, has also been noticed in Singapore and China. The innovation process of China is rendered more sophisticated by multi-ministerial governance (Cai & Liu, 2015; Wang, 2018).

Existing research largely focuses on either broadly discussing the relative roles of U-I-G or mapping shifts in local helix configurations. This supply-driven perspective assumes that by introducing the "missing" compatible helix, when government efforts, industrial structures, and higher education capacity match, a balanced Triple Helix optimistically takes shape (Ha & Lin, 2023). However, in laissez-faire or statist models, even when the three actors have roughly equal capacities, misalignment between demand and capacity can lead to fragmentation rather than integration.

The multi-level government structures under the overarching leadership of the central party-state, a distinctive and influential force in shaping China's innovation strategies and organisation of innovation activities within and across institutions, remain under-examined in both NIS and Triple Helix literature. Government actors are often simplified as a homogeneous agent, obscuring the differentiated roles, authority, and interactions across administrative levels, as well as the dual governance structure of institutional heads and Party secretaries.

Similarly, the heterogeneity of industrial actors remains under-studied. Variations in institutional ownership significantly shape their decision-making and strategic capacities in innovation. State-owned enterprises (SOEs) wield quasi-governmental authority in policymaking, strategic deployment of innovation in key sectors, and often administrative responsibility over the supply chains within their domains. They play a key role in the state's innovation diplomacy by partaking for instance, in BRI to expand globally through infrastructure projects, M&As, technology exports and setting international standards (Leutert, 2020; Cardinale, Landoni, & Mi, 2024).

2.3.3. Heuristic strengths

The framing of the relationship between innovation, higher education and socioeconomic development through Triple Helix and Enterprise University have created epistemic communities that bring together a mass of academics, practitioners, policymakers and other influential individuals through the informal associations in multiple disciplinary fields. Community members share similar positions, norms, and values, and are sustained through informal associations and communication channels. The involvement of influential individuals reinforces the policy relevance of particular conceptual frames, shaping how innovation is understood and governed. Beyond the material components of innovation systems, the informational and relational dimensions—embodied in the scholarly and policy discourse and mediated through these networks—contribute to paradigmatic shifts in how innovation is framed and practiced (Sharif, 2006).

In this light, though ontologically distinct, innovation frameworks have been influential heuristics to examine the GBA's innovation systems. The System approach leaves room for comparison across contexts. Triple Helix is valuable in the degree of detail that maps out different scalars of actors, activities and interactions for suggestive innovation frameworks. This can be particularly indicative to the GBA where some of the subsystems (e.g., Donguan, Zhongshan) are still in nascence while the regional innovation model remains to be articulated.

Regional innovation system is another reduced concept featuring geographic specificity (rather than national generality); and greater distance from national policy frameworks (Den Hertog et al., 2001). Albeit its normative character and operational challenges, Triple Helix has been a heuristic to elucidate the principles of identifying regional stakeholders. The idea that innovation systems are self-replicable at different scales is particularly useful in outlining the complexity of modern economies, the ongoing internal changes across national economy, and various forms of regional and local capitals and institutional capacity to address these changes. This geographical and institutional demarcation takes into account resource availability, preceding industrial and enterprise practices and government policy priorities. The regional constellation secures a broader political legitimacy for local interventions and garner visibility for the generation of regional initiatives and identities. Its application as a common but locally permeable framework makes it possible to address macroeconomic challenges across the nation while pursuing more confidence, consistency and coherence at the sub-national scale.

The neo-institutional and evolutionary perspectives of Triple Helix is also significant meso-foundation for understanding the components, functions and interactions within innovation systems. Although Triple Helix remains a relatively simplified heuristic, it is open to adaptations. Built on Etzkowitz and Leydesdorff (1998)'s initial proposal, scholars and practitioners from plural domains have been discussing and testing the model against different contexts. For instance, one stream of scholarship argued that a quadruple helix model fits better with contexts where the civil society or the media and culture-based public has a strong presence in innovation (e.g., Carayannis & Campbell, 2009; Afonso et al., 2012; Ivanova, 2014; Kimatu, 2016). As innovation systems evolve and become more open, Triple Helix indicators can be extended to N-tuple of helices (Leydesdorff, 2012; Amir & Nugroho, 2013). On revision of Triple Helix, the polyvalent nature of knowledge has also been acknowledged, being both theoretical and practical, publishable and patentable (Ranga & Etzkowitz, 2015); and the process of formulating a university-centred endogenous strategy for regional development is deemed a complex long-term phenomenon (Ranga & Etzkowitz, 2010). This makes possible for a more nuanced conceptualisation of innovation activities and outcomes, particularly those related to universities.

2.4. Application of conceptual frameworks

2.4.1. The economic conceptualisations of innovation

A substantial body of innovation literature is grounded in economic theories, particularly the Schumpeterian tradition, which conceptualises the relationship between human capital, innovation, and economic development. Schumpeter (1911/1919) defined innovation as "new combinations" that drive economic change—introducing new products, production methods, business models, and market entries. These innovations, though rooted in existing structures, disrupt equilibrium through "creative destruction." Central to this view is the heroic entrepreneur who induces structural change through creative and pioneering acts under uncertainty, drawing on individual imagination, knowledge, and capabilities (e.g., managerial experience, education). As "first movers," such entrepreneurs enjoy temporary monopoly power and profits, which then attract imitators—driving the cyclical waves of innovation typical of competitive capitalism.

While these perspectives highlight the role of human capital, particularly individual agency in driving innovation, they tend to understate the significance of top-down, coordinated collective efforts. Rooted in the historical context of Western capitalist economies, such economic frameworks often fail to account for collective strategies more prominent in non-Western settings—such as the integration of large firms and entrepreneurs into China's central party-state apparatus—as well as the growing reliance on strategic planning and systemic design in contemporary Western innovation policy. Schumpeter himself acknowledged this limitation and advocated for case by case/context-specific approaches to understanding innovation trajectories, especially in relation to the state capitalism he envisioned as a later stage of capitalist evolution.

Within and across societies, the human capital (e.g., measured by knowledge, skill, and educational level) and social capital generated from networked innovation activities through and in higher education are positioned as drivers of innovation and economic growth, though their impacts are often intertwined and context-dependent (Burt, 1992; Dakhl & De Clercq, 2004).

2.4.2. Sociology of innovation studies

The multiplicity and complexity of society's working and the innovation undertakings illuminate that "more discursively open-ended concepts" should be created and brought to the forefront to crystallise plural imaginaries of modernities and the projects of innovation (Jasanoff, 2002, p. 271). Informed by the sociology of Science and Technology literature, as Amir and Nugroho (2013) put it, the role of STI needs to be reframed from being solely an engine of economic development to an institutionalised mechanism supportive of social equality and cultural diversity. This requires transformation in structure, culture and epistemology.

"Structure" refers to the political, economic and social relations built around states, "technoscientific institutions and class structures in society" (Amir & Nugroho, 2013, p.122). The directions, orientations and outcomes of innovation are framed by existing social structures. On the premise that innovation and technological independence are key to national security and capacity-building, states seek to reap benefits from entrepreneurial returns in domestic economy and global diaspora networks that capitalise on STI (Ibata-Arens, 2020). Nonetheless, the conceptualisation of innovation being scientific and technological production strongly oriented to economic performance, led by the triumvirate of the state, business and university, and primarily based on Western developed contexts, leaves out the wider societal benefits innovation can engender (e.g. the creation of a more widely accessible common pool of knowledge, the formation of integrated regional identities and indigenous innovation paradigms). It reinforces a technoscientific regime that is inclined to rule out social actors regarded as incompetent in participating in innovation activities (Sharif, 2004, 2006, 2015).

It is thus important to unpack the ways in which innovation is framed by different social structures, particularly the nuanced but oftentimes neglected cultural and epistemological dimensions. As Amir and Nugroho (2013) illuminated, one strategy is to take a more fluid and accommodating approach to understanding how innovation is locally perceived and accepted, identifying the potential cultural barriers related to local embeddedness and rearranging innovation activities and practices in a way more permeable to local realities. Another strategy is to look into the epistemological components of innovation. This deals with the ways innovation agenda is identified, defined, organised and evaluated as well as the methodologies appropriate for indigenously generating knowledge and connections. Both strategies have first been touched by discussing the widely-adopted innovation frameworks in the previous sections, which in part reflect and influence the thinking and practices of relevant innovation stakeholders (e.g., Triple Helix has become a popular academic and policy discourse). In this line of thinking, the following sections review the global, national and local contexts that affect the way innovation is perceived and practised.

2.4.3. "Glonacal agency heuristic": multi-scalar innovation

Though primarily focusing on higher education, Marginson (2022d)'s "Glonacal agency heuristic" is explanatory to the multi-scalarity of innovation and instrumental in integrating system approaches, Triple Helix theory, and social network theory into a coherent conceptual framework. It informs this study's two units of analyses: the university as an institution (university innovation models) and the university as a node within "glonacal" innovation networks (interaction models).

Moving beyond single-scale perspectives that NIS heavily rests on, or simplistic global/local binaries, innovation should be conceptualised with an "open ontology" where global, (pan-)national, regional, and local scales coexist, interact, and shift in primacy within dynamic configurations (p.24). Neither the nation-state nor a monolithic global exclusively contains innovation activities, despite intertwined tendencies of techno-nationalism and globalism. Powerful homogenising trends such as global rankings, the WCU agenda, and publication regimes, shape innovation practices, yet local adaptations and epistemic pluralism persist.

University innovation thus sits at the interface of global, international, national, and local scales, containing both productive opportunities and tensions. At the local level, university innovation models help conceptualise universities as innovation institutions, highlighting key organisational factors that influence innovation. For instance, the Entrepreneurial University emphasises innovation through knowledge commercialisation and startup creation, with entrepreneurial culture and executive control as important configurations (Etzkowitz & Zhou, 2017). The WCU agenda frames innovation more closely with universities' social and cultural missions, emphasising attributes such as academic collegiality as essential to fostering innovation (Marginson, 2017; Yang, 2017).

2.4.4. Definitions of key innovation concepts

In this study, "innovation" refers to the disruptive creation or incremental transformation of process, product, or intellectual and social organisation at the levels of institution and social system. Innovation can occur throughout the stages of identifying new needs, in conjecturing, forming, implementing and institutionalising new solutions (Cai, 2017). Novelty and implementation are the core features of innovation (Tierney et al., 2016). Only when an innovative idea, concept or product is made explicit and has its novelty perceived by a critical audience can it be considered as an innovation.

In higher education, innovation can take the form of new or improved processes in teaching, research, management and governance; or creation of products (e.g., graduates, publications, patents, licensing), intellectual organisation (e.g., applied and contract research, consultancy) and social organisation (e.g., technology transfer office, spin-offs), the aims of which is to create new value for the university's stakeholders and contribute to social and economic well-being (Cai, 2017). Anything that an individual or institution does to fulfill these aims are **"innovation activities"**, the customary application of which becomes **"innovation practices"**. In a similar vein, any interactions oriented towards the aims of innovation can be referred to as **"innovation-oriented collaborative activities"**.

The System theory defines an **innovation system** as the assemblage of institutions engaging in knowledge production, diffusion, and application of new technologies (Freeman, 1987), which are key to enhancing the growth and productivity of economy (OECD, 1999). The system is replicable at local levels, such as **regional innovation systems** at (pan-) provincial, city and district levels. Therefore, while the system approach advances thinking at a macro-level that identifies the common national framework by which all Chinese universities are conditioned, regional innovation system captures the geographic specificity of innovation within the GBA, the sub-systems within which universities are also nested.

With a focus on both meso- and micro-levels, Triple Helix specifies innovation (sub) systems as the functional division of labour among government, industry and university. According to Etzkowitz and Zhou (2017), the analysis of **industry** takes firms as the basic unit while government can be substantiated as government institutions at different levels. In the case of China, **government** comprises the Communist Party of China, ministerial departments and their local divisions. For this study, the local divisions at provincial, city and district levels, which also contain members from the Party, serve as the basic unit to analyse local government's interaction with the case universities. The triad is reproducible, being global, regional, sectorial and technological systems, and across the dimensions of separate enterprises and projects (Ivanova & Leydesdorff, 2014).

Ideally, the self-organising interaction of the triad makes possible the development of **innovation ecosystems**, where personnel, resources and knowledge flow freely across institutional spheres. Beyond the functional economic spheres mandated by political intervention, innovation (sub)ecosystems are self-perpetuating and mostly depending on the voluntary collaborations of institutions and actors.

The System and Triple Helix approach suggest that universities contribute directly (knowledge production, dissemination and commercialisation; creation of new ventures) and indirectly (education and workforce training) to regional innovation. Both help to identify the configurations and/or factors involved in motivating universities' interaction with government and industry partners. For instance, universities expected to directly commercialise knowledge more often engage with the industry through intermediary organisations and producing startups, licensing, and patents.

2.5. Innovation systems in China

2.5.1. Triple helix in China

Numerous studies have applied Triple Helix to analysing innovation systems in China, —ranging from descriptions of Triple Helix relations (Xue & Zhou, 2011), to its development within specific industrial sectors (Zhang et al., 2013) and regions (Cai & Liu, 2015; 2018), as well as focused examinations of issues such as technology transfer (Tang, 2008; Rao, 2013). A shared view across this literature is that while the Triple Helix offers a viable approach to enhancing China's innovation capacity, its implementation remains challenging.

Testing against the institutional logics of Triple Helix, Cai (2014) noted that China is moving closer to the West in terms of the beliefs in technology innovation as an engine for economic growth; IPR protection; market orientation and competition. There is limited trust between academia and industry in part due to the weak protection of IPR. Accordingly, the central government has heavily invested in national priority projects and science parks to promote university–industry collaboration, with firms in these parks and university spin-offs enabling more effective participation in Triple Helix. Nevertheless, process management, democracy in policymaking and civil society, the three important institutional logics, are largely absent in the Chinese context. Feedback has been difficult to be assimilated in central policymaking, the reality of which is entrenched in the traditions and political systems in China and thus likely to endure in the future.

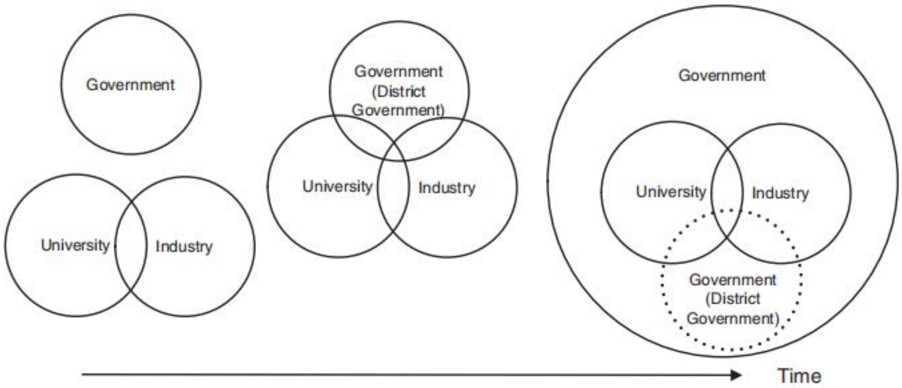
The distinctively different political, economic, social, cultural and institutional environment in China from that of West where the model largely rests on, can be both barriers and potential sources of innovation. On one hand, it is an opportunity to improve the innovation environments in China (Cai, 2014). Government intervention can effectively establish regional innovation systems, especially in critical national situations, as seen in Northeast China during the early years. While the top-down model can yield quick results, it often leads to a lack of adaptability in universities and industries, potentially causing severe path dependency in future development, as observed in the decline of the Northeast region's Triple Helix model since the late 1990s (Ha & Lin, 2023).

On the other hand, the statist model, though largely fitting with the state's central role in steering innovation systems, is not deemed the only option. As Cai and Liu (2015) suggested, under central governance, provinces comprise the basic units of establishing innovation systems. Provincial governments enjoy a high level of economic and administrative autonomy over the design of local innovation and industrial policies; the administration of provincially-located universities and their innovation output. The actual interactions and suitable Triple Helix models vary by the disparate conditions of regions in China.

For instance, in Kang et al. (2019)'s study, university–government bilateral collaboration remained the tightest network in Shanghai; whereas in Beijing, university–industry bilateral collaboration is the tightest in recent years. Triple Helix was just about to take shape in both cities yet already showing signs of decline in the long run. In another case study of Shanghai, Cai and Liu (2015) noted that the district government served as an equal partner of university administrated by the central and the provincial governments.

Different from the statist-to-interactive transition Etzkowitz prescribed, the Tongji Creative Cluster emerged from the unmediated collaboration between Tongji University and the surrounding community to meet common demands for facilities and services. Later as part of the urban regeneration plan, the cluster was upgraded under the joint planning of Tongji University and Yangpu District government and eventually integrated into municipal and central governments' regulation as its social and economic influences enhance. This was when its Triple Helix became government-led, and district government took on more encompassing roles in mediating top-down and bottom-up initiatives (Figure 2.4).

Figure 2.4. Triple Helix in Shanghai



Delayed government-led model.

Source: Cai & Liu (2015)., p12

By mapping the distinctive evolutionary pathways of six Chinese regions, Ha and Lin (2023) also illustrated the local variations and dynamic trajectories of Triple Helix in China. Numerous innovation clusters originated in universities or industries, exhibiting a bottom-up approach where governments selected winners and supported industry policies through initiatives of introducing higher education resources and establishing science parks. Similar to the Tongji Cluster, Beijing Zhongguancun electronic information cluster illustrated a transition from a university-led single helix to a balanced Triple Helix. Initially driven by university-industry collaboration, the cluster gained momentum through grassroots entrepreneurial activities by scientists and university-affiliated enterprises. Recognising its strategic potential, the municipal government later introduced formal policies and resources, transforming it into a nationally recognised innovation hub and an exemplar of China's Triple Helix.

By comparison, the Yantai biopharmaceutical cluster in Shandong province emerged under industry leadership and gradually evolved into a balanced Triple Helix through strategic partnerships with universities and growing support from government's industrial clustering policies and platform strategies. Both Wuhan and Shenzhen transitioned from government-led initiatives to balanced Triple Helix models through market reforms and innovation policies, though Wuhan leveraged its established academic bases whereas Shenzhen introduced and built new academic institutions to address its under-supply of higher education alongside development of high-tech industries. Nevertheless, not all transitioned to a Triple Helix. The Northeast region, for example, shifted from a government-led, university–industry collaboration to a university-led development. Initially, strong government support fostered industrial and academic growth, but over time, regional disadvantages, delayed reforms, and the decline of government involvement led to the breakdown of the Triple Helix, leaving universities to develop independently.

Table 2.5 Various Helix Evolutionary Trajectories and Final Forms across Six Chinese Regions

Region	Helix Evolution	Key Developmental	Final Form

		Stages	
Beijing Zhongguancun Electronic Information Cluster	University → Industry → Government	University-led development; absence of government guidance	Balanced Triple Helix
Wuhan Optics Valley Optoelectronics Cluster	Government → University → Industry	Government planning stage; disconnect with industry demand	Balanced Triple Helix
Yantai Biopharmaceutical Cluster	Industry → University → Government	Industry-only operation; absence of government guidance	Balanced Triple Helix
Shenzhen Industrial Upgrading	Government → Industry → University	Government planning stage; insufficient intellectual support	Balanced Triple Helix
Formation and Transformation of the "Jinjiang Model"	Industry → Government	Industry-only operation; insufficient intellectual support	n/a
Decline of the Northeast Old Industrial Base	(Government + Industry + University) → University	Balanced Triple Helix under state intervention; university-led development	n/a

Source: Author's translation from Ha & Lin (2023)

Drawing on these comparisons, Ha and Lin (2023) highlighted how Triple Helix evolution normally started with one leading sphere before engaging the others, and the sequence of which shapes the system's opportunities, and challenges. Government-initiated models often encounter bureaucratic inertia. University-origin models emphasise knowledge-intensive research whereas industry-led models drives rapid commercialisation. Although drawing primarily on the Chinese cases, this context-specific, evolutionary approach to understanding and examining Helix configurations is indicative to wider contexts that Helix configurations vary as each helix assumes different leadership roles and innovation capacities shaped by its relative strengths and interaction dynamics.

While various network perspectives such as social network analysis, actor networks, and innovation systems have been applied to conceptualise cross-sectoral connections, much of the existing literature focuses on mapping institutional and intra-/inter-regional networks. Some studies have employed quantitative methods to analyse technology transfer and knowledge spillover patterns across regions in China (Ma et al., 2020; Yang et al., 2022; Zhao et al., 2024).

2.5.2. Innovation systems of the GBA

2.5.2.1. Guangdong: the statist-fading innovation system and entrepreneurial visions

Guangdong's innovation primarily concentrates in manufacturing-based enterprises, with innovation mainly occurring in design and production sectors (Liu, 2023). Outside Guangzhou and Shenzhen, both industry and higher education exhibit underdeveloped innovation capacity and limited interaction (Li & Li, 2022). Many universities are primarily teaching institutions, focusing on supplying skilled labour, while key industries remain concentrated in manufacturing and see noticeable convergence in technology-intensive sectors (Zhuo, Yang & Ma, 2020; Yang & Qing, 2024). Notwithstanding the absence of WCU, Guangdong province shares the nationwide aspiration for enterprise universities with world-class status. As the pilot case of joint administration, the State Education Commission and provincial government have been jointly administering and funding SYSU and SCUT since 1993 (Zhang, 2018). This pilot status has brought more autonomy to the self-mastery of Guangdong province. The socialist market system is leveraged to support local adaptiveness in response to socioeconomic changes (Mok, Welch & Kang, 2020).

The GBA Initiative has expanded the provincial imaginary of enterprise universities that is conducive to the ambition of becoming a world-class bay area. Convergent with the influential global imaginaries, enterprise universities are envisioned as the engines of innovation, magnets of research resources and global talents. In line with the national imaginary, the GBA is positioned as a demonstration zone for international higher education to attain leadership in global research through the DFC (Wang, 2019) and a further array of regional innovation initiatives. Economic development of the GBA is attached increasing significance amid the USA-China trade war (Berlie & Hung, 2020).

For leapfrog development, governments are instrumental in questing for new growth areas and implementing more flexible policies to support innovation start-ups. The strong intention to engage multi-actors including university, industry, the business sector and civil society to promote innovative economies becomes a feature of "an adaptive and entrepreneurial state" (Mok, 2017, p.206). The DoST of Guangdong plays a central role in implementing and adjusting the Specialised Towns Programme, ranging from industrial parks to innovation clusters. To increase efficiency, the department has established and funded innovation platforms for the specialised sectors, pushed the innovation centres to operate in a competitive market logic while keeping control over their operations through the board of directors who define the strategic priorities and areas of intervention (Barbieri et al., 2019).

Industrial structure deviation exists in the secondary industries of both Guangdong and HK. This indicates the complementarity within the GBA: the number of science and engineering talents graduating from the universities in HK exceeds the demands of its local needs, while the science and engineering talents cultivated by universities in Guangdong cannot satisfy the needs of its secondary industries (Ma et al., 2020). The common need to improve higher education and innovation systems, as well as the geographical, cultural and language proximity among Guangdong province, HK and Macau, becomes an incentive to encourage a wider range of innovative collaborations.

Amid such provincial imaginaries, Guangzhou and Shenzhen are the two most pronounced cities in building up local innovation systems and facilitating regional integration, with one being the capital of the province and the other as the only Special Economic Zone (SEZ) inside the province. Both cities are relatively advanced in their processes of industrialisation, urbanisation and internationalisation.

Based on a evolutionary review of institutional logics, Liu and Cai (2018) highlighted that Shenzhen SEZ exemplifies a "statist-fading balanced" Triple Helix. The central state initially drove reform through fiscal and administrative devolution, gradually receding as local government, industry, and universities, starting with Shenzhen University, followed by Tsinghua and Peking, formed synergistic partnerships grounded in state rescaling, market orientation, and professional expertise. Shenzhen's innovation system evolved from government-led infrastructure and low-end manufacturing to industry-driven high-tech upgrading, ultimately culminating in university-driven innovation capacity (Ha & Lin, 2023).

Guangzhou, another subcentre of Guangdong, also marks the transition from a planned economy to a market-oriented innovation system through decentralisation of administrative power (Lo, 1994; Xu & Yeh, 2005). Guangzhou government plays a key role in establishing special economic zones, attracting foreign investment, and planning science and industrial parks (Guangzhou Municipal Government, 2003, 2006; Barbieri, Di Tommaso, & Huang, 2010). As market forces strengthened, enterprises began to innovate independently and form industrial clusters. Guangzhou has a more developed higher education system, with the highest concentration of universities. However, academic institutions have been disconnected from its traditionally labour-intensive and export-oriented local industries, though university-industry collaboration began to emerge with industrial upgrading and government facilitation (Zhuo, 2025).

Although research on the helix configurations of subsystems outside Shenzhen is limited, the integrated literature suggests that, despite intra-provincial disparities, Guangdong broadly exhibits a statist-fading innovation system given its strategic role as the piloting demonstration zone of China for market reform and opening up, where local governments have been granted significant discretion in fostering their industries and higher education. However, whether Guangdong is transitioning into a Triple Helix, and to what extent, still warrants further investigation and empirical evidence.

2.5.2.2. HK: the laissez-faire innovation system and visions for an international education hub

HK's higher education vision is located within a greater ambition to become an international education hub[5], shaped by market-driven principle that emphasises the commercialisation of education through the import and export of foreign demand and supply, leading to transnational initiatives, broadening opportunities for both international and domestic students (Kleibert, 2021). The HKSAR government has traditionally been a "market facilitator" (Lo, 2018). Under the influence of neoliberal governance, it also introduced a self-financing model for postgraduate and sub-degree programs, which has led to rapid growth of full-cost recovery programs in both public and private HEIs to attract non-local providers and students.

Universities compete for diversified resources, focusing on key areas of excellence and striving for higher global rankings (Chan & Ng, 2008). Operating under an increasingly corporate governance model, universities experience a paradox of "decentralisation-centralisation", balancing institutional autonomy with stringent accountability (Mok, 2019). Under the push for self-financing and income diversification and the valorisation for mainland-HK cooperation, HK HEIs increasingly seek entrepreneurial opportunities for building new institutions and programs through provincial/municipality-university collaborations. Most HK universities (e.g., HKU, CUHK, HKUST, Lingnan University) have established or are in the process of building cross-border campuses, research institutes, and hospitals in emerging subcentral city-regions in Guangdong. These cross-border institutions allowed HK universities to expand physical presence, attract a larger pool of talents and students, thus enhancing their reputation and competitiveness (Tao & Hou, 2023). The proximity to Mainland China's vast market and application scenarios also facilitated collaboration with local governments, institutions and industries, advancing collaborative funding application, research and commercialisation (Tang, 2019; Shenzhen Municipal Government, 2022).

However, the efforts to develop higher education industry competitively within the Chinese market (Tsang, 2011) have encountered criticisms for being a form of "mainlandisation" (Lai & Maclean, 2011) and for self-financing transnational programs and mainland institutes being stigmatised as inferior to their parent universities (Waters & Leung, 2017; Lo & Li, 2023). Progress in hub projects and innovation-driven development through academia-industry-government collaboration is been critiqued as slow due to HK's non-interventionist, laissez-faire tradition (Mok, 2016; Beecher et al., 2020; Lo & Wan, 2021). Unlike Singapore, Malaysia, and South Korea, which incentivise foreign universities, HK's market-driven approach lacks visibility, strategic positioning, and effective government coordination (Mok, 2016). Compared to Singapore, a smaller city-state with a well-established global education system, HK's efforts are seen as less robust, and world-class soft power needs to be

[5]"A planned effort to build a critical mass of local and international actors strategically engaged in crossborder education, training, knowledge production and innovation initiatives" (Knight, 2011, p. 277)

built through broader regional and international cooperation (Cheng, Cheung & Yuen, 2016).

Mok (2016) further emphasised that the sustainability of hub projects depends on political will, policy adaptation, and responsiveness to HK's evolving political economy amidst the rise of major Chinese cities. One challenge consists in the perennial reconfiguration of university roles, particularly its increasing blurring line with business and civil society, which is notable but arguably not unique to HK. Yang (2012) contended that the entrepreneurial insights in HK stem from its history of business and international trading, with the colonial legacy of capitalism still influencing higher education's operational logic. Culturally, HK aligns with China in its Confucian values and a tradition of pursuing material success and social status, which supports entrepreneurship and innovation and may converge more closely with the mainland in future (Marginson, 2021). Nonetheless, universities, especially those top-ranking ones, remain disincentivised owing to the facts that academia is well-paid without linking performance to entrepreneurial activities.

Notably, the HKSAR government has signaled a shift from a laissez-faire to a more proactive approach to strategic innovation deployment, construction of innovation infrastructures, increased public funding for innovation and multisectoral collaborations such as the research matching grant scheme (HKSAR Government, 2023, 2024). Scholarship noted these changes as efforts to enhance universities' entrepreneurial roles and align research with societal impact, though the extent to which they signify a departure from Hong Kong's laissez-faire tradition remains contested (Lam, 2018; Kang & Jiang, 2019; Mok, 2020). For instance, Mok (2020) highlighted that the UGC introduced the Newby Report and the University Accountability Agreement to incentivise universities' broader engagement in knowledge transfer, particularly in urban and social innovation. Funding from the HKSAR Government and evaluation measures indicated increased cross-sectoral collaborations towards a Quadruple Helix.

However, there remains a bias towards the commercial value of university-industry collaboration, with most academics still reducing knowledge transfer to technology transfer and economic outcomes, which disadvantages social sciences and humanities. HK's path dependency in finance-driven economic growth may also transforme the vision of long-term innovation initiatives into short-term finance and business policies and activities (Tang, 2022). Despite efforts, HK's industries still lag behind global peers in technological upgrading and advancing up the value chain (Sharif, 2020), and academia remains confined to opportunities in the finance sector (Lo & Tang, 2020).

Another changing context is the subnational regionalisation of higher education presented by the GBA Initiative, where HK is increasingly positioned as a radiating educational hub with advantages in cultivating professionals, attracting elites to the surrounding city-regions, promoting internationalisation of higher education, science and technology knowledge transfer and the innovation ecosystem in Guangdong province (Lo & Li, 2023). The concentration of professors, research, capital, academic freedom, interdisciplinary faculties, and international research networks makes HK universities the "niches of affluent international social networks and social capital" (Chan, 2018, p.17). Nonetheless, there are concerns that integration may bring with it increased control by the Beijing's censorship and political ideology over academic freedom, and tensions arisen from the new National Security Law, undermine the consensus base of regional integration (Yu, 2021; Bamberger & Morris, 2024).

Therefore, the (re-)conceptualisation of HK's role in relation to the GBA and Guangdong province instead of to China as a singular homogeneous unit will yield fruitful analyses of intra-regional interactions of innovation policies, activities and practices while allowing more nuanced comparisons across different regions of China. Understanding the emerging role of HK as a radiating innovation hub of the GBA, especially the capacity in which it can spearhead the economic and social innovation in Guangzhou and Shenzhen (Lo & Li, 2023), will uncover crucial opportunities and challenges and support better-informed policymaking in building the regional innovation system. Meanwhile, it also remains to see how HKSAR government's efforts to incentivise a more "collaborative network model" in combination corporatised governance can facilitate a quadruple helix configuration across various innovation domains (Mok, 2020), and how the central planning depositions from Mainland China, along with the facilitation from the GBA initiative, affect the HKSAR's shift from laissez-faire approach to innovation capacity-building.

2.5.2.3. Macau: an uprising region-to-global player

As a former colony and island-state, Macau possesses a hybridity of Western-Eastern traditions, a small population and land size as in HK. However, Macau's imaginary is harmonious and receptive to both its Luso-colonial past and reintegrating Chinese national identity. Its hybrid character and going international have been "justified as good means of serving China and Macau economically and politically" (Lam, 2010, p.663). Macau's return is perceived more as an opportunity of achieving regional co-prosperity than a constraint to development. This openness is in part shaped by a laissez-faire but pragmatic government tradition (Tang & Bray, 2000) and Macau's stronger sociocultural and identity alignment with mainland China[6].

Open to reintegration, Macau made no restriction to enrolling students from mainland China. According to Li and Bray (2007), universities in Macau target this niche market through Mandarin-medium programs[7] and attracting average-level senior high

[6] Chinese identity was predominant even before the handover in Macau (Lam, 2010). Local students reveal the most integrative feelings to Cantonese, followed by English, Mandarin and Portuguese (Yan, 2017). Hao (2016) argued that the semi-democratic and largely authoritarian Portuguese heritage meshes with Chinese authoritarianism.

[7] Shaped by traditions in mainland China, Macau University of Science and Technology has most teaching in Mandarin.

school graduates who desire bachelor's degrees but fail to secure places at home. To have more space for concentration of talents and research capacity-building, Macau University relocated to Hengqin Island of Guangdong Province in 2014[8]. This strategic relocation illustrates expansion in the formation of cohesive educational narratives amid the strong presence of the Chinese state (Wu & Vong, 2017).

Given a strong focus on local economy (Bray & Kwo, 2003), Macau's university innovation activities start with the regional and is largely unexplored. Macau's knowledge and innovation bases are constrained by its small, fragmented, and predominantly private and vocation-oriented higher education sector (Tang & Bray, 2000); weak faculty governance; and the absence of science and technology-driven industries (Hao, 2016). Despite this, its emerging role as a region-to-global player through collaboration with Guangdong and HK is also indicative to the building of regional innovation system, but literature and empirical evidence regarding the innovation system configuration of Macau remains lacking.

2.6. GBA as a world-class innovation highland: imaginaries and challenges

Strategic governmental steering has been deemed practically useful and indispensable to the success in establishing innovation systems in the GBA (Wu, 2007; Yuan & Zhao 2011). There is pervasive use of spatially targeted initiatives with heterogeneous purposes and types. Albeit within the common policy framework, the development of science and technology varies by size, specialisation, development stage and degree of urbanisation (Barbieri, 2019), the innovation landscapes of which is further complicated by the legal, political and socioeconomic heterogeneity among Guangdong, HK and Macau (Xu & Lu, 2019). Exploration of these heterogeneous contexts provides a lens to understand how the perceived roles of universities are localised in different innovation subsystems.

The GBA's innovation-driven strategy translate global aspiration for research leadership and national ambition of a peaceful rise into a local vision of a world-class innovation ecosystem. There is a shared vision for universities to take on leading roles in creating an enterprising culture that fosters the integration and influence of the region while giving back to the local community, besides normalised roles in talent cultivation, institutional innovation, knowledge creation and transfer (Xu & Huang, 2020). This may direct future thinking and efforts towards the aggregation of world-class and enterprise universities of various types, being research-intensive multiversities, specialised universities (e.g. polytechnics), collaborative regional universities (e.g. CUHK-Shenzhen) and research institutes and high-tech industries (Lu & Lao, 2018), or emerging models derived from the openness of Chinese imaginary (Cai, 2020).

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[8] The Hengqin campus is governed by Macau's laws and connected to MSAR with a 24-hour underwater tunnel free of immigration check (Wu & Vong).

However, challenges remain in cooperation between stakeholders given the legal, political and socioeconomic heterogeneity inside the GBA (Xu & Lu, 2019). The formation of a world-class ecosystem largely depends on the GBA's capacity to forge new regional identities and bringing together its diverse actors and resources into addressing regional problems. It remains to see how the balance between top-down planning and bottom-up innovation, between short-term projects that produce quick results and large-scale ones initially beyond the region's repertories, is achieved. Although much discussion revolves around the importance of innovation-driven integration (Luo & Lao, 2018; Ou, 2018; Xie, Li & Liu, 2019), the conceptualisation of the enterprising role is largely normative. In practice, policy implementation is often subject to varied interpretations.

While Chinese imaginaries of the university are important in their own right and contribute to a global dialogue of civilisations (Li, 2012), key questions remain under-explored—what constitutes a university with Chinese characteristics, and how the entrepreneurial element fits into the reproduction of the WCU paradigm. Existing research has largely concentrated on 985 and 211 institutions, which comprise only a small segment of the GBA's higher education landscape. As an extension of the BRI, the GBA serves as a pilot zone for China's efforts to achieve leapfrog development through enhanced regional cooperation in science and technology. It thus presents a critical case for exploring and experimenting with university models that navigate the intersecting imaginaries of WCUs with Chinese characteristics and enterprising universities that both respond to and shape the regional innovation system.

2.7. Research Questions

Innovation is framed by different social structures, cultural and epistemological dimensions (Amir & Nugroho, 2013). So are the universities in the GBA. In higher education, innovations and the human and social capitals mobilised through networked activities are arguably more diverse than normatively discussed in the economic and innovation literature. While literature offers a conceptual lens with which to consider some of these components, the ways innovation and the role of universities are defined, organised and evaluated in the policy realm as well as the day-to-day practices of institutions and innovation actors remain to be unpacked through empirical research.

This research aims to broaden the conceptual understanding of innovation beyond competitive capitalism and individual entrepreneurship. With a nested multi-scalar approach, it seeks to understand the role of universities in the GBA afresh, specifically: What are the actual and possible roles of the universities in the GBA innovation system?

RQ1: How do stakeholders (academic, industry, government) understand innovation?

RQ2: How do stakeholders (academic, industry, government) understand the roles of each other in the regional innovation system?

RQ3 How do universities in the GBA engage in innovation-oriented collaborations with government, industry and civil society?

RQ4: What are the key influencing factors shaping the GBA's innovation system?

Chapter 3 Methodology

This chapter outlines the research design, rationales of case selection, sampling strategies and data collection methods. It then reveals how data were managed, translated, coded, analysed and developed into themes, concluding with the discussion of the researcher's positionality, ethical considerations and the challenges and limitations involved.

3.1. Research design

Drawing on Chapter 2, there are functional divisions of labour among the university, industry and government within both national and regional innovation systems. The university serves as both the institution of innovation, for instance, in research, commercialising knowledge and generating spin-offs, and the node connecting innovation actors across sectors. Hence, this study focused on the levels of regional innovation system, institution, collaborative project, and individual. The global, international, and (pan-)national levels were touched upon in policy document analysis, where (supra-)national scale of innovation constitutes a standalone recurring theme. All scales were integrated in the discussion of influencing factors (Chapter 8).

A single nested case study design was employed to analyse multi-level innovation activities in the GBA holistically with a bricolage of evidence from interviews, documents, websites and media. Semi-structured interviews were conducted with university faculties, industrial partners and government officials. Key policy documents were downloaded from the websites of various government departments at different levels, including the State Council, the Ministry of Science and Technology (MOST), the Ministry of Education (MOE), the Department of Education (DoE), and the Department of Science, Technology and Innovation (DoSTI)at provincial (Guangdong), municipal (Guangzhou, and district, i.e., Haizhu, Tianhe, Panyu) levels. Institutional documents were collected from university websites and WeChat Accounts.

To address RQ1 (Chapter 4), thematic analysis was applied to policy documents and interview transcripts, highlighting similarities and differences between the two. RQ 2 and 3 (Chapters 5–7) were examined by mapping SYSU's innovation strategies and practices through thematic analysis of interviews, policies, institutional documents, and official WeChat posts, with insights into industry and government roles drawn from interviews. RQ4 (Chapter 8) was explored through an integrated analysis of policies, interviews, and documents, building on findings from Chapters 4 to 7. The overarching question of the university's contribution is discussed in Chapter 9.

3.2. The nested case study approach

The case study is defined as a research design frame that analyses "persons, events, decisions, periods, projects, policies, institutions or other phenomenon" holistically with one or multiple methods to elucidate some analytical themes (Thomas, 2021, p. 24). A single nested case study design was chosen given both the nature and particular attributes of this research.

Innovation collaborations take place at multiple levels where individuals are clustered, for instance, in project teams and schools. This feature determines that a nested case study design is particularly suitable for comparing different levels of innovation engagement within the case university and its interaction with the industry and government. In this study, examples were drawn from the units such as influential individuals, project teams, departments and their collaborative partnerships that were integral parts of the wider case. This design was sensible for the GBA where numerous contingencies and processes are at play in a sophisticated way (Harrion & Easton, 2004). It increased the number of embedded cases, namely departments and individuals of the case university and the university's collaborative networks across the region. Specific rationales are as follows.

First, the study of innovation in higher education, particularly regarding the GBA, still stays in a pre-paradigmatic stage where innovation needs to be conceptualised further (Cai, 2017). Given the embryonic nature of this topic field and the dearth of empirical research that generates robust framework to understand the innovation dynamics in the GBA, the case study approach is essential in bringing studies of what have hitherto been global studies of theories and practice to the local level of day-to-day realities (Yang, 2002). As the appropriate frame to observe the naturally occurring innovation processes and interactions in the "real-world context" of the GBA (Yin, 2018, p. 15), this approach potentially reduces the hiatus among conceptualisation, policy, and practice that has been under-examined.

In particular, the GBA features diversity of political, economic and institutional environments that further complicates the realities for regional collaboration and innovation. The nested case design empowers research of complex occurrences with diverse perspectives gained from a portfolio of research methods and evidence, which can be historical-phenomenological and empirical. This "polyhedron of intelligibility" (Foucault, 1981, p.4) enables triangulation of local and institutional activities within various historical contexts. It conduces to a richer, more rounded and balanced picture of the motives, dynamics and the tensions involved in the collaborations within the GBA. It endorses a more creative and critical approach to addressing the "why" and "how" questions for the development of this embryonic area beyond methodological formulae (Thomas, 2021).

Furthermore, this approach takes interest in both the uniqueness of GBA as a whole and the completeness of specific innovation dynamics within the region touching upon different levels and actors. Small questions concerning the realities of the case university, or the industrial and governmental stakeholders, the "idiograph" (Thomas, 2021, p.6), potentially lead to bigger answers to the development of the GBA, the greater China and even the rest of the world that strives to fertilise self-sustaining innovation systems. Therefore, this research followed an abduction inference logic that on one hand, explored the particularity of innovation units drawing on the theories and studies regarding the wider case and the context surrounds (e.g., NIS, Triple Helix, WCU agenda). On the other hand, the evidence derived from the integral units was conjoined to generate compelling insights of the case and the "glonacal" imaginaries of universities and regional innovation systems.

Finally, this approach was notably flexible in returning to the sites to gather more data within the four-year time frame. This conduces to the depth and detailed capturing of structure-agency morphogenesis, where agents' conceptualisations of innovation was in part shaped by, changing with, and feeding back to the innovation activities they engage in. Although most fieldwork was conducted in a period (Jan 2022-Sep 2022) that witnessed the change of university leadership and some institutional practices, a few more interviews were conducted thereafter (Feb-Sep 2023) following a snow-balling strategy to attain real-time and retrospective data. During data analysis, some follow-up responses were also obtained from interviewees to clarify or substantiate what was mentioned.

3.2.1. Case selection

Given the trade-off between a feasible scope for DPhil and gaining richer data on the university's interaction with other sectors, two units of analysis are addressed in this study: the universities as institutions of innovation, and the universities as nodes of multisectoral networks within local innovation systems. With the selected case university and its interacting stakeholders in higher education, the industry and the government within the GBA as an integrated case, the research sheds light on the important features of university innovation models and innovation-oriented interaction at the meso- (sub-ecosystems comprising other universities, local government organisations, and industry partners) and micro-level (project-level collaborations and individual relationships).

3.2.1.1. The case university: SYSU

To explore how the university serves as both the institution and node of innovation networks, Sun-Yet-San University (hereafter noted as "SYSU") was selected as the case university because of: 1) its long-standing academic excellence in relation to the WCU agenda and notably comprehensive disciplinary profile; 2) its favorable localities in the most affluent or key strategic cities outlined in the initiative (i.e., Guangzhou, Shenzhen, Zhuhai); 3) its extensive formal and informal connections with universities within the GBA and leadership role in Guangdong-Hong Kong-Macau University Alliance. These attributes are specified in the following overview of university history and profile.

Founded in 1924, SYSU has been the top-ranking and historic DFC University in Guangdong Province[9]. It was titled as "the pillar of the south" (南天一柱) by Premier

[9] National ranking of Chinese universities is accessible at: https://www.shanghairanking.cn/rankings/bcur/202010

Li Keqiang during his visit in 2021[10], as a testament to its resilience, perseverance, and down-to-earth approach in pursuing the pinnacle of knowledge, erudition, and accomplishment for over a century. This commendation was also cited by interviewee UNI-LS-P3.

Notwithstanding its long-standing academic excellence, as suggested by Premier Li, SYSU has undergone notable reverses. Amid the reorganisation of national higher education in the early 1950s, most faculties of SYSU were dismembered into independent colleges. Its School of Engineering, Education, and Agriculture were turned into SCUT, SCNU, and SCAU respectively, which become notable DFC Universities in the GBA (MOE, 2022a). Its School of Medicine and major faculties in Philosophy, Linguistics, Law, Finance and Business Studies were hived off to other universities such as Peking University and Hunan University but were reassembled after the late 1950s. The separation of agriculture, education, engineering and medicine in the 1950s further enhanced the central role of basic theoretical studies as SYSU's focus and advantage.

Since the late 1970s, SYSU has been rebuilding its School of Business, Law, Science, Engineering, Pharmaceutical Studies, Public Health and Agriculture. In 2001, Sun-Yet-Sen University of Medical Sciences was merged into SYSU and became Zhongshan School of Medicine, along with its 7 affiliated hospitals. To strengthen its applied sciences, over 10 engineering schools were established between 2010 and 2020. SYSU is now the university with arguably the most comprehensive sets of discipline and the largest number of First-Class Disciplines in Guangdong Province (Table 3.1 and Figure 3.1).

Table 3.1 List of First-Class Disciplines of universities in Guangdong (2022)

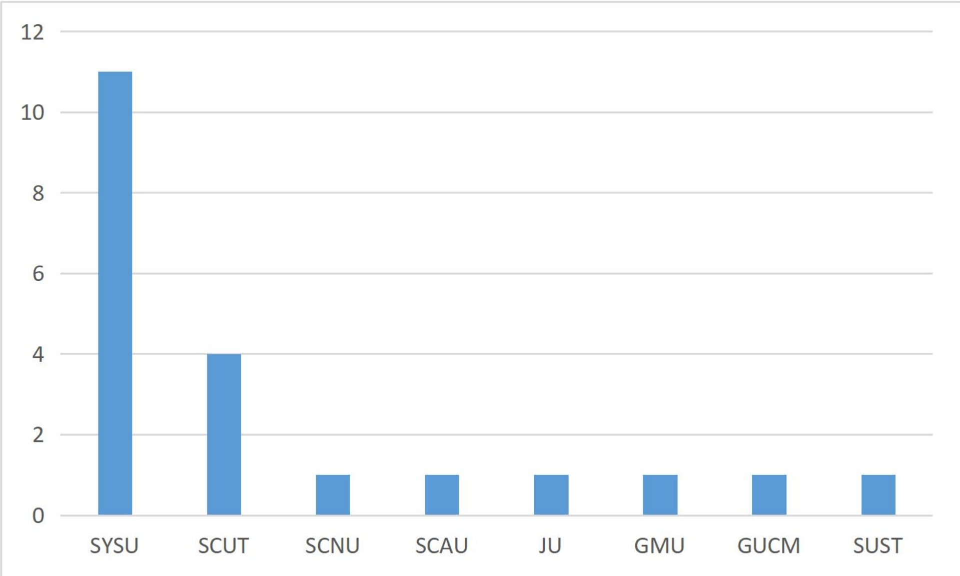
Sun-Yet-Sen University (SYSU)	Ecology, Biology, Chemistry, Material Science & Engineering, Electronic Science & Technology, Pharmacy, Basic Medical Science, Clinical Science, Business Management, Mathematics, Philosophy
South China University of Technology (SCUT)	Chemistry, Material Science & Engineering, Light Industry Technology & Engineering, Food Science & Engineering

[10] https://www.sysu.edu.cn/news/info/2161/479771.htm

South China Normal University (SCNU)	Physics
South China Agricultural University (SCAU)	Agronomy
Jinan University (JU)	Pharmacy
Guangzhou Medical University (GMU)	Clinical Science
Guangzhou University of Chinese Medicine (GUCM)	Traditional Chinese Medicine & Pharmacy
Southern University of Science and Technology (SUST)	Mathematics

Source: MOE (2022)'s List of First Class Disciplines Translated by the author

Figure 3.1 Number of Universities with First-Class Disciplines in Guangdong (2022)



Source: adapted from Table 1 by the author

To take full advantage of its favorable localities in Guangdong and comprehensive disciplinary profile, in 1999, SYSU built its Zhuhai campus in cooperation with the Zhuhai Municipal Government. The new campus contains 20 schools that cover Science, Engineering, Social Sciences and Humanities and aims to serve the national strategies of strengthening ocean power, space science and technology, and the One-Belt-One-Road Initiative with interdisciplinary research and development[11]. In 2015, the Shenzhen campus was officially established after SYSU signed the *Strategic Cooperation Agreement on Building a World-Class University* with Shenzhen Municipal Government. Meanwhile, a number of regional research centres such as the Centre for HK, Macau, and Pearl River Delta Studies and Collaborative Innovation Centre for HK, Macau, and Mainland China, both of which were built into a national think tank, Institute of Guangdong, HK, and Macau Development Studies,

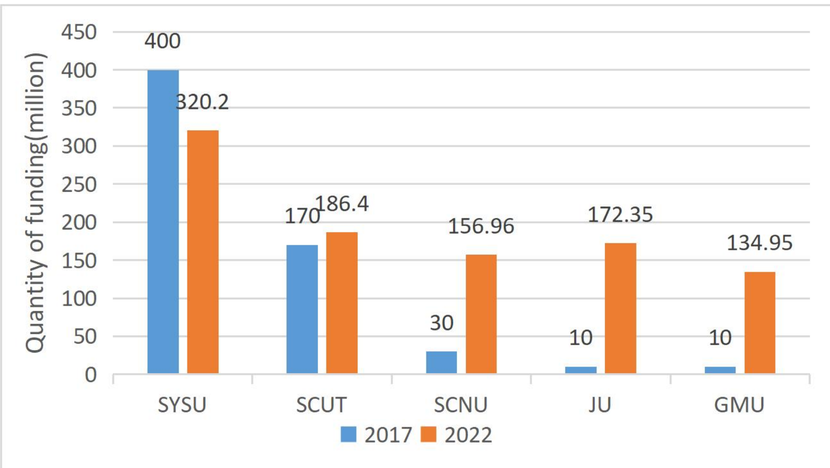
[11] https://fgw.sysu.edu.cn/zhuhai/about

in 2015[12]. In collaboration with Macau University and Chinese University of Hong Kong, SYSU led the establishment of Guangdong-Hong Kong-Macau University Alliance in 2016, which has included 26 Guangdong universities, 9 Hong Kong universities, and 7 Macau universities by 2022.

Over almost a century since its establishment, SYSU has grown into a comprehensive conglomerate university with substantial physical infrastructures, educational programmes, and resources (e.g., research funding, facilities, faculties, student bodies). By 2022, SYSU has 69 schools with 141 undergraduate, 64 Masters, 57 Doctoral programs, and 44 post-doctoral centres, 35 national key laboratories, research institutes, and centres across its five campuses in Guangzhou, Shenzhen, and Zhuhai and over ten affiliated hospitals. It has a faculty of 4,771 and an enrolment of 10,163 Doctoral candidates, 23,125 master's candidates, 33,224 undergraduates, and 623 oversea students (SYSU Information Disclosure, 2022).

Notably, in the past three decades, SYSU has been enlisted in the WCU agenda and receiving support from both central and provincial government. Since the 1990s, SYSU, along with SCUT, the merely two universities under the dual governance of MOE and Guangdong province, was enlisted in and funded by Project 985 and Project 211 as the first batch of Chinese universities to be built into WCUs (MOE, 2005, 2006, n.d.). Since 2017, Project 985 and Project 211 were replaced by the DFC Project, the university list of which renews every five years (MOE, 2017). SYSU was enlisted in the DFC in 2017 and 2022. Albeit the quantity of funding granted by MOE was not made public, SYSU received the most funding from Guangdong province (Figure 3.2). Besides direct funding, SYSU has been granted 78 key national projects ever since 2016, and over a thousand funded projects from NNSFC each year starting from 2021 (SYSU News, 2022).

Figure 3.2 Distribution of Double First-Class University provincial funding in Guangdong (2017 & 2022)



[12] https://ygafz.sysu.edu.cn/introduction

Source: adapted from Department of Education of Guangdong Province (2017) and People's Government of Guangdong Province (2022) by the author

SYSU serves as a notably representative case of a MoE–administered university in the GBA, whose President and Party Secretary are respectively appointed by the Organisation Department of the Communist Party of China (ODCPC) and the Guangdong provincial Party committee. The president holds a sub-provincial or ministerial-level rank, placing the appointment authority within the purview of the ODCPC, and situating decision-making power over the university's innovation strategies and practices under the control of the central party-state.

SYSU's multidisciplinary profile throws light on the similarities and varieties of how innovation are conceptualised and practised across different disciplines and schools. Being a long-standing conglomerate with abundant resources and commitment to multi-disciplinarity in pursuit of WCU agenda, SYSU arguably reflects some features of the "multiversity" (Kerr, 1963). Its plural localities and extensive collaborative connections within the GBA make it a critical node of innovation networks. Hence, this case study provides crucial implications for the distinctive features of university model and the role of universities in regional innovation system in relation to the WCU agenda in the GBA experience.

3.2.1.2. Selection of schools

The multi-disciplinary feature of SYSU adds insight to the potential disciplinary differences in conceptualising innovation. To represent such diversity, 12 schools across five campuses were selected. However, the predominant focus was on the Guangzhou campuses, the most historic and established ones that Zhuhai and Shenzhen campuses built on and in part shared faculties with.

With a focus on the collaborations within the GBA, the primary selection criterion was the scope of external connections with non-university actors. Preliminary screening of school websites and faculties' profiles indicated that schools of Engineering were most active in collaborating with non-university institutions (e.g., listed partnerships, external collaborative projects and funding) and transforming innovation achievements for instance, into patents and semi-products, followed by schools of sciences. Faculties in Social Sciences and Humanities mostly only displayed lecturing courses, academic publications and projects funded by NSSFC on web pages. Selection also took into account the connections with HK and Macau, the diversity of First-Class/non-First-Class statuses, localities and founding time.

Following these considerations, the overwhelming majority selected were schools of Engineering and Sciences. Participants in Social Sciences and Humanities were mostly selected from the Institute of Guangdong, HK and Macau Development Studies, whose faculties come from various schools such as School of Law and

School of Government. Schools ultimately included due to the snowballing strategy also conduced to the diversity of this sampling (Table 3.2).

Table 3.2 The Profile of sampled schools

Name of School/Institute	Title	Locality	Founding Time
Material Science & Engineering	First-Class Discipline	Panyu District, Guangzhou	2015
Electronics & Information Engineering		Panyu District, Guangzhou	2015
Electronics & Communication Engineering		Guangming District, Shenzhen	2015
Environmental Science & Engineering	Non-First-Class Discipline	Panyu District, Guangzhou	2002 (1929)
System Sciences & Engineering		Panyu District, Guangzhou	2018
Civil Engineering		Xiangzhou, Zhuhai	2016
Chemistry	First-Class Discipline	Panyu District, Guangzhou	1994 (1924)
Life Sciences/Ecology		Haizhu District, Guangzhou/Guangming District, Shenzhen	1991 (1924)/2018 (1924)
Pharmacy		Panyu District, Guangzhou	2002 (1995)
Atmospheric Science	Non-First-Class Discipline	Xiangzhou, Zhuhai	2015 (1961)
Computer Science		Panyu District, Guangzhou	1979
Physics		Haizhu District, Guangzhou	2015 (1924)
Institut Franco-Chinois de l'Energie Nucléaire		Xiangzhou, Zhuhai	2010
Information Management		Panyu District, Guangzhou	2010
Geography & Planning		Panyu District, Guangzhou	2002 (1929)
Management		Haizhu District, Guangzhou	1985
Development Studies		Haizhu District, Guangzhou	2016

Note: year in bracket refers to the founding year of faculties where the current school was derived from.

3.2.1.3. Selection of industrial and governmental actors

The selection of industrial and governmental interviewees prioritisesd those who had collaborated with SYSU, followed by collaborators recommended by university interviewees. To diversify representations of collaborative networks, the study recruited interviewees from different types of enterprises (e.g., state-owned large enterprise, private small-medium enterprise, university spin-offs) and industries (e.g., biotechnology, electric power), and taking varying professional roles (e.g., executive, engineer, researcher).

The original plan was to approach the Department of Science and Technology at the provincial (i.e., Guangdong), municipal (i.e., Guangzhou, Shenzhen, Zhuhai), and district levels (i.e., Haizhu, Tianhe, Yuexiu, Panyu, Guangmin, Xiangzhou), the key units that affect SYSU's innovation-oriented collaborations. The DoSTI of Guangzhou takes major responsibilities in structuring provincial/municipal innovation policies, systems, implementation plans and incentivising mechanisms; guiding the research, science and technological development, and collaboration of local universities and industries; establishing key laboratories, science and technology transfer facilities, and management platforms for provincial/municipal research funding and projects; and organising reviews of science and technology awards[13]. The District Bureau of Science, Technology, Industry & Information is accountable for implementing higher-level innovation policies (e.g., making development plans, initiating specialised campaigns); organising, guiding and monitoring the development of industrial parks, information facilities as well as collaborative and demonstration platforms for science, technology and innovation; coordinating and managing intellectual property work of the districts[14].

Due to the practical challenges in gaining access to governmental stakeholders and travel constraints for cities other than Guangzhou (i.e., where the researcher was based in), recruitment concentrated on Guangzhou and the districts where universities were located in (i.e., Tianhe, Haizhu, Panyu).

3.2.1.4. Recruitment of individual participants

3.2.1.4.1. Purposive sampling

Purposive sampling was employed to select interviewees who were most likely to "yield appropriate and useful information" (Kelly, 2010, p.317) and identify sub-cases that make effective use of limited research resources to address research inquiries (Palinkas et al., 2015). In line with the school selection strategy, the primary inclusion criterion for individual participants was the scope and intensity of their collaboration with non-university actors—measured, for example, by the number and duration of collaborative projects and the amount of external funding received. Individuals with at least one such project were considered eligible, with priority given to those with more extensive collaborative experience.

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[13] http://gdstc.gd.gov.cn/; https://kjj.gz.gov.cn/gkmlpt/content

[14] https://www.thnet.gov.cn/gzthkgx/gkmlpt/content

The study diversified interviewees on the basis of academic titles, roles and educational backgrounds. Recruitment subsumed professors, associate professors, lecturers, research or/and post-doctoral fellows who met the primary criteria and had various educational backgrounds (e.g., SYSU graduates, graduates from other Chinese universities, returnees from different countries); Dean, Associate Dean, Dean Assistant and Administrator with pertinent roles in innovation-oriented collaborations. The Dean, Associate Dean and Dean Assistant were faculties with extra managerial responsibilities. Each school had one Dean overseeing the working of the school and several Associate Deans and Dean Assistants for particular areas such as research, discipline construction, industry-university-research collaboration and undergraduate education, who are all noted as "senior leadership" in this project. The Administrator was non-academic and mainly provides secretarial and general support such as sending, receiving and filing documents, and managing the logistics of some school-level activities.

Participants were identified through systematic screening of faculty webpages, which included publicly available information such as contact details, educational background, academic and administrative roles, research interests, team affiliations, project involvement, publications, patents, and teaching awards. Their eligibility, particularly in terms of collaborative experience, was further verified through supplementary sources such as Google Scholar, ResearchGate, media coverage, social media, and policy documents. In total, over 700 eligible individuals across 12 schools were contacted via email, resulting in 44 confirmed interviews.

3.2.1.4.2. Snowball sampling

Snowball sampling was also employed for its networking features and convenience in garnering access and trust to more eligible interviewees (Parker, Scott & Geddes, 2019). This strategy captured an increasing chain of potential interviewees based on the recommendation from the invited interviewees, who were more likely to provide firsthand and insider information regarding colleagues, collaborators or competitors. Such recommendation was crucial in obtaining access to collaborative networks and hard-to-reach populations in this study.

Concerns regarding confidentiality and institutional restrictions on external contacts or the confidential nature of some collaborative networks were noted multiple times both in the responding emails to interview invitations and during the interviews. Potential interviewees to some extent were hard-to-reach populations. Contacts of university leaders as well as industrial and governmental stakeholders remained largely confidential. Taking advantage of existing social networks through snowball sampling potentially balances researcher-researched power relations and sheds light on the social knowledge entailed (Noy, 2008). For example, the interviewees' decisions regarding who were suitable and comfortable to contact to some extent, reflected the familiarity or quality of relations between them. Some comfortably referred to their collaborators, who were regarded as friends and long-term partners.

Yet some refused or hesitated as they contended that the communication terminated with contracts.

The limitations of snowballing are also acknowledged. Referrals may not necessarily fit the need of research since interviewees usually do not have a full grasp of inclusion criteria or tend to make referrals by convenience. Hence, the researcher has major responsibility in verifying the type of chains, the number and eligibility of referrals and data quality. Snowballing also poses practical difficulties: many interviewees either declined to provide referrals outright or agreed but later withdrew. In some cases, referred individuals did not respond to the interview invitation, further limiting recruitment.

Securing referrals for governmental stakeholders proved particularly challenging. According to most university interviewees, government collaborations were typically established through open application or bidding processes, with oversight by committees of experts and officials during project initiation, mid-term review, and final reporting. Direct contact with individual government representatives was rare, especially during the pandemic when meetings were held online. Moreover, government projects were often initiated through top-down channels by senior leaders from both sides, limiting faculty access to specific governmental actors. Consequently, only a small number of industry participants were recruited, and referrals to government stakeholders were scarce once the initial referral chain was exhausted.

3.2.1.4.3. Interviewees in the “Consensus Space” and “Innovation Space”

Informed by Etzkowitz and Ranga (2013) in Chapter 2, stakeholders oftentimes convene in “Consensus Space” that nurtures or consolidates innovation-oriented collaborations through supportive frameworks, incentivising initiatives and assembly platforms and “Innovation Space” where resources are aggregated to generate new themes, organisational forms, or institutional roles in support of innovation. To expand access to non-university interviewees and collaborative networks, the researcher actively engaged with both types of spaces by attending multiple innovation-focused events where multisectoral stakeholders convene. These included seminars, forums, roadshows, matchmaking events, policy briefings, and project launches primarily held in Guangzhou. Information about these activities was sourced through news media, institutional websites, official WeChat accounts, and reposts by university faculty.

One notable example was the “Launching Ceremony of Hard & Core Technology Enterprise Cultivating Initiatives” hosted by Guangzhou (International) Tianhe Base for the Transformation of Scientific and Technological Achievements in August 2022. The Ceremony involved briefing of a notice issued by the Ministry of Science and Technology, the launch of Guangzhou as the host of the Initiatives and the placement of key organisations’ role in financing, liaising and supporting Hard & Core Technology innovation, transfer and enterprise growth. Officials from the DoSoT of

Guangdong, Guangzhou, Tianhe, Haizhu, Panyu, Nansha and Huangpu Districts, along with an array of research institutions, media, technology and investment companies, attended the Ceremony. The researcher managed to approach two officials from the district bureau on site.

The profiles of recruited interviewees are listed in Table 3.3-2.5. Despite aiming for diverse representation based on academic titles, roles, disciplines and gender, only two interviewees from the District Bureau of Science, Technology, Industry & Information were secured in 2022. In July 2023, during a return to the field, three additional government interviewees at municipal and provincial levels were recruited, as the researcher attended public events where these individuals were keynote speakers. The Dean or Associate Dean of six schools agreed to participate in the interview. In schools where the Dean or Associate Dean refused, the Dean Assistant was invited instead. By snowballing, this research also managed to include interviewees with leadership roles in the School Party Committee and Technology Transfer and Research Office.

Table 3.3 Profile of university interviewees by professional title and role

	SYSU	SCUT	SUST	HKU	LN	CUHK	MU	MCU
Professor	36	2	1	1	1	1	2	
Associate Professor	12	n/a	n/a	n/a	n/a	n/a	1	1
Assistant Professor	1	n/a	n/a	n/a	n/a	n/a	1	n/a
Research Fellow/ post-doc	6	1	n/a	n/a	n/a	n/a	n/a	n/a
Administrator	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Leadership role (Dean, Dean Assistant, Party Secretary)	13	2	n/a	1	1	1	1	1

Table 3.4 Profile of university interviewees by discipline and professional unit

Discipline/ university	**SYSU**	**SCUT**	**SUST**	**HKU**	**LN**	**CUHK**	**MU**	**MCU**
Computer Science (CS)	6	1	1	n/a	n/a	n/a	n/a	n/a
Life Science (LS)	4	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Material Science (MatS)	8	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Medical Science (MedS)	1	n/a	n/a	1	n/a	n/a	1	n/a
Pharmacy (PHA)	5	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Environmental Science (ES)	4	n/a	n/a	n/a	n/a	1	n/a	n/a
System Engineering (SE)	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Electronic Communication & Engineering (ECE)	8	n/a	n/a	n/a	n/a	n/a	1	n/a
Electric Power (EP)	n/a	2	n/a	n/a	n/a	n/a	2	n/a
Civil Engineering (CE)	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Nuclear Energy (NE)	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Physic (PHY)	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Chemistry (CHE)	1	1	n/a	n/a	n/a	n/a	n/a	n/a
Geography & planning (GEO)	7	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Management (MGT)	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Develop Studies (DS)	1	n/a	n/a	n/a	1	n/a	1	n/a
Political Science (PS)	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cultural Tourism (CT)	1	n/a	n/a	n/a	n/a	n/a	n/a	1
Technology Transfer Office (TTO)	n/a	1	n/a	n/a	n/a	n/a	n/a	n/a
Research Office (RO)	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a

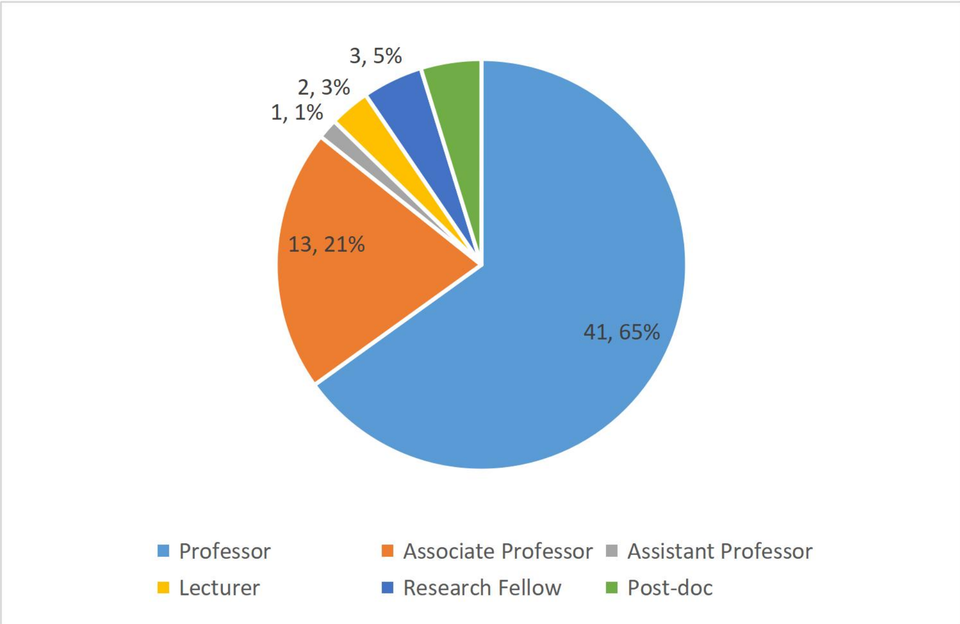
Table 3.5 Profile of interviewees from the industry and government

	Professional title/academic qualification	Gender	Position
IND-P1	Advanced engineer	M	STI manager
IND-P2	n/a	M	Investment manager
IND-P3	n/a	M	CEO

IND-P4	n/a	M	Operation manager
IND-P5	n/a	F	Vice general manager
IND-P6	PhD	M	n/a
IND-P7	n/a	M	CEO
IND-P8	PhD	M	CEO
IND-P9	PhD& Part-time postgraduate supervisor	M	CEO
IND-P10	Part-time postgraduate supervisor	M	Chairman & Executive Director of GBA Entrepreneurship Alliance
IND-P11	n/a	M	Regional manager
IND-P12	PhD	M	CEO
IND-P13	PhD	M	CEO
GOV-P1	District Bureau of Science, Industry, and Information Technology	M	Consultant
GOV-P2		M	Leadership
GOV-P3	Municipal Bureau of Science and Technology	M	Leadership
GOV-P4	Municipal Bureau of Industry and Information Technology	M	Leadership
GOV-P5	Provincial Bureau of Science and Technology	F	Leadership

The pool of lecturers is remarkably small. Indicated by digital profiling, lecturers tended to be teaching-focused, lacking project experience, and mostly failed to meet inclusion criteria. As Figure 4 shows, relatively more interviewees with professor titles were recruited as a result of disparities in interview acceptance and eligibility (e.g., more collaborative projects and networks). At some schools (e.g., School of Material Science and Engineering, School of Computer Science), the number of recruited interviewees surpassed the original plan since there were more faculties per se in these schools and faculties in these disciplinary areas were also more application-focused and thus proactive in collaborations with the industry.

Figure 3.3 The percentage distribution of university interviewees by academic titles



The percentage of female interviewees was also lower than expected (nearly 10%). This is because a gender gap persists in Chinese academia. The percentage of women academics is much smaller in prestigious universities such as SYSU, accounting for merely 28% (Tang & Horta, 2021) and is even lower in schools of Science and Engineering. For instance, 2 out of 40 professors are women in the schools of Electronics & Information Engineering whereas there was merely one female out of the 65 Chinese faculties in the Institut Franco-Chinois de l'Energie Nucléaire. As noted by the interviewees, women faculties also faced greater pressure in balancing family, teaching duties, research and evaluation of academic titles (UNI-GEO-P4). Resultantly, fewer managed to become professors, engage in collaborative projects or could spare time for this study. Consequently, the profile of interviewees varied from the original plan, but still met the overall inclusion criteria. In total, 88 interviews were conducted.

3.3. Data collection

Data collection proceeded in three stages. The combination of interviews, documentary analysis, and websites and media content analysis provided different windows to read between the lines of innovation-related discourses in the academic, policy, organisational or the general public spaces while triangulating such information through stakeholder interviews. Triangulation of data sources and perspectives helps reduce or counterbalance the deficiency of a single method, making possible the representation of multiple constructed realities with enhanced “scope, depth and consistency” (Sands & Roer-Strier, 2006, p.241). Since some of the most insightful findings may emanate from the case study, in this study research design and data collection were iterative. For instance, pilot digital profiling informed the adoption of additional data collection and analysis methods.

3.3.1. Semi-structured interview

Semi-structured interviews were conducted with 69 university academics from SYSU and its collaborating universities, 12 enterprise partners and 5 government officials. Interviewees from different disciplines, institutional locations and with varying status and connections are entitled to the explanatory power to make sense of these realities, enabling the researcher to delineate how diverse imaginaries directed thinking and practice. The way in which these actors describe the elements that comprised innovation, and the innovation system as a whole, shapes how the system is practised. The descriptive features of innovation and innovation activities are perceived and defended by actors who access resources and maintain autonomy over their particular ways of thinking (Sharif, 2015). The comparison of these interpretations and strategic focuses unveils the patterns of interaction among the individuals and institutional units involved, throwing light on the strategic and operational challenges in managing multiple missions.

The interviews were semi-structured with a list of questions prepared in advance (Appendix 1). These questions invited the interviewees to conceptualise innovation, summarise the types of innovation-oriented collaborations they engage in, the motivation and challenges involved, and their perceived role of the university, industry and government in regional innovation, including in relation to the WCU agenda and the GBA Initiative. The semi-structure format allowed partial flexibility in adapting to the interviewees' responses and following-up questions outside the preliminary scope but stayed relevant to the research questions (Punch & Oancea, 2014).

Initially, interviewees were invited through emails with a brief introduction of the researcher, the participant information sheet (Appendix 2), and participation consent form (Appendix 3). Interviewees could choose their preferred format of interview (WeChat, Zoom, Tencent Meeting/phone call/face-to-face) and language (Mandarin/Cantonese/English) upon their acceptance of the invitations. Nevertheless, the response rate to cold emails remained low and some potential interviewees indicated that they were uncertain about their suitability to participate (e.g, being unfamiliar to the topic, uncertain about whether the interview questions were sensitive). Some were very occupied, indicating that the interview questions appeared too long and general, and suggested answering them in written forms.

To enhance the response rate, written responses were included as a supplementary method when interviewees insisted. A list of major interview questions designed according to each interviewees' disciplinary backgrounds and project experiences was attached to the invitation emails. Eventually, 24 and 58 interviews were conducted online and in-person, respectively. One interview and responses to follow-up questions thereafter was in written form. In line with interviewees' preference, most in-person interviews took place inside the universities (i.e., faculties' office, research labs, and meeting rooms). Off-campus interviews were conducted in public spaces such as the interviewees' enterprises or halls where the interviewees had networking activities.

Prior to the interviews, a pilot study was conducted at the end of January in 2022 with a university and an industrial interviewee, through the researcher's personal network. The pilot indicated that interviewees found it difficult to start directly with an abstract question regarding conceptualisations of innovation. Resultantly, the sequence of interview questions was adjusted. The original opening question (i.e., the conceptualisation of innovation) was placed after questions regarding innovation-oriented collaboration, which allowed the interviewees to begin with sharing more familiar day-to-day experiences.

The interviews were conducted during February 2022 and September 2023, though the overwhelming majority was scheduled intensively between April and June 2022, when the interviewees had relatively synchronic experiences in relation to their contextual and institutional settings (e.g., commonly mentioning some policies and practices emerging in that period). Such synchronic and longitudinal features allow comparisons of within-case perspectives in the same period and the tracing of changes on the case study sites. Most interviews were conducted in Mandarin, and a few with HK and Macau interviewees were in Cantonese.

The researcher typically began the interviews with pleasantries, briefing concerning the context and the purpose of the research, reassurances in relation to anonymity and confidentiality, and seeking consent for audio-recording or note-taking. During the interviews, the researcher strove to ask different interviewees the most valuable questions in relation to their roles and experiences within available time. Consequently, the length of interviews was flexible, ranging from 15 minutes to 3 hours. The variation in length was contingent on the interviewees' responses to the questions and their available time. The number of interviewees mentioned in different finding chapters varied because not all interview questions were covered. For instance, all interviewees were asked about their collaboration experiences (Chapter 7), but only 67 of them were asked to conceptualise "innovation" (Chapter 4). At the end of the interviews, the researcher expressed appreciation to the interviewees for their participation and asked them to recommend collaborating partners.

3.3.2. Documentary analysis

Document analysis is a systematic method for reviewing and interpreting documents to derive meaning, gain insight and generate empirical knowledge (Corbin & Strauss, 2008). Various document types, such as institutional reports, government publications, press releases and public records, can be used for systematic evaluation and analysed as both "a source of fact" that contextualises the research and as "text" conveying themes, discourses, and the framing of problems, irrespective of conventional institutional explanations (Karppinen & Moe, 2012, p.9). Hence, as Bowen (2009) summarised, documents provide background and context, raise additional questions, offer supplementary data and enable tracking of change, development, and implementation and verification of findings:

> "The rationale for document analysis lies in its role in methodological and data triangulation, the immense value of documents in case study research, and its usefulness as a stand-alone method for specialised forms of qualitative research." (p. 29)

This study employs policy and institutional document analysis as both a contextualising factual source and the text imbued with ideas and discourses that possess their own force. When these ideas and discourses become publicly accepted and routinely practiced, social reality itself changes. Besides serving as a comparative data source, these documents are particularly useful in pre- and post-interview scenarios. They provide leads for asking probing questions and information pertinent to events or situations that warrant observation, thereby enhancing the credibility and explanatory power of this research.

3.3.2.1 Policy document analysis

Government policies offer ongoing guidance to innovation. This is particularly evident in China's "documentary politics", a long-standing tradition of utilising government documents to govern national affairs (Wu, 1995, as cited by Han & Xin, 2019).

Policy documents serve as a symbol and a carrier of power, through which the power of government is transformed into authority and political rituals, and discourses are generated, legitimised and publicised to mobilise collective social actions at different levels (Hou, 2022). Within China's multi-governance structure, central documents primarily establish broad policy contexts, rationales, and visions for long-term higher education and innovation capacity building. Subsequently, ministerial departments such as MOE and MOST issue corresponding policies. In alignment with central directives, local governments tailor these policies to address local contingencies. Hence, the analysis of central and local documents can shed light on the policy discourses and political rituals involved in conceptualising and mobilising social actions towards innovation and innovation-oriented collaborations. It can also reveal how these central guidelines and discourses are translated into local initiatives and actions, creating tensions and discretion that allows for institutional innovation.

The system level was examined by analysing key policies concerning S&T, innovation, education, and socio-economic development from central and local governments in the GBA. Local policy documents guiding SYSU's Guangzhou campuses, where most fieldwork was conducted, encompassed those issued by Guangdong province, Guangzhou city, and Haizhu District. Tianhe district documents were also considered due to a government interviewee's affiliation and the clustering of SCUT and other universities. Analysis sheds light on a) the conceptualisation of innovation in the policy sphere, particularly how it was constructed across levels and over time; b) the stipulated roles of universities, industries, and governments in national and local innovation systems; c) outlined collaborative activities, policy instruments, and governance structures targeting the recognition, incentivisation, and support of innovation activities and outcomes. Comparative analysis of documents and interview data illuminates how innovation and innovation-oriented collaboration are framed in political discourse and how they shape actors' interpretations and practices.

Document selection was based on relevance to S&T, innovation, higher education, and the GBA since 2006, the turning point when innovation became an official national strategy in China (State Council, 2006). These documents were searched on government websites using key words such as "innovation", "achievement transformation (*cheng guo zhuan hua*)", and "university-industry-government collaboration" (*zheng chan xue yan*). Additional documents referenced in the selected policies, which elucidated previous or high-level policies they followed, were also included. The search concluded in April 2023, thus including documents issued between 2006 and 2023. Considering potential access restrictions, all chosen documents were downloaded from government websites and stored with full reference to their origins, dates, authors, and purposes to establish their contexts and significance to this research. This transparency allows future confirmation and contributes to the validity of documentary data.

To facilitate comparisons across issuing authorities, time periods, and data sources, abbreviations incorporate the data source (Document=D), the relevant Five-Year Plan period (numbered 11-14), and a combination of the issuing authority level's initial capital (National/Provincial/City/District), document title abbreviations, and specific districts ("Tianhe=TH" and "Haizhu=HZ" for district documents). In total, 72 policies were selected for documentary analysis (appendix 4).

3.3.3.2. Institutional document analysis

The institutional level of analysis involved data on official websites and WeChat accounts at university and department levels. Available documents downloaded from websites included the university's regulations related to R&D, collaboration, and achievement transformation; University Development Plan and Work Plan; and the mission statement of SYSU Science Park (Table 3.6).

The SYSU News website and WeChat accounts of SYSU Research Office, Human Resource Office, United Front, and Science Park, which centrally publicise university leadership directives, strategies, and activities, were reviewed and screened using key terms as "collaboration," "visits," "exchanges," and "innovation," along with additional terms drawn from interview data. For instance, the "Faculty-system Reform" was considered an institutional structure that facilitates cross-disciplinary collaboration and innovation by several interviewees and was thus added as a key search term to trace the implementation of this reform. After screening for content relevance and removing duplicates released till Apr 2025, a total of 140 releases were identified out of over 1000 by seven content categories (Table 3.7). These subsume, for instance, consortium agreements, and media reports on collaborative partnerships and training in support of innovation and entrepreneurship contests.

These documents offered valuable context on collaborative networks, activities, key actors, and institutional support structures for innovation-oriented collaborations. They also enabled comparison with institutional narratives shaped by powerful systems of language and knowledge (Gorsky & Mold, 2020), which adapt government policies to serve institutional interests while influencing how the university and its faculties interpret and enact these policies.

Table 3.6 List of institutional documents downloaded from university websites

Document type	Title
University Regulations	SYSU Technology Achievement Transformation Regulations
	SYSU Internal Research Institution Management Measures
	SYSU Implementation Measures for Strengthening Decision-Making Research
	SYSU Horizontal Research Project Management Measures
	SYSU Research Institute's Horizontal Division Technology Achievement Transformation Services
University Development Plan	SYSU World-Class University Development Plan
	Double First-Class University Construction Overall Plan
	SYSU 13th Five-Year Business Development Plan
Annual Work Plan	SYSU 2022 Work Priorities
	SYSU Double First-Class Construction Progress Report 2018
Mission Statement	SYSU Science Park Introduction

Note: Horizontal Division manages University-Industry-Government Collaboration affairs

Table 3.7 List of major content categories and example releases

Content categories	Example release titles
Collaborative activities (e.g., cross-discipline, cross-institution)	"Gold-Level Partner! Sun Yat-sen University and Guangdong Unicom Forge a New Chapter in Industry-University-Research Integration" (SYSU Research Office, 2025-04-04) "Industry-University-Research | Guangzhou Science and Technology Bureau Surveys Regional Technology Transfer Efforts around Sun Yat-Sen University and Beyond" (SYSU Research Office, 2023-03-29)
Innovation infrastructures	"Industry - University - Research | Launch of the Sun Yat-Sen University Joint Rural Revitalisation Research

	Institute and Release of Initial Achievements" (SYSU Research Office, 2024-01-06)
R&D organisation and service professionalisation	"Expert Training in Strategic Research Management | Practical Exchange on University-Industry Collaborative Project Management" (SYSU Research Office, 2023-03-17)
Institutional innovation	"[Foci on the Two Sessions] Deepening Reform of Research Funding Management! Here's What President Gao Song Said at This Year's Two Sessions" (SYSU United Front, 2024-03-09)
Entrepreneurial activities & training	"Grand Prize! Sun Yat-Sen University Excels Again at the 2nd Guangdong-Hong Kong-Macao GBA PhD & Postdoc Innovation and Entrepreneurship Competition" (SYSU Human Resource, 2024-11-06) "University-Industry-Government Collaboration: Intellectual Property Week Serial Event" (SYSU Research Office, 2023-04-07)
Innovation awards, funding, and achievements	"Congratulations | Academician Zhang Peizhen of Sun Yat-Sen University's School of Earth Sciences and Engineering Wins the 'Nanyue Innovation Award'" (SYSU Research Office, 2021-11-03)
Innovation strategies and directives (including relevant party-building activities)	"Anchoring Discipline Development to New Directions: What New Changes Are Coming to Sun Yat-Sen University?" (SYSU Human Resource, 2021-10-29) "First Party Branch of the Institute of Scientific Research Holds Thematic Study on Xi Jinping's Speeches on Technological Innovation and the Party History of the Socialist Revolution and Construction Era" (SYSU Research Office, 2021-06-09)

3.4. Data analysis

3.4.1. Analytical method

Thematic analysis was applied to analysing interviews and documents. As a method for systematically identifying, organising, and generating "insight into patterns of meaning (themes)" across datasets (Braun & Clarke, 2019), it involves a focused re-reading and close examination of data for coding and category construction based on its characteristics to identify emerging patterns related to the phenomenon under study.

Throughout the selection and analysis of data, the researcher strove to demonstrate objectivity (representing the data fairly) and sensitivity (addressing even subtle cues to meaning). The analytical process was iterative, involving review of relevant literature and theory that helped to refine emerging themes and their patterns and probe into both manifest and latent meaning. Themes conveyed by the text, including context were carefully examined since documents are not created explicitly for research, and they provide limited details for analysis (Bowen, 2009).

Following the initial round of open coding, codes derived from interview transcripts and documents were compared and cross-checked to identify interconnections and thematic clusters. When new categories emerged, earlier codes were revisited to assess their relevance and presence. This iterative process helped refine underdeveloped categories and consolidate overlapping ones. Upon integration, overarching themes and major sub-themes from both datasets were defined and summarised in tables (Appendix 5). All codes and categories were organised in NVivo.

3.4.2. Analysis process

Informed by Dey (1993), Braun & Clarke (2019), Saldaña (2021), the analysis for this study entailed three stages:

(1) *Preparation*: interviews were transcribed in Mandarin, Cantonese and English, and imported into NVivo along with selected policy and institutional documents. Interview transcripts were categorised as cases by sector, institution, discipline and professional title of the interviewees. Policy documents were classified based on issuing authority level (i.e., central, provincial, municipal, district), policy type (i.e., innovation, S&T, economic & social development, education, regional plan) and issuing period (e.g., “13th Five-Year”). Institutional documents were organised by university and departmental levels. This classification was prepared for within-case and cross-case analyses.

(2) *Data immersion and emergent coding*: the researcher read through the data and identified iterative themes related to the research questions. Data were analysed in Chinese through open coding, pattern coding and a final stage of comparing, clustering and thematic integration (Saldaña, 2021). Operational model diagramming and analytic memo were applied as exploratory heuristics throughout the analysis process to “disentangle the threads” of voluminous and sophisticated data in a more intelligible way (Dey, 1993, p.192).

Interview data was analysed inductively with multiple coding strategies such as magnitude coding, versus coding and causation coding through the first-round open coding on Microsoft Word. Transcripts were placed on the left. Codes and diagrams were on the right column, allowing for straightforward and convenient comparison of the transcripts, codes and analytic memos. In the second round, pattern coding explored the causes, rules, explanations or any emerging theoretical processes and constructs in the data. “Meta-codes” were developed to group and label similarly coded data (Saldaña, 2021, p.209). The iterative codes and categories developed in Microsoft Word were labeled as nodes on NVivo to enable more efficient management of data, formation of a coding framework and the weaving, comparison, clustering and integration of key codes, categories, themes and concepts in the final stage. The use of both Microsoft Word-based manual coding and NVivo provided different spaces for analysing, reorganising, visualising and verifying the data and a clearer trail of evidence that conduced to the credibility of research.

Document analysis involved both inductive derivation of coding frameworks and refinement of codes through the application of existing coding frameworks. This iterative process of refinement continued until the coding frameworks were deemed coherent and comprehensive. Specifically, line-by-line coding was primarily conducted on 7 innovation policy documents and 14 S&T innovation documents to develop an initial coding framework comprising top-level nodes such as "globalisation of innovation", "systemhood" and "holistic innovation" with operational definitions. To maintain relevance to the conceptualisation of innovation, the same framework was subsequently applied to extract pertinent codes from the remaining documents, which were not primarily focused on innovation, in order to refine the top-level nodes. In a similar vein, a coding framework was first developed from inductive analysis of institutional documents and then refined by applying the interview coding framework to extract relevant data.

(3) *Theme integration*: the data-emergent codes were arranged into themes such "scale of innovation" and "nature of innovation" and information was extracted from each theme to create grounded descriptions. The themes generated from interviews and documents were also compared to explore similarities and differences in the conceptualisations of innovation and the role of various innovation actors in policy and practice. This comparison subsumed the perceptions and actual involvement of the interviewees, throwing light on the similarities and differences between policy expectations and practical experiences.

3.4.3. Translation issues

To enhance accuracy, translation of codes and key quotes referred to government documents, official media reports, university's websites, English-medium publications, and online dictionaries (e.g., Cambridge Dictionary, Oxford English Dictionary). The original Chinese terms and phrases, the English explanation of their meanings, and the examples of translation are summarised in Translation Glossary (Appendix 6). The back-translation strategy was also employed to improve translation quality. Two exemplary transcripts were fully translated into English and partly reviewed and had back-translation by two bilinguals who are proficient in academic writing (Appendix 7).

3.5. Positionality of the researcher

Researchers' positionality in qualitative research is fluid, situated in specific contexts of research and researcher-participant relations, and based on other factors such as ethnicity, language and educational background, where researchers could be positioned as insiders, outsiders and most likely both (Berger, 2015; Kim, 2024).

The researcher was in part considered an outsider by some interviewees due to the researcher's current affiliation with a UK institution. This appears to indicate a lack of legitimacy and access to the case university, unless with entry permit. The outsider position tended to slow down and impede the researcher's physical access to the field and more suitable interviewees. Many potential interviewees turned down the invitations for reasons such as "disclosure of information to individuals affiliated with oversea institutions is not permitted", and "accepting external interviews" and "in-campus visits of anyone external" required "administrative approval". During the interviews, being perceived as an outsider potentially constrained the researcher's access to information and knowledge deemed sensitive and internally confidential by the interviewees.

The researcher might be perceived as an insider, as being a Cantonese, who grew up and received education in the GBA, and was thus familiar with the local context and the case university. For interviewees who moved to the GBA after obtaining PhD overseas, the researcher, a current DPhil at Oxford, was potentially regarded as an insider to the academic life of returnees based on the similarity of educational background. The insider position in relation to the research context, the institution and population involved potentially enhanced the breadth and depth of understanding of the case and ideally gave the researcher more access and legitimacy to the institutions and individuals pertinent to the case (Kanuha, 2000).

Although Mandarin, Cantonese and English were available language options for the interviews, some interviewees noted that the fact that the researcher was Cantonese, sharing the same identity, language or in part living and learning experiences with them, was the main reason that they agreed to partake in the study. Some indicated that having the opportunity to communicate in Cantonese, their first language, allowed more comfortable, fluent and lucid expression of ideas. On the researcher side, the insider status also enabled more effective understanding of some "historical and practical happenings of the field" (Chavez, 2008, p.479) and indigenous notions in the local policy documents or by the interviewees.

Nevertheless, as Dwyer and Buckle (2009) note, the insider position has limitations in that interviewees might make assumptions of similarities and thus fail to fully explicate individual experiences. Familiarity may also affect the researcher's ability to uncover the taken-for-granted assumptions and the discrepant factors inside the community or population with which the researcher shares similarities. Hence, adequate distance is necessary for the conceptualisation of the assumptive, ambivalent, mixed, or potentially contradictory motives, thoughts, and feelings involved in the case study field so as the wider connections, patterns, and factors external to the field. Beyond the insider-outsider binary, the core of enhancing the trust or the quality of qualitative research lies in the capability of being open, honest, authentic, deeply interested in and committed to understanding and representing the experience of one's research participants sufficiently and accurately. The potential concerns associated with insider and outsider statuses can be reduced through "disciplined bracketing" and "detailed reflections" on how the researcher's situated positionalities affect this project, as demonstrated above (p. 58).

On realising the impacts of insider-outsider status, the researcher adopted strategies to enhance access to the case field and to the more nuanced perspectives of participants. To mitigate the challenge of access as an outsider affiliated with an UK institution, in the interview invitations and participant briefing, the researcher highlighted her identity as a local (Cantonese) and the genuine intention to contribute to the development of the GBA with this research upon her return from doctoral studies. As a result, more participants agreed to partake in the study and offer more insider information during the interviews. To understand individual experiences fully and beyond assumed familiarity, the researcher digitally profiled each participant, prepared interview questions accordingly, and strove to elicit more explanation of underlying assumptions from the participants. Some participants, assuming the researcher's familiarity with the UK context, shortened explanations with phrases like "you know." Despite shared backgrounds, individual interpretations varied, so the researcher encouraged fuller elaboration to capture personal perspectives.

With close awareness to one's personal biases and perspectives, the researcher can be reflexive in relation to how the critical realist position adopted in this study influences the research design and processes. Critical realism acknowledges a reality (being in the world) existing independently of human perception (knowledge of being in the world). As Sayer (2004) noted, the reality is always mediated by pre-existing repertoires of conceptual resources. Such mental construction of the world, the "construals", contingently informs and in part shapes material constructions such as organisational forms and practices through both the conceptual and material acts of agents (p.7). The stock of conceptual resources can be individual, social (e.g., accepted theories, social norms), and rooted in practice as the result of antecedent encounters with "entities other than ourselves" (Fleetwood, 2004, p.28).

In accordance with critical realism, innovation is a social phenomenon that cannot exist independently of "the agents' conceptions of what they are doing in their activity" (Bhaskar, 2014, p.38). Social structures, the nexuses of connections among agents that causally influence the actions of agents and in turn are causally influenced by agents (Porpora, 1989, p.344; cf. Flweetwood, 2004), are also largely interdependent with the innovation activities they govern (Bhaskar, 2014). Hence, this study began with an inquiry into the stakeholders' conceptualisation of innovation and the roles of each other in the innovation system, and their experiences in innovation-oriented collaborations. While RQ1 to RQ3 focus on the "what" dimension of innovation and collaborative activities, RQ4 explores the explanatory "whys", the "generative causalities" (Harrion & Easton, 2004, p.183) in the GBA context. On realising that theories as conceptual resources are diverse in explanatory power for particular social phenomenon, Chapter 9 (Discussion) and Chapter 10 (Conclusion) discuss the knowledge generated from this case study in relation to the implications for extant theories of universities.

A critical realist case study approach is particularly well suited to the complicated but relatively bounded phenomena studied in this research (Easton, 2009). The bricolage of data drawing from multiple sources provides rich account of both the structures (e.g., physical setting, institutional regulations and norms) and the agentic understanding, activities, and practices involved in the case study sites, teasing out different layers of realities in quest for generative mechanisms and contingencies.

As a critical realist case study, the primary concern is not with empirical regularities, but idiographic and epistemological validity. The purpose is to clarify structures and related generative mechanisms that contingently produce the innovation phenomena observed (Tsoukas, 1989, p.556). Particular attention is on studying the significant contexts of the GBA and the nature of innovation and collaborative phenomena therein, identifying in-depth explanations in this one instance that potentially becomes a notable contribution to both wider theorisation, policy-making and practices.

3.6. Ethical Considerations

Interviews potentially result in various participants' burdens and risks. Commitment of time and effort may disturb participants' schedules while the voluntary participation itself does not generate explicit rewards. Resultantly, the initial response rate of cold email invitation was low, as noted. To avoid faculties' busiest period at term end, email invitations and interviews were scheduled at the beginning and middle of the term. The estimated interview duration was revised from "one hour" to "30 to 45 minutes", contingent on the availability and willingness of interviewees to provide further insights.

Access negotiation, confidentiality and anonymity are key concerns in such studies. As stated earlier, gaining administrative approval was considered necessary by many potential interviewees while the researcher's access request was often neglected or denied due to affiliation with a foreign university. According to some interviewees, the researcher faced a dilemma where administrative approval was necessary but unlikely to be obtained. Hence, access was largely contingent on individual consent. Interviewees who agreed to participate and applied for visiting access for the researcher took certain administrative risks. Some interview questions appeared challenging as the interviewees had not considered them before. While the interview questions are not contentious by nature, some responses concerning collaboration contained politically or commercially sensitive information.

This was particularly evident in ongoing collaborative projects that involved key innovative achievements, where confidentiality was a legal requirement and crucial to both parties' first-mover advantage. Some interviewees from HK and Macau also perceived comments regarding the challenges of collaborating with mainland China and the GBA initiative to be "politically sensitive" (UNI-DS-P1, UNI-GEO-P7). Substantial efforts were required from both the researcher and interviewees to negotiate access to necessary information while staying mindful of the boundaries of the questions and answers. It was difficult to see whether the conversation had made the interviewees uncomfortable and whether a break was needed.

Since this is a case study of a university and its collaborating networks, the name of the case university, collaborating universities, and guiding government divisions are disclosed. Nevertheless, individual interviewees were pseudonymised with abbreviations indicating their institutional sphere (i.e., UNI for university, IND for industry, GOV for government), followed by a unique number. For university interviewees, the pseudonym also subsumed an abbreviation indicating their disciplines, placed between the institutional sphere and the individual number (e.g., UNI-GEO-P1).

Despite pseudonymisation, there were still tensions between obtaining detailed responses essential for an in-depth understanding of the research questions and revealing information of the context that could compromise the interviewee's anonymity. Disclosing interviewees' professional roles, organisation, gender, and experiences could make the individual to some extent identifiable, especially considering the limited number of female faculties and interviewees undertaking administrative roles. In addition, it was also possible that some interviewees might have considered the interviews as a means of public communication, with desire to be identified and heard, particularly in the case of elite interviews. Even when the interviewees agreed to be recorded, there could still be concerns about what was recorded and how the recording was managed.

All these situations could cause different levels of stress and risks for both the researcher and the interviewees. To address these issues, the researcher thoroughly prepared for the interviews prior to the fieldwork, ensuring the efficient use of interviewees' time. Following the CUREC Best Practice Guidance, the researcher stgrove to balance the benefits and the risks associated with the research, treating participants with full respect and conducting the research with integrity. Consent forms and participant information sheet were attached to invitation emails prior to the interview, to formally solicit voluntary participation. At the outset of each interview, the researcher re-assured the confidentiality, anonymity, and purely academic nature of the study and obtained consent for recording or note-taking. In cases where interviewees had not reviewed the attached documents, the researcher provided a brief explanation and obtained oral consents in person.

In the presentation of the interviewee's profile, administrative roles are pseudonymised as "leadership role". The professional titles, roles, gender, and disciplines of university faculties are presented only in terms of the percentage of the whole interviewee profile comprised by the category concerned. In line with the EU and UK Data General Protection Regulation, Hong Kong Personal Data Ordinance, Personal Information Law of China, the Oxford University's Guidance on Data Protection and Research, and CUREC Best Practice Guidelines, all data accessed for this study were stored securely on the University of Oxford's OneDrive facility in encrypted form.

3.7. Challenges and limitations

Advocates of the case study method such as Yin (2003) and Stenhouse (1978) acknowledged its limitations in producing "statistical generalisation" and "predictive generalisation" across a population based on the empirical data. They noted that the purpose of case studies is not to make assertions or predictions, but to achieve analytical, retrospective, and naturalistic generalisation. As Yin (2003, p.10) argued, case studies "expand and generalize theories (analytical generalization)", but do not "enumerate frequencies (statistical generalisation)". Case studies aim to achieve "retrospective generalization" that maps "the range of experiences" rather than identifying "the laws in scientific sense" within that range. Stake (1995, p.85) proposed that case studies generate "naturalistic generalisation" through thick descriptions of "personal engagement in life's affairs" or "vicarious experience so well constructed" that the readers feel as if it has happened to themselves.

Hence, this single case study is not intended for "statistical generalisation" or "predictive generalisation", but the development and expansion of theory, documentation of experiences, and advancement of understanding and learning. Nevertheless, whether the "experiences" documented are generalisable to other universities remains an open question. The predominant focus on one university may limit the study's ability to capture the full innovation landscapes and dynamics within the area as some of the important innovation actors are left out and under-researched.

The time frame of this doctoral research is limited. While the case study captures some variation at the meso-system level, it is insufficient for broad generalisations about how universities interact with other actors or how the Triple Helix manifests across different cities in Guangdong—many of which are emerging innovation players under the GBA Initiative. A case study involving stakeholders across one university, industry, and government requires substantial efforts and resources, particularly to secure adequate participation.

Potential participants from SSHA, who often work more independently than their science colleagues and see themselves as less relevant to the topics of innovation and collaboration, are underrepresented. Consequently, the findings of this research primarily reflect the conceptualisation and practices of science, but they still offer valuable insights into the broader experiences of university faculty engaging in innovation and regional development in the GBA.

Research drawing upon documents is constrained by their availability and quality. Documents may not provide sufficient details for understanding for instance, the conceptualisation of innovation, since they are produced for “some purpose other than research” and are “created independent of a research agenda” (Bowen, 2009, p.31). Guiding by the research purpose and questions of this study, a balance was maintained between objectivity and sensitivity, and both inductive and deductive approaches were employed to scrutinise and refine the interconnections and relevance of categories and themes under study.

Lack of translation equivalence is another challenge when transcribing the Chinese (Mandarin and Cantonese) interview verbatim into English without compromising the meaning and context. The researcher has sought to enhance translation transparency and accuracy by referring to officially translated documents and literature, back-translation with two proficient bilinguals, and cross-checking with two native English-speaking academics, and the development of a translation glossary. The translation process involved negotiations and balance in demonstrating the situated meaning of the source text while pursuing accurate translations in English. For instance, “technology transformation” was preferred over “technology transfer” since the former was commonly used in official Chinese policy documents, while the latter was more prevalent in English literature.

Chapter 4 Conceptualisations of innovation

This chapter examines how innovation is conceptualised (RQ1) in key policy documents issued by governments at different levels, including the State Council, MOST, MOE, DoE and DoSTI at provincial (Guangdong), municipal (Guangzhou), and district (Haizhu, Tianhe) levels. It then compares how interviewees from the university, industry and government conceptualised innovation by feature, purpose, nature, type, stage and evaluation, concluding with the discussion of similarities and differences between the conceptualisations in policies and that of the stakeholders.

4.1. Conceptualisations of innovation in policies

The policy conceptualisation of innovation involves global, international, pan-national, national, and sub-national or regional scales that are potentially synergistic. With indigenous innovation capability at the core, cross-scale innovation activities and relations are envisioned as social constellations taken together to expand the collective resources and "innovation development space" of the Chinese state. Although scales vary in characters and their intersections are perceived as expanding the potentials of innovation, national interest and power, in policy conceptualisation the building of national innovation capability of the Chinese state remains primary within multi-scalar innovation.

4.1.1. Innovation in the global scale

Globalisation has led to global flows of innovative factors, networked innovation activities and restructuring of industries and economies. Coupled with the new wave of technological revolution, these factors have reshaped the "global innovationscape" (全球创新版图), which increasingly features "innovation multipolarity" (D-13-NSTI).

The "global innovationscape" suggests a relational view of innovation in the global scale as a set of spatial and social relations in a constant state of becoming. It is where multi-scalar forces are integrated with innovation in sophisticated and dynamic ways. Associated with the conceptualisation of "global market" and "global innovation network", it features competition, learning, opportunities, "open innovation" and collaborative innovation" (e.g., D-13-NSTI, D-13-NI, D-14-PSTI, D-14-CEI). Global flows of innovation resources and mobile configurations of networks, technology and expertise can liberate and empower, providing economic and learning opportunities while producing new forms of domination.

On one hand, the "global innovationscape" allows the Chinese state to engage in a broader spectrum of innovation activities and innovation-oriented international cooperation as players in the global market and nodes within the global innovation network. This multiplies the state's sources of learning and opportunities to develop, utilise and promote indigenous innovation. The following is a typical example of China's efforts to capitalise on the opportunities presented by the "global innovationscape":

> "Expand openness. Persist in planning and promoting innovation with a global perspective, make the best use of global innovation resources, comprehensively enhance China's position in the global innovationscape, and strive to become a leader in several crucial fields and a participant in the formulation of important rules." (D-13-NI)

On the other hand, the "global innovationscape" relativises nation-states by innovation activities and practices in the global scale and reinforces a convergent teleology that global connections are desirable. It triggers China's anxiety and aspiration to assert agency by adapting to the "global competition state" (Cerny, 1997) and framing innovation for a global knowledge economy. The Chinese state utilises the global scale as a focal and benchmarking device to provide cutting-edge standards, rankings and role models of innovation. This allows China to compare global-national-local provision and performance, and to gauge and imagine its positioning within the "global innovationscape". Policies employ the "global innovationscape" to emphasise the external pressure faced in innovation, rationalising the significance and urgency of staying competitive in the global innovation race.

For instance, during the 11th Five-Year Plan period, the global emphasis on enhancing innovation capabilities—due to their critical role in international competition—became the driving force for prioritising their development in China's policies. This trend led governments, particularly those in developed and emerging industrialised countries, to prioritise the cultivation and effective utilisation of innovation capabilities as central national goals. As a developing country long reliant on "extensive economic growth and low-level industrial structure", China faces notable pressure to catch up with innovation-driven competition, and to protect national interests and domestic industry against the technological monopolies of developed countries through indigenous innovation capabilities (D-11-NI). This line of thinking is typically demonstrated in the following policy text:

> "Globalisation brings new opportunities and challenges to building China's indigenous innovation capabilities. Economic globalisation has accelerated the cross-border flow of innovative factors, international industrial structure adjustment, and the integration of China's economy into the world economy, enabling us to better utilise global scientific and technological resources to promote indigenous innovation capabilities. Concurrently, innovation capability increasingly becomes the focus of international competition. Developed countries with existing technological advantages are further strengthening intellectual property protection and maintaining their technology monopoly positions. Effectively protecting national interests, safeguarding national industrial security, and enhancing indigenous innovation capabilities have become challenges that all countries, especially developing countries, must face." (D-11-NI)

Global benchmarking guides innovation objectives, strategies and measures that enhance national and sub-national innovation capabilities. Nevertheless, as indicated in the text above, national objectives and values, such as China's determination to countervail developed countries' monopolies, can also critically interrogate the global or international template of innovation. The Chinese state's resistance to "unilateralism, protectionism, hegemonism" is even more pronounced during perceived times of global crisis:

> "The international environment is increasingly complex, marked by instability, uncertainty, the COVID-19 pandemic's impact, backlash against globalisation and global turbulence. Unilateralism, protectionism and hegemonism pose threats to peace and development. Shifting towards high-quality development, China must maintain strategic focus in managing our own affairs, understanding development laws, carrying forward a spirit of struggle, establishing a bottom-line mindset and accurately responding to changes. It is crucial to seize opportunities in crises and break new ground amid changing circumstances." (D-14-NESD)

China's perception of the "global innovationscape" and its associated opportunities and challenges evolve with its national innovation capabilities and global positioning. From the 12th Five-Year Plan period onwards, policies display a notable shift from the catch-up mentality, in which China perceives itself as a "significantly behind" developed country (D-11-PLST), to a key node in the global innovation network and a quasi-innovation leader that units developing and neighbouring countries (D-12-NESD). This vision further evolves, with China emerging as one of the leaders in "innovation multipolarity" in global innovation governance, influencing global innovation projects, agenda and standards (D-13-NSTI, D-13-NI). Building upon this, China underscores its major responsibilities in countervailing global and international threats and supports more developing countries in becoming significant "multipolarity" players (D-14-NESD).

Although "developed country" remains synonymous with leading international standards across various innovation domains and the front-runners to surpass in global competition, and their standards continue to inform the development of innovation objectives at both national and local levels, China now perceives itself as approaching a state where the "overall level runs parallel with developed countries, and in some areas achieves a leading position" (D-13-NSTI). The primary concern of STI policies in "reducing the path dependency on tracking and replicating" develop countries' innovation activities is overtaken by "building innovative strategic partnerships with technologically developed countries" and "enriching the technological connotations of new-type major-country relations" (D-13-NSTI).

These (re-)positionings reflect China's increasing confidence about its national innovation capability, including innovation diplomatic strategies. More importantly, the policies highlight the categorical forces of repositionings on the power balance of international order, thus urging strong state's commitment to expanding territoriality ("physical distance and space") and sovereignty ("governance structures and policymaking") of innovation (Montresor, 2001).

4.1.2. State commitment in multi-scalar innovation

State commitment, on one hand, centres on strengthening indigenous S&T innovation capability. Anchored in the "innovation-driven development" directive, this commitment is driven by a pragmatic systemhood ethos. When fortifying its National Innovation System (NIS), China targets areas with first-mover advantages and harnesses opportunities from the "large-scale science, big data, and internet" epoch through centralised state-led coordination of systems, innovation blueprints and investments in national large-scale scientific infrastructures. Key strategies include "comprehensive layout and forward-looking deployment" of disruptive innovation, and global scientific frontiers; piloting of innovative technologies and reformative practices in demonstration regions; clustering policies highlighting innovation agglomeration; the building of advanced data-driven information networks and the fostering of open, collaborative paradigms that amplify mass innovation and entrepreneurship. As illustrated in the following policy text:

> "Guided by major S&T challenges and national large-scale scientific infrastructures, leverages premier innovation units...establish organisation forms, academic and personnel management systems that are consistent with the scientific research patterns of the large science era...create strategic scientific and technological forces that reflect national will, achieve world-class standards, and lead development...adapt to the internet era's open-source innovation trends, explore research crowdsourcing...foster spaces for collective problem-solving." (D-13-NSTI)

On the other hand, to strengthen indigenous innovation capability, the production of key innovations is repatriated to nurture domestic R&D capacities and ensure security and control in significant industries, infrastructure, strategic resources, major technologies and standards, thereby achieving a higher level of self-sufficiency. This focus has been conspicuous since the 11th Five-Year Plan period and has potentially escalated amid the US containment of China in trade, science and technology:

> "Establish 100 new national engineering laboratories to overturn the industry's severe dependency on foreign technology, particularly in areas such as forward-looking industrial technology, core technologies, experimental designs for major equipment and key technical standards, enhancing the indigenous development capability of Chinese industries." (D-11-NI)

> "Concentrate on the breakthrough of indigenous R&D in key core technologies and components...significantly reduce China's dependence on foreign core critical components, markedly improve the product quality and reliability of high-end general scientific instruments and substantially enhance the core competitiveness of China's scientific instrument industry." (D-13-NSTI)

As the multipliers for boosting indigenous innovation capability, global innovation resources are clustered in national or sub-national scale, supported by favourable policy measures to improve domestic S&T, legal, financial, educational and institutional structures. Building a "regional innovative highland" and "cluster" with global influence enables more domestic localities to integrate into global production, market and innovation network, serving as crucial nodes for the nation's proactive integration into the global innovation network and strategic positioning. This contributes to creating more "international innovation collaboration public goods". Simultaneously, these sub-national innovation localities provide space for policy pilot trials, innovation demonstrations and nationwide promotion of successful models, providing "core support" for national innovation capacity-building and exerting a "leading and radiating effect" on other domestic regions (e.g., D-13-NSTI, D-13-GBA, D-14-PSED).

The policy texts below exemplify the state's commitment to strengthening national innovation capability by harnessing global and international opportunities to capitalise on sub-national or regional levels, leveraging the distinctive potentials generated by the intersections across innovation scales:

> "Create regional innovation demonstration and leading highlands. Optimise the layout of national indigenous innovation demonstration zones...implement comprehensive innovation reform experiments in regions, build innovative provinces and innovative cities, foster growth poles for the development of emerging industries, and enhance the radiating and driving functions of innovative development." (D-13-NI)

> "Coordinate both domestic and international imperatives, promoting the agglomeration and efficient flow of innovation resources. Focus on building regional innovation highlands to drive and improve the overall level of regional innovation development. Deeply integrate and strategically deploy within the global innovation network, comprehensively enhance the internationalisation level of scientific and technological innovation." (D-13-NSTI)

> "Improve multilateral scientific and technological collaboration mechanisms, promote in-depth implementation of joint funding programs, and proactively attract top laboratories, research institutions, universities, and multinational

> corporations from Europe, America and other regions to establish scientific laboratories, global R&D centres and open innovation platforms in Guangdong." (D-14-PSTI)

On the other hand, the Chinese state is committed to enhancing global connectivity through innovation diplomacy, which aims for deeper, more multidimensional engagement in the "global innovationscape" and international collaboration with "country-specific strategies". China aims to take a leadership role in global scientific research, technological innovation, and innovation governance, leveraging national foresight and advanced strategic deployment to address global challenges and enhance global science and technology development. This commitment is coupled with the drive to bring Chinese indigenous innovation outputs, such as technologies and standards, to the global stage, boosting their presence, legitimacy and influence.

Institutions and individuals are construed as crucial agents in innovation diplomacy. In addition to "strengthening the global deployment of overseas S&T institutions and diplomats", China strives to foster "world-class innovative enterprises, brands, standards", "world-class universities and disciplines" and teams of innovative talents, including "world-class scientists, technology leaders and engineers". For instance, China supports enterprises in "deploying global innovation networks", "overseas listings, restructuring, mergers, and acquisitions", "establishing oversea R&D centres", "leading the development of advantageous technologies and standards" and promoting them into international standards. China also encourages research institutions and academia to engage in large-scale international research, enhance the international influence of their disciplines, and form Chinese academic schools that lead the "development of global academia" and "drive domestic R&D" (e.g., D-13-NI, D-13-NSTI, D-14-NESD). These are exemplified by:

> "Fully engage in the management of the ITER project to enhance China's R&D capabilities in nuclear fusion energy and enable more domestic institutions to participate in international R&D, enhancing China's capability of managing large scientific projects and setting a Chinese example in international scientific project management." (D-13-NSTI)

In provincial policies, multilateral innovation diplomacy with neighbouring countries reveals a more pronounced focus on exploiting learning and economic opportunities:

> "Strengthen "Belt and Road" open innovation by promoting collaboration in technology, data, talent and capital. Establish joint labs, technology transfer platforms and collaborative relationships among science parks. Leverage Macau's role as a bridge to Portuguese-speaking countries and support foreign young scientists to work in Guangdong. Encourage the establishment of Guangdong offshore innovation centers and promote the integration of technology and capital from "Belt and Road" countries with the Guangdong

market." (D-14-PSTI)

Innovation is construed as not simply a matter of economic and technological competition, but of strategic significance to international relations and security. This requires stronger integration of innovation and diplomacy. The 13th National STI Plan specifically emphasises the strengthening role of "S&T diplomacy" in steering the internationalisation of S&T innovation and China's overall diplomacy. However, the policy documents in fact deploy a broader spectrum of instruments spanning diplomacy in S&T, economy, governance and culture to fulfill national interest in the geopolitical arena. "Innovation diplomacy" thus captures the integration of innovation with foreign affairs through both diplomacy for innovation and innovation for diplomacy, which are distinguished by their primary goals to (innovation vs. broader political agenda).

Diplomacy for innovation underscores economic opportunities, learning and the production of "international science and technology cooperation public goods". For these purposes, the diversification of innovation-oriented international collaboration and the pursuit of S&T innovation leadership aim at addressing globally-concerned scientific problems and facilitating resource-sharing, open and collaborative innovation and the development of world science. Issues of trade in high-tech products, standardisation, and IP ownership and protection are also high on the innovation diplomatic agenda. Hence, the expansion of international innovation bases or pan-national "collaborative innovation community" aims at establishing China's global competitiveness in advantageous industries and enhancing China's position in the global value chain.

Moreover, diplomacy for innovation also expects global "innovation dialogues" to promote mutual learning of innovation practices and policies, culture and education while facilitating the cultivation and flows of innovative talents. Engaging in global innovation governance to address challenges facing humanity (e.g., sustainability, security) is construed as an "international responsibility and obligation". As the cross-border transaction of technologies and R&D entities (firms, scientists, engineers, and research institutions) increase, the Chinese state's participation in international rule-making, policy coordination and negotiation covering areas of trade, intellectual property rights and foreign direct investments is deemed crucial to secure a fair and stable R&D environment on a global scale.

In contrast, innovation for diplomacy aims to enhance China's "global geopolitical influence" and "institutional discourse power". This is reflected in China's autonomy and "discourse power" in setting global innovation agenda, rules and standards, holding "multi-level innovation dialogues" that promote "China's story" and mutual trust with multilateral innovation partners. China's multilateral "country-specific strategies" uncovers the diplomatic attempt to build a "mutually beneficial innovation community" with neighboring countries to foster regional cohesion and international alliance power; and meanwhile, to “establish strategic innovation partnerships with developed countries” and “enrich scientific connotations of new major-country relations”, where collaboration merely takes place in specific domains with mutual interests. This selectivity involves exercising caution in areas concerning national security and power, such as cyberspace and semiconductor technologies, while focusing more on multilateral collaboration to countervail the dominance and monopolies of major powers.

Hence, the “global innovationscape” embodies both productive and reproductive characters, each driving the Chinese state in different directions. The productive facet emphasises learning, advancement and competition, featuring “open innovation” and “collaborative innovation”. It motivates China to catch up, leapfrog and pursue first-mover advantages in cutting-edge frontiers of global innovation. The reproductive facet, characteristic of threats from technological dominance and monopolies of developed countries, urges China to pursue indigenous innovation ownership, promote global legitimacy and strategise global innovation partnerships in order to ascend towards leadership in both global innovation market and global innovation governance.

In either navigation, a national innovation system, with robust indigenous innovation capability at the core, alongside effective innovation diplomacy, are essential for China to accumulate global currency and excel as a multipolar leader in the “global innovationscape”. China’s commitment to multi-scalar innovation reflects a systemhood thinking that multi-scalar innovation unleashes potentials greater than singular scale. Yet efficacious system functioning requires a balance between openness and closure. Thus, global connectivity and international collaboration are conditioned by overarching national priorities and interests.

4.1.3. The economy of valuing innovation

Value, an abstract intentionality of creation, carries connotations of significance and expectation for the fulfillment of purpose, playing a crucial role in shaping societal priorities and resource allocation. Discussion of various values produced through innovation provides imperative definitions of what is worth desiring, seeking, appraising and prizing for. They become the bases for evaluating the productivity of innovation inputs and outputs and rationalising redistribution. This examination constitutes the economy of valuing innovation.

Determining which values to produce, where to source them from (e.g., land, labour, transactions, capital), and how to reinvest and redistribute them touches on the fundamental question of how society should be constructed. Hence, a nation’s conceptualisation of value evolves with the changes in production factors, relations and organisations. The shift in focus from “labour” (2001) during the 10th National Five-Year Plan to “foreign trade” (2006) during the 11th, and then towards a holistic spectrum centred on “scientific, technological, economic, social, and cultural value” since the 12th (2011), indicates an expanded view of productive factors in developing an innovation-driven economy. This shift also legitimises and reinforces the teleology that innovation is all-powerful in value creation, positioning it as the ideal model for problem-solving and addressing emerging demands.

4.1.3.1. Demand-purpose

In holistic innovation, "demand" extends beyond a specific and identifiable economic concept related to innovation in the private sector. It embodies unlimited human needs in social issues, national goals, scientific choices and changing social conditions that necessitate innovation. It functions as a vocabulary for understanding the input, output, choices and costs of innovation in both public and private sectors, informing priorities for public expenditures.

Demand has concrete manifestations in policies. "Social demands" are articulated by consumers through markets and by society collectively through the political process. In the private sector, "market", "industrial" and "enterprise demand" mainly pertain to the quest for "use" and "exchange value". For public organisations, "national major demand" or "urgent demands for social development" are budget appropriations, political justification and implementation of publicly sponsored programs for the public good. Variegated demands necessitate structural overhaul of innovation supply:

> Promote supply-side structural reform. Economic enhancement, efficiency, and transformation...Ecological civilisation urgently requires scientific and technological innovation to overcome resource and environmental constraints. Addressing population aging, eliminating poverty, enhancing public health quality, innovating social governance, and supporting improvements in people's livelihoods...safeguarding national security and strategic interests all urgently require scientific and technological innovation to provide a robust guarantee." (D-13-STI)

Innovation, a product of both demand-driven and supply-pushed forces, stimulates new demands in both private and public sectors. The synergy between innovation demand and supply paves the way for "new development patterns". Complementing supply-side reforms with demand-side innovation policy guidance fosters a sustainable cycle of innovation:

> "Economic transformation and upgrading, continuous improvement of people's livelihood, and modernisation of national defense have created significant demand for innovation...Strengthen the guiding role of demand-side innovation policies, and establish a government procurement system in line with international rules...to reduce enterprise innovation costs and expand the market space for innovative products and services." (D-13-NI)

> "Accelerate the cultivation of a comprehensive domestic demand system and holistically merging the expansion of domestic demand strategy with

> supply-side structural reforms, propelled by innovation and high-quality supply to steer and generate new demand." (D-14-NESD)

> "With the deepening of supply-side structural reform as the main focus, reform and innovation as the fundamental driving force, and meeting people's ever-growing demands for a better life as the ultimate goal... Accelerate the construction of a strong city in scientific and technological innovation." (D-14-CESD)

4.1.3.2. Value indicators: "quality, contribution and performance"

Although demand-purpose provides a rationale for innovation, it falls short in operationalising evaluation. Hence, the value of innovation is instrumentalised through major indicators—"quality, contribution and performance"—which reflects the fact that innovation possesses dynamic qualities, that can be weighed on intangible scales in order to establish their degree of significance in satisfying human demands and measured this by the efforts required for their acquisition.

"Quality" evaluates the necessary attributes and communal standards for innovation. For instance, in the context of private sector and public procurement, quality supply relates to functionality and "reliability" achieved through standardised quality control and the "diversity of product type" addressing various demands. "Development quality" signifies "optimising structure" and "promoting sustainable development" through a shift from reliance on labour-intensive to innovation-intensive industries. In academic research, "quality" is associated with "originality", "indigenous ownership" and "transformation of sci-tech achievements" (D-11-NESD, D-13-STI, D-14-NESD).

> "Focus on building indigenous brands, improving **quality**, diversifying product types to satisfy diverse demands, expand high-end market share and enhance the competitiveness of the textile industry." (D-11-NESD)

> "Refine the innovation and **quality**-oriented evaluation system for university research and intellectual property rights (IPR), reward research innovation and IPR creation and establish a system conducive to the transformation of sci-tech achievements." (D-11-PLERD)

"Performance" (绩效) evaluates goal achievement (绩)" and effects (效), which further manifest in "efficacy", "efficiency" and "benefit". As an output indicator, "benefit (效益)" considers a comprehensive and long-term spectrum of impacts generated by innovation, such as the "international influence" of Chinese academia and industries, "public benefits of scientific infrastructures", "utilisation benefits of construction funds" and "industrial development benefits". In monetary terms, it refers to absolute returns such as technical contract turnover and technology transfer revenue (e.g., D-11-NI, D-13-NSTI, D-14-PSTI). "Efficiency (效率)" measures the ratio of output to input (e.g., time, cost, energy), underscoring the economisation of resource allocation and utilisation to optimise the scale and pace of yielding innovation output and its transformation into productivity (e.g., D-11-NI, D-12-NI, D-13-NI).

"Efficacy" (效能) considers both process "efficiency" and output "benefit". It measures the "degree of success in achieving innovation objectives", such as problem-solving (D-13-NSTI). In line with systemhood thinking, it also suggests the optimal functioning and orchestration of the "innovation system", where the innovation capabilities of composite units (e.g., universities, enterprises) are effectively unleashed, and the orderly flow, effective allocation and full utilisation of resources across units yield benefits such as regional innovation externalities in entirety that exceed the sum of composites. The following examples illuminate how these indicators are conceptualised in policy texts:

> "Overall deployment of China's independent innovation capability building: ...strengthen the integration, sharing and efficient utilisation of scientific and technological resources... support the leapfrog development of science and technology... stimulate innovation vitality across society and improve innovation **efficiency** and **benefits**." (D-12-NI)

> "Significantly improve innovation **efficiency** and **benefit**. Substantially boost the self-sufficiency rate of key core technologies and major equipment...Achieve more convenient and efficient transformation of scientific and technological achievements into productivity, with an annual turnover of technical contracts reaching 500 billion yuan." (D-14-PSTI)

> "Leverage the advantages of concentrated scientific and educational resources to unlock the innovation **efficacy** of universities and research institutes...deepen enterprise-lead university-industry collaboration to enhance the competitiveness of strategic emerging industries, while playing a leading, demonstrative, and radiating role in promoting innovation and development." (D-13-NSTI)

While "benefit" underscores the absolute returns of innovation, "contribution" captures the relative impact of innovation on beneficiaries such as industries, nation-states, global science and human society. Anchored in the mission to "serve society and enhance human welfare", "contribution" remains an abstract impetus for innovation reinvestment:

> "Persist in outstanding **contributions**...Leverage science and technology innovation to address critical real-world challenges, enhance people's living standards, invigorate China's sustainable socio-economic growth, guide policymaking and contribute to global problem-solving." (D-13-NSTHE)

Whether at national or institutional levels, “contribution” also provides proportionate measurements of return and quantitative justification for reinvestment. A high contribution rate signifies innovation-driven mastery of core technologies in key areas, promoting industries to the high-end of the global value chain. This ascension relies on effective transfer, commercialisation and wide dissemination of innovative achievements. In national accounting, “contribution” highlights the proportional returns of innovation on economic development by assessing the share of R&D expenditure to total investment and R&D output to GDP:

> “China has expedited the development of indigenous innovation capabilities, significantly **contributing** to national competitiveness, overcoming major technological barriers in economic growth, and ensuring national security and social progress.” (D-11-NI)
>
> “Enhance the source-supply of innovation...making greater **contributions** to human scientific and technological progress...improve the national economic accounting system, progressively incorporate R&D expenditures to reflect innovation activities in investment statistics and the **contribution** of intangible assets to the economy, highlighting the input and effectiveness of innovation activities.” (D-13-NI)

Institutional contributions, for example from universities, are evaluated by their execution of national projects, establishment of innovation facilities, and receipt of innovation awards, the quantities of papers, patents and transactions resulting from innovative transformations in relation to the national total. The share of income universities generates from serving industrial and societal demands is also factored into contribution assessment (D-12-NSTHE, D-13-NSTHE, D-13-NSTI).

Despite different emphases, these indicators are interconnected. “Quality” establishes the benchmark for improving “performance” in functioning, goal attainment and steering “contribution” towards beneficiaries. It reinforces public accountability in ensuring that “quality” is not compromised for pure “efficiency”. While “quality” provides references for horizontal comparison, “performance” and “contribution” also highlight the vertical “added value” of innovation outcomes, signifying continuous value enhancement throughout the development process. Optimal “performance” enhances the scope, scale and pace of quality innovation whilst “contribution”, as an impetus for reinvestment, sustains opportunities and resources for continuous quality innovation. Collectively, these indicators facilitate a comprehensive and dynamic evaluation and incentivisation of innovation.

In certain cases, these indicators intersect and overlap in meaning. Notably, high value-added or a high-end position in the value chain serves as both a quality standard and a shared goal that directs performance and contribution. In contexts where innovation aims at addressing societal challenges in education, healthcare and sustainability, "benefit" and "contribution" emphasise the value innovation generated for public good over fulfillment of bureaucratic performance measures. Besides "originality", research's quality is also demonstrated through its "efficacy" in solving scientific problems and further corroborated by its social and economic contributions, marking a "departure from traditional academic evaluation that focused solely on publications and awards" (D-12-NSTHE). As indicated below:

> "Establish evaluation systems aligning with the characteristics and patterns of basic research. For exploratory research, adopt long-term evaluations and international peer review, emphasising **originality** and academic **contributions**; for goal-oriented basic research, emphasise the degree of goal achievement and evaluate the **efficacy** in solving significant scientific problems; establish evaluation orientation on innovation **quality** and academic **contributions**." (D-13-NSTI)

The excerpted policy above also indicates a stronger attempt to develop a more scientific approach to categorically evaluating and allocating funding for innovation activities with different "characteristics and patterns". Nevertheless, despite the effort to balance attention on input, output quality and quantity, policy reports on innovation achievements often default to a linear correlation, presuming that increased R&D expenditure naturally yields an increase in outputs. "Efficacy" or "efficiency" is typically conceptualised in isolation, based on the scale of monetary investment, quantitative output and their respective growth rates over the five-year policy-planning period. This line of thinking is typically demonstrated in the extract below:

> "During the '12 Five-Year Plan', university science and technology funding totaled 593.6 billion yuan, a 78% increase from the '11 Five-Year Plan'. Universities led over 80% of National Natural Science Foundation projects and numerous national initiatives, including the 973 and 863 programs. They directed the development of 5 out of 16 major national scientific infrastructure projects, established 60% of key national laboratories and received over 60% of the three major national science and technology awards." (D-13-NSTHE)

4.1.3.3. Value dimensions: "scientific, technological, economic, social and cultural value" and "knowledge value"

Considering the versatile and contested constructs of innovation and its beneficiaries, policies endorse a holistic evaluation approach that also acknowledges the quasi-public value of innovation, which exhibits characteristics of both a non-exclusive public good and a competitive commodity.

Notions such as "scientific value" and "cultural value" in part draw attention to non-monetary valuation and the synergy among innovation in culture, science, technology, economy and society. However, monetary valuation, particularly the input-output relationship in national economic accounting, remains dominant in evaluation. Value dimensions serve to enhance performative and normative forces that shape the conceptualisation of innovation and actors' behaviour, relating to stringent auditing regimes.

> "Promote the market-oriented reform of the factor pricing mechanism, strengthen rigid constraints in areas such as energy resources and ecological environment, increase the weight of innovation factors such as technology and talent in product pricing, and allow those who excel at innovation to gain greater competitive advantages". (D-13-NI)

As this excerpt indicates, valuations are primarily underpinned by the regulated market principle, which strives to maximise innovation value by effectively employing, incentivising and distributing returns from various innovation factors, guiding towards sustainable economic development. Value dimensions vary in primacy and characteristics but also exhibit similarities, intersections and coexistence, which are further discussed in the sections that follow.

4.1.3.3.1. Scientific value

Much of the scientific value is ascribed to innovation in natural sciences and basic research that yield original discoveries and theories, fostering "new scientific understanding" and filling "knowledge lacuna" (D-13-NSTI). It is conceptualised in relation to "what science does" and "what science could do" in the service of human society and social transformation (Bernal, 1939).

"What science does" epitomises in the "trial-and-error exploratory value of scientific research" and the "truth" value generated from the pure pursuit of advancing knowledge of the material world. Amid trial and error, "originality" emerges from breakthroughs that transcend and challenge existing frameworks. This process pushes cognitive boundaries toward greater diversity and depth, enabling accumulation of knowledge, experience and expertise that makes possible the production of "non-consensual" (非共识, *fei gong shi*) and "transformative" innovation. The production of immanent scientific value hinges on honoring the "serendipity of scientific inspiration, the flexibility in research methodologies, and the uncertainty inherent in the research trajectory"; and harnessing scientists' "curiosity", "academic interest", "sensitivity", "confidence" and "autonomy" in selecting research subjects, devising audacious hypotheses, and conducting thorough verification (D-13-NI, D-13-NSBSR).

"What science could do" highlights scientific value in its social function. Besides truth-seeking and theoretical innovation, this includes "shaping collective "scientific literacy and rational spirit" (D-13-NI), enhancing scientific policymaking (D-12-PPSSD), responding to long-term development and national security demands by addressing "bottleneck scientific problems", "accumulating original resources for industrial technological advancement" and enhancement of productivity, and "charting new frontiers and directions" for national development (D-13-NI, D-13-NSTI). Serving the common purpose of knowledge development, scientific value also extends to "leading global research directions in various fields" and "enhancing China's contribution to human scientific exploration" (D-13-NI). As the following extract illustrates:

> "Promote a pluralistic academic culture that respects the individuality of scientists and enables diverse schools of thought to contend, enhancing the confidence to innovate and the dare to lead, take risks, and question. Honor the trial-and-error exploratory value of scientific research and establish mechanisms that encourage innovation and tolerate failure. Create a relaxed research atmosphere, safeguard academic freedom for scientific and technological personnel...Improve scientific literacy among the general public and cultivate a spirit of scientific rationality within society." (D-13-NI)

The social function highlights the potential of scientific value to transform or generate spillovers into technological, economic, cultural and social value. By emphasising a learning process perspective, scientific value calls for attention to the value created between the input and output stages of the innovation process, which distinctively captures the accumulative and discursive nature of innovation. Due to the exploratory nature and diverse intellectual "individuality" involved, scientific value features strong uncertainty in expected outcomes and a longer period of value discovery. The power of evaluation is primarily attributed to scientific intellectuals, the scientific community, and potentially the public, who determine the value of original discoveries. The emphasis on scientists' "not chasing hot topics" but instead "warming up the cold benches" (把冷板凳坐热, vital but under-explored areas)", underscores the relative independence of the inherent value of scientific innovation from its societal function.

4.1.3.3.2. Technological value

Technological value, fundamentally characterised by its social function and market-orientation, emerges from inventions and progress in S&T, such as enhancing production efficiency, decreasing energy costs, and ensuring that critical technology remains "safe, autonomous and manageable" (D-13-NI). The "creative" facet is manifested in "innovativeness" that advances existing knowledge, technologies and methods, or integrates and applies them to other disciplines and domains.

Unlike scientific originality, technological value can be produced through various degrees of improvement without disruptive changes. It mainly conduces to the production of "application value" and "economic and social benefits" (D-13-NSTI, D-14-PSTI). This includes fostering sustainable competitiveness for products, enterprises, and industries, enhancing their viability against rivalry imitation and leading industrial development (e.g, D-11-NESD, D-11-DST-TH, D-12-NESD); and giving rise to "new economies, industries, business formats, and models, profoundly impacting human production, lifestyles, and even ways of thinking" through the collective emergence of disruptive technologies (D-13-NSTI).

Technological value embodies the potential to transform into commercial, industrial, economic, ecological, and social value. For instance, the value of information technologies in innovating social governance and supporting new urbanisation, modern city development and public services can create social value (D-14-NESD). Innovative green technologies promote clean production and foster eco-friendly industries and sustainable development, which in turn generates commercial, industrial, economic, and ecological value (D-13-NI). The policy excerpt below elucidates how scientific value is conceptualised in relation to technological value:

> "Improve the evaluation criteria for science and technology awards. For natural science awards, emphasis should be placed on reviewing the originality, recognition, and scientific value of the achievements. For technology invention and scientific and technological progress awards, focus on evaluating the innovativeness, advancement, application value, and economic and social benefits of the achievements." (D-14-PSTI)

4.1.3.3.3. Economic value

Economic value, principally concerned with resource scarcity and the "maximisation of innovation value" (D-13-NSTI), manifests at various levels. At the level of national wealth, it highlights innovation's "contribution" to GDP growth and economic ascension. In production, it underscores the value produced through the "consolidation of indistinguishable human labour"—a Marxian concept—manifested in both material and immaterial forms and embodied in productive factors such as "data value" in cybernetics, computer control and "digital productivity" (D-14-PESD, D-14-CESD). In transaction and consumption, it reveals itself as the "application value" of innovation in facilitating human practices (D-11-CED, D-12-CSTD) and the "commercial value" of innovative products that meet market and user demands (D-12-DMP-HZ, D-13-NSTI).

4.1.3.3.4. Cultural value

Cultural value involves dissemination of both cultural as a kind of general spirit; and value-added of cultural goods through innovation in scientific research, technologies, facilities, management and development models. Innovative culture manifests as "a pioneering spirit" that "dares to be the first, respecting free exploration and tolerating failure" and a favourable atmosphere for innovation and entrepreneurship (e.g., D-13-STI, D-13-NESD, D-13-PI).

As innovative products, cultural research and creative literary work demonstrate significant value in aesthetic enrichment, creative activation and spiritual uplift. Outstanding works celebrating the spirit of innovation and stories of creation and entrepreneurship conduce to elevating public ethos and fostering motivation for mass innovation. Both contribute to forging collective emotional resonance, identity, and the image and reputation of localities in which they occur (e.g., D-13-PESD, D-12-DMP-HZ). Of particular note is the "contemporary red culture value"[15] in enriching the spiritual connotations, strengthening patriotism, fostering social cohesion, and enhancing the city's branding value:

> "Foster urban vitality through innovation culture... Hone the spirit of Guangzhou's red culture and unearth its contemporary significance. Concentrate on red culture theory research and literary creations...Enhance Guangzhou's reputation as a heroic city... Nurture maker, entrepreneurial, creative, and inventive cultures, advocating innovation as a guiding value, mindset, and lifestyle for society at large." (D-14-CESD)

The value-added of cultural goods reflects innovation's auxiliary effect in augmenting the value of existing cultural heritages, facilities, industries and urban space or unlocking their capacities and potentials for further cultural value creation. One manifestation is the development of creative industries and economic regeneration, wherein cultural value is constructed as an instrumental "tool" to enhance economic value through wider economic spillovers. Integrating traditional industries such as agriculture, textile, and garment with local cultural characteristics leads to high-end service industries that combine exhibition, eco-tourism, modern business, and creative culture. This synergy provides an efficient service network for collaborative industrial upgrading. Deserted industrial sites can be renovated into "urban open spaces blending historical heritage and aesthetic landscapes" (D-12-DMP-HZ). In commercial contexts, "cultural value" also manifests as "branding value", the symbolic significance and competitiveness of local industries and regions.

Besides benefits of cultural tourism and economic development, innovation amplifies the "historical, artistic, scientific value" of cultural heritages and facilities as public goods (D-12-DMP-HZ). By addressing key public cultural service demands in "heritage value recognition, protection planning, restoration, maintenance, monitoring, inheritance utilisation", and "public cultural resource sharing", research innovation, technology breakthroughs, and application demonstrations contribute to the preservation and demonstration of shared, non-renewable human legacies and cultural diversity (D-13-STI, D-13-NSTISD). This facilitates the appreciation of both past and present; the value of cultural heritages as landmarks that embody collective memory, convey communal meaning and identity, and evoke civil pride; and innovation in

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[15] The cultural, political, and historical aspects related to the Chinese Communist Party (CCP) and its revolutionary history, which highlight the struggles, sacrifices and achievements of the revolutionaries.

science and technology. Cultural heritages provide a direct source of scientific knowledge with the potential to address modern-world problems and create demands for innovating archaeological methodologies, supporting technologies and facilities for heritage excavation, study, and preservation.

The cultural value of innovation largely presents a hierarchical conception that commences with the romanticised notion of culture but transitions towards social and economic purposes pertaining to the evaluation of “benefit”, “impact” and “outcome”. Innovation is construed as given inputs in an economic valuation, including the economic exploitation of resources for social purposes (e.g., social cohesion, region image-building) under the umbrella of “culture”.

4.1.3.3.5. Social value

With “public nature” (公共性) and “social nature” (社会性), the social value of innovation encompasses a broad spectrum of long-term impacts and values in science, technology, industry, economy, education and culture. The dissemination of scientific and technologically innovative achievements to augment public literacy possesses scientific, educational, cultural, and social value. Innovation in high-tech environmental protection industries generates technological, economic, ecological and social value.

However, “social value” distinctively concentrates on key areas such as biotechnology, population health, resource exploration, environment protection, urbanisation, public safety, and cultural and sports industries. Nationally, the paramount aim is to enhance public welfare, people’s livelihood and their perceptible “sense of gain” through wide-reaching and authentic populace engagement with innovation benefits, thus constructing “a healthy, beautiful, and safe China”. At the international and global levels, the focus is on addressing shared concerns such as geological exploration, climate change, population health control and sustainable development while enhancing China’s international influence and discourse power in global innovation governance (e.g., D-13-NSTISD, D-13-GBA, D-14-PESD). Key areas of social value are targeted within the context of national, international and global innovation objectives, with some areas being exclusively addressed at the national level (Appendix 8).

4.1.3.3.6. Knowledge value

While aforementioned value dimensions primarily scrutinise the tangible outcomes of innovative products, knowledge value delves into the intellectually-intensive character of innovation. It underpins that the realisation of innovation value is contingent on the distinctive characteristics of intellectual labour that span across varying innovators, innovation fields and processes, and mandates equitable rewards for knowledge-contributing actors (D-13-DPGIKV).

Knowledge value intertwines strategies, commodification and politics. Within the knowledge economy, organisations such as universities and research institutes and individual researchers are construed as "crucial knowledge assets" (D-11-DST-TH). Their autonomy in mobilising essential "human, financial, and material resources" for innovation and exercising "decision-making power over technological paths" form the crux of knowledge value generation (D-13-NSTI). Knowledge value takes form as intellectual properties or "knowledge ownership" that can be codified, commodified, and transacted to yield economic benefits. This ownership encompasses long-term usage of "patents, copyrights, new plant variety rights, and proprietary rights for integrated circuit layout design", and can be converted into "innovation talent's equity, stock options and dividend incentives" (D-13-NESD, D-13-DPGIKV, D-14-CESD). Embodying both production and exchange value, knowledge value holds strategic significance with commercial and legal boundaries that demand valuation and protection from professional service organisations.

Numerous STI and ESP policies, cognisant of the discursive and cumulative process of innovation, endorse an "income distribution system that reflects the augmented value of knowledge" in order to enhance respect for "labour, knowledge, talent and creation" (D-11-DST-TH, D-12-NSTI, D-13-NSTI, D-13-NESD, D-13-PESD, D-13-PI, D-14-PESD, D-14-CESD). *Opinions on Implementing Distribution Policies Guided by the Increase in Knowledge Value* specifically underscores the virtuous cycle where "knowledge creation is valued, and value creators receive equitable reward" and a balance between distributional fairness and individual talent incentives, performance evaluation and reasonable compensation for intellectual labour and rewards for different types of intellectual labour. This strategic and rational deployment of intellectual labour "rank" is essential for an efficacious innovation system. Table 4.1 illustrates various forms of intellectual labour and their corresponding evaluation and income distribution criteria.

Table 4.1. Forms of intellectual labour, evaluation and distribution criteria

Functional positioning and development direction	**Evaluation and income distribution criteria**
Basic, agricultural and social welfare research with long R&D cycles	Steadily improve basic salary income, establish and perfect the feedback mechanism for the income of subsequent scientific and technological achievements
Applied research and technology development	Incentivise and reward based on market mechanisms and performance of scientific and technological achievements

Philosophical and social science research	Establish a rational compensation incentive mechanism for intellectual labour based on key evaluation criteria (i.e., theoretical innovation, decision-making support, social impact); Employ government procurement to fund suitable think tank projects
Teaching and research	Establish teaching performance and achievements as key criteria for teacher promotion and income distribution; Increase the proportion of basic performance pay in total remuneration; Tilt evaluations in favour of innovation in theoretical teaching research, teaching methods and development of high-quality teaching resources

Besides commodification, knowledge value, being quasi-public, mandates innovation actors to prioritise and fulfill core public service responsibilities such as teaching and research and to engage in public welfare innovation activities, including decision-making consultation, poverty alleviation, scientific popularisation, legal assistance and academic exchanges (D-13-DPGIKV). Achieving this requires the de-coupling of a stable income, subsidisation for public service roles and compensation for indirect labour costs incurred during the innovation process from the number of projects undertaken or funding secured. It also necessitates incentive-based rewards tied to intellectual achievements, including intangible accolades (e.g., commendations for innovation) and tangible benefits (e.g., intellectual property rights, commercialisation income, manuscript remuneration, royalties). This approach appreciates that the value of knowledge rests largely on an intellectual's "self-dedication" (D-13-PESD) and intellectual contributions, although intangible, remain productive and are closely tied to individual agency.

The forthcoming excerpt typically demonstrates this intellectual-centric valuation and emphasises the balance between equitable, long-term and incentivising distribution in support of innovation actors' fulfillment of public services and responsibilities:

> "Address misalignment between researchers' contributions and income distribution and the absence of long-term incentive policies...closely align researchers' income with the scientific, economic and social value they generate...Balance incentives and regulations...Regulate income disparities across regions, institutions and among different personnel...Steadily increase the basic income for those involved in fundamental, agricultural and social welfare research with longer R&D cycles...Prioritise teaching performance and outcomes as key determinants for academic promotion and remuneration

distribution." (D-13-DPGIKV)

4.1.3.3.7. Synergy of innovation values

The economy of valuing innovation captures not only the multiplicity of value dimensions, their individual primacy and characteristics, but also their similarities and intersections.

Both scientific and technological value are conceptualised as "creative contribution" to social transformation, with articulated performative metrics for evaluation and distribution. Despite these similarities, technology value is fundamentally marked by its application value and market orientation whereas scientific value holds primacy with "original", "non-consensual" and "transformative" discoveries that produce truth of the material world and enhance collective scientific literacy. Similarly, cultural and social value are manifested in the enhancement of public literacy and ethos. Nevertheless, akin to economic value's emphasis on application and GDP contribution, cultural value often reduces to its value-added or economic spillover effects while knowledge value, an additional dimension, also accentuates the commodification, transaction, and transformation of innovation into tangible economic value. By contrast, social value prioritises public welfare and the shared "sense of gain" from innovation, which involves synergy of values and impacts across domains (e.g., science, economy, education) and scales (e.g., global, international, national). Knowledge value, regarding innovation as both a commodity and a (quasi-) public good, also emphasises equitable distribution of innovation benefits among value creators.

Table 4.2 Summary of the primacy of different value dimensions

Value dimension	Primacy
Scientific value	Truth value and contribution to collective scientific literacy of "original", "non-consensual" and "transformative" discoveries
Technological value	Application value and market orientation
Economic value	Contribution to GDP
Cultural value	Enhancement of public literacy and ethos; value-added or economic spillover effects
Social value	Public welfare and the shared "sense of gain" from innovation
Knowledge value	Commodification and transaction value; quasi-public good and equitable distribution of benefits among value creators

Due to this multi-faceted nature, a single innovation can simultaneously carry a constellation of values. As exemplified in the following excerpt, the value of social sciences is threefold: scientific, cultural and social. It plays an integral role in "inheriting human civilisations, advising government and educating people":

"Launch serial landmark achievements with significant theoretical innovation

> and cultural heritage value...Broaden channels for outstanding achievements to influence Party Committee and government decision-making, fostering the transformation of research outcomes into curricula, social dissemination, policy decisions, and cultural products." (D-12-PPSSD)

Within the "global innovationscape", the synergy of innovation across fields and value creation is deemed an inevitable trend with profound impacts on variegated aspects of human production and social transformation:

> "The evolving landscape of social development and scientific-technological innovation is accelerating the integration of technology, industry, and management across diverse fields. This global fusion, intertwined with social and economic values, is spawning new economies, industries, and business models. The impact is profound, altering social development trends, economic production modes, lifestyles, and even ways of thinking." (D-13-NSTISD)

Innovation actors and their intellectual labour remains the subject of value creation while institution normalises and legitimises the evaluation of innovation, or the de facto process of value attribution, through performative indicators and ascription of various value dimensions. Such institution serves to regulate actors' social behaviour and optimise allocation of innovative resources to meet evolving social demands.

4.1.4. Nature of innovation

4.1.4.1. Novelty

Novelty embodies addressing "lacuna" (空白, *kong bai*) at national and international levels as well as "originality" that epitomises in indigenous innovation ownership (D-13-NSTI, D-14-PSTI). Indigenous ownership plays a central role in both domestic self-reliance and international leadership. It has gained increasing prominence due to growing concerns about domestic industries' over-reliance on imported innovations since the 11th Five-Year Plan period when "introduction, digestion and re-innovation" was still highlighted as a critical approach parallel to indigenous and integrated innovation.

Bridging national lacuna is pivotal for resolving China's long-term development constraints and national security issues that necessitate strategic foresight in basic research and a ramp-up of high-tech breakthroughs towards self-reliance (D-13-NI, D-14-DESD-HZ). Foreign or international lacuna often associates with scientific exploration in key uncharted territories (e.g., international economic cooperation corridors, polar regions, the oceans) and global challenges, necessitating China to "lead the run" (领跑, *ling pao*) in collaborative initiatives. These may include industry demonstrations in aerospace, agriculture, biomedicine, energy, IT and marine science, or promoting shared biological resource development and health services through traditional Chinese medicine.

Novelty is framed on a spectrum distinguished by its continuity with existing or past developments. At one end are "disruptive" and "transformative" breakthroughs that "reset (归零, *gui ling*) established investment, talent, technology, industry and rules" while "reshaping crucial scientific or engineering concepts", which instigate new research paradigms, academic fields and growth cycles and establish competitive advantages (D-13-NI). At the other, it manifests as incremental and steady advancements that elevate basic universal standards and expedite the diffusion of low-cost, energy-efficient technology products and consumption models. Another spectrum differentiates novelty between "common" (共性, *gong xing*) versus "non-consensus" innovations based on their rarity or scope of application. "Common" innovations are construed as "collective breakthroughs" that "lead the development of emerging industry clusters" and "upgrade to mid-to-high-end industries" (D-13-NSTI). This is premised on the concern that the global trend of a collective technological revolution, featuring "intelligence, sustainability and ubiquity", will significantly reshape the international industrial division (D-13-NI).

As noted in the scientific value, "disruptive" and "non-consensus" innovations are largely credited to curiosity-driven basic research that challenges conventional paradigms and authority. These innovations, likely borne out of interdisciplinary convergence, are distinct in their stark discontinuity and rarity compared to existing concepts, symbolising a leap from nothing ("0") to original prototype ("1"). They are conceptualised as strategically pivotal for enhancing China's scale and speed of "seizing the commanding heights of innovation" in the techno-globalism playing field (D-14-PESD, D-14-CESD).

> "Strengthening basic research from '0 to 1', charting new fields, proposing new theories, developing new methods, and attaining significant pioneering original achievements, is the commanding height of international science and technology competition. Original breakthroughs from '0 to 1' require both long-term accumulation and sedimentation of knowledge and scientists' eureka; both long-term stable support for basic research and concentration on areas with comparative advantages, further emphasising key aspects while being selective in pursuits." (D-13-NIPSBR)

As this excerpt indicates, "0 to 1" progression necessitates long-term strategic deployment on innovation areas, sustained knowledge growth and sedimentation, and a game-changing breakthrough where "1" is brought to fruition by "scientists' eureka". Nevertheless, what remains under-discussed are the potential tensions between steering "0 to 1" innovation and prioritising areas with extant comparative advantages, the discursive evolution of such innovation and the ambition to hasten attainment of international leadership. Incremental and "common" innovation manifest the "1 to n" processes where original breakthroughs are optimised through innovative applications to diverse contexts or industries, or by improving cost and resource efficiency. These processes potentially instigate new demands for or further cycles of “0 to 1” innovation.

Innovation is conceptualised as both the processes and outputs generated at various stages of the innovation chain, coming into being in various forms. Within the “0 to 1” progression of frontier basic research, it emerges as the discovery of novel principles, laws, theories and methods. In the “1 to n” processes, it manifests as R&D of novel technologies, solutions for industrial technology innovation, cultivation of novel patents, brands and product varieties, and their application demonstrations, industrialisation and proliferation. From the 13^{th} Five-Year Plan period onwards, innovation, “non-consensual” one in particular, is perceived as not only a scarce and competitive social resource, but also a quasi-public good requiring both “competitive and stable non-competitive support” to counterbalance potential market failures (D-13-NI, D-13-NSTI).

4.1.4.2. Holistic innovation

With innovation being a “national will and collective societal action” (D-13-NI), holistic innovation is an overarching theme in D-13-NSTI, D-13-NESD and D-14-NESD. “Holism” is conceptualised as “systematic, comprehensive and synergistic” innovation reform experiment, which spans across various domains such as S&T, institution, policy, business, education and social governance, and involves actors ranging from the general populace to the “Communist Party’s self-renewal”.

By domain and actor, “cultural innovation” is conceptualised as “flourishing artistic creation” and enhancing “the quality of cultural and artistic products” that better cater to the needs of the populace. “Mode innovation” is grounded in China’s regional diversity in resources, industrial features, locational advantages and developmental stages. The pursuit of distinctive innovation-driven models and influential regional innovation hubs are envisioned to invigorate surrounding locales. Crucially, “mode innovation” also hinges on versatile financing models that support the entire innovation trajectory, from experimental research and pilot testing to full-scale production. In educational innovation, this manifests as an embrace of industry-university collaboration and research-teaching synergy, fostering educational approaches that equip students with both “innovative spirit and practical acumen. This also necessitates a transformation of university system and culture, imbued with “distinct modern Chinese characteristics” that augment university autonomy and vitality.

Unraveling “Chinese characteristics” also stands as a significant undertaking for “social science innovation”, which emphasises the organic integration of upholding Marxism’s guiding position with the pursuit of academic excellence. This venture engages with the innovation of academic perspectives, disciplinary systems, and research methods to deepen the understanding of the Communist Party’s governing principles, the tenets of socialist development, and the broader trajectories of societal evolution. Such exploration results in the conceptualisation of novel governance ideologies and stratagems, offering both a scholarly theoretical framework and a pragmatic roadmap to intensify reforms, embrace broader openness and expedite socialist modernisation in contemporary contexts (D-12-PESD, D-11-NESD, D-13-NESD).

The strategic vision for innovation in SSHA, is further operationalised in the *New Liberal Arts Initiative* (新文科建设), launched at the 2020 National Conference on New Liberal Arts Development. SSHA is valorised both for its intrinsic role in building "endogenous Chinese knowledge systems" (自主知识体系) and for its instrumental function as a catalyst for interdisciplinary innovation. Strategically positioned to construct a distinctively Chinese disciplinary, academic, and discourse system, SSHA contributes to the articulation of ideas, principles, and solutions that reflect Chinese perspectives, wisdom, and values by "innovation grounded in tradition" (守正创新). This enables the reinterpretation and creative transformation of traditional culture through new research paradigms that enhance its contemporary relevance and promote inclusive, pluralistic modes of expression and dissemination. SSHA serves as a critical enabler of "cross-boundary innovation" (跨界创新) in response to technological progress, facilitating convergence across domains and fostering value-led curriculum design, programme development, pedagogical innovation, and a culture of academic quality (D-14-NEDU).

Despite the diverse priorities across domains, S&T innovation remains pivotal in leading holistic innovation. For instance, innovations in business, service and product hinge on merging traditional industries with mobile internet, cloud computing, big data and the Internet of Things to foster new business models, commercial patterns, consumer behaviours and employment modalities. Similarly, institutional and managerial innovation are predicated on providing support for ex-ante S&T innovation platforms. One focus is on enhancing the role of market in directing technological innovation so as to incentivise and reward stakeholders across varied roles, for their contributions to the creation and commercialisation of original breakthroughs. Another focus consists in refining the governance of the Party and state, particularly in enhancing their grasp of S&T innovation trends and decision-making precision in innovation, and the scrutiny of power execution. Concurrently, policy innovation pivots towards a more inclusive fiscal and tax policy for enterprise innovation and accelerating the deployment of mature pilot policies nationwide.

"Holistic innovation" is also conceptualised by different trajectories of innovation. While "convergent innovation (融合/融通创新)" highlights underscores the amalgamation of S&T with industries such as healthcare (D-13-NSTI) and the facilitation of symbiotic relationships across the industrial value chain (D-14-NESD), "integrative innovation (集成创新)" targets system-level integration and collective breakthroughs in core technological challenges in industrial clusters to hasten the transition from innovation to industrial application (D-11-NESD, D-12-NESD, D-13-NESD, D-13-NI). While both advocating innovation-oriented collaboration, "open innovation (开放创新)" emphasises innovation diplomacy and multi-scalar innovation whereas "cross-boundary innovation" aims to spur growth in emergent, cutting-edge and intersecting innovation domains through interdisciplinary, inter-domain, inter-regional, and inter-institutional collaborations (D-12-NESD, D-13-NI, D-13-NSTI).

4.1.5. Summary

Despite acknowledging the diverse nature of innovation activities and trajectories, innovation is often conceptualised as a linear process, progressing from "0 to 1" and "1 to N" progression. It is governed by the term "innovation" in financial and funding calculations, auditing, incentive structures, with decision-making processes perceived as a concept to be formally institutionalised through evaluations and a public culture that reveres innovation (N-13-NSTI). Notwithstanding the emphasis on more rigorous accounting of innovation expenditures, "innovation" is legitimised as utilitarian considerations of addressing societal needs and producing public good. As an "assimilated symbolic system serving as a tool and standard for potential choices between alternatives", evaluation reinforces the "preferential trend" toward optimal productions of innovation (Grunberg, 2000, p.20).

4.2. Interviewees' conceptualisations of innovation

4.2.1. Initial response to "what innovation is"

When asked "what innovation is", most interviewees consider "innovation" too "broad", "general" and "elusive" to define or capture. To operationalise this "macro concept", many interviewees resorted to distinguishing between various scopes (e.g., broad vs narrow) and anchoring "innovation" to specific contexts or perspectives (stakeholder, disciplinary, personal) with which they were familiar and confident. Other initial responses encompassed retrospecting on how innovation had been historically framed and developed in a national context or touched upon in teaching practices, ascribing its significance to academia and its role as a primary "driving force of modern socioeconomic progress" (GOV-P1) and identifying the necessary conditions and sources for its emergence.

While most industrial interviewees dived straight into defining the core features of innovation, some university interviewees revealed hesitancy, describing the attempt to answer this "never-thought-of" question as "difficult" and problematisign the iteration of "innovation" as given and indispensable for its own sake. These variegated responses support the notion that innovation is a site of conceptual ambiguity and contestation.

Table 4.3 Type of interviewees' initial response and sample quotations

Types of Initial Response	Exemplary interview quotes
Ascribing	"For universities, no innovation means no development." (UNI-ES-P1) "Innovation is of upmost importance because of the

	unpredictability of our research subjects.” (UNI-NE-P1) “Innovation is the main theme of modern economic and social development, and the most important driving force for growth.” (GOV-P1)
Attributing	“Innovation requires proper soil and environment. It is very challenging.” (UNI-EP-P8) “Innovation merely has two sources...” (IND-P9)
Operationalising	“All concepts have broad and narrow senses. For us, innovation is...” (UNI-LS-P2) “Different people have different answers. For science, innovation means...” (UNI-CHE-P1) “Depend on who you are asking this question for. For Chinese or foreign stakeholders?” (UNI-EP-P1)
Retrospecting	“Our country talks about innovation all the time.” (UNI-MatS-P2) “In the past, I thought that China only had institutional innovation, but not technological innovation.” (UNI-MGT-P1) “This is a question that I always ask my students.” (UNI-ECE-P4)
Orientating	“I was mainly involved science and technological work, so I am familiar with technological innovation...” (GOV-P1) “I know better about innovation in scientific research...”(UNI-P4)
Characterising	“This question is very large and general.” (UNI-CS-P5) “The scope of innovation is very wide...” (IND-P2) “Innovation is a macro concept per se.” (GOV-P2)
Hesitating	“It’s very difficult. I’ve never thought of this question...I am not sure how to define innovation.” (UNI-CS-P3) “I haven’t thought about it specifically.” (UNI-CS-P6)
Problematising	“You can’t ask a question that way. ” (UNI-CS-P2) “I think we should not repetitively mention innovation.” (UNI-MatS-P3) “Do not innovate for the sake of innovation.” (UNI-GEO-P3)

4.2.2. Novelty: a significant feature of innovation

When reasoning what an innovation is, most interviewees characterised innovation with “novelty” or the combination of “novel” and particular items such as “technology”, “product”, “institution”, “management style”, “idea”, “theory”, “phenomenon”, and “formula”. Almost half of the interviewees from the university and industry conceptualised “novelty” in comparison to what already existed, noting novelty as the “rediscovery of things in the past”, “a step further”, “repairing something extant", "an improvement", or "a breakthrough" based on or going beyond existing technologies, approaches, and frames (e.g., UNI-MatS-P1, UNI-MGT-P2, UNI-GEO-P2, IND-P9, IND-P10).

"The extant" appears to be a significant source of innovation and a parameter of comparison for intended progress to achieve. For instance, as IND-P8 noted, the S&T innovation is "a summary of existing technologies and principles" per se. Such in-principle knowledge was a prerequisite foundation for innovation, enabling more cross-disciplinary knowledge nexuses and acute identification of existing problems and their solutions (e.g., IND-P9, UNI-MatS-P2, UNI-GEO-P3, UNI-CHE-P1, UNI-SE-P2). In particular, UNI-ECE-P1 exemplifies that many innovations in Optoelectronics were based on applying new materials and technologies to the extant principles of apparatuses, laid down by notable predecessors. When addressing new problems, "the extant" also served as an indispensable benchmark for comparing why and how particular innovations outperform, underpinned by UNI-ECE-P4:

> "Only through comparison will we know why it is better than the extant and is better in what aspects. No judgement can be made without comparison. All innovation needs benchmark." (UNI-ECE-P4)

The extent to which "novelty" progresses from "the extant" tended to vary. At one end, "repairing", "improvement", or "a step forward", for instance, represented a comparatively incremental and modest description of novelty. Existing accomplishments were construed as "the shoulders of giants" upon which innovation commonly built. As UNI-ECE-P2, UNI-MatS-P1, IND-P5, and IND-P8 illuminated:

> "Many current innovations stands on the shoulders of giants. It is impossible to innovate out of nothing. Perhaps it is, but it must be rare." (UNI-ECE-P2)

> "Innovation is more about creating something novel...even it is not that innovative, say just one step or less than one step further than extant technologies." (UNI-MatS-P1)

> "Innovation doesn't have to be disruptive or ground-breaking, but a small improvement of something in our daily life." (IND-P5)

> "In experiments, I consider the ten-stage technique of an equipment to be too complicated. I improved it into eight stages with similar performances. This is also innovation...Perhaps I'm not being very stringent. It doesn't have to be an invention out of nowhere." (IND-P8)

At the other end, "breakthrough" conveyed a more radical expectation of novelty that transcended and potentially disrupted the existing frames to make way for new possibilities, though some interviewees held contested views regarding its feasibility.

These perspectives were typically expressed as follows:

> "Innovation means charting a novel course...breaking away from conventional methods and seeking a more efficient way." (UNI-ECE-P2)

> "Being institutional, technological, or theoretical innovation, it is about breaking through the existing framework and developing towards a better and more useful novel direction." (UNI-GEO-P2)

> "The so-called innovation is often a change and modification within the existing framework in many cases, but in fact, now we always expect breakthrough or framework-transcending innovation. Not saying it's difficult. It's infeasible and impossible." (UNI-MGT-P2)

With an emphasis on the void, lacuna or niche that innovation potentially filled, "novelty" was also explicated as something "not yet in existence", "creating something from nothing" (从无到有, *cong wu dao you*), "uncharted territory (无人区, *wu ren qu*)", "currently absent", "no one has ever done" and "others have not done" (e.g., UNI-GEO-P1, UNI-CHE-P2, IND-P3, IND-P7). "Not yet in existence", "creating something from nothing" and "unexplored territory" suggested a complete lacuna that expected disruptive/groundbreaking innovation. "Currently absent", "no one has ever done", and "others have not done" were used to indicate a partial lack or absence, implying that something already existed but remained untapped in certain territories. "Others have not done" could also indicate benchmarking, implying that there might be unsatisfactory attempts and examples. Some interviewees further qualifed this as others "cannot" or "dare not to do". Although these terms had similar meanings, they encapsulated different nuances and were employed in distinct settings by interviewees from the university and industry. The exploration of "unexplored territory" or benchmarking to "others" occurred across individuals, academic and professional fields, industries, markets and human society.

Among university interviewees, "no one has ever done" or "others have not done" were specified to undiscovered phenomena, unproposed formula, concepts and theories, unexplored experiments and unpublished achievements (e.g., UNI-ECE-P1, UNI-CS-P1, UNI-LS-P2). Several interviewees in basic science emphasised "atypical" novelty with a clear "departure from traditional methods, means and tools" (e.g., UNI-NE-P1, UNI-CHE-P1). The void, lacuna, or niche was generally identified by examining existing scholarly work within the academic or scientific community, or more broadly, the extant creations in the world. Some interviewees also highlighted the role of stakeholder demands—such as those from policymakers, enterprises and the public—as starting points for innovative endeavours. Typically noted by UNI-CHE-P1, UNI-GEO-P1 and UNI-MGT-P2:

> "Innovation means doing something no one has ever done...it must be rooted

> in a thorough understanding of what has been accomplished previously, including the review of previous papers and data. Research must then be continued on this foundation." (UNI-CHE-P1)

> "Innovation is creating something not yet in existence in the world, and the creation will bring people convenience, save money and time, and improve lives." (UNI-GEO-P1)

> "The demands for innovation are proposed by the government and institutions...making it clear from the outset that what I am asked to do is novel...New policies are created only because there was a void or lacuna." (UNI-MGT-P2)

Industrial interviewees more commonly perceived novelty as addressing a partial lack or absence, rather than creating something entirely non-existent, benchmarking against "others" at the level of market, industry and system. As IND-P2 and IND-P4 illuminated, novelty was generated by filling what remained "currently absent" or urgently demanded in new markets, or by establishing fresh brands in established markets. In comparison to counterparts working in the Internet of Things (IoT) industry, IND-P3 construed the persistence in advanced R&D and national commercialisation of IoT technologies as a remarkable example of doing "what others dare not or cannot do":

> "The IoT technologies we are working on are indeed challenging. Many forgo in the research process, but we have persisted in the national transformation of our technologies and have successfully commercialised our research and technological achievements." (IND-P3)

IND-P9 observed a significant gap in the current efforts to translate innovative achievements in response to social needs within China's science, technology and business system. In response to such lacuna, IND-P9 strove to achieve what "no one has ever done" by establishing an enterprise that coordinated various innovation actors in biotechnology and materials. "Creating something from nothing" was commonly conceptualised as a pioneering process in "uncharted territory" of theory, technology, management and institution (UNI-CHE-P2, IND-P6, IND-P7). Nevertheless, with a focus on system, IND-P7 further refined this idea as "forgoing past successes" and starting an enterprise that could outcompete others in the existing system. To achieve this, it was crucial to be forward-looking and employ a "leaping frog tactic", taking unconventional steps to successively overcome competitions. In the words of IND-P7:

> "An entrepreneur can never outrun others by doing what is established in the system...Many others are well-prepared for what is currently visible. You may outcompete in one or two things but are left behind in perspective. It's

> thus crucial to look into the future and adopt a leaping frog tactic...hopping to a place that is compatible with your capabilities and experiences." (IND-P7)

What was common to both university and industrial interviewees was the reference to fields and individuals when conceptualising what "others have not done". For instance, as an investor for innovation projects, IND-P2 indicated that novelty addressed a partial lack in the domestic market, which meant sifting tracks and competitive projects from "urgent fields". As IND-P9, UNI-ECE-P6 and UNI-TT-P1 contended, "novelty" was demonstrated in "borrowing" achievements from different fields to where they remain absent or largely unavailable:

> "Another source of innovation is transdisciplinary integration, which means taking something from field A and applying it to address major problems in field B, and then combining achievements in both fields...Say I study Biological Materials and I found a method in an adjacent industry that could solve my own problem. I can use it to promote the transformation of technologies." (IND-P9)

> "If you come up with a verified solution to a problem applying a method that hasn't done before or is novel in this field, then that's an innovation." (UNI-ECE-P6)

> "One example is borrowing achievements from other fields to a field where these achievements have never been reported or known but can produce positive outcomes...This also applies to the industry." (UNI-TT-P1)

At the individual level, interviewees benchmarked against counterparts with similar backgrounds and resources, either consciously or unconsciously. As another example of doing what "others have not done", IND-P3 compared himself to most state-own enterprise employees in their 40s and noted that it took both great courage and a combination of conditions for him to quit a stable job, start a business and persist in innovating IoT technologies. Although most PhD graduates pursued careers in academia or government, IND-P9 saw "great value" in transforming S&T achievements and making full use of his industrial mindsets and PhD background. He then established a biotechnology enterprise that linked S&T achievements with the demands of clients and considered this a "calling". Similarly, some university interviewees such as UNI-MatS-P4, UNI-CS-P2, and UNI-PHA-P3, attributed their capacity for engaging in what "others have not done" to the combination of a strong theoretical foundation and rich practical experiences.

Despite being discussed in various contexts by university and industrial interviewees, "novelty" was merely defined as the "change" of forms and a "presentational feature" of innovation by GOV-P2. As GOV-P2 indicated, "novelty" could not lead to innovation unless the purpose of value creation was fulfilled, an understanding echoed by UNI-MatS-P1, UNI-PHA-P1 and UNI-GEO-P2. The key distinction between “novelty” or “change” and “innovation” consisted in the substantive improvement in product function or “work efficiency and quality”. Typical examples of superficial “novelty” were “repetitive work” and “copycats” that eschewed intellectual property protection, especially after the expiration of original patents. Focusing on feasibility, UNI-MGT-P2 and IND-P10 differentiated “change” from “innovation”, underlining the former’s lack of “operational systems”. IND-P10 also noted that “change” was “directional” and more commonly used in policy contexts. Typically illuminated in the words of UNI-GEO-P2, UNI-PHA-P1, and IND-P10:

> “Innovation requires a positive or better change. If a novel institution does not significantly improve the efficiency and quality of work, it can only be called a ‘change’.” (UNI-GEO-P2)

> “Many Chinese pharmaceutical firms are imitating Western new drugs by changing the shape of the ‘cup cap’ while leaving the ‘cup body’, namely the main drug functions unchanged...Whether in publishing papers or developing products, imitation that circumvents intellectual property rights cannot be considered as innovation.” (UNI-PHA-P1)

> “Policy relates more to ‘change’ than ‘innovation’. Only ‘change’ with operational systems is counted as innovation. What’s purely directional stays as ‘change’.” (IND-P10)

Besides “change”, interviewees from the university and industry also discussed “novelty” in relation to synonyms “creativity”, “invention”, and “originality”. As both IND-P3 and UNI-ECE-P2 indicated, “creativity” referred to the capacity to generate novel ideas and imagine new possibilities, which, however, were not necessarily feasible. Some saw “novelty” interchangeably as the “invention” or “creation” of what previously did not exist. For instance, UNI-MatS-P7 explicated that the Chinese equivalent of “innovation” comprisesdtwo characters: “creating (创， *chuang*)” and “newness (新, *xin*)”. “Newness” denoted recent coming into existence whereas “creating” means “doing innovative work”. “Innovation” was deemed a broader term since “invention” involved creating something from nothing while “innovation” included improving something extant or rediscovering the value of unexploited inventions (UNI-CS-P2, UNI-ECE-P1, UNI-GEO-P1, IND-P8, IND-P9, IND-P10).

“Originality” (原创/开创性) was characterised as “creating something from nothing” in “uncharted territory” (IND-P6), with the aim of developing and proposing something unique and ideally pioneering. However, the understanding of “uncharted territory” appeared specific to disciplinary fields. For UNI-CHE-P1, “originality” entailed exploring “fundamental and originating questions” in science, while UNI-EP-P1 perceived “original research” as meeting China’s distinct demands and being unique and pioneering by international standards. UNI-ECE-P3 defined "novelty" as the "differences from the original basis", noting that it was easy to discern the advantages of something different, especially in terms of publication value. UNI-CS-P6, IND-P8, IND-P10 and UNI-PHA-P1's remarks exemplified the similarities and differences of these synonyms:

> "A direct understanding of 'novelty' is something that did not exist before and needs to be created." (UNI-CS-P6)

> "I was not involved in inventing or creating something new. Rather, I take something that already exists and improve it or integrate it into a system." (IND-P8)

> "Innovation is not invention, but what's still left in our society even after three or four decades and is eventually put in use and revealing its value in contemporary time...Invention is starting from scratch..many [inventions] are set aside for years..." (IND-P10)

> "Only in the last two days was there a report that a Chinese pharmaceutical firm had attained approval for the first original novel drug in China that was recognised globally. Genuine and original new drugs are not just about making a small profit in the Chinese market, but about global sales that demonstrates China's ability in the research and development of new drugs" (UNI-PHA-P1)

While most interviewees from the university, industry and government recognised the significance of "novelty" in innovation, they also considered it insufficient and attribute varying levels of importance to this particular feature. As demonstrated earlier, "novelty" was regarded as a "presentational feature" by GOV-P2. Many interviewees indicated that "not everything novel is worthy of exploring". Uncritical pursuit of novelty for its own sake risked addressing mere "innovation quotas" or "faking achievements" without actual value (e.g., IND-P1, UNI-MatS-P1, UNI-MatS-P4, UNI-GEO-P1). Substantive innovation entailed fulfillment of purposes such as "value creation" and "problem-solving", which will be further discussed in subsequent sections. As GOV-P2, UNI-MatS-P4 and IND-P3's remarks exemplified:

> "You're not innovating just for the sake of being novel, right? The novelty of innovation is merely a presentational feature...By transforming from one form to another, I aim to create novel value." (GOV-P2)

> "Innovation is more about creating new things. They should be novel. However, as I understand, novelty does not mean everything new is worthy of creation...Novelty should come with meaningfulness and usefulness as well." (UNI-MatS-P1)

> "Innovation does not equal anything that no one has ever done before. The largest possibility is that it is meaningless to do so." (UNI-MatS-P4)

> "The core feature is novelty, but after all, we are running a business, so there must be a value judgement as well." (IND-P3)

Although "novelty" was generally considered insufficient, nearly one quarter of the university interviewees perceived novelty as a defining feature, describing it as the "requisite" and "epitome" of innovation. Most of them came from basic science backgrounds[16] such as Physics and Chemistry, including those from schools of Engineering Science. For these interviewees, "novelty" remained a principal focus in academic work, despite the unpredictability in the input required and achievable outcomes. For instance, UNI-MatS-P5, UNI-MatS-P6, UNI-ECE-P5, UNI-CHE-P1 and UNI-CS-P1 all insisted that novelty remained requisite to innovation given the exploratory nature of science and its unpredictable usefulness or benefit. Such exploration was intrinsically important and required no value judgement. The prospect of much scientific research takes years to see. As UNI-CS-P1 contended, some innovations may "appear too complex to comprehend" at the time because of the constraints of social conditions and public understanding. The application scenarios of many emerged later when there was sufficient technological support such as computing ability, social demands and public acceptance. Hence, what stood the test of time also attested to its value, as noted by UNI-MatS-P5, UNI-MatS-P6, and UNI-ECE-P5.

4.2.3. Value creation: the purpose of innovation

Most interviewees from the university, industry and government considered "value creation" as the core feature and overarching purpose of innovation. They contended that "value creation" revolved around changing demands and was dynamic since the perception of value changed over time. Time not only attested to value, but also enabled its exploitation and rediscovery.

> "Innovation is about taking past events or objects and utilising them in the current era, making them valuable again. Contemporary value needs to be rediscovered. Otherwise, even if there were numerous inventions, they will become dusted and forgotten." (IND-P10)

> "In project application proposals, everyone usually claims that innovative research is conducted on certain things, which is a neutral statement. The usefulness can only be judged by time. Graphene researched at the University

[16] The distinctions between "applied science and engineering" and "basic science" pertains to the faculties' principal research fields instead of their school affiliation. In schools such as Computer Science, Pharmacy, Material Science and Engineering, faculties work in both applied and basic sciences.

> of Manchester won the Nobel Prize in just two years, which is significant endorsement, but I think it's still too early to tell. Time is needed to determine whether it's good or not." (UNI-MatS-P6)

Government interviewees perceived "value creation" as a general goal to adapt to the evolving demands of people, businesses and society as a whole. This broad understanding did not involve specific classifications of value or goals, but rather focused on "achieving higher value", which demonstratesda commitment to continuously enhancing living standards. As GOV-P2's exemplified:

> "Innovation definitely has a purpose...the ultimate purpose is to achieve higher value...Why do you want to innovate? It's because the shape of the entire society, people's characters and behaviours, like the post-2000s and post-90s generations, are all changing. Your way of thinking might be different from ours...so innovation revolves around people's changes, and the whole society advances based on people's needs." (GOV-P2)

For university and industry interviewees, "value creation" meant enabling "substantive" and "meaningful" improvements that could be put in use to better meet the demands of production, consumption and social development, potentially leading to economic and social benefits. "Value creation" was discussed as an umbrella term that encompasses "problem-solving", demand fulfillment, benefit generation and "meaningfulness".

Notably, the perception of value was enhanced by the degree of challenge and scarcity since accomplishing something "challenging" and within the reach of fewer individuals typically required exceptional expertise and perceived efforts. "Meaningful" creations required overcoming certain challenges. Some interviewees emphasised that creations lacking a sufficient level of "threshold", "barrier" and "complexity" were still considered "meaningless", even if they fulfilled certain demands. Addressing challenges was rewarding. It could for instance, help academics gain publication advantages and assist enterprises in forging technological "barriers" and competitive advantages. As IND-P1, IND-P9, UNI-CS-P6 and UNI-ECE-P4 illustrated:

> "Innovation primarily epitomises in value, requiring substantive progress on existing foundations, being both novel and meaningful...Everything that remains to be done but cannot be kicked off at present reveals a demand for innovation...This involves addressing both existing and foreseeable issues." (IND-P1)

> "Why am I starting this company? Because the fewer people do something and the more difficult something is, the more valuable it is...I see great value in transformation of S&T achievements, but only a very small number of

people are doing this. With both rigorous scientific training and industrial mindsets, I thought that this was my calling. Now I realise the water is deep here, I have indeed dived headfirst into it." (IND-P9)

"Literally speaking, innovation is something challenging and no one has done before. Creating a cage without corners is new, but completely meaningless. This is what everyone could have thought of, but since it has no use, nobody made it. Hence, innovation is not simply creating something non yet in existence but about creating something with value. The understanding should not be too literal and should involve meaningfulness." (UNI-CS-P6)

"Smart home includes many combination locks that are actually very convenient, but from our perspective, this is technological has little meaning because it is too simple...little technological complexity is involved, but the locks have changed people's life..." (UNI-ECE-P4)

4.2.3.1. Types of innovation value

Various types of value were discussed by university and industry interviewees, reflecting the diverse perspectives and priorities across different fields and roles. "Technological value", "engineering value" and "application value" were mostly mentioned by those from engineering or applied science backgrounds, some of whom also associated them with "commercial", "market" and "economic value". These values focused on the practical, often economic impacts and potential benefits of innovation.

"Technological value", "engineering value", and "application value" revolved around the "usefulness" and "utility" of innovation, though with varying emphases. "Engineering value" specifically emphasised adherence to technical standards and specialisations (UNI-ECE-P3, UNI-MatS-P1, UNI-CE-P1) whereas "technological value" underscored the "foresight" of technologies and their potential for "industry and enterprise empowerment" (IND-P3). In addition to "usefulness" and "utility", "application value" stressed the wide-ranging applicability of innovative technologies in industry (UNI-PHY-P2, UNI-CS-P6). Beyond potential applicability, "actual value" demanded greater "feasibility", emphasising the real-world outcomes and tangible benefits of innovation after implementation (IND-P8, UNI-ECE-P7).

"Commercial", "market" and "economic value" centred on cost-and-benefit balance, market demands, the monetisable quality of innovation and "short-term value" (IND-P1, UNI-MatS-P5). Nevertheless, those in public welfare-related fields such as the power industry and environmental science highlighted that "scientific", "long-term" and "strategic value" primarily originated from basic research. They were not necessarily commercialisable but contributed to the long-term production of "social", "humanistic", "ecological" and "environmental value". In particular, IND-P1 cautioned that excessive focus on "commercial value", particularly the short-term returns on investment, could lead to myopia and uneven development since scientific innovation was inherently exploratory and had indeterminate "market value" (UNI-ECE-P5, UNI-MatS-P5):

> "Commercial value can be a dimension to direct innovation, helping to create more meaningful values, but should not be the end of innovation. Excessive focus is distorted, resulting in uneven development. This specifically refers to short-term commercial value. It's better to understand it as the value of applied innovation." (IND-P1)

> "New materials are not necessarily accepted by the market, which involves many issues. The first is cost, and the second is practical effect - whether the effect is good enough for the market to accept and whether they are willing to spend more money than the current products to manufacture them, thereby creating profits. Therefore, we need to be aware of all scientific innovations, but not all of them necessarily generate actual market benefits." (UNI-MatS-P5)

"Social value" varied in its creation, ranging from improvements in areas of crucial public interests or collective welfare (UNI-ES-P2, UNI-SE-P2), gaining social "recognition" (UNI-MatS-P4), to a multifaceted concept that reflected both social purposes and recognised or encompassed multiple types of value with consideration of overall social benefits (IND-P1). While IND-P1 explicitly emphasised a broader spectrum of values, most industrial interviewees tended to focus on "technological value" and "actual value", expecting innovation to satisfy consumers, markets and industrial development while enhancing their companies' competitive advantages. As IND-P8 and IND-P9 illuminated:

> "It's significant to look at actual value and application...we definitely focus primarily on demands and then evaluate the cost-effectiveness and performance of the corresponding photovoltaic power station. After doing this, at least there is actual value for us, helping us for example, to set some standards and establish technological advantages." (IND-P8)

> "The industry we want is one that continuously creates value to provide the best products to consumers. Ideas that are not grounded in reality and only sound good as empty talks have little value." (IND-P9)

While industry interviewees affirmed the importance of serving stakeholder demands and organisational interests in value creation, university interviewees demonstrate da more nuanced understanding. They noted that valuing was complicated and difficult due to its alignment with different standards and stakeholders. Many indicated that academia concentrated on scientific, theoretical and publication value, which were exploratory, cumulative and discernible from existing knowledge bases.

The industrial interviewees on the other hand, were concerned more about “practical”, “application”, “engineering” and “market value”, which imposed many “practical constraints” on innovation such as the examination of “problem-solving”, “usefulness” and “feasibility”. To successfully apply to industry, the “scientific value” of academic innovation needed to be translated into “market value” (UNI-MatS-P5, UNI-MatS-P1, UNI-ECE-P7). Creating value for productivity was an intricate process that required monetisation of “scientific”, “technological”, “commercial”, “market” and “actual value” (UNI-CS-P2). As UNI-ECE-P3, UNI-CS-P6 and UNI-MatS-P5 state:

> “Evaluation criteria in academia are that as long as the idea is novel and different from the original basis, such difference easily leads to an advantage in publication value. However, industry is very demanding, requiring not only theoretical value, but also engineering value, which places a great deal of practical constraints, like a signal processing approach we are working on, whether it is useful in reality or is good to use.” (UNI-ECE-P3)

> “In my field, the application value and feasibility of innovation can be evaluated by seeking assistance from enterprises, asking them whether something is good and has application value or not...but determining application value is inherently complex. Innovation can be what we propose purely based on our own knowledge background or can be derived from enterprises’ commissioned demands. It’s difficult to say which ones are more suitable and which ones are not.” (UNI-CS-P6)

> “The innovation of basic research primarily has scientific value, and then the second focus is on output, that is, whether this scientific merit can be transformed into market value. Some innovations cannot be transformed, such as in the case of mathematicians...However, our School of Materials Science is closely related to the market. Whether this material is useful, whether it has a market, and where it has value in which applications must all be considered.” (UNI-MatS-P5)

The excerpts above also indicated variations in the interests, orientations and capacities for value creation among the academics and across respective disciplines. Typically, those in applied science and engineering tended to balance scientific, publication and application value, but some remained more interested and specialised in basic research and theoretical innovation (e.g., UNI-ECE-P3, UNI-SE-P2). Interestingly, some in basic science with industrial experiences also managed to leverage resources to convert academic innovation for practical use (UNI-PHY-P2, UNI-CHE-P2, UNI-LS-P3).

While considering various standards and stakeholders’ priorities on value creation, university interviewees tended to maintain a realistic or optimistic view regarding the opportunities and constraints inherent of the process. They persevered even if the value they produced was yet to be recognised by stakeholders, which was often the case with scientific and publication value. This line of thinking was typically expressed in the words of UNI-ECE-P5:

> "We conduct our research in the hope that our technologies can be applied widely and effectively, not only considering economic value, but also scientific innovation...The value of something can be determined, but some others are just temporarily unknown...we don't just consider the needs of companies. Our funding mostly come from national government's research budget, and we explore scientific problems that we are interested in." (UNI-ECE-P5)

4.2.3.2. Problem-solving

Among university and industrial interviewees, "value creation" was also discussed in relation to "problem-solving". Problems were classified by various fields (i.e., scientific, technological, engineering, environmental, production, societal), time horizon (i.e., long-term or short-term) and scope of priority (i.e., partial vs holistic/commonly unsettled, enterprise/industrial vs national vs international). The diversity of goals involved reflected the interviewees' positioning of themselves or their areas of expertise, guiding them towards various innovation activities and practices.

Interviewees delving into "scientific", "theoretical" and "mathematical problems" typically committed to pursuing original, upstream and long-term breakthroughs. They used experimental simulations to explore and develop novel scientific expressions and theories, identifying solutions that were eligible for industrial application and had the potential to stimulate new demands and production (e.g., IND-P6, UNI-CHE-P1, UNI-ECE-P5). Due to the depth of scientific exploration required, these breakthroughs often targeted "partial" problems one at a time whereas complex holistic problems required interdisciplinary integrated solutions (IND-P9, UNI-MatS-P3, UNI-GEO-P5). Notably, while scientific problems remained a common interest among academics, this trend was observed in industry interviewees predominantly with a science PhD (IND-P6, IND-P9). As UNI-ECE-P3 and IND-P9 articulately put it:

> "We use mathematics as a means, tool, or language to think and make breakthroughs. After achieving certain innovations in mathematical theory, we translate them into technology...primarily achieved through lab simulations... Simulations are necessary to analyse the performance of encoding and decoding schemes. This is the first step from theory to technology and what most university professors are engaged in." (UNI-ECE-P3)

> "Some people have to consider the problem of transforming S&T achievement. The biomaterials I was studying happened to be an intricate hotspot for this. That's why I started my own business...I collaborate with professors, seeing how production problems can be solved through cooperation with certain capitals or industries...Only a person whose theoretical knowledge has reach a certain depth can articulate the reasons behind things. However, such a person usually can only solve partial problems, not holistic problems." (IND-P9)

Those who focused on "engineering", "production" and "enterprise's problems" prioritised practical needs, deliberating over various factors such as demand, technology, cost, and sustainability with a short-term orientation. These interviewees typically viewed "engineering" problems as opportunities to instigate immediate changes in efficiency improvement, energy consumption and production costs reduction (e.g., UNI-ECE-P4, UNI-GEO-P1, IND-P8). While both groups valued practicality, university interviewees tended to expect higher technological sophistication and challenge than industry counterparts, who prioritised process simplification, production outcomes and enterprise survival. To address "production problems", many university interviewees construed industry-university communication as major avenues for comprehending industrial demands. Nevertheless, IND-P1, IND-P9 and UNI-EP-P1, who were involved in the power industry where most originating innovation arose from enterprises, underscored the necessity to collect front-line demands and feedback.

Notwithstanding differences in focus, these problems were not discussed in isolation. Many university and industry interviewees recognised the complementarity of "engineering" and "scientific problems". University interviewees drew particular attention to the divisional roles of science and engineering in innovation. Scientific problems targeted uncovering fundamental principles, some of which helped to resolve engineering bottlenecks, while the process of solving engineering problems could generate new scientific inquiries. As UNI-ECE-P1 illustrated:

> "Improving materials requires basic scientific research. It sounds like an engineering problem, but it's actually solving a scientific problem...say to reduce loss, it's necessary to understand the mechanism inside the materials and factors that cause losses to improve them in subsequent production." (UNI-ECE-P1)

For industry interviewees, this complementarity was broadly the integration of science and engineering in addressing system problems in comprehensive application scenarios such as medical science and marine science (IND-P9); or the interplay where the resolution of engineering problems was pivotal to enterprise survival whereas the addressing of scientific problems was conducive to long-term organisational competitiveness and viability (IND-P3).

While solving “engineering”, “production” and “enterprise’s problems” tended to be regarded as “small practical innovation”, addressing “key national problems” was construed as achieving breakthroughs beyond the combination of existing knowledge bases and attaining independent intellectual properties in strategic areas, which were critical responses to domestic and external pressures such as key material shortage and constraints imposed by international trade disputes. These concerns were particularly pronounced among interviewees working in strategic sectors such as the power and chip industries. Addressing national problems necessitated a “deep grasp of foundational disciplinary knowledge and scientific breakthroughs”, interdisciplinary integration, and robust support from national policies, scientific research initiatives and sustained medium-to-long-term strategic planning (IND-P8, IND-P9, UNI-MatS-P3, UNI-MatS-P7). As IND-P8 and UNI-MatS-P7 highlighted:

> “Without appropriate macro-regulation and early-stage layout at national level, now we are encountering many factors that cause instability in industry, such as shortages of glass, silicons, and chips...To solve these key national problems, higher-level support is required, such as national-level policies for scientific research and technology.” (IND-P8)

> “The current Sino-US trade war...the presence of bottleneck problems, necessitates us to consider alternative approaches, including the development of our own intellectual properties. Securing core materials has become a crucial strategic leverage. The trade war and bottleneck problems also present opportunities, unleashing significant demand for indigenous R&D of materials such as chips.” (UNI-MatS-P7)

Some interviewees also demonstrated concern for “commonly unsettled problems” at regional, international and global levels and their implications for addressing national problems. Industry and university interviewees tended to vary in focus, with the former leaning towards global production and the latter towards global science. For instance, IND-P8 highlighted the international division in addressing common problems based on comparative R&D and production advantages. For commonly used products such as photovoltaic modules, China was mature, stable and superior in production and manufacturing compared to developed countries. However, in certain high-end sectors of the production chain, particularly those involving core patents and technologies, China largely remained import dependent.

Sharing a concern for national self-sufficiency and independence, UNI-GEO-P6 underpinned the significance of regional variances and specificities when applying global solutions locally and the strategic role of universities in addressing (sub-) national bottlenecks:

> “Innovation requires solving commonly unsettled problems. For instance, the

> accuracy of remote sensing models developed for a certain region may not be sufficient when applied to other regions. This necessitates physical models that articulate the reasons for regional variances...Universities can solve some bottleneck problems facing the country through cutting-edge research.The high-precision sensors in our field requires substantial investment, and many of them are currently only available for purchase from foreign supplies." (UNI-GEO-P3)

Beyond the national scope, UNI-NE-P1 emphasised the "international" nature of science as the "ultimate pursuit of humanity". Hence, resolving common problems in the high-energy physics necessitates international collaboration, open knowledge sharing and navigation of the benefits and challenges arising from international collaboration and competition:

> "The sharing of scientific knowledge and data is of utmost importance. The entire humanity depends on this single set of data that must must withstand rigorous scrutiny before acceptance...Unlike the insular nature of biomedical research, the more countries participating in research development, the better...International cooperation and competition coexist. To ensure reliability, normally two groups work on the same problem... Primacy is given to first-movers...but in a transparent academic environment, this competition fosters collective progresses." (UNI-NE-P1)

As these excerpts illustrate, international collaboration and competition mutually fostered validation and propelled collective advancement. Addressing "commonly unsettled problems" therefore required a balance of "glonacal" priorities and strategic utilisation of global solutions and collaboration across different levels. The propensity towards international collaboration was also discipline-specific.

The role of "problem-solving" was conceptualised differently by university and industrial interviewees. While industrial interviewees rarely emphasised "problem-solving" as the purpose of innovation, most university interviewees regarded it as a specific and more implementable starting point or initial goal that directs them to deliberate on the potential value of innovative work. "Problem-solving" was also deemed a requisite to addressing demands or catering to users. In particular, UNI-ES-P1 and UNI-ES-P2 noted that environment science was problem-oriented per se, and they innovated "only when there is pollution". Some even prioritise d"problem-solving" and "feasibility" over "novelty". The comments of UNI-CE-P1, UNI-MatS-P2, UNI-GEO-P1 and UNI-GEO-P3 typically expressed such concerns:

> "My understanding is that the best 'novelty' is problem-solving. Even if it is entirely novel, it only stays at the level of papers if no one uses it." (UNI-CE-P1)

> "The first important thing about innovation is problem-solving. The second is user's acceptance...If doctors consider the materials useful and are willing to use them, then it's a success." (UNI-MatS-P2)

> "I can invent something complex enough to write papers, but they can't be used in effect and are not helpful for solving problems." (UNI-GEO-P1)

> "Do not innovate for the sake of innovation...Many 'innovations' in project application are far-fetched, possibly have no value. Personally, I think innovation should address commonly unsettled problems." (UNI-GEO-P3)

4.2.3.3. Usefulness

As stated earlier, "usefulness" was considered a significant "practical constraint" for innovation. Nearly one third of university interviewees considered it significant that their innovations could be "put in use" and gain "users' acceptance". What constituted "usefulness" was conceptualised in relation to notions such as "practicality", "feasibility", "performance" and "effectiveness". "Feasibility" emphasised the possibility of landing (UNI-NE-P1, UNI-ECE-P2, UNI-MGT-P2) or developing into products (UNI-MatS-P1). "Practicality" specified "usefulness" as the quality of being able to withstand real-world scrutiny and gain people's acceptance for effective application (UNI-MatS-P4). Beyond utilisation, both "performance" and "effectiveness" indicated the extent to which innovations achieved intended outcomes. "Performance" was discussed by academics from engineering backgrounds in relation to "efficiency", "convenience" and "experience". The connotations of these notions in part varied by domain and individual understanding.

For instance, UNI-GEO-P1, who specialised in geographical engineering, construed "performance" as savers of time, cost and energy that bring convenience and improve lives. Focusing on a wider range of aspects, UNI-GEO-P2 defined "usefulness" as "better performance" in technology, "greater efficiency" in institution and "stronger explanatory power" in theoretical innovation. For UNI-ECE-P3, who worked on coding computation, "performance" meant improving "efficiency", the "transmittal reliability" of communication systems. UNI-ECE-P5 and UNI-ECE-P6 associated "efficiency" with "power duration" and "resolution' when referring to electronic monitors. From a notably practical stance, UNI-ECE-P4 contended that "performance" always needed trade-offs. Instead of pursuing ideal systems that were highly costly, "better performance" in reality meant "90% performance is better than existing performance" and producing systems for "common and widely used cases". Beyond applied examples, UNI-ECE-P2 theorised "better performance" as "1+1>2" that maximising the combinational strengths of existing technologies and approaches.

"Effectiveness" tended to be applied to medical context. For UNI-MatS-P1, "effectiveness" meant the stable combinations of biomedical materials, but for UNI-PHA-P1 and UNI-PHA-P2, "effectiveness" meant "drug safety", intake convenience, transmittal efficiency to infected areas, and users' acceptance and compliance with medical advice. Despite the variety of specific conceptualisations, at the core of "usefulness" lay a "user", who played a central role in deciding whether an innovation was useful or applicable, and how useful it was compared to existing products. User or market acceptance, as most university interviewees indicated, remained a crucial indicator when examining the performance and practicality of innovative products. Besides being referred to interchangeably as "the market", the scope of user partly overlapped with that of "peer", where researchers, producers and other specialists of common products were included.

With "application" being a routine aspect of work, most industrial interviewees did not explicitly incorporate "problem-solving" or "usefulness" into their conceptualisation of innovation. "Usefulness" was merely mentioned by IND-P9 as a criterion for evaluating academic work. "Problem-solving" was seen more as a result or a byproduct of innovation rather than purpose. As IND-P3 indicated, "problem-solving" was primarily associated with resolving short-term and "survival" obstacles that could impede desirable outcomes. IND-P8 contended that novel concepts and technologies arising during the process of innovation were in high demand, even in the absence of specific problem-solving. This interviewee expected the "value" of innovation to go beyond fixing specific problems to address broader and long-term demands, including those that were yet to manifest. To achieve this, it was necessary to gain a deeper understanding of the underlying priorities and goals on the basis of development strategies. In the interviewees' words:

> "A company must use engineering technologies to solve some survival problems...say if a project is a problem that a company needs to address immediately in the short term, then adopt a quick and efficient approach to solve it...However, the foresight of technological develop should be considered...a balance of both enables us to persist in our trajectory." (IND-P3)

> "It's important to work on novel products, processes and pathways. Even if I still cannot solve some problems very well, I have basically grasped the concept, and this kind of technology is actually very much needed behind the scenes." (IND-P8)

4.2.4. Demand-source of innovation

As previously noted, most industrial interviewees and some university interviewees who worked in applied science and engineering perceived "value creation" as fulfilling demands, which were utilitarian, societal, political, moral and aesthetic. University, industry and government interviewees commonly contended that the interaction between these sectors fostered a better understanding of each other's innovation demands, resources and capabilities. Innovation arose from a wide range of production factors such as technology, science, culture and institution. Nonetheless, there were differences among sectors in attributing the primary sources of innovation.

Government held an encompassing view that innovation sprung from addressing the public's changing demands through various production factors and mass innovation across all sectors. Despite working in all of science, technology and industry, GOV-P1 reveals stronger emphasis on the principal role of enterprise innovation:

> "Businesses are the principal actors in market economy. For significant strides in innovation, all entities, including universities, property owners and other design agencies, must ultimately collaborate with enterprises—the principal actors in the market economy—creating effective platforms and channels that serve their development and innovation demands." (GOV-P1)

> "Innovation in China is progressing at a dramatic pace where I can see various elements and forces of innovation. Whether it's in society or government, innovation permeates every facet...innovation and the progress of the entire society and era revolves around people's evolving demands." (GOV-P2)

Industry and university interviewees commonly contended that innovation arose from theoretical accumulation and transdisciplinarity, though university interviewees place notably greater weight on these sources. For them, "demand" was primarily intellectual, concerning the satiation of curiosity or academic interests, the requirements of scientific research, and the application prospect of academic innovations. Beyond product development for the industry or market-determined knowledge production, application epitomised the possibility of knowledge diffusion (Limoges et al., p.4). Expectations of what and how demands were addressed varied according to university faculties' disciplinary fields and their understanding of stakeholders' demands. UNI-CHE-P1, for instance, noted that innovation in arts embodied significant aesthetic value for audiences. Innovation in social sciences addressed utilitarian and political demands by improving institutional efficiency and policy feasibility (UNI-MGT-P2, UNI-GEO-P5). In biomedical science and pharmacy, innovation directly benefited end-users such as doctors and patients by improving access to medical care, its efficacy and public well-being (UNI-MatS-P1, UNI-MatS-P2, UNI-PHA-P2).

Those in basic science, which was somewhat distanced from immediate application, identified the primary sources of innovation as tripartite: knowledge sedimentation through extensive literature review, theoretical accumulation from ongoing research, and validation of novel findings through experimentation. Some even argued that "there is no standard value for innovation in pure sciences as knowledge pursuit has no explicit demands" (UNI-CHE-P1). Besides these tripartite sources interviewees in applied science attributed more importance to problem identification through hands-on technological and engineering work or by engaging with industry and government stakeholders to understand practical demands. These differentiated sources of innovation were illuminated in remarks from UNI-CHE-P1, UNI-CE-P1 and UNI-MGT-P2:

> "In basic science disciplines (e.g., mathematics, physics, and chemistry), innovation is predicated on thoroughly understanding predecessors' accomplishments, reviewing past papers and data, and continuing research based on this foundation...though engineering and medical fields share elements of originality with basic sciences, their innovation primarily targets application—transforming established theories into practical outcomes or uncovering novel problem-solving approaches." (UNI-CHE-P1)

> "I draw research questions directly from my engineering work rather than academic papers. To me, the most potent innovation addresses real-world problems...and should be evaluated within engineering industries." (UNI-CE-P1)

> "Similar to engineering disciplines, we emphasise social and practical value. When drafting relevant documents...the government and institutions initially propose their innovation requests...They provide a foundation for my innovation, establishing from the outset that my task at hand is novel." (UNI-MGT-P2)

From the industry perspective, front-line production, market and policy demands constituted the most direct sources of innovation. Aligning innovation projects and entrepreneurship initiatives with these demands was considered critical for enterprise sustainability, securing policy support, seizing market opportunities and contributing to industrial development. In contrast, even for faculties in applied scientific fields, the primary focus remained on meeting the exploratory and accumulative demands of scientific research;. Addressing industrial or enterprises' demands remained secondary benefits. The diverging demand priorities between universities and industries were exemplified in the remarks of UNI-ECE-P5, IND-P2 and IND-P3:

> "Engineering is often application-driven, doing whatever the demand requires. New discoveries may emerge in the development process, which do not have an immediate use, but may be useful in the future. This is because scientific research does not always have clear anticipated outcomes. We not only consider enterprise demand." (UNI-ECE-P5)

> "We normally reference to government's innovation directories to find out what's in urgent demand. Picking tracks in this way makes it easier to gain policy support." (IND-P2)

> "Many industries will be empowered by IoT. Such technological value and market strengthen our resolve to persist in this trajectory." (IND-P3)

Notably, compared to private enterprise counterparts, industry interviewees from large SOEs demonstrated a more pronounced orientation towards central policy guidance for high-value and high-demand innovation. As IND-P1 illuminates:

> "The specific issues, backgrounds, plans and contexts outlined by policies all become the subjects of our innovation and R&D efforts. Policies simply articulate these matters and assign importance to key areas of innovation, usually ones of high value and demand, such as rockets and chips, or institutional obstacles and reform challenges in sectors like healthcare, education and SOEs." (IND-P1)

Expanding on this, IND-P1 summarised three key demand-purposes that should guide meaningful innovation: a) front-line production; b) central policies; c) social development and public welfare.

> "I will go to the front-line to talk to people, interview them and provide them with good service so that they will always come to me when they have problems in the future. That's usually the way I gain the most important feedback. You can't just sit in the office and imagine something that only you think is innovative and important, but actually no one needs it! Additionally, researchers may also engage in innovation activities that they consider meaningful, forward-looking and beneficial for social development and the welfare of people." (IND-P1)

Though both university and industry interviewees concurred on the goal-orientation towards addressing national and user demands, industry, exemplified by IND-P1, underscored interdepartmental collaboration, mobility and a persistent feedback loop between production frontline and policy-prioritised innovation domains. Innovation was produced in multiple sites and the social and physical interactions therein. This stood in contrast to most academic innovation, which primarily relied on literature and was confined to a fixed, singular locality, typically "the office". The rarity and associated challenge for university faculties of leaving the comfort of the office and familiar scholarly practices as paper writing, to traverse between universities and production sites, was corroborated by UNI-MatS-P4, who spends half of the time in the field:

> "Writing papers do appear a lot easier than pursuing innovation in technologies, products and industries. Sit in the office and write...innovation requires very solid theoretical foundation and substantial practical experiences, the combination of which is a rarity...At least three days a week, I need to wear a safety helmet and work uniforms to guide on-site."

(UNI-MatS-P4)

4.2.5. Benefit and contribution

Some interviewees from the university and a few from industry and government discussed innovation's value in relation to "benefit" and "contribution". While "problem-solving" and "usefulness" primarily focused on inherent utility, "contribution" and "benefit" referred to outcomes more explicitly aimed at beneficiaries. A common understanding across academia, industry and government was that "contribution" and "benefit" explicated the quality of being "put in use" and making improvements in academia, industry or contributing to wider societal and economic development. In academia, "contribution" often referred to the enhancement of human knowledge, potentially generating tangible positive impacts or spillovers in enterprises' innovation performance, government policymaking and community livelihoods, as UNI-ECE-P1, UNI-PHY-P2 and UNI-GEO-P4 exemplified:

> "Like we made an apparatus and let people know it can have such remarkable performance, this is itself a contribution to community, or even to human knowledge in a larger sense." (UNI-ECE-P1)

> "What universities currently seeks to evaluate is product or domain with actual social contribution...seeing where innovation achievements can be put in use...the purpose of innovation is improving people's lives and creating novel products, applications and domains." (UNI-PHY-P2)
> "

> "Innovation is improving status quo...learning about the problems enterprises encounter during innovation and providing government with feedback and feasible suggestions. Any improvement is a contribution to the innovation of enterprises." (UNI-GEO-P4)

Both university and industry interviewees associated "benefit" with economic returns but attributed different significance. UNI-MatS-P7 and UNI-CS-P5, who had worked with innovation beneficiaries, saw "benefit" more broadly as synonymous with "problem-solving" and technological progress, and economic benefits as spillovers. In contrast, IND-P2, an innovation investment manager, considered economic benefit as a precondition, or the predominant goal of realising innovation's value. This stance was supported by many university interviewees who agreed that, for enterprises, the value of innovation value equates "economic benefits".

Discussion around "benefit" also revealed mixed perceptions on the neutrality of innovation. UNI-ECE-P4 contended that "benefit" served as an inclusion criterion that innovation was a "commendatory term with positive meanings". Inventions devoid of benefits such as "a new way of taking drugs" were disqualified. Conversely, UNI-MatS-P6 and IND-P7 argued that innovation was neutral and tantamount to any novelty, even some new but "bad ideas". IND-P7 ascribed this indeterminacy of "benefit" to the "distinctive characteristics of Chinese culture", where "good" and "bad" are not static opposites, but conditional, interdependent and mutually convertible. This blend was often inevitable when innovating from scratch. As they explained:

> "Innovation is akin to an uncharted path that comes into existence once embarked upon. However, it remains uncertain whether it veers towards a good or bad direction." (UNI-MatS-P6)

> "Many innovations are bad ideas per se, exploiting policy loopholes for greater benefits. However, when these 'bad ideas' gradually appears to point in the right direction, they can be steered towards yielding positive outcomes." (IND-P7)

For government and industry, "technological contribution" took central stage. Besides novelty, the applicability and profitability of innovation in specific fields was deemed crucial for successful transformation and market acceptance (GOV-P2, IND-P2). From a macro perspective, GOV-P2 emphasised the social contribution of innovation, especially those emanating from university-based research, in enhancing economic vitality, leading technological revolution and advancing national development. This quasi-economic governmental conception of value, aiming to fuse universities' "original innovation" with industry's "economic benefits", was corroborated by some university interviewees, as illuminated by UNI-CHE-P2:

> "The government not only emphasises universities' original innovation, but also hopes this innovation can meet business demands, especially in terms of product development and service to enterprises. Novelty alone, without tangible benefits or industry relevance, garners limited governmental interest. Therefore, the emphasis is now on industry-led innovation that integrates the prowess of universities." (UNI-CHE-P2)

This extract also substantiates the previously noted governmental orientation towards industry-led innovation (GOV-P1). However, this governmental ideal was also problematised by IND-P8 and IND-P9. They highlighted the lack of comprehensive governmental mechanisms and civil servants well-versed in facilitating university-to-industry innovation transitions, and the challenges in specifying the relative contributions and allocating rewards within innovation research teams, given the dynamic and variable inputs required at different stages of innovation.

4.2.6. Meaningfulness

"Problem-solving", "usefulness", "demand" and "benefit" mostly related to the objective of externally verifiable dimensions of value, subject to validation by "user", "time", "reality" and "society" (e.g., GOV-P2, IND-P10, UNI-MatS-P1, UNI-MatS-P4). By comparison, "meaningfulness" pertained to the subjective dimension, where interviewees, mainly from universities, attached significance to the innovation they participated in, deeming their work "meaningful" and "worthwhile".

Some subjective comments appeared supplementary to the objective dimensions. To enhance the consistency of understanding, for instance, UNI-MatS-P4 perceived innovation that was not being put in use as "pointless". In similar vein, UNI-GEO-P1 stated that "re-inventing the wheel is pointless" after defining innovation as what improves lives. IND-P1, the only industry interviewee who mentioned "meaningfulness", defined it as "substantive improvement" and critiqued 'innovation' fabricated merely to meet performative indicators. However, "meaningfulness" appeared more independent from external evaluation among university interviewees. It reflected the goal orientation where interviewees established their own guiding principles to ascribe value, make choices, coordinate themselves in axiological systems and legitimise the suitable means to achieve the goals, notwithstanding the tensions between the objective/external and subjective evaluations.

University faculties still took pride in their work even if its value awaited recognition. For instance, regarding university faculties as the overarching innovation actors, UNI-MatS-P5 indicated that discovering "scientific and practical meaning" is itself an agentic process. It is in fact "not that meaningful" to work on something "perfectly well-defined" and "with an easy end in sight" (UNI-PHY-P1). Many explorations that advance thought without yielding immediate benefits constituted "meaningful" innovation (UNI-CS-P1, UNI-CS-P3, UNI-ECE-P5). Sometimes it was "worthwhile" to reconcile the level of novelty in order to fulfill practical purposes. Even a modest improvement that was not deemed innovative by the academic community or in science and technology domains still constituted a meaningful innovation if it met user demands or had social contributions.

"Meaningfulness" revealed an affective dimension resulting from the active involvement of desires, sense-making, feelings and choice developed towards innovation, regarding its qualities that fulfill plural demands, being utilitarian, political or aesthetic. Those in basic science or in applied science with target beneficiaries for innovation managed to derive a strong sense of worth, notwithstanding the lack of explicit objective affirmation of "usefulness", "benefit" or "academic contribution", as illustrated by UNI-MatS-P2, UNI-GEO-P3 and UNI-PHA-P2:

> "Our materials may be improved based on existing ones and are not that innovative from the aspect of Material Science, but it is still innovation from the aspect of social contribution." (UNI-MatS-P2)

> "If some remote designs can largely reduce costs and address commonly unsettled problems, they are innovations even if there is not much

> contribution to scientific theories.” (UNI-GEO-P3)

> “The clinical problems I am solving are very meaningful, even if they are neither innovative enough in science and technology, nor appealing enough to gain funding from National Natural Science Foundation.” (UNI-PHA-P2)

With relatively high expectations for functionality, UNI-MatS-P2 also stresses that creation that failed to address the core demands of users and remained ornamental, was “meaningless”:

> “Something like a more good-looking phone case. This novelty is totally meaningless to the functions of a phone but only satisfying individual feelings.” (UNI-MatS-P2)

External evaluation potentially legitimisesd and facilitated internal benchmarks for innovation. Gaining positive feedback from doctors, the users of biomedical materials and drugs, UNI-MatS-P1, UNI-MatS-P2 and UNI-PHA-P2 perceived their products as successful even in the absence of academic peer review. In line with the goal of “problem-solving”, UNI-MatS-P2, UNI-MatS-P4, UNI-PHA-P1 and UNI-GEO-P1 problematised the pursuit of “meaningless” novelty that adds little value to products or for users. Taking this further, UNI-CS-P1 cautioned about the limitations of subjective meaning-making: not all meaningful innovation managed to gain social recognition, which was conditioned by societal development, and it remained challenging to predict future trajectories based on subjective evaluations.

The conceptualisation of value creation contained both objective and subjective dimensions. The objective dimension involved solving problems (scientific, technological, engineering, environmental, production, and societal), addressing demands (scientific research, production, market, people), and generating benefits or contributions. The subjective dimension concerned “meaningfulness”, perceived value that was relatively independent of external scrutiny. Despite the common perception of “value creation” as the purpose of innovation, interviewees from the university, industry and government prioritised different types of values, revealing a complex interplay of factors that determined what problems were deemed worthy of attention and how they were approached. This diversity underscored the multi-faceted nature of innovation’s value, as it manifested through different kinds of problem-solving strategies and objectives; understandings of “usefulness”, “benefit” and “contribution”; and ascription of meaning within and beyond institutional spheres.

For university interviewees, “value creation” primarily targeted academic communities, followed by the application side of stakeholders and users. “Problem-solving” remained a primary goal to kick-start innovation, leading to diverse “benefits” and “contributions”, including the advancement of knowledge and its spillovers. While an application-oriented context increased faculties' sensitivity to the broader implications of their innovations, they maintained intellectual autonomy in attributing meaning to these innovations. Industry interviewees, on the other hand, prioritised value creation for the enterprise itself, followed by meeting production, market and policy demands, which also led to "benefits" for the enterprise (e.g., economic gains, enterprise competitiveness and viability) and "contributions" to society (e.g., enterprise empowerment, industrial transformation, improvement in livelihood). "Problem-solving" was perceived more as a byproduct rather than purpose of innovation, whereas "benefit" served as a yardstick to measure the achievement of that purpose. For government, the purpose of innovation was to achieve greater values from a notably macro-level, by adapting to the evolving demands of people, businesses and society. The focus was on general and systemic adaptations, not on addressing specific problems.

4.2.7. Scale, stage and type of innovation

Innovation was compared by scale, type and stage. A common perception across university, industry and government interviewees was that innovation took on diverse trajectories, from original and disruptive creations developing from scratch to small incremental innovations based on imitation and the improvement of something extant. Despite GOV-P2's emphasis on "ground-breaking" and "disruptive achievements" as the intrinsic core of university's research innovation, discussions regarding the scale of innovation were more substantial among university and industry interviewees, and the focuses on different types of innovation and configurations at each development stage varied across sectors.

4.2.7.1. Scale

By scale of novelty and continuity with the extant, innovation was conceptualised as "grand", unprecedented and "disruptive" innovation at one end, and "small", common and "incremental" innovation at the other. "Disruptive innovation" was characterised as commanding cutting-edge theories in basic research and revolutionary technologies. Despite being "highly-novel" (UNI-ECE-P1, UNI-CS-P5), "fate-changing" (UNI-ECE-P4) and "unprecedented in history and unparalleled in the future" (UNI-GEO-P5), it was considered rare by university, industry and government interviewees. This scarcity was attributed to the challenges involved, including the need for "a clever mind" (UNI-MatS-P7, UNI-ECE-P1, UNI-PHY-P1), the persistence in "warming up the cold benches", engagement in transdisciplinarity, sustained national investment in these intellectual efforts, and potentially even a degree of luck for success (UNI-MatS-P3, UNI-MatS-P4, IND-P1, IND-P9, GOV-P2). These multifaceted challenges were aptly highlighted by UNI-ECE-P4 and GOV-P2:

> "Fate-changing innovation is certainly marvelous, but also extremely difficult, requiring notable long-term accumulation, trial-and-error, plus luck to attain. Personally, I think this is something serendipitous and impossible to quest for, requiring luck, aptitude and diligence. None is dispensable. With so

> many factors at play, the probability is very low. Most people start by changing their immediate surroundings. Any efficiency-improving efforts should be encouraged.” (UNI-ECE-P4)

> “For ground-breaking and disruptive achievements, we must master advanced theories and technologies through basic research, a forte of universities... Continuous national investment is essential...without these, attaining truly revolutionary technologies, which necessitates leading others, becomes impossible—a task far from easy...Basic research definitely requires patience and the ability to endure solitude.” (GOV-P2)

GOV-P2’s remark highlighted a pronounced focus on bolstering China’s global innovation leadership through “disruptive innovation” and the leading role of universities therein. The complexity of pioneering innovation also arose from the sustained, concerted efforts of government and universities. Though not explicitly mentioning “disruptive innovation”, IND-P9 also characterised it as an “insurmountable technical barrier”. This necessitated the integration of theoretical breakthroughs achieved within universities, their interdisciplinary cross-fertilisation, and application across different fields—elements that seemed to constitute “tacit knowledge” of success unknown to many:

> “Innovation has only two sources ... first I need to find university scholars who have accumulated 40 years of theoretical research and then merge their work with other fields, to forge a key, insurmountable technical barrier. Many people observe this phenomenon without understanding the underlying reasons.” (IND-P9)

Small incremental innovation, primarily predicated on doing the same things better, was seen as more commonplace, readily implementable and more likely to succeed despite the general fascination for disruptive innovation. Incremental innovation could take the form of refining existing knowledge or techniques to gain a “novel understanding” or a “novel explanation” of known phenomena (UNI-CS-P1, UNI-CS-P4, UNI-CHE-P1); devising “novel solutions” to recognised problems (UNI-ECE-P1, UNI-SE-P1, UNI-GEO-P5); adopting “novel approaches” to meet existing demands or enhance performance (UNI-ECE-P4, UNI-MatS-P2, UNI-PHA-P2, IND-P5, IND-P8); and applying established methods to new domains and contexts (UNI-ECE-P6, UNI-MatS-P4, UNI-ES-P1, IND-P2, IND-P4, IND-P9, IND-P10, GOV-P2).

Industry interviewees highlighted the scarcity of “disruptive innovation” primarily to contrast with the prevalence of incremental innovation. Their emphasis on applying existing methods to new contexts consisted in importing and imitating foreign innovations into domestic markets (IND-P2) or re-branding existing products in established markets (IND-P4, IND-P10). “Disruptive innovation” and “small innovation" were perceived as a categorical difference rather than hierarchical "levels", contrasting with the viewpoints of many university interviewees. IND-P4 and IND-P5's remarks were typical in revealing these lines of thinking:

> "Often when people talk about innovation, they imagine the disruptive type. However, in reality, small innovations are more likely to succeed. Many landed by enterprises are small innovations. There are many ways to succeed, as long as they achieve purposes or create value. Say a HK company successfully established a new brand in an established market." (IND-P4)

> "Innovation does not necessarily have to be disruptive. Perhaps it could be a very small but good change in our daily life. I don't think innovation should be categorised as being 'grand' or 'small', as long as it contributes to human progress. Even something small but time-saving accounts." (IND-P5)

Conversely, university interviewees generally held high expectations for "disruptive", "ground-breaking", "world-changing" and "written-into-textbook" innovation (UNI-PHY-P1, UNI-MatS-P3). Some even deemed it a responsibility of scientific researchers to pursue "grand innovation" that extended human cognitive boundaries (UNI-CHE-P1, UNI-SE-P1). They delved into the complexities and challenges that render "disruptive innovation" scarce. One line of reasoning dwelt on the inherent complexity of research innovation, including the unpredictability of exploratory subjects and processes (UNI-NE-P1, UNI-MatS-P6, UNI-PHY-P1), "non-linear connections of multiple factors" (UNI-MatS-P3), and collective trial-and-error over times to reach "ground-breaking rules" (e.g., UNI-CHE-P1, UNI-MatS-P6, UNI-ECE-P4). These complexities were further compounded by the significance of first-mover advantage in the global scientific community (UNI-NE-P1, UNI-PHY-P1). As UNI-PHY-P1 explicated:

> "Scientific phenomenon is often random and unpredictable...yet we must persist in exploring what piques our curiosity...This is the nature of science...The results of the Daya Bay Reactor Neutrino Experiment that receive common recognition are not 'claims made by one place', but have been verified through similar experiments conducted in many other places. Why is the Daya Bay Experiment the only one recognised? Because this is the first one. Primacy is key in scientific research." (UNI-PHY-P1)

Another strand highlighted the challenge in elevating the scope of innovation impacts to spur transformations in nature, society and the world at large through enduring "disruptive" innovation (UNI-SE-P1, UNI-PHY-P1, UNI-MatS-P4, UNI-MatS-P6). This perspective classified these impacts as different levels of innovation, indicating university interviewees' personal commitment to pursuing high-level, "disruptive" innovation. As UNI-SE-P1 and UNI-MatS-P6 illuminate:

> "Based on system engineering theories, innovation operates at three levels. Initial innovation involves synergy of existing domestic and international theories and methods to optimise their collective power. The second focuses on local or partial breakthroughs while the third and most challenging level takes a macro perspective, aiming for remarkable and comprehensive breakthroughs influencing nature, society, and the world at large." (UNI-SE-P1)

> "Innovation exists at different levels. Even slight modifications to existing things can be considered innovation, but my understanding of innovation is disruptive...Personally, I have high standards for innovation." (UNI-MatS-P6)

Some university interviewees perceived "disruptive" and incremental innovation as merely variant "sensitivities" to innovation's deviation from something existing (UNI-CS-P6, UNI-ECE-P3). Accumulation of "small innovation" was deemed indispensable as "qualitative changes" for "grand innovation" (UNI-MatS-P3, UNI-GEO-P5). Nevertheless, UNI-PHY-P1 argued that the accumulation of knowledge systems, notwithstanding its significance, potentially backfires on innovation. This was more likely to happen among senior academics, who, through extensive reading, become increasingly "indoctrinated" by pre-existing knowledge structures that were developed in the past and do not necessarily apply to the present or the future:

> "Like us who grow senior also become more dogmatic in scientific research whereas the juniors are less restricted by conventions. Reaching a balance between such contradiction hinges on opportune timing, place and human conditions, plus luck. This is an inherent dilemma of academia and irrelevant to working environments...many things in papers gradually merge into your knowledge systems, but whether these 'truths' are right or wrong, perhaps right to some extent at the time of discovery and starts limiting your innovative thinking after some time." (UNI-PHY-P1)

Despite the allure of "disruptive innovation", UNI-CS-P5, UNI-GEO-P1, UNI-ECE-P1, UNI-MatS-P1 and UNI-PHA-P2 cautioned that excessive novelty could compromise feasibility and remain as in-theory innovation. Though critical for high-profile publication, it was unlikely to be implemented. As MatS-P1 and PHA-P2 explain:

> "We always feel that we do not have sufficient novelty, not novel enough. However, things that are too novel are difficult to develop into products, considering acceptability and the time required for development...Such novelty is eutrophic. Theoretically a thing plays out well with multiple

> elements combined, but when transformed in practice, these elements may entail countless extra elements that turn out to constrain each other and are thus inappropriate to be productised. The best outcome of such 'pure innovation' is probably the publication of papers." (UNI-MatS-P1)

> "Innovation should bring about drugs that do not currently exist in clinical practice and enhance the safety and efficacy of clinical medication, but extreme novelty in drugs is unattainable." (UNI-PHA-P2)

4.2.7.2. Stage

Among university, industry and government interviewees, "disruptive" and incremental innovation were associated with different stages in the development of innovation capabilities. Incremental innovation, typically in the form of imitation or reintroduction of imported innovation to domestic markets, was construed as an experience in the initial developmental phase for both enterprises and the nation.

While industry interviewees still regarded imitation as a common practice, both university and government interviewees perceived it as a vestige of China's "wild growth", catch-up era when talents and technologies were lacking and the economy was primarily driven by import-export trade. However, this development mode no longer aligned with the current era where innovation and associated IPs had become the core competitive strength for enterprises and nation-states. Imitation that infringed upon IPRs incurred legal consequences under increasing government regulation. These contrasting perceptions of imitation were typically highlighted by IND-P2, GOV-P2 and UNI-EP-P1:

> "Innovation often begins with imitation, as long as it can generate benefits and address the lacuna in the domestic market." (IND-P2)

> "In the initial stage, China's innovation centred on sales and trade. We had neither the talent nor the technology then, and imitation, even copycat, was prevalent. However, it was a necessity and a reflection of the times. Today, Chinese enterprises heavily prioritise innovation, as it is integral for business expansion and avoiding legal pitfalls, and the government also strives to establish an overall credit platform and reinforce protection of intellectual properties...We have moved past the era of 'wild growth'. Innovation now is the key competitiveness." (GOV-P2)

> "Decades ago, Chinese academics understood innovation as imitation, primarily referencing foreign articles and advanced nations' pioneer research on emerging scientific issues. Our researchers then expanded on these established innovations without the need to initiate and analyse the points of novelty themselves. This practice was common among my mentors and me, and characterised China's innovation approach for about twenty years.

> However, our understanding underwent a radical change after setting Industrial 2.0 and the second centennial goals a few years ago. Now we perceive innovation as driven by the practical needs of Chinese enterprises in both manufacturing and application industries." (UNI-EP-P1)

UNI-EP-P1's remark above also indicated a shift from emulating innovation pioneered by advanced nations to embedding more in domestic industry demands as China progressively fortified its innovation capabilities and national priorities. UNI-ECE-P1 observed that this transition from "disruptive" to more incremental, application-based innovation correlated with the developmental stages of a field or industry. For example, in Optoelectronics, "disruptive innovation" often occurred during the early stages when overarching methods and principles had been thoroughly elucidated by the field's pioneers. As the field matured, the focus shifted toward enhancing the performance of established elements that were deemed crucial.

Besides its association with national and institutional development stages, innovation was also conceptualised as a progression from ideation to implementation. The determination of when an innovation became substantive, and the priorities concerning particular stages, varied across university, industry and government and even within the same institutional group.

The transformation of universities' innovative achievements into productivity was construed as a relatively linear process by GOV-P1 whereas GOV-P2 noted that theoretical and technological prototypes produced by universities and enterprises follow two separate development trajectories. The former aimed for future competitiveness while the latter addresses short-term viability. This dual view, recognising theory-driven or prototype and application stage as facets of innovation, was also shared by many industry interviewees, who predominantly worked in high-tech sectors that required both advanced innovation and commercially viable technologies. Notably, half of these industry interviewees hailed from SOEs or held a PhD degree (IND-P1, IND-P3, IND-P6, IND-P8, IND-P9).

While governmental and industrial perspectives mostly focused on transforming mature innovation (e.g., testified theories, applicable prototypes) into productivity, over one third of university interviewees delved into greater granularity in delineating different forms of innovation, particularly the "first mile" of nurturing innovative achievements, and the respective importance of each development stage. For most university interviewees, "ideas" were the starting points and preliminary forms of innovation, followed by the formation and development of hypotheses, theories and technologies, experimental and empirical verification and eventually transformation into products. Nearly half of them regarded "ideas" as innovation given their differentiation from the existing ones, and the potentiality to be honed, published and eventually accumulates into larger innovation. UNI-ECE-P4 highlighted that both theoretical and practical ideas contributed to productivity, albeit being embryonic:

> “Every idea is innovation, no silly idea in the world. Perhaps small ideas can expand into large ones...The implementable ones are practical ideas. Those solving theoretical problems are theoretical ideas, which is also contribution since new theories also induce production of something novel.” (UNI-ECE-P4)

This conceptualisation of “idea” being a necessary stage and form of innovation is echoed by IND-P8. As a part-time mentor and research collaborator at multiple universities, IND-P8 further emphasised the necessity of “failing ideas” within the trial-and-error cycle of innovation while discouraging “plagiarism” and “borrowism”:

> “Innovation should beget failures...set stages for future endeavours...that’s how I mentor my students. Even failed attempts proven ineffective are valuable outcomes...However, many confuse minor tweaks with genuine innovation. That’s why we now see plagiarism, or so-called ‘citation’, which is essentially borrowism, quick and less likely to encounter problems.” (IND-P8)

By contrast, those who excluded “idea” from innovation argue that ideas were voluminous, “imaginary” and mixed in quality. With high failure rates due to the lack of feasibility, innovation became substantive merely at the “verification” stage (UNI-ECE-P2, UNI-ECE-P6, UNI-GEO-P3, UNI-GEO-P4). For UNI-MatS-P1 and UNI-ECE-P8, only ideas reaching the “implementation” stage were sufficiently mature to qualify as innovation. As UNI-ECE-P2, UNI-ECE-P8 and UNI-MatS-P1 exemplify:

> “Ideas don’t count because they always fail. Innovation needs creativity and feasibility. Only then will ideas become reliable, so the key is verifying feasibility, which requires evidence...Many enterprises perform quality examination on our achievements.” (UNI-ECE-P2)

> “Innovation must be implemented, not just imaginary ideas.” (UNI-ECE-P8)

> “Ideas at the embryonic stage is only the preliminary form of innovation, with no value attached. Ideas can be novel if they did not exist before but must be practised and transformed into products to be counted as innovation...For me, substantive innovation must land.” (UNI-MatS-P1)

IND-P1, while not explicitly classifying ideas as innovation, noted that their feasibility depended on effective institutions while in state-owned large enterprises, bureaucratic impediments often led to innovative ideas not being “properly received, valued and implemented”.

4.2.7.3. Type

When considering goals and the expected outcomes, interviewees from university, industry and government conceptualised innovation from the dimensions of scientific research, technology, institution, business model, politics and culture. However, the emphasis on these dimensions varied according to their institutional affiliations and sometimes even within the same group.

"Mode innovation", driven by various forces, is the focal dimension for government interviewees. Working in science, technology and industry department, GOV-P1 and GOV-P2 construed enterprises as their main service targets. Besides recognising business model innovation across society, they focused on technological, managerial, indigenous and path innovations within enterprises and the according innovation in governmental services, both of which they believed should adapt to the shifting social demands at domestic and international levels.

Research innovation was mostly discussed by university interviewees regarding the division of contributions between basic science and engineering science. Those in engineering science tended to identify themselves as "engineers" and others working in basic science as "scientists". The responsibility of scientists was to "discover unknown facts" (UNI-ECE-P6, UNI-CHE-P1, UNI-PHY-P1) and "fate-changing" theories (UNI-ECE-P4, UNI-SE-P1) whereas that of engineers was to create feasible solutions (UNI-GEO-P1) and new products (UNI-ECE-P6) and "address productivity problems to facilitate social development" (UNI-ECE-P4).

Basic science played an overarching role in discovering fundamental and originating (本源, *ben yuan*) problems that potentially yielded theories, papers and patents (UNI-CHE-P1, UNI-CS-P2, UNI-CS-P3, UNI-MatS-P2). Theoretical problems could be identified from existing academic literature (UNI-SE-P2, UNI-CHE-P1, UNI-PHY-P1), state-of-the-art in specific domains (UNI-MatS-P2) and social demands (UNI-ECE-P1, UNI-ECE-P4, UNI-ES-P2). Theoretical innovation herein was expected by many university interviewees to be unprecedented and to expand the frontiers of human society notwithstanding uncertain prospect.

Innovation in applied science tended to be 'practical', 'useful', 'close to application', and 'of engineering value', noted by university faculties in both basic science and engineering science (e.g., UNI-MatS-P1, UNI-CS-P3, UNI-CHE-P1). Identifying problems from social demand, most innovations had an 'application background' and 'market prospect', despite the fact that not all could be put into immediate use. For many in engineering science (e.g., UNI-SE-P2, UNI-MatS-P4, UNI-ES-P1), technological innovation remained the focus of research innovation, targeting the development of novel "technologies", "equipment", "approaches" and "technological integration" for "enhanced performance" and broader applications.

Both basic and engineering science can lead to "scientific breakthroughs"

(UNI-MatS-P3) and advancement of human knowledge (UNI-ECE-P1). "Theoretical breakthroughs" and "practicality" represent different evaluation criteria for contributions (UNI-ECE-P6) Preference for either merely reflected an individual "taste in scientific research" (UNI-ECE-P1), as long as goals were articulated (UNI-MatS-P2). Notably, the symbiotic relationship between basic and engineering science was observed by many university interviewees: theory-driven innovations in the former often spurred incremental, application-driven advances in the latter, which potentially induced new demands for theoretical innovation, either for purpose or as spillover. As UNI-ECE-P1, UNI-ECE-P3, UNI-ECE-P4 and UNI-ECE-P5 explain:

> "Producing good materials requires substantial research in basic science. It appears to be an engineering problem but is actually addressing scientific problems as well. For example, to ensure that my chips can be used by everyone, we need to produce larger ones, but this may influence the stability of materials...after production, we need to figure out the mechanisms of materials and what causes wastage so that we can improve our subsequent techniques." (UNI-ECE-P1)

> "A feature of engineering science is that the mathematics we use have application backgrounds, so we lever mathematics as means, tools, and language to think and break through. When there is certain mathematical innovation, we step forward and apply that to technology." (UNI-ECE-P3)

> "Novel theories can induce the production of other things. Like the material I am making is based on molecular-level research." (UNI-ECE-P4)

> "Engineering sciences are application-driven, working on what is demanded, but novel formula may be worked out during this process." (UNI-ECE-P5)

Nevertheless, theoretical innovation remained a common "threshold" for academic publishing. This focus generated friction among different research priorities and potentially disadvantaged application-oriented faculties. For instance, UNI-GEO-P1 lamented that his "engineer-mindset", geared towards novel application, had restricted his opportunities for publishing in high-profile journals. Even those who had succeeded in high-profile publications, such as UNI-MatS-P2 and UNI-PHA-P2, concurred that application-oriented research was often deemed "insufficiently advanced" for such outlets.

For social science faculties (UNI-GEO-P2, UNI-GEO-P4, UNI-MGT-P2, UNI-DS-P1, UNI-MGT-P1), research innovation aimed to provide evidence-based insights for decision-making and institutional innovation that improved stakeholders' "efficiency" and "quality" of work. UNI-MGT-P1 noted that innovation evolved over different stages. While institutional and cultural innovation had a longstanding history in China, scientific and technological innovation had gained momentum in the last two decades, but remained insufficient. Despite this, these emerging innovations had become pivotal in shaping "the idea of innovation" within China and "the brand-card of China" together with the support of entrepreneurship.

While research innovation had the potential to create paradigm shifts in technologies and industries, industrial interviewees tend to perceive incremental "small" improvements as more prevalent and feasible. In particular, IND-P1 argued that research was not a panacea for all emerging issues, some of which required managerial innovation:

> "Research is like planting more trees to generate achievements for production, central policies, social development and people's welfare. However, occasionally the loss of assets resulting from ineffective management may well surpass what's been augmented by research. Say employees only take business orders that they can take advantage of, regardless of the benefits for their enterprises or society. These are managerial problems." (IND-P1)

4.2.8. Evaluation of innovation

When asked how innovation could be evaluated, interviewees commonly identified peer review as a consensus approach to scrutinise its purpose, validity, and viability through expert feedback from relevant specialists (e.g., GOV-P2, IND-P1, IND-P6, UNI-GEO-P2, UNI-PHY-P1). Applicable in various scenarios such as governmental and industrial project assessments, grant proposals, patent pursuits, and student innovation defenses, this process embraced insights from "large peers" in corresponding sectors and "small peers" with more specialised knowledge. for instance, taking the biomedical domain, UNI-MatS-P1 illustrated that peers includes academics working across the disciplines of Biology, Engineering, Material and Medical Science, suppliers of clinical products, and the end users - doctors and patients. These groups, each with their distinct evaluation criteria, contributed to identifying innovations that were not only theoretically sound but also practically transformative:

> "Doctors care more about whether the innovation outperforms existing medicines and medical equipment, and where the differences are. Enterprises pay attention to whether the innovation generates profits...Though we appear to work in different domains, in fact we all have our own judgement and evaluation upon common products...Like a corneal material my student is developing...Based on animal experiments and doctor's feedback, our product is the best of its type in the world. Although the product is not that innovative from the perspective of Material Science, the way it is designed and used and the positive effects it created, all meet the end of innovation." (UNI-MatS-P1)

While the endorsement of publication value by the "academic society" continued to be a predominant evaluation criterion "establishing basic requirements and guidance to guarantee intrinsic academic interest" and facilitating connections within the global scholarly community (UNI-ECE-P3, UNI-NE-P1, UNI-MatS-P4, UNI-MatS-P7), feedback from "small peers" provided a more diverse array of innovation pathways to explore. For both university and industrial interviewees, peer review was significant since engaging and investing in innovation were "consecutive learning processes" (IND-P2) that necessitated the breakdown of cross-sector knowledge barriers, establishment of consensus benchmarks for innovation, and collaborative cultivation of innovative talents (IND-P9, UNI-MatS-P1, UNI-CS-P3, UNI-CS-P6, UNI-ES-P2, UNI-GEO-P2, UNI-ECE-P2, UNI-ECE-P3, UNI-ECE-P6).

Despite GOV-P2 regarding peer review and IP evaluation as established procedures to filter and safeguard innovations, both the university and industrial interviewees voiced explicit concerns regarding the integrity of the peer-review system. Concerns about its reliability and validity arose from potential challenges in finding apt "small peer" reviewers, the existence of reciprocal "favors", or strategic manipulation to "pass" novelty assessments (UNI-MatS-P4, UNI-MatS-P5, UNI-ECE-P4, IND-P1). Effective review from the industry often relied on large enterprises with "sufficient professional abilities and talent pools to discern the quality of university's achievements" (UNI-ECE-P3). Besides individuals' maneuver of "strategic" keywords, some advanced patent agencies specialised in navigating the verification processes of Intellectual Property Office successfully. As IND-P1, IND-P8 and UNI-MatS-P5 illustrate:

> "Getting the right people to evaluate innovative work is also important. There are just cases where the assessors just don't understand what the innovative work really is and approve those only appearing to be 'innovative'". (IND-P1)

> "Novelty sifting is strategic. If I expect something to be 'non-existent', I can simply adjust keywords...Each year, as we initiate projects, university libraries face a deluge of work creating novelty sifting reports. However, since we author the keywords they use, this process seems largely superficial and insincere...An array of individuals and organisations live by doing this...with just a name or an abstract, they can craft the necessary application documents for you...Their familiarity with the scrutiny methods of patent examiners have streamlined their process, basically guaranteeing one-time pass." (IND-P8)

> "Normally validating innovation involves applying for patents, but I feel like the accrediting organisations are far-fetched, perhaps just conducting a bibliographic search to ensure no one did it before. What I feel strange is that such verification seems to fail if I coin the achievement in different terms or expand on the chemical equations. I am uncertain how these organisations

actually work, but I suspect they might not be fully equipped to accurately assess originality.” (UNI-MatS-P5)

As UNI-MatS-P2, UNI-GEO-P1, UNI-GEO-P3 and UNI-MatS-P4 observed, these challenges were even more notable in societies where rewards were largely bound up with the quantity of papers and patents, leading to large numbers of low-quality outputs. The volume of submissions overwhelmed domestic journal editors while the inadequate English proficiency of domestic academics limited the possibility of international peer review. More concerning, the impartiality of assessment was possibly undermined by the manoeuvre of *guanxi* and the monetisation of academic publication:

> “In western countries, or even in Singapore and Hong Kong, academic achievements are all sent out abroad for review...This doesn’t work in China. Few professors can proficiently communicate in English and articulate the significance of their research. Even when I used prestigious journal papers for teaching, numerous errors are apparent. Editors don’t have time to review them. It is very harmful. Therefore, many foreign journals make money out of this from Chinese people, which usually start free but charge once become well-known, taking 20,000 RMB to publish one paper...collective vote is another way...This doesn’t work in China either. People will lever all sorts of *guanxi* to figure out who are the assessors.” (UNI-MatS-P4)

Hence, both university and industrial interviewees cautioned against excessive assessment that could adversely foster a “race for quick success and immediate benefits”, where individuals meet requirements through “far-fetched innovations” or “fabricated propositions”, resulting in resource wastage (IND-P1, IND-P9, UNI-MatS-P4, UNI-MatS-P7, UNI-GEO-P3, UNI-PHA-P2). Furthermore, many university interviewees also noted the discrepancies between self-perceived value and peer review outcomes. There was often a divergence between the trending topics in peer-reviewed publications and what academics personally deemed meaningful. This misalignment potentially backfired on the intrinsic interests and exploratory freedom of academics. As UNI-PHY-P1 and UNI-PHA-P2 state:

> “Sometimes, what we find interesting and try to publish garners little attention. Conversely, the ‘small things’ we do for fun seem to captivate more people’s interest.” (UNI-PHY-P1)

> “Exploring appropriate medication forms after ensuring drug safety and efficacy is what our discipline [Pharmacy] should do, but many deviate...they go upstream to Chemistry and Material Science because this allows them to publish high-profile papers.” (UNI-PHA-P2)

Noting such discrepancies, some university interviewees proposed additional approaches for “a third-party perspective” or “a technically neutral position”: persistent falsification (UNI-CHE-P1), algorithmic and experimental verification (UNI-ECE-P3, UNI-ECE-P4, UNI-MatS-P1, UNI-CS-P1, UNI-CS-P5), and consulting publication and patent databases (UNI-CHE-P1, UNI-ES-P2, UNI-SE-P2, UNI-ECE-P5, UNI-ECE-P6). These approaches enabled university faculties to identify and examine innovation based on their own expertise (UNI-CS-P6), while also being critical of existing databases, since many accomplishments were shaped by the specific temporal and social contexts of their inception, potentially limiting their applicability as contemporary references (UNI-PHY-P1).

As discussed above, both university and industrial interviewees noted that challenges in securing the objectivity, validity and reliability of evaluating innovation in a way that preserved academic integrity and freedom, notwithstanding the variety of approaches. Evaluation was merely a preliminary gauge of potential impact. Yet its ultimate contributions needed to be attested by time, in particular its endurance and adaptability within an evolving social landscape (GOV-P2, IND-P8, IND-P9, IND-P10, UNI-CS-P1, UNI-CHE-P1, UNI-SE-P1, UNI-MatS-P5, UNI-MatS-P6, UNI-ECE-P5).

4.2.9. Summary

Despite the conceptual ambiguity and contestation of “innovation”, most interviewees from university, industry and government managed to employ various definitional strategies. Generally, they identified innovation’s genus (e.g., “improvement”, “breakthrough”), differentia (e.g., transcending “existing frames”, “positive commentary”, yielding “benefit”) and key properties (e.g., “novelty”, “value creation”, “usefulness”), which collectively shaped the criteria for “substantive innovation”. These criteria were then nuanced by various factors, including the level and scale of innovation, each receiving varying degrees of emphasis.

These definitions were further delineated by different domains (e.g., science, institution, culture), sectors, disciplines and research types (i.e., basic vs applied research), highlighting its context-specific connotations. “Level” classified innovation by different scopes (e.g., “partial” vs. “holistic”) and degrees (e.g., “ground-breaking” vs. “minor repair”; “fate-changing” vs. “small”). “Layer”, “type”, or “dimension” allowed for a more granular comparison of its manifestations across scientific research and technological applications, encompassing both theoretical and practical dimensions.

Some interviewees also employed lexical definitions, tracing innovation’s etymology from the Chinese characters “creation” and “newness” while differentiating it from synonyms such as “change”. Others provided ostensive definitions through observable instances such as “patents” and “papers”, supplemented with theoretical and stipulative definitions that persuade the significance and purpose of innovation. As Table 4.4 indicates, these categorisation appeared similar to how ‘research’ was conceptualised in Oancea et al. (2022)'s study, attesting to innovation's broad, elusive and transferable nature.

Table 4.4 Types of Definitions and Example Quotes from Interviewees

Types of definition	Example interview quotes
Lexical definition	"'Creation' (*chuang*) means doing innovative work, both of which are valuable. 'Newness' (*xin*) refers to something not yet exist." (UNI-MatS-P7) "Only 'change' with operational systems is counted as innovation, but what's purely directional stays as 'change'." (IND-P10)
Operational definition	"In nature sciences, innovation means something that no one has done before...Engineering and medicine are different. Although similar to natural sciences, they have originality, but the focus is more on application...As for humanities, there isn't a clear standard to measure innovation." (UNI-CHE-P1) "Substantive innovation solves practical problems. Many publication of papers are not innovation. Some problem-solving innovation is not necessarily represented in the form of paper and patent." (UNI-MatS-P4)
Analytical definition	"Innovation is the creation of new values, comprising both novelty and usefulness." (UNI-CS-P2) "Innovation primarily epitomises in value, requiring substantive progress on existing foundations, being both novel and meaningful." (IND-P1) "The novelty of innovation is merely a presentational feature. The purpose is to achieve higher value. By transforming from one form to another, I aim to create novel value." (GOV-P2)
Ostensive definition	"Published papers and patents all count as innovation." (UNI-SE-P1) "Innovation essentially means doing what others haven't done, saying what others haven't said and generating new ideas. These are but a few examples. " (UNI-ECE-P1) "Innovation is multifaceted and not exclusive to businesses...even a new type of cuisine invented by a chef is a form of innovation. From a culinary perspective, the

	emergence of new brand restaurants in China, including bubble tea shops, all exemplify innovation." (GOV-P2)
Persuasive definition	"Innovation does not equal something that no one has ever done before. The largest possibility is that it is meaningless to do so." (UNI-MatS-P4) "Often, when discussing innovation, people think of the disruptive type, but in reality, small innovations are more likely to succeed. Many companies implement small-scale innovations, and there are diverse paths to success." (IND-P4) "The meaning of innovation is very broad, and indeed, it should be regarded as the main theme of modern economic and social development, and the most important driving force for growth." (GOV-P1)
Theoretical definition	"Based on system engineering theories, innovation operates at three levels. Initial innovation involves synergy of existing domestic and international theories and methods to optimise their collective power. The second focuses on local or partial breakthroughs while the third and most challenging level takes a macro perspective, aiming for remarkable and comprehensive breakthroughs influencing nature, society, and the world at large." (UNI-SE-P1) "Why do we need innovation? As Marxism suggests, it is because existing methods are inadequate to meet the demands of 'understanding and transforming the world'." (IND-P1)
Stipulative definition	"...pioneering the process of 'creating something from nothing'...venturing into 'unexplored territory'." (IND-P6) "Innovation is creating something not yet in existence in the world, and the creation will bring people convenience, save money and time, and improve lives.'Re-inventing the wheel' is pointless." (UNI-GEO-P1)

Compared to the industry and government's conceptualisations, university interviewees tended to go into greater granularity in identifying and justifying the variety of innovation's genus, differentia, and key evaluation criteria and analytical ways to operationalise the definitions.

4.3. Comparison between policy and interviewees' conceptualisations

4.3.1. Context of innovation: temporality and spatiality

In polices, innovation was conceptualised at a spatial-temporal nexus where innovation, as “the spirit of the era”, was a significant, common and irresistible trend of the contemporary world, displaying ambitions to leverage inward-outward innovation resources and positioning itself as a key pole in an increasingly multi-polar “global innovationscape”.

Comparatively, temporality gains more currency in interviewees’ conceptualisation, where innovation unfolds over time and must stand the test of it. The global and international space remain peripheral in interviewees’ conceptualisation while the core centres around their academic milieu. Notably, only the government interviewees underlined innovation’s significance to China’s modernisation and socio-economic advancement, mirroring policy discourses. Most interviewees related innovation to their organisational growth, professional trajectories and individual interests. A distinct domestic-foreign divide emerged in their narratives, noting that the pandemic had stalled international exchanges. Discussions around the “foreign” largely revolved around the Sino-US trade conflict, viewed as both a challenge and a catalyst to bolster national innovative prowess.

4.3.2. Nature of innovation: novelty, purpose, type and evaluation

In both policies and interviews, value reflects instrumental, affective, normative, and projective dimensions. Evaluation of the value created by innovation serves to rationalise and envision its role, using varied indicators to define and institutionalise anticipated benefits aligning with future aspirations. Indicators as “demand” and “problem-solving” are norm-setting and continuously steer the course of innovation efforts. Notably, even after meeting certain innovation objectives, emerging necessities dictate further actions, stirred by the “inventiveness of value” (Grünberg, 2000, p.20). Both the presence and absence of certain value dimensions indicate its selective feature, the hierarchy of goals or particular preferential trend of social construction that is made objective.

However, in policies, the articulation of value serves as normative prescription embedded within performance evaluations, audit processes and allocation systems, which pivot on competition for policy preferences, resources and funding. Value creation is institutionalised into national and organisational targets, performance indicators and defining criteria for successful innovation, shaping the practices and discourse through which actors demonstrate their innovative work’s value. It was corroborated by many interviewees that aligned innovation with authoritative expectations was crucial for securing preferential backing and resources. This often involved framing challenges in line with key national imperatives (UNI-ECE-P5, UNI-MatS-P7, IND-P2, IND-P8, IND-P9).

In interviews, novelty was typically framed as addressing lacuna in academic disciplines, driven by the quest for uncharted “meaningful” innovation. Innovation as a blend of process and product could always be codified into “indigenous” ownership with legal boundaries, as required in policy contexts. For many interviewees, “novelty” was a hallmark and even a requisite of innovation, but in policies, though frequently mentioned, “novelty” does not constitute a standalone evaluation criterion.

Policies paint a broad spectrum of innovation values encompassing economic, social and cultural realms. While STI remains the predominant focus across policies and interviewees, SSHA innovation is distinctly articulated in policies as critical to constructing an endogenous knowledge system that supports Party-building and promotes Chinese values, theories, and practices. Interviewees generally concentrated on the tangible impact of their work on stakeholders and end users. The affective dimension of value, the sense of “meaningfulness” in particular, weighed heavily in their conceptualisation and engagement in “valuable” innovation. Indicators such as “performance” and “efficiency” were termed in both policies and interviews, but interviewees tended to align them with different modes of inquiry across disciplines. Indicators stayed as benchmarks for quality control and institutional instruments to drive and shape innovation in policies whereas interviewees often perceived themselves as having considerable autonomy, navigating their own innovation trajectories despite institutional constraints (e.g., UNI-MatS-P1, UNI-PHY-P2, UNI-ECE-P4, IND-P7, IND-P8).

Besides macro domains, both policies and interviews also categorise innovation by its level of originality and impact: “disruptive” vs “common/consensual” and “original” vs “adapted/absorbed innovation”. There is a shared emphasis on the critical role of basic science in “disruptive” original breakthroughs, warranting steady, non-competitive investment whereas “consensual innovation” is framed as the engine for industrial progression and economic transformation. A discernible policy shift from “imported and absorbed renovation” to “indigenous innovation”, finds resonance in the sentiments of interviewees. They acknowledged China’s past reliance on imitation and see a current evolution towards a more pronounced role in global innovation. While policy documents and some interviewees placed “disruptive” and “original innovation” at the forefront, a more pragmatic sentiment also emerged from many interviewees that “incremental innovation”, albeit smaller in scope, were often more feasible starting points for individual innovators.

The chasm between policy intent and practice in reality became evident when discussing the valuation of basic vs. applied science innovation. While policies sketched a harmonious blend of the two, interviewees revealed a nuanced landscape where academics encountered tensions in balancing “publication-valued” innovation and applied innovation tailored to industrial and societal imperatives. Basic and applied innovation, instead of being distinct compartments, shared a symbiotic relationship. The policy iteration around “quality” and “contribution” did not explicitly offer alternatives to the entrenched metrics of academic success such as publication counts and citation impacts.

Overall, the definitional boundaries of innovation remained semi-open for reconceptualisation by innovation actors. Interviewees offered nuanced conceptualisations of innovation, dissecting it by scale, level and stage, and elaborating on its overarching purposes and characteristics. For some, resistance to a fully-fledged definition of innovation and a deterministic or simplistic interpretation of its value was also a push-back to the impact of performance regime and auditing culture on academic work. Instead of being a mere tool institutionalised by policy, "innovation" for many interviewees remained as a critical site for conceptual, economic and political contestation, marked by a blend of multiple logics and rationales.

Chapter 5 Universities in the GBA innovation system

Addressing RQ2 and RQ3, section 1-3 of this chapter compares the perspectives of university, industry, and government interviewees on the core innovation activities and roles of universities within the GBA innovation system. Most interviewees noted different drives, activities, resources, capabilities, potential impacts, and ideally a division of labour in innovation. The university was widely regarded as a curiosity-driven institution, consistent with the intrinsic nature of scientific inquiry. Its core innovation activities and missions centred on cultivating talents and leading scientific research and original innovation, alongside the generation of applied innovation that drives technological advancement, addresses industrial and societal demands, and holds potential for commercialisation and academic entrepreneurship. Entrepreneurial activities remained secondary to the core missions, and often necessitated careful navigation given the institutional and financial risks associated with university's public institution status. Nevertheless, the boundary between research and entrepreneurship appeared increasingly blurred as academic engagement in later-stage commercialisation grew in response to rising expectations for universities to assume larger roles in economic and societal development.

Section 4 integrates evidence from interviews and institutional documents from "SYSU News", "SYSU United Front", "SYSU Research Office", "SYSU Human Resource" and "SYSU Science Park", the official accounts that publicise leadership directives, institutional strategies, innovation activities, partnerships, and infrastructures, complemented by relevant reports from official government and media websites. By focusing SYSU as an integrated case, this section examines SYSU's intended and actual participation in the GBA innovation system, focusing on the university's institutional vision regarding its core activities and responsibilities in innovation and how capacity-building can and should be pursued in comparison to perspectives and experiences of interviewed staff and external partners.

5.1. Fundamental responsibility: education

Across university, industry and government, the primary role of universities broadly in the nation, and in the GBA's innovation system, was perceived by interviewees as in education, which included not only the traditional reproduction function of training people for employment, existing social positions and citizenship, but also new human innovation capacities that transformed the social reality of innovation (Baker, 2014). According to GOV-P2, the rapidly changing social demands and innovation landscape resulted in transformations in universities. "Entrepreneurial university" and "innovative and entrepreneurship institute" are typical institutional models that allowed students to cultivate interest in and awareness of entrepreneurship. IND-P4, who worked in a quasi-government innovation service enterprise guided by GOV-P2, also noted the significance of college innovation and entrepreneurship activities. In the words of GOV-P1, GOV-P2, and IND-P4:

"University is the utmost important organisation and carrier（载体）for

> cultivating talents, so its innovation must integrate into Guangdong Province, the local context...including the innovation of educational model and approach, must cater to the demand of social and economic development, cultivating personnel who are more capable of undertaking social responsibilities." (GOV-P1)

> "University is oriented to fundamental education and has some innovation. Perhaps now university is more proactive than it used to be, seeing the emergence of some innovative institutes and entrepreneurial universities. Two decades ago, university students merely knew how to start small businesses like opening a bar, but now many explore and find their way to entrepreneurship, with high possibility of success. Therefore, innovation activities alike have significantly fostered the awareness and thinking of entrepreneurship." (GOV-P2)

> "I think the major contribution of universities to innovation is the cultivation and supply of personnel. To match the demands of labour market, the first and foremost is employability, followed by entrepreneurial capabilities. Something like College Student Innovation and Entrepreneurship competition is such an exercising opportunity." (IND-P4)

University interviewees were also aware of the increasing external pressure on universities to innovate educational models and approaches. Many had endeavoured to collaborate with enterprises, engage their students in collaborative projects, and encourage students to explore a wider range of career opportunities inside and outside academia. These endeavours were deemed conducive to both the academic development and employment of students. The remarks of UNI-ES-P1 and UNI-PHY-P2 were typical in explaining this line of thinking:

> "Horizontal collaborative projects (横向课题) are mostly completed with the help of my students. Our proprietors usually come to us with highly challenging technological problems. Some are at the international frontier, so these achievements also enable students to graduate with good papers. Working on projects is not in conflict with accomplishing studies." (UNI-ES-P1)

> "Many works driven by enterprises become more purposeful and impactful, in turn benefiting the cultivation of students. Now my students are working more closely in this direction, combining basic research and industry, instead of doing 'useless' research. Many are employed by large enterprises upon graduation." (UNI-PHY-P2)

Half of the university interviewees also believed that teaching could innovate in approaches, materials, plans, and tools by introducing new scientific approaches, domain-specific perspectives, up-to-date knowledge, or simply "explaining the profundity in a plain manner" (UNI-ECE-P6). It is important to advance teaching with time because "problems change all the time" (UNI-SE-P1) and students get bored by outdated knowledge and materials (UNI-CS-P1, UNI-SE-P2). Therefore, the fundamental responsibility of universities was to impart current knowledge to students and enable them to attain new knowledge, interests, and abilities. During their education different methods of assessment and diverse teachers' interests and abilities also contributed to innovation in teaching (UNI-MatS-P7, UNI-SE-P1). Though regarding the supervision of students as routine work, UNI-SE-P1 still noted that applying scientific approaches such as system theories to guide supervision improved efficiency, and innovation in teaching was less demanding than that in research and technological work.

Nevertheless, university interviewees held mixed attitudes regarding whether teaching counted as innovation activities. Their views largely depended on individual interest and understanding of teaching responsibilities (e.g., impart standardised contents vs. teach up-to-date knowledge; employ traditional approaches vs. adjust approaches to interest students and facilitate learning). Some regarded the parallel of teaching and research as a consensus academic tradition where teaching, characterised by standardised content delivery fell outside the scope of innovation. For instance, UNI-CS-P3 found it difficult to "associate teaching contents with innovation" since teaching was "mainly about imparting and consolidating extant knowledge" notwithstanding the input of new theories. There was "scant interest" in teaching innovation given that major academic pressure came from research. Similarly, UNI-CS-P6 (the associate dean who administrates undergraduate education) explained that:

> "Traditionally we separate the innovation in teaching and research. Teaching has innovation in teaching approaches, plans, and tools. There are both awards for S&T and teaching... However, teaching belongs to something we are less responsive to when thinking of innovation activities, at least to my knowledge, my colleagues and peers certainly think so as well. Speaking of innovation, what come up are generally the development of technology and research innovation." (UNI-CS-P6)

Taking this further, UNI-MGT-P2 pointed out that "innovation is not the purpose of teaching". At the core of teaching lay learning, which did not involve the degree of novelty required in common innovation activities. UNI-ECE-P8, though acknowledging the possibility of innovating in approaches to teaching, contended that his teaching followed traditional approaches, and professors who were "relatively good at teaching" may reach different conclusions.

UNI-ECE-P4 and UNI-ECE-P1 noted that teaching helped to guide students to innovate, but the contents of teaching remained different from the exploratory interests of teachers. For students, doing research projects and developing soft skills were innovation activities, as long as they learned something new. For enterprises, innovation activities centred on addressing business demands and expanding markets. However, speaking from the perspective of himself as a teacher, UNI-ECE-P4 merely included technological innovation. Students' activities were duplicate work since the target abilities to be cultivated were "largely similar" in accordance with employers' requirements: there had been only minor adjustments in his teaching over the years. Similarly, UNI-ECE-P1 indicated that to teach students, he was obliged to learn "what students need to know", not selectively acquire what interested him, as in scientific research. Hence, the key inclusion criteria of innovation activities lay in the agentic attainment of knowledge.

Despite acknowledging stakeholders' expectations for more employable and entrepreneurial personnel, UNI-ECE-P4, UNI-PHY-P1, UNI-PHY-P2, and UNI-LS-P3 indicated that the comprehensive student capabilities that university and academics strove to foster did not always fully overlap with what was expected by the employer and the industry. For instance, UNI-ECE-P4 explicated that currently the thesis-driven educational model merely assessed technological capabilities upon graduation but neglected the soft skills that prepare students for business practices. As long as the baton of administrative power remained unchanged, most university faculties would continue to have a lopsided focus on cultivating students' technological capabilities.

In a similar vein, UNI-PHY-P2 and UNI-LS-P3 observed that students appeared reluctant to spend too much time on industrial collaboration projects. Some considered the technical work as too basic and lacking the "innovativeness" desired for academic publication, which was a graduation requirements for most postgraduate degrees. Others felt industrial collaboration was too demanding due to practical constraints and the need for additional knowledge, resources, and capabilities. As a result, many faculty members and students preferred to remain within their comfort zones, following conventional academic career paths despite the fierce competition for attaining tenure positions and securing funding. In the words of UNI-PHY-P2 and UNI-LS-P3:

> "Students from SYSU focus more on theories. If you ask them to work on electric soldering or coding, they are not necessarily willing to, probably thinking such work is too 'low'." (UNI-PHY-P2)

> "Everyone in my team wants to do things right and publish good papers but lacks the 'knack and channel' for commercialisation. All want to publish high-quality papers first. It's pretty normal to think that way. My original plan was also starting to involve in commercialisation after the age of 50..Job-seeking is truly difficult for graduate students...now the post-90s

> generation are facing much greater involution than us [the 70s]...but they [postgraduates and post-docs] are reluctant to step out of the university." (UNI-LS-P3)

Accordingly, UNI-LS-P1 and UNI-LS-P4, two postdocs supervised by UNI-LS-P3, indicated that research-related innovation was a safer pathway in academia. While both regard "research in the lab" as a comfort zone, UNI-LS-P4 attributed this to his "chilled" personality, whereas UNI-LS-P1 viewed it as a compromise, citing a lack of reliable resources and understanding of market demands.

While facing pressures to educate students more in line with stakeholders' expectations, university interviewees still inclined to respect and teach according to the diversity of students' personalities, aptitudes, and interests. For instance, UNI-ECE-P1 and UNI-PHY-P1 guided students who had a prominent aptitude and passion for basic science to delve into "grand scientific subjects" that potentially led to "written-into-textbook" innovation, even though UNI-ECE-P1 contended that his enterprise collaborative projects were also meaningful, teamwork-intensive, and in fact, would benefit from the participation of more students. However, in the case of the majority of students, UNI-PHY-P1 noted that it was essential to help them narrow the grand subjects into smaller and more manageable directions through curriculum and guided literature review.

5.2. Vital contribution: research and production of sci-tech achievements

University research was construed by university and industrial interviewees as a crucial source of fundamental inquiry, generating innovation for productivity and the improvement of policymaking. University's "forward-looking research" addressed the "bottleneck problems" or "technological barriers" besetting the nation and domestic industries, facilitated the production chain, and ideally enabled industrial upgrading (UNI-LS-P2, UNI-ES-P1, UNI-MatS-P3, UNI-MatS-P6, IND-P1, IND-P9).

The exploratory, intellectual-driven environment and the wealth of talents at the university enabled novel concepts, theories, and prototypes to be brewed and honed through persistent trial-and-error and the frequent exchange of ideas. These novel productions offered theoretical underpinnings and technological bases for industrial development. The remarks of IND-P9 and UNI-ECE-P1 were typical in illuminating these expected roles of university research:

> "For Power Electronics, perhaps universities have some remarkable layered accumulations (积淀)...ideally there is high tolerance for failure at universities...even if there are no readily practical solutions, a concept or an idea of how problems can be solved is still crucial underpinning for the development of new products, techniques, and trajectories." (IND-P9)

> "The university is primarily where novel thinking sprouts...a highly vigorous arena for fundamental theories, the breakthroughs from theory to practice, the combination of production, education, and research, the participation in technology transfer, and the formation of products and patents in line with the demands of the GBA...perhaps for the industries, also combining with their products and bringing more breakthroughs in product performance and function." (UNI-ECE-P7)

Universities with superior disciplines also led the organisation of research teams to tackle the barriers encountered by different segments of the production chain. Some academic experts provided direct support to industry by bringing their "accretive achievements" to enterprises and taking leadership roles in management or research (UNI-MatS-P4, IND-P9). Leading scientific probing often involved high risk and a long development cycle, requiring substantial research teamwork that was most likely available in universities or large enterprises. Though appearing to be of 'low efficiency' at a time, such probing paved the way for the transformation from "quantitative to qualitative changes" in scientific breakthroughs (UNI-MatS-P3, UNI-GEO-P5, UNI-PHY-P1, UNI-PHY-P2, IND-P8) and potentially drove generational evolution in the industry.

For instance, IND-P8, UNI-PHY-P1 and UNI-MatS-P3 indicated that given the unpredictable nature of scientific research, persistent probing was a crucial process of accumulation before ultimately identifying the key directions for innovation. IND-P3 and IND-P7, whose enterprises strove to empower and transform industries with the technologies of Internet of Things (IoT) and Artificial Intelligence (AI) respectively, noted that the "fundamental", "exploratory", but "forward-looking" research and technological development were mostly undertaken by their university collaborators. Notably, UNI-ECE-P3 also explained that:

> "Stimulation that analyses the performance of coding and decoding solutions is the first step of transforming from theory to technology, and basically what most university professors are doing...the innovation of these coding technologies is the original drive behind the generational evolution of mobile communication network...it's highly theoretical research, entailing long cycles and high risks, so most small and medium enterprises wouldn't do this. Only large enterprises such as Huawei, Alcatel-Lucent, and Qualcomm have sufficient professional capabilities and talent pools to verify the quality of professors' or academic achievements." (UNI-ECE-P3)

Despite the potentiality of university research, some expressed the caution that the prototypical innovation from university was developed in small-scale and optimal experimental settings, relatively distanced from eligible standardised production. In the words of IND-P9 and UNI-MatS-P7:

"Everyone is so keen on papers for the sake of writing, but I think application starts with experiments in the lab. The so-called success usually means getting desirable results in one out of 100 experiments and then selecting several for paper writing. However, in the industry, the whole batch is problematic if 1/100 product fails the quality test...so university research to the industry, there is still a long way to go." (IND-P9)

"University research inclines to be fundamental, searching for novel phenomena or materials via scientific probing or experiments...but there are many key indicators for products in the market. Perhaps university's sci-tech achievements outperform in some certain ones, but no weak spot is tolerated. Every spot needs to be eligible." (UNI-MatS-P7)

Besides the contribution of university research to productivity, UNI-GEO-P4, UNI-MGT-P2, and IND-P10 also discussed its contribution to enterprise's institutional innovation and government policymaking. As UNI-GEO-P4 exemplified, through research on the status quo of the regional innovation system, she managed to provide local enterprises with suggestions for establishing innovation-incentivising schemes, and provide government with decision-making evidence in reducing different actors' barriers to innovation. Besides offering evidence and suggestions, UNI-MGT-P2 engaged in drafting policies and institutional documents through research driven by stakeholders' practical demands. Collaborating with the university in a policy research project, IND-P10 also illuminated that:

"University is at the forefront of government. Many things that are research-based can be counted as innovations. Like the youth policy research I am collaborating with South China Normal University, we can't expect instant implementation, which may take two or three years, but research or anything exploratory and directional is innovation." (IND-P10)

Government interviewees did not discuss the specific roles and processes of university research but shared the same focus with industry concerning the transformation of the university's sci-tech achievements into actual productivity. Positioning enterprises as the principal innovation actors, government interviewees underlined that effective transformation of sci-tech achievements was usually contingent on the collaboration between enterprises and universities or research institutes, which centred on enterprise's innovation and development:

"The principal innovation actor is the enterprise...if universities, proprietors, or research institutes want to make a difference in innovation, I think ultimately they need to return to the collaboration with the enterprise, considering how to build up effective collaborative platforms and channels to serve and facilitate the innovation and development of the enterprise."

(GOV-P1)

> "Scientific research or the transformation of sci-tech achievements could be counted as innovation in university...there are some unique technologies and patents, though not necessarily needed by the market...perhaps university teachers are unclear about their technological contributions or which domains to apply to...so now we hope to facilitate the 'marriage' between entrepreneurs and scientists through this innovation platform." (GOV-P2)

University interviewees appear to have a different understanding about what "meaningful" research to prioritise. For most, research was an intrinsically overarching innovation activity of the university. Undertaking funded research projects and the publication of research constituted the major forms of academic innovation. Unlike the practical constraints placed on innovation in the enterprise and government, ideas, theories, and methodologies differentiating themselves from prior work could easily gain advantages in publication and demonstrate theoretical value in academia. The university was a "storyteller". The novel concepts, theories, and methodologies proposed and disseminated by universities, though not necessarily feasible and occasionally deemed 'too advanced' from industrial application, still manage to lead thinking, while cultivating more talents to persistently tap into something new (UNI-PHY-P1, UNI-PHY-P2, UNI-LS-P2, UNI-ECE-P7).

> "Scientific research is a must-do for university professors. First and foremost, innovation in basic research should produce scientific merit. Second to that, pay attention to whether such scientific merit can be transformed into market value. Some can't be...That means we wouldn't work on it? No, we still need to publish papers. The novelty of papers takes years to reveal and does not necessarily have short-term commercialising prospects." (UNI-MatS-P5)

> "Everyone knows about innovation in scientific research, telling stories and writing papers...this is the innovation of university, proposing novel concepts. Even if not every story succeed, still there is some leading role, justifiably training an array of personnel to explore something new." (UNI-PHY-P2)

Being curiosity-driven, academics were highly selective about the type of challenges to address and the results to publish. Problems without a sufficient level of intellectual "threshold" or "challenge", including some proposed by enterprises, tended to be perceived as less 'meaningful' and less likely to be transformed into high-profile publications. For instance, as UNI-LS-P3, UNI-CS-P1, UNI-CS-P5, UNI-MatS-P5, UNI-MatS-P6, and UNI-ECE-P6 noted, as an additional way to diversify research experiences, collaborative research with enterprises was not innovation-oriented but more about applying their "mature" sci-tech achievements to address enterprise's problems. Despite a general expectation about "forward-looking" research that represented notable intellectual challenges and potentialities for scientific breakthroughs, some contended that it was equally significant to devote themselves to "smaller" research that addresses 'commonly unsettled' problems (e.g., UNI-GEO-P3, UNI-ECE-P2, UNI-ECE-P4).

Through innovation in principles, materials, designs, techniques, and solutions, application-oriented research also helped to address certain industrial problems and improve enterprises' product performance, with some such work leading to new products, patents, and markets. For academics who deemed it more meaningful to orient research towards industrial or clinical demands, there were concerns about being marginalised or disadvantaged by the priority given by academia to theoretical innovation and publication value. As UNI-GEO-P1 and UNI-PHA-P2 reveal:

> "University's innovation is not necessarily applicable, mostly theoretical or in-principle innovation, supposedly useful for writing papers...Recently one of my papers got stuck. I made something novel but perhaps not having sufficient in-principle innovation to be accepted by SCI. Perhaps I remain in the engineer-thinking, but the industries don't care whether the approach is novel, as long as it is problem-solving, feasible, and inexpensive." (UNI-GEO-P1)

> "The clinical problems I am solving are very meaningful, even if they are neither innovative enough in science and technology, nor appealing enough for National Natural Science Foundation funding...Delving into suitable forms of medication after verifying drug safety and effectiveness is what Pharmacy people should do, but many just don't...they go upstream to Chemistry and Material Science to increase the chances of high-profile publications." (UNI-PHA-P2)

Both university and industrial interviewees cautioned that an excessive orientation towards papers could mislead academics into 'writing papers for the pure sake of publication' and neglecting the actual value of innovation, resulting in 'repetitive', 'low-quality', 'make-believe', or 'false-proposition' research, and a waste of resources (UNI-MatS-P2, UNI-MatS-P4, UNI-MatS-P6, UNI-GEO-P3, IND-P1, IND-P9). It was thus essential to have a university environment that facilitated and protected the intrinsic academic interest in research whilst guiding academics to enhance their innovation capabilities and devote themselves to research with substantive values in addressing the 'hard-nut' or 'commonly unsettled' problems in science, industry, or societal development. Such research would naturally lead to high-quality papers, patents, and talents. In the words of IND-P1, MatS-P2, and MatS-P7:

> "Now we have much university research done for the sake of funding and ending up in low quality. Universities should improve their innovation capabilities and their academic influences...They should undertake the

> responsibilities of cracking hard nuts and addressing bottleneck problems." (IND-P1)

> "We still need papers, but anything especially research should not take publication as the only goal...It is important to clarify the goal, being theoretical or technological innovation, solving either theoretical or practical problems. These processes will naturally generate papers and patents; cultivate high-level talents, or what we now call talents wearing titles." (UNI-MatS-P4)

> "Paper is just one evaluation criterion...People with intrinsic interest in research do not need to be assessed every day. Excessive assessment adversely leads to hustle for quick success and immediate benefits, or making-believe false propositions 'created' to meet assessment indicators. Innovation needs to address real problems...A favorable environment is a more important space for everyone to develop and make plans." (UNI-MatS-P7)

5.3. Industrial collaboration and entrepreneurial activities: vital or secondary/additional?

The majority of university interviewees also foregrounded technological innovation and the transformation of scientific and technological achievements, which in part connected with enterprise innovation and made university-industry collaboration possible. Nevertheless, there were mixed expectations for university-industry collaboration, technological transfer, and other entrepreneurial activities.

Advocates from the university, particularly those who identified as academic entrepreneurs, underscored the significance of serving the enterprise demands, the principal innovation actor of the production chain. Others in the middle ground suggest a division of labour within academia, between those working in basic and applied innovation domains, and those interested in commercialisation and entrepreneurship. Interviewees in engineering science tended to identify themselves as engineers and others working in basic science as scientists. As UNI-CHE-P1, UNI-CS-P3, and UNI-MatS-P2 note, basic science plays an overarching role in discovering and addressing fundamental and originating problems. Such theoretical innovation is expected to be unprecedented and was inherently critical in expanding the frontiers of human society despite uncertain usefulness and prospects. It was crucial for basic scientists to be patient with, and persist in, long-term fundamental scientific exploration.

According to UNI-ES-P1, UNI-ES-P2, UNI-SE-P2, UNI-MatS-P2, UNI-MatS-P4, UNI-MatS-P5, UNI-ECE-P3, and UNI-ECE-P5, engineering science mainly contributes to the development of innovative solutions, approaches, technologies, products, and industries. Identifying problems on the basis of social demand, most innovations had ‘application background’ and ‘market prospect’, notwithstanding that not all could be put in immediate use. Hence, the responsibility of the scientist was to “discover unknown facts” (UNI-ECE-P6, UNI-CHE-P1, UNI-PHY-P1) and “fate-changing” theories (UNI-ECE-P4, UNI-SE-P1) whereas that of the of engineer was to create feasible solutions (UNI-GEO-P1) and new products (UNI-ECE-P6) and “address productivity problems to facilitate social development” (UNI-ECE-P4). As UNI-ECE-P1, UNI-MatS-P2 and UNI-LS-P1 noted, preference for basic research, or application, was also a matter of the individual’s taste in scientific research. Academics who felt more comfortable with teaching and research should be given the space to “sort things out” in their preferred domains. Comparatively, it wa more ideal for others who pay closer attention to industrial demands and feel competent in communicating with enterprises to engage in the transformation of sci-tech achievements.

Nevertheless, industrial and government interviewees stressed that entrepreneurial activities and commercialisation were additional roles to be taken. on only when primary responsibilities in education and ‘forward-looking’ research are fulfilled. University spin-offs or academic entrepreneurship faced a high possibility of failure due to insufficient commercialisation expertise, resources, and market experiences. Even academics working in enterprises predominantly focused on research, and successful academic entrepreneurs were in the minority. According to GOV-P2, the university was a “comfortable zone” with venture-averse academics, lacking motivation for and capability in entrepreneurial activities. Only a few managed to become both scientists and entrepreneurs with “venturesome spirit”.

> “University teachers have some professional technologies, but lack market judgement, experience, and passion...a professor from SCUT who works on 3D printing facilities and started business in our platform is a typical example. That company was burgeoning, but all of a sudden acquired by a ready-to-be-listed company in Shenzhen. Very quick actions. Even working in enterprises, professors are still working on scientific research.” (GOV-P2)

Akin to the remarks of UNI-MatS-P2, IND-P1 also cautioned that the division of labour between academia and enterprise was significant, considering limited energy and time. The priority of the university consisted in enhancing academic influences rather than technology transfer and business startups:

> “If I am occupied with my own enterprise, there is no time left for conducting experiments and teaching students. There should be division of labour and collaboration within a society, allowing some people to comfortably and steadfastly work on the innovation of core technologies whilst others working on the promotion of innovation products.” (UNI-MatS-P2)

> "Universities need more academic weight than social weight. Some entrepreneur academics may indulge in managing their political and business relationships, but they are likely to end up with repetitive research since this brings higher returns on their investment. Therefore, social weight might have some positive influences on universities but should not be a priority...universities don't have the capacity, the time, and energy to do that. Plus, there are companies that are more competent in transferring and applying innovations." (IND-P1)

5.4. SYSU: innovation by an enterprising multiversity in the GBA

SYSU's institutional visions, echoing the stakeholders' perspectives discussed above, underscored that the university's success in becoming a world-class, enterprising university hinged on the strength of its intrinsic core—the education and research that underpinned its innovation capacity in social service or the "third mission".

These visions, as articulated by President Gao Song, also closely aligned with STI policies designating high-level research universities as "key components of national strategic scientific and technological capacity" and the "principal driving force" in basic research and talent cultivation, deeply aligned with regional innovation systems. With "enterprises being the principal actors in the technological innovation system, universities were expected to strengthen application-oriented research and knowledge transfer and commercialisation in line with industrial priorities—by enhancing problem-solving capacities, promoting the co-construction of university-enterprise innovation platforms, cultivating high-value intellectual property, and fostering interactive, mutually beneficial collaborations (SYSU Research Office, 2023-05-26; Guangdong STC, 2022).

Building such capacity required strategically integrating high-quality research with interdisciplinary talent development, while bridging national strategic needs and academic inquiry. Basic research and regional industrial development were intrinsically connected, as resolving critical technological bottlenecks ultimately depended on original upstream innovation (SYSU Human Resource, 2025-03-17). As President Gao put it,

> "A high-level research university must fully recognise the importance and urgency of basic research and enhance its capacity to address fundamental scientific and key technological challenges at the source. Research agendas should integrate goal-oriented inquiry with curiosity-driven exploration, with efforts made to translate major national demands into compelling scientific questions that can spark academic interest." (SYSU Research Office, 2023)

SYSU's innovation capacity was therefore shaped by both its development as an enterprising multiversity with a competitive academic core, and also strategically leveraging the GBA's political momentum and geographical advantages as a vanguard, pilot, and demonstration zone for China's reform, opening-up, and innovation-driven Dual Circulation Strategy (SYSU Human Resource, 2021-10-29; SYSU, Research Office, 2022-04-18). This dual strategic orientation strengthened its ability to attract and mobilise talent, funding, infrastructure, and networks, reinforcing its intrinsic capacity and responsiveness to evolving external demands.

The University's mission was operationalised into SYSU's multi-campus configuration and the development of a comprehensive, multidisciplinary profile across Guangzhou, Zhuhai, and Shenzhen—the three core growth poles of the GBA, aligning with national STI priorities in promoting organised innovation with large-scale infrastructures, mega-projects and mission-oriented team-building; fostering "new engineering, medicine, and liberal arts" and facilitating interdisciplinary innovation; and promoting multisectoral collaboration and the coordinated integration of the "innovation, industrial, capital, and talent chains" to strengthen systemic synergy in STI (NDRC, 2023). The following sections provide a detailed discussion of these visions, strategies, and their implementation outcomes.

5.4.1. Organised Innovation: Building Capacity Through Big Science, Large-Scale Innovation Infrastructures, Mega-projects, and Teams

A key strategy revolved around strengthening organised research by targeting major platforms, projects, and scientific infrastructures such as key laboratories and large-scale science facilities to consolidate the university's role as a leading force in basic research and original innovation. These platforms not only supported high-impact research but also served as training grounds for nurturing future faculty, researchers, and top-tier experts across diverse fields. By engaging students early in frontier research and embedding them in large-scale research teams and facilities, SYSU aimed to foster a virtuous cycle of "top-notch talent cultivating more excellent talent".

This strategic vision was reflected in SYSU's efforts over the last decade to build a comprehensive research platform system supported by the development of multiple disciplinary clusters through a phased approach of "planning, nurturing, maturing, and constructing" across five levels: departmental, university, provincial-ministerial, national-level incubator, and national-level. By the end of 2022, the university had established over 400 innovation platforms. This included major scientific infrastructures such as "SYSU Marine Research Vessel" and "SYSU Polar Icebreaker", forming a comprehensive "deep sea-polar-open ocean" marine innovation capability that had received high-level recognition from both central and local governments.

Many of SYSU's innovation platforms were co-developed with local governments and industry partners to support its sustainable spatial expansion and strengthen its role in original STI production and commercialisation through diversified funding. These collaborations had also fostered institutional innovation, particularly through the formation of hybrid organisations. A flagship example was the Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai), established by the Zhuhai Municipal Government and managed by SYSU under a "government-owned, university-managed, board-guided, and committee-led" model. Granted a high degree of autonomy, the laboratory received sustained policy and financial support from both Guangdong Province and Zhuhai City. It was envisioned not only as a demonstration base for marine STI, but also as a model for how local governments could play an active role in shaping innovation and knowledge spaces, taking the roles traditionally associated with academia in support of its "marine powerhouse city" strategy while offering a sustainable pathway for university-based neo-type R&D institutes.

University-enterprise joint laboratories also illustrated this trend. They were primarily established with leading firms centred on large SOEs and high-growth high-tech companies. These top-down partnerships were typically launched through inauguration ceremonies endorsed by the SYSU leadership, industrial partners, and the relevant government departments overseeing the respective sectors. They were, in part, driven by shared interests in fulfilling political performance in promoting government-university-industry collaboration. Based on joint platforms, these partnerships adopted a "project-driven, application-oriented" education model, jointly establishing postgraduate training bases that integrated foundational learning with applied research through task decomposition and coordinated collaboration. Some also regularly organised Party-building exchange activities, maintaining close communication in advancing university-industry-research collaboration.

By the end of 2023, SYSU had co-established over 30 joint research platforms with industrial leaders such as China Unicom, Sinopec, GAC Group, and Huawei. In 2023 alone, 14 new joint platforms were launched, with enterprise R&D investment exceeding 200 million RMB. Selected examples are presented in Table 5.1. These co-constructed platforms had enhanced SYSU's capabilities in original innovation, commercialisation, and innovation-oriented talent cultivation, while also serving as drivers of enterprise and industrial innovation. As noted by SYSU's former leadership involved in launching the "Tianqin Centre for Gravitational Physics", the construction of major innovation infrastructures had catalysed complementary innovations in equipment, manufacturing processes, materials, and related technologies, contributing to the upgrading of associated industrial chains.

Table 5.1 University–Enterprise Joint Research Platforms Co-Established by SYSU and Leading Industrial Partners (examples publicised in institutional documents)

Joint platform title	Collaborating Units	Established Date
SYSU-Guangdong Unicom Computing Power Research and Application Laboratory	China United Network Communications Corporation Ltd., Guangdong Branch	2022.11

National Supercomputing Center in Guangzhou-Unicom Subcentre	China United Network Communications Corporation Ltd.	2023.06
SYSU-Mengniu Joint Research Centre for Nutrition and Health of Middle-aged and Elderly People	Mengniu Group	2025.01
SYSU－Zhaolian Digital Finance Joint Research Centre	Zhaolian Consumer Finance Co., Ltd.	2021.11
SYSU-SenseTime AI Innovation Empowerment Joint Laboratory	SenseTime (Chengdu) Technology Co., Ltd.	2024.01
SYSU-China Post and Telecom Equipment Joint Innovation Centre for Smart Health Space Technology	China Post and Telecom Equipment Group Corporation Ltd.	2023.12
SYSU-Yuehai Group Strategic Cooperation Framework Agreement	Yuehai Group	2023.08
SYSU-Taishan Marine Development Joint R&D Centre for Superior Aquatic Species and Smart Aquaculture	Taishan Marine Development Group Co., Ltd.	2023.12
SYSU-Sinopec Energy Conservation and Low Carbon Joint Research Centre	Sinopec Energy Conservation Technology Service Co., Ltd.	2023.08

Source: compiled by the author drawing from institutional documents

5.4.2. Spatialising multiversity strategies and university-municipal partnerships

According to interviewees and institutional documents, SYSU's development as a multiversity had unfolded in distinct phases with shifting emphases and spatialising strategies. Prior to 2014, SYSU was described by interviewees as a period of academic openness and intellectual diversity, characteristic of the flourishing of international partnerships, active cross-sectoral collaboration initiated by university leadership, and establishment of joint research institutes, some of which were co-founded with both municipal governments and international university partners.

This trajectory encountered key turning points due to a mix of internal and external factors such as leadership changes and escalating US-China geopolitical tensions. Notwithstanding shifts of leadership, the central ethos underpinning SYSU's spatial strategies had consistently centred on fostering a "symbiotic relationship of mutual growth and prosperity" with the localities it is situated within (SYSU Human Resource, 2025-03-17).

5.4.2.1. "Three campuses, five sites" multiversity agglomeration

From 2014 to 2021, under the central strategy of "growing bigger before becoming stronger", the "three campuses, five sites" structure was proactively developed across Guangzhou, Zhuhai, and Shenzhen, supported by municipal investments (SYSU News, 2020). This expansion increased campus infrastructure, enrollment capacity, and institutional influence, enabling the formation of a comprehensive disciplinary portfolio spanning humanities, sciences, medicine, engineering, agriculture, and the arts. Adopting an enterprising approach to managing resource dependency, SYSU proactively diversified resource acquisition channels and improved its organisational autonomy and resilience within an increasingly competitive, performative environment. The multi-campus structure was strategically developed to align disciplinary layout with local industrial structures and priorities to attract external resources and to leverage application-driven development in strengthening academic capacity while supporting the growth of local innovation clusters.

The vision of building a multiversity through proactive resource acquisition to enhance institutional innovation capacity, instead of "waiting, depending, or requesting" (entitlement-based attitudes), it is notably illustrated in the former university president's remarks:

> "By establishing science and engineering schools in the Zhuhai and Shenzhen campuses to meet national and regional innovation demands, we expanded the natural sciences, significantly strengthened engineering, and built a comprehensive disciplinary structure spanning the humanities, sciences, medicine, engineering, agriculture, and the arts, making SYSU a truly comprehensive university." (SYSU Human Resource, 2021-10-29)

The strategic goal of building SYSU into a multiversity was accompanied by a strengthened performative regime and auditing culture, with institutional objectives to achieve a leading position among domestic universities and entering the global top 100 pursued through "objectively comparable indicators" such as the quantity of prime disciplines and university rankings (SYSU Human Resource, 2021-10-31). This was shaped both by DFC's periodic evaluation and the university's WCU agenda, which notably prioritised national service and societal reputation over international academic recognition. The criteria of WCU, as highlighted by the former president in a speech at the 13th National People's Congress,

> “The foremost criterion is being “first thought of by the state” for delivering internationally leading outcomes that contribute directly to national strategy. The second is being “first thought of by society”, through reputation and attractiveness to prospective students. The third is being “first thought of by the scholarly community” in frontier research and debates.” (People’s Daily, 2020)

However, the WCU agenda, which translated into valorisation on the basis of high-profile publications measured by objective indicators, was critiqued by many interviewed faculty in applied science and engineering for pushing application-oriented fields into a standardised pathway grounded in basic science. Publication pressures often led to an opportunistic rush towards “upstream” research from which it appeared easier to yield high-impact articles, while neglecting core priorities within their specific domains. Notwithstanding the drastic expansion of engineering disciplines, some talent recruits, particularly returnees with substantial industrial and commercialisation experience, felt sidelined, struggling to reconcile institutional priorities with their own domain-specific priorities and professional aspirations (UNI-CS-P2, UNI-PHA-P2, UNI-PHA-P3, UNI-GEO-P1, UNI-MatS-P4, UNI-MatS-P8, UNI-ECE-P1). These tensions were typically illuminated by an early-career returnee:

> “In pharmacy, we focus on the final stage...like creating tablets, capsules, or injections. However, in China, many shift upstream to chemistry or materials science, where high-impact publications are more attainable. Isn’t this a policy orientation issue? If you're in downstream areas, you have no access to resources.” (UNI-PHA-P2)

This state-centric approach to WCU, where the national agenda took precedence over internationalisation and engagement in global science, had largely succeeded. However, since 2022, strategy had shifted from “scale expansion to quality enhancement” under the new president, who previously served at SCUT and Peking University, to secure greater resources for WCU agenda and shedding the impression of being “large but not strong” (SYSU News, 2025a). While many faculty interviewees (e.g., UNI-CE-P1, UNI-PHA-P3, UNI-NE-P1) found the distinctions between campuses unclear, the new president reinforced a strategic articulation of differentiated yet coordinated campus development.

The century-old Guangzhou campus consolidated traditional strengths in SSH, sciences, and medicine, alongside enhanced interdisciplinary integration and steady growth in core engineering fields and arts; while the Zhuhai campus, originally housing SSH and a few science schools, was strategically upgraded into frontier domains aligned with the city’s Marine Powerhouse Strategy in deep-sea, deep-space, deep-earth, and deep-blue innovation upheld by basic scientific disciplines. Established in 2018 through municipal investment, the Shenzhen campus maintained the strongest alignment with local strategic demands, prioritising emerging disciplines in medicine, engineering, and agriculture through an integrated model led by medical-engineering convergence and interdisciplinary synergy.

5.4.2.2. Pioneering into the strategic innovation space of HK

In October 2024, the SYSU HK Advanced Institute was inaugurated as the first comprehensive research institution established by a mainland university in HK. It was strategically located in the HK Science Park, the largest hub for scientific research and business incubation, with strong commitments to both frontier research and applicable innovation. The institute operates as an independent legal entity, with Prof. Xu Anlong, the former President of the Beijing University of Chinese Medicine and former Vice President of SYSU, appointed as its director. With a vision to "'break through the sky" (顶 天) by advancing frontier science, basic research, and interdisciplinary innovation, and to "stand firm" (立 地) through the commercialisation of innovative achievements" (SYSU OSRD, 2024-10-15), the Institute embodied SYSU's innovation agenda in alignment with the DFC initiative and the GBA strategy, as noted by Director Xu,

> "The Institute marks an innovative endeavour by SYSU to integrate the DFC initiative with the national strategy for the GBA. With a clear top-level design, we seized the opportunity to experiment boldly and make breakthroughs, advancing the institute with an open and inclusive mindset—from 'pilot testing' to 'demonstration leadership'." (GDSTC, 2024)

On one hand, combining SYSU's disciplinary strengths with HK's development priorities, the Institute focused on biomedical sciences, applied mathematics, and interdisciplinary SSH innovation, promoting the commercialisation of SYSU's existing innovation achievements in HK. One the other hand, the Institute aimed to establish world-leading laboratories, leveraging HK's international advantages to attract global talent while serving as a platform for deepened collaboration between mainland and partners in HK and abroad. The interdisciplinary SSH centre was primarily supported by SYSU's GBA Development Research Institute, focusing on Chinese national conditions and Lingnan culture[17], Southeast Asia, and the Belt and Road Initiative. Since its establishment, the Institute had signed multiple cooperation agreements with HK universities and companies, both within and outside of HK, receiving investment and donations. Table 5.2 exemplifies the partnerships established since the Institute's founding, including agreements with universities and enterprises across research collaboration, talent training, dual-degree programmes, research commercialisation, and philanthropic support.

[17] The regional culture of South China, featuring openness, pragmatism, reformism, and integration with foreign influences through trade and coastal exposure, and values human-centred pursuit of happiness and desire-driven behaviours that support individual well-being and development (Xinhong, Dingju & Yingxi, 2023).

Table 5.2 Summary of Collaborative Agreements Signed by SYSU's Hong Kong Advanced Institute (as of Mar 2025)

Partner Name	Collaborative Type
City University of Hong Kong	Framework agreement on medical research and hydrogen energy
The Hong Kong Polytechnic University	MoU on medical-engineering interdisciplinary collaboration; joint lab; dual-degree programmes (4+4 BS + potential PhD in medical-engineering)
The Chinese University of Hong Kong	Agreement to establish joint lab in plant synthetic biology; collaboration in applied mathematics
The University of Hong Kong – School of Chinese Medicine	Intent agreement on traditional Chinese medicine research
CUHK – Institute of Mathematical Sciences	Intent agreement on mathematics research collaboration
Hetao Biolab, Eighth Affiliated Hospital of SYSU	Collaboration agreement on global talent recruitment and biomedical R&D
Shenzhen Kangtai Biological Products Co., Ltd.	Industry-university-research collaboration agreement
Guangdong Hencan Technology Co., Ltd.	Industry-university-research collaboration agreement
Guangzhou Xieno Investment Group	Industry-university-research collaboration agreement; funded innovation centre (i.e., the Institute's Xieno Innovation Centre); research commercialisation investment; donation
Fok Ying Tung Education Foundation	Donation
Guangdong Zhujiang Investment Co., Ltd.	Donation and collaboration on research, talent recruitment and training
Yuehai Group	Collaboration on scientific research, talent introduction, and student training

Source: compiled by the author based on information from SYSU and Guangdong government websites

The Institute's strategic role in GBA innovation had been recognised and supported by multiple government bodies, including the General Office, the Office for HK, Macao and Taiwan Affairs, and the MOE's Department of Higher Education. This significance was notably underscored by Vice Minister of Education Wu Yan during his visit to the Institute in February 2025, where he called on SYSU to continue advancing innovative development and build the Institute into a high-level hub for attracting, cultivating, and retaining talent for HK's development, the GBA, and national priorities.

> "The Institute not only belongs to SYSU, but is also part of HK, and more importantly, China." (SYSU OSRD, 2025-02-16).

5.4.2.3. Revalorisaiton of SSHA innovation space

While previous institutional practices arguably disproportionately centred on expanding engineering disciplines (UNI-CHE-P1, UNI-ECE-P4, UNI-MatS-P7), the current strategies reflected the growing valorisation of innovation in the SSHA. SSHA was increasingly recognised as critical to fulfilling President Xi's directives on realising the university's foundational mission in constructing indigenous theory, ideological education, and interdisciplinary collaboration. SSHA innovation supported the creative transformation of traditional Chinese culture and drove advances in knowledge, theory, discourse, and methodology with increasing global reach. It also played a critical role in fostering systems-thinking around China's innovation realities and developmental path, including shaping the trajectories of other disciplines. Through both forward-looking academic inquiry and applied policy research, SSH contributed to evidence-based policymaking and the modernisation of national governance.

In line with the initiative for "New Liberal Arts" construction, President Gao had reaffirmed the enduring value of the SSHA in "addressing major theoretical and practical questions of China's modernisation" and "construct an autonomous knowledge system" grounded in discipline-specific concepts and original theoretical contributions. These directives resonated remarkably with SYSU's legacy of humanistic tradition and intellectual innovation (SYSU Personnel, 2025-03-17). In response to these directives, efforts were underway to reform governance and evaluation structures in ways that reflected the distinct characteristics of SSHA disciplines. This included the establishment of permanent institutes for sustained inquiry alongside flexible joint research teams. SSHA divisions were increasingly organising diverse forms of innovation activities, with growing expectations to protect the "solitary thinker" and maintain a balance between organised research and intellectual autonomy.

Three provincial-level key laboratories for philosophy and social sciences were established in 2022: the *Key Laboratory for the Humanities Community in the GBA*, the *Key Laboratory of Mesoeconomics and Regional Industrial Synergy*, and the *Collaborative Innovation Laboratory for Philosophy of Medicine and Humanistic Practice*, housed respectively within the School of Sociology and Anthropology, Lingnan School, and the School of Philosophy. For further exploration of cross-disciplinary integration and an innovative model for promoting interdisciplinary research, since 2024, SYSU had successively established the Rural Revitalisation Joint Research Institute, the Medical Humanities Joint Research Institute, and the

Digital Humanities Joint Research Institute. These platforms were designed to: mobilise disciplinary strengths to foster cross-disciplinary dialogue and resource integration; serve as entry points for rethinking organisational and governance models tailored to the development of SSHA; and produce forward-looking, high-impact research aligned with the university's broader strategy for high-quality development (SYSU Research Office, 2022-04-18; SYSU Human Resource, 2025-03-17).

5.4.3.4. University hospitals: medical innovation engines and enterprising healthcare providers

The role of university medical schools and affiliated hospitals in fostering innovation remains under-discussed in the literature on entrepreneurial and enterprising universities. Nevertheless, they are integral to the innovation capacity of many WCUs (e.g., Johns Hopkins University, University of Oxford, University of Toronto), attracting substantial public investment and enabling the full-loop integration of research, education, clinical application, and marketisation. At SYSU, the strategic expansion of affiliated hospitals with varying specialisation were essential to enhancing the university's innovation capabilities and public service functions. Affiliated hospitals arguably represented SYSU's most prominent contribution to regional innovation and development in advancing medical innovation, healthcare provision, and improving local attractiveness to innovation resources, talent and industry (UNI-MatS-P1, UNI-MatS-P2, UNI-MatS-P4, UNI-MedS-P1, UNI-CS-P5, UNI-CS-P7, UNI-PHA-P3, IND-P6, IND-P9).

University hospitals were distinctively research and teaching-oriented, serving as critical bases for clinical training, trials, and clinically driven scientific and technological innovation. Equipped with certified clinical trial platforms, they provided the institutional legitimacy and regulatory infrastructure necessary for national R&D projects, international clinical collaborations, and industry engagement. SYSU's affiliated hospitals support dual-track training and employment for clinician-scientists between its medical school and hospitals. This connection also provided opportunities for interdisciplinary collaboration and joint mentorship across management, medicine, engineering, and data science etc. across and beyond SYSU (SYSU Business School, 2021; SYSU Fifth Affiliated Hospital, 2024; SYSU News, 2023c, 2024b; SYSU School of Life Sciences, 2023a, 2023b).

Leveraging the innovation resources and outputs generated by its affiliated hospitals, clinical science had remained a core pillar in SYSU's DFC evaluation and a strong magnet for talent recruitment and collaborative engagement (UNI-MatS-P1, UNI-PHA-P3, IND-P9; MOE, 2022a; SYSU School of Medicine, Shenzhen, n.d.).The hospitals functioned as both generators of clinical innovation demand and sites of frontier R&D, housing research teams capable of producing original scientific discoveries as well as clinically translatable outcomes. This dual role enabled a synchronised internal loop of research, education, and commercialisation, underpinned by a shared institutional logic that valued student training, high-profile research and publication, and the social impact of innovation, as noted by interviewees from SYSU and its affiliated hospitals who had collaborations (UNI-LS-P3, UNI-MatS-P1, UNI-MatS-P2, UNI-ECE-P8, UNI-ECE-P9, UNI-CS-P5, IND-P6).

SYSU's hospitals played essential roles in university-local government collaboration and drawing resources in support of its multiversity-building. Through partnerships with governments in (Guangzhou, Shenzhen, Zhuhai, Zhaoqing, Huizhou) and beyond the GBA (Guizhou, Guangxi, Gansu province), SYSU had established over ten affiliated hospitals to extend high-quality clinical, managerial, and human capital resources to under-served regions while pluralisinging its medical specialisation (Shenzhen Health Commission, 2022; SYSU News, 2021a, 2022a, 2022b, 2022c, 2023b, 2024a, 2025c, see Table 5.3). For instance, SYSU Sixth Affiliated Hospital in Huangpu Knowledge City of Guangzhou focused on orthopaedics, sports rehabilitation, and smart medical systems while Huizhou Hospital promoted precision and minimally invasive medicine (SYSU First Affiliated Hospital, 2021; SYSU News, 2023b, 2025c). In places where medical systems were under-developed, SYSU introduced its medical management, technology, and brand to foster medical services and capacity building of local hospitals (Guangxi Zhuang Autonomous Region Government, 2022; SYSU News, 2022a, 2022c).

The hospitals generated spatial agglomeration of key innovation projects, talents, firms, and financial resources while serving as a catalyst for institutional innovation, internationalisation, and the integration of medical systems across the GBA. SYSU Sixth Affiliated Hospital in Huangpu Knowledge City had jointly developed smart rehabilitation and life-monitoring devices with medical firms and was co-developing a translational biomedical innovation institute with the district government. In Nansha district, SYSU First Affiliated Hospital had pioneered medical infrastructure innovation to support an integrated land-sea-air emergency response system between SARs and Nanshan. The hospital had also established partnerships with over 60 leading universities and medical institutions worldwide. Notable collaborations included the joint establishment of the International Institute of Healthy Aging with the University of Birmingham, the first Joint Laboratory for Precision Medical Engineering in China with Nanyang Technological University, and extensive cooperation with Harvard Medical School, involving 18 specialised departments and participation from over 250 Harvard experts and 3,000 medical professionals and students (SYSU News, 2023c, 2023d).

Designated as Shenzhen's pilot institution for reforming the ownership of innovative achievements, SYSU's Seventh Affiliated Hospital had also significantly contributed to licensing of patents to and the clustering of startups and high-end biomedical enterprises (Shenzhen Guangming District People's Government, 2024). It also co-established the first international Clinical Research Institute with the University of Birmingham in Shenzhen (SYSU News, 2023a). With ongoing expansion, SYSU continued to strengthen its leadership in medical innovation and public service, supporting inclusive healthcare and national self-reliance in medical science and technology.

Table 5.3 Overview of SYSU-Affiliated Hospitals: Location, Founding year, Investment Amount and Bodies

Hospital Name	Location	Founding Year	Investment Amount (CNY)	Investment Bodies
SYSU First Affiliated Hospital	Yuexiu District, Guangzhou	1910	90 million	Guangdong Provincial Government Fund (2015-2018)
	Nansha District, Guangzhou, Guangdong	2025	4.823 billion	Hospital's self-raised funds and Nansha District Government
	Huangpu District, Guangzhou, Guangdong	2023	2.2 billion	Central budget, Guangdong Province, Huangpu District, and hospital's self-raised funds
	Daya Bay District, Huizhou, Guangdong	2013	740 million	Daya Bay Government
	Guizhou Province	2021	5.14 billion	Hospital's self-raised funds and Guizhou Provincial Government
	Guangxi Province	2023	n/a	Hospital's self-raised funds and Guangxi Zhuang Autonomous Region Government
SYSU Third Affiliated Hospital	Tianhe District, Guangzhou	1971	50 million	Guangdong Provincial Government Fund (2015-2018)
SYSU Fifth Affiliated Hospital	Xiangzhou District, Zhuhai	1992	12 million	Guangdong Provincial Government Fund (2015-2018)
SYSU Sixth Affiliated Hospital	Tianhe District, Guangzhou	1964	18 million	Guangdong Provincial Government Fund (2015-2018)
	Huangpu District, Guangzhou,	2025	n/a	Hospital's self-raised funds and Huangpu District Government

	Guangdong			
SYSU Seventh Affiliated Hospital	Guangming District, Shenzhen	2016	n/a	Shenzhen Municipal Government
SYSU Eighth Affiliated Hospital	Futian District, Shenzhen	1998	n/a	Shenzhen Municipal Government
SYSU Memorial Hospital	Yuexiu District, Guangzhou	1835	53 million	Guangdong Provincial Government Fund (2015-2018)
SYSU Ophthalmic Centre	Yuexiu District, Guangzhou	1965	40 million	Guangdong Provincial Government Fund (2015-2018)
SYSU Stomatological Hospital	Yuexiu District, Guangzhou	1974	17 million	Guangdong Provincial Government Fund (2015-2018)
SYSU Cancer Centre	Yuexiu District, Guangzhou	1964	70 million	Guangdong Provincial Government Fund (2015-2018)
Cancer Hospital, Gansu Hospital	Gansu Province	2022	1.3847 billion	Central government: 300 million; Gansu Province: 1.07 billion; hospital's self-raised funds: 14.7096 million

Source: compiled by the author based on official announcements and reports from SYSU and relevant local government websites.

5.4.2.5. The entrepreneurial space: university science and industrial parks

University science and industrial parks are integral to national innovation platform-building and serve as strategic extensions of the university, enhancing its capacity to attract innovation resources, facilitate external engagement, and elevate institutional visibility and status. SYSU established its first science park in November 2004, in Guangzhou as a wholly university-owned platform dedicated to I&E incubation. In August 2006, it was officially recognised in the fifth cohort of national university science parks, making SYSU the second university in Guangdong Province to receive this designation after SCUT. Since its inception, it the time of the research the park had supported nearly 500 faculty and student-led innovation and entrepreneurial projects and incubated over 1,200 start-up enterprises, 13 of which have grown into unicorn companies (SYSU Science Park, 2025-04-03b).

The park was positioned as an entrepreneurial "extension" supporting the cultivation of innovative talents, projects, spin-outs or start-ups, brokerage of external innovation resources and partnerships, and contribution to diversified income generation. It provided physical infrastructure and a social environment that facilitates close engagement between the university and external innovation actors. Its proximity to SYSU allowed convenient participation of faculty and students, while co-location with enterprises offered students internship and employment opportunities and enabled faculty to access collaborative innovation resources.

As a commercial and professional entity, the park also hosted and supported a range of I&E activities such as innovation policy briefings, project application training, competition and pitch sessions, and resource matchmaking (SYSU Science Park, 2025-04-03a), functions that exceeded the capacity of traditional university administrative units. However, for most interviewees, particularly those who had located their companies in the park, it was primarily valued for its convenient proximity to campus while offering limited perceived advantages in spatial capacity, services, or rent compared to external alternatives, with relocation becoming necessary as their businesses expanded (UNI-PHY-P2, UNI-PHA-P3, UNI-CS-P2, UNI-ECE-P1, UNI-MatS-P4). There were expectations that, as a de facto functional extension of SYSU, the park should have taken a more proactive role in reaching out to individual faculty and offering tailored support for commercialisation and external collaboration (UNI-MatS-P1, UNI-ECE-P4, UNI-CS-P3).

At the end of 2022, building on this initial park, SYSU collaborated with the Guangzhou Municipal Government, GAC Group, and GPHL Group to jointly establish the GBA's pioneering "Future Industry Science and Technology Park" dedicated to biomedicine and new transportation (SYSU Science Park, 2025-04-03). Since the launch of the 14th Five-Year Plan, SYSU had collaborated annually with over 1,150 enterprises in science and technology, with an average annual growth rate of 12% (SYSU United Front, 2025-03-11).

The university had shifted from a project-centric approach to a full-chain, systematised model of innovation management, refining the structure for university-industry collaboration and the benefit-sharing mechanism for research commercialisation. Emphasising the transformation of high-value intellectual property, it had aligned with regional industrial priorities and explored new models of cooperation. In November 2022, leveraging its national university science park, SYSU partnered with the Guangzhou Municipal Government, GAC Group, and Guangzhou Pharmaceutical Holdings to secure approval for one of the first national Future Industry Science Park pilots, focused on biomedicine and next-generation mobility.

5.4.3. Mission-Driven Innovation: Advancing National and Local Goals Through Rural Revitalisation, Public Health, and Societal Engagement

Although mission-driven innovation is, in a narrow sense, a form of organised innovation, its emphasis lies less on big science and disruptive innovation, but more on enabling inclusive innovation and development by supporting education, science, industry, and regional growth in less-developed areas within and beyond the GBA.

SYSU had made significant progress in building high-level hospitals, contributing to the "Healthy China" and "Rural Revitalisation Strategy", enhancing regional innovation and development capacities of those within and beyond the GBA. The establishment of joint research institutes represented a proactive response to rural revitalisation and the implementation of the "Hundred-Thousand-Ten Thousand" project. Since 2013, the university had engaged in targeted poverty alleviation in Fengqing County, Yunnan Province through industrial development, medical support, and educational assistance contributing to its removal from the national poverty list. These initiatives aimed to contribute Chinese knowledge and solutions to global agricultural development and poverty reduction, promote interdisciplinary research, and train high-level talent. They also addressed key scientific challenges and core technologies in rural revitalisation by aligning research with the needs of local governments and industries to support regional innovation and industrial upgrading.

A widely cited example in both institutional documents and interviewees' accounts was the projects led by a professor from the School of Pharmacy, which helped over 6,000 rural households in northwestern Guangdong escape poverty through the development of *Hongzhu Capsule*, an innovative pharmaceutical product. With a transfer value of 20 million RMB, it was the highest single-technology commercialisation contract in SYSU's recent history.

Mission-driven innovation was pursued not only as the social responsibility of universities as public institutions, but also as a leadership mandate of CPC to deepen the integration of Party-building with research and innovation. This was enacted through the dual roles of academics as both scholars and Party members, and through joint Party branch activities across universities, enterprises, and government. Increasingly, party-building initiatives and cadre training focused on collective study of CPC STI directives, site visits to innovation infrastructures, and cross-sectoral exchanges that discussed challenges and opportunities in innovation and seek to promote innovation partnerships through Party-led coordination.

While most extant efforts focused on research, collaborative innovation, and commercialisation in aquaculture, pig breeding, Chinese medicine, and rice cultivation, provincial government had also urged SYSU to leverage its GBA Development Research Institute to provide actionable policy advice on addressing regional imbalances in agricultural and rural development across the GBA (SYSU News, 2021b).

5.4.4. Institutional reform

5.4.4.1. Recalibrating the Baton of Administration

Following the Break the Five-Onlys reform, SYSU established a representative output evaluation system, introducing a suite of policy documents including the *Interim Measures for the Management of Teaching-Research Track Faculty*, *Interim Measures* *for the Appointment of Research-Oriented Faculty*, *Interim Measures for the Appointment of Teaching-Oriented Faculty*, the *Implementation Plan for Strengthening the Cultivation and Utilisation of Young Scientific and Technological Talent*, and the *Regulations on the Appointment of Senior Academic Positions*. Together, these measures aimed to form an evaluation framework based on representative achievements, encompassing publications, monographs, awards, patents, technical standards, policy research outputs, new clinical technologies, and pharmaceutical certifications.

The university also aimed to foster a governance culture grounded in trust and good administration, alongside an administrative ethos oriented toward supporting scholarship, faculty, students, and institutional development. It was committed to ensuring stable and sustained investment in research and innovation, promoting a balance between free inquiry and organised research, further increasing investment in basic research as a share of overall R&D funding, and fostering an academic environment that values diversity of thought, open debate, and "harmony without uniformity" was seen as essential for cultivating top talent and generating breakthrough innovations. The university was improving differentiated talent evaluation mechanisms and implementing a well-structured tenure system, with a focus on attracting, developing, and retaining young academic talent.

Many faculties, including those from basic sciences, emphasised the need for a discipline-specific rather than a one-size-fits-all approach centred on impact factors and publication quantity, especially considering SYSU's multidisciplinarity and the emergence of interdisciplinary innovation (UNI-MatS-P3, UNI-CHE-P1). Although earlier university leadership had made some progress in fostering a collegiate and collaborative culture, SYSU had remained shaped by a bureaucratic institutional culture, arguably intensified in recent years by a leadership style resembling that of government officials, characterised by KPI-driven management oriented toward political career advancement (e.g., UNI-MatS-P4, UNI-ECE-P2).

5.4.4.2. Division Reform for Integrated and Interdisciplinary Governance

To better coordinate standards and resources across related disciplines and promote interdisciplinary innovation, SYSU had established a three-tier academic governance structure comprising the university, divisions, and departments. It also advanced differentiated evaluation mechanisms and cultivated a supportive academic climate in which scholars could focus deeply on impactful research in a stable, reassuring, and intellectually nurturing environment.

5.4.4.3. Professionalising support for research, innovation, and entrepreneurship

SYSU also aimed to establish a collective decision-making mechanism led by the senior leadership team for major matters concerning academic innovation and commercialisation. This was supported by a coordinated, multi-level mechanism involving the President's Executive Meeting, the Research Commercialisation

Leadership Group, the Technology Transfer Office, functional departments, the asset management company, and academic units with clearly defined responsibilities and collaborative workflows.

To enhance professionalisation, third-party service providers had been introduced to offer targeted support to key research teams. High-value patent cultivation centres had been set up in two national key laboratories, providing services such as patent landscape analysis, pre-filing evaluations, and patent literacy training. A digital platform for open patent licensing had also been developed to facilitate external access to existing patents, alongside the exploration of developing shared pilot-scale platforms to support the translational phase of innovation. By promoting equity-based technology transfer and other mechanisms, it aimed to accelerate the commercialisation of high-quality research outputs, foster the growth of high-tech enterprises, and build an integrated, full-chain system connecting universities, major innovation platforms, and enterprises.

Through innovation and entrepreneurship contests and university-industry-government matchmaking events, SYSU aimed to build platforms to bridge innovation resources and networks, coordinated by university leadership, its science park, research office, and academic divisions. These activities took diverse forms and were hosted by a range of actors. Some were hosted internally, involving mutual visits between different schools and pertinent external organisations, whereas others were co-organised with intermediary agencies specialising in innovation contests, matchmaking, and roadshows, or with local governments that had strategic partnerships with SYSU to support their STI (e.g., Shantou, Yunnan).

The roles of the university president and Party secretary had become increasingly intertwined, jointly advancing STI and WCU agendas, and innovation activities, including multi-sectoral collaboration, are organised under both academic affairs and Party-building. Party-building had become an expanding force in steering innovation, fostering greater interaction among Party branches across intra- and inter-institutional levels. These efforts were exemplified by meetings and cadre training sessions focused on President Xi's STI directives, policy and STI-pertinent theoretical learning aimed at enhancing professionalisation. The integration of Party-building into STI governance positioned ideological leadership as a key force in coordinating innovation, embedding political authority within the academic core while reinforcing its legitimacy through the appointment of academically qualified Party secretaries.

5.4.4.4. Diversifying Graduate Education for Innovation-Driven Talent Development

Though not typically viewed by faculty interviewees as primary sites of innovation, higher education education institutions were recognised as essential arenas for cultivating the future drivers of innovation and explicitly positioned in SYSU's institutional narrative as the "fundamental benchmark for evaluating all university functions", particularly in moral and intellectual development and the cultivation of "socialist builders and successors" (SYSU News, 2025b).

However, universities have varied in how they interpret this strategic vision. At SCUT, it was often framed as producing the "cradle of engineers and entrepreneurs", a perspective reflected in institutional documents and echoed by interviewees from both SCUT and SYSU (SCUT News, 2020; School of Entrepreneurship Education SCUT, n.d.; UNI-ECE-P4, UNI-LS-L1, UNI-CHE-P2, UNI-RO-P1). Comparatively, SYSU embraced a more encompassing vision, shared across institutional discourse and interviewee accounts, of cultivating top-tier, new-generation "high-quality innovative workforce" capable of creative work across professional roles and sectors, translating innovation into productivity.

As articulated by the current SYSU president, creativity emerged from the dynamic interplay of three core capacities: learning ability, critical thinking, and practical action. Since education equipped students with today's knowledge to address tomorrow's challenges, it was inherently future-oriented. Learning ability enabled independent knowledge acquisition; critical thinking fostered analytical depth and originality; and practical action, embodied in SYSU's motto of "steadfast practice", empowered students to translate ideas into meaningful outcomes. Toward this end, SYSU was deepening reforms in postgraduate education by advancing differentiated pathways that reflected the dual mission of graduate training: supplying high-end talent and driving scientific and technological innovation. Academic degree programmes emphasised the integration of research and education to strengthen original innovation capacity, while professional degree programmes focused on industry–education integration to enhance practical and applied skills.

Efforts were being made to transform its strengths in interdisciplinary research into capacity in interdisciplinary education. Research training courses had been introduced to guide students in formulating research topics based on real projects, reinforce systematic scientific training, and encourage early and active engagement in cutting-edge research. In 2022, over 80% of the university's NSFC projects involved postgraduate students, with graduate students accounting for more than 50% of participants in key projects. Since 2022, the university had jointly recruited and trained nearly 150 professional master's and doctoral students with enterprises and industrial parks in fields such as nuclear science and technology, marine engineering, biomedicine and advanced medical equipment, and artificial intelligence (SYSU News, 2022).

Disciplinary planning, degree programme design, and talent cultivation were increasingly aligned with national strategic priorities, scientific frontiers, and the demands of future industries. Priority was given to emerging interdisciplinary fields, strategically significant and undersupplied areas, and the development of high-calibre disciplines, with the aim of nurturing future-oriented, innovative talent. This approach was problem-driven and sought to dismantle disciplinary and curricular silos, fostering conditions for interdisciplinary, research-based, practice-oriented, and internationally engaged learning experiences.

5.4.5. Concluding remarks

As the SYSU case illuminates, institutional-level innovation activities are markedly distinctive from those enacted or perceived by individual interviewees, which centre on the day-to-day research, teaching/mentoring, and production activities. Institutional innovation activities primarily unfolded across four domains:

(1) university-wide strategic meetings and cadre training organised around "learning" national/local STI agendas and university leadership directives; (2) top-down strategic engagements for partnership-building and resource alignment, such as institutional visits, agreement signings, cross-sectoral exchange forums, and joint platform inauguration ceremonies involving senior stakeholders from academia, industry, government, and civic organisations, typically leadership of the partnering organisations; (3) institutional and managerial innovation in the strategy (e.g., deployment of campus space and disciplines), organisation (academic division reform, "large team, mega-project, and platform" model), governance (e.g., IPR and incentive policies, establishment of dedicated units and optimisation of governance mechanisms for managing innovation projects and outputs), and valorisation of innovation (e.g., evaluation frameworks centred on plural representative output); and (4) innovation in talent development, encompassing innovative design of student educational programs, academic leadership cultivation pathways, engagement in innovation and entrepreneurship contests, and capacity-building for administrative staff to professionalise innovation support services.

As entrepreneurial demands increased, institutional autonomy and intellectual freedom in pursuing innovation agenda were negotiated with state-driven priorities and market pressures that increasingly required integrating demand-side mindset into academic innovation. The central party-state and government steers innovation priorities through ideological oversight, policy directives, and performance audits closely linked to resource allocation and the reproduction of institutional status while allowing some autonomy and flexibility in enacting institutional strategic deployment and innovation practices. Market and industrial demands, often aligned with party-state objectives, further shaped academic innovation with application orientations. As illuminated by Clark (1983)'s trialogue of academic, government, and market forces, universities and scholars navigated the innovation priorities and practices of their intrinsic core with national demands and entrepreneurial opportunities. This interplay unfolded within a distinctive institutional environment where university innovation was concurrently shaped by central steering, political and market pragmatism, and academic agency (Zhu & Yang, 2024).

Despite the expectation for universities to take on multiple missions, policy documents tend to under-discuss tensions regarding the different institutional logic and priorities involved, as well as the internal heterogeneity of university faculties' interests. Efforts to introduce classified evaluation to streamline universities' innovation (as outlined in Chapter 4) face institutional and operational challenges in practice. For instance, as many university interviewees suggest, being curiosity-driven means that they are highly selective in the challenges they address and the results they publish. Problems without a sufficient intellectual "threshold", including many proposed by industry, tend to be opted out. For faculties who deem it more meaningful to orient research towards industrial or clinical demands, concerns arise about being marginalised or disadvantaged by academia's prioritisation of theoretical innovation and publication value.

Chapter 6 Government and industry in the innovation system

In response to the rest of RQ2, this chapter compares interviewees' perspectives on the core innovation activities of/within government and industry in relation to their respective roles in the GBA's innovation systems.

6.1. Industry

6.1.2. Principal actor in production, redistribution, and marketisation

The common perception across the three domains was that enterprises were survival-driven entities gearing towards business and market opportunities. Within an innovation system, the enterprise served as the principal actor in redistributing production materials and resources (e.g., control of product quality, cost, and price) and innovating business models in line with market demands. The innovation activities of the enterprise centred on production and commercialisation, though R&D also appeared prominent in some large enterprises or high-tech SMEs.

Both university and enterprise participants underscored the division of labour and collaboration in commercialising the university's innovative products. The resources and mostly also the interests of university academics merely enabled the development and testing of prototypes in small-scale ideal experiments. Most were yet to be eligible for standardised production, and not all contained commercialisation prospects. Given the distance between university innovation and the market, the enterprise took a principal position in sifting the prototypes or semi-products that catered to market demands, improving them with pilot-scale production and testing, and raising the yield of qualified products before mass production and commercialisation. In the words of UNI-ECE-P2, IND-P7 and IND-P9:

> "When technological barriers are mostly solved, the innovative achievements from universities will be transferred to enterprises for commercialisation." (IND-P7)

> "As long as the direction is right, and the functions or apparatuses are already semi-products, but funding is limited or there are other practical constraints from the market, then universities can hand them [semi-products] over to enterprises for mass improvement and large-scale commercialisation." (IND-P9)

Without specifying the processes of commercialising innovative achievements, the government participants also highlighted the principal role of enterprises in managing the market judgment, cost, and pricing of innovative products; attracting investment and eventually bringing these products to markets with effective business strategies and models. The 'marriage' between universities and enterprises was the most effective way to compensate the academics' lack of market knowledge and practical experiences. Based on combining the respective advantages of both, enterprises could 'launch innovative projects that illuminated new development trajectories or innovate business models such as taking the path of fin-tech to consecutively draw venture capitals and ultimately get listed' (GOV-P1).

Similar to the governmental expectation of attracting investment, the enterprises saw themselves playing a larger role in funding the "forward-looking" research at universities, even though this role tended to be played down among the academics. For instance, IND-P7 noted that enterprises "offer some convenience and support in research funding and facilities" at the early stage of technological innovation. Albeit agreeing that lending facilities from enterprise partners is more cost-saving than direct purchase, UNI-CS-P3 stated that the funding from collaborative projects with enterprise was oftentimes "very tight", "paid by installments", and just enough to cover the minimal costs. Even academics such as UNI-ECE-P3 and UNI-MatS-P4, who received a relatively larger amount of funding from enterprises indicated that funding was a trivial or less considered factor in relation to innovation-oriented collaboration. As stated above, the key contributions of the enterprise were still construed as the identification of demands, production, and commercialisation.

6.1.2. Heterogeneous STI capacities: exploratory and exploitative innovation

Despite these similarities, there were varying understandings regarding the drives of the enterprise to innovate, particularly in advanced STI, and whether the enterprise versus the university is the principal actor of innovation. Through the lens of university participants, the enterprise was also profit-driven, risk-averse, and highly utilitarian, always striving to minimise cost, improve performance, and secure a quick return on investment. Innovation was merely one of the means to serve these ends. Given the prudent consideration of cost and benefit, the enterprise's innovation tended to be incremental and exploitative, which oftentimes included "copycat", imitation, or "old solutions for new purposes" as common practices (UNI-PHA-P1, UNI-MatS-P5, UNI-CS-P5, UNI-ECE-P4, UNI-GEO-P1). Many of these were not even considered substantive innovations from an academic perspective. The comments from UNI-ECE-P4 and UNI-CS-P5 were typical of this line of thinking:

> "As business-driven entities, enterprises perhaps do not necessarily achieve much technological improvement, but as long as such improvement lowers cost, it is remarkable innovation...home automation including many combination locks, are indeed very convenient, but from our perspective, this technology is not that meaningful because it is too simple." (UNI-ECE-P4)

> "Albeit working in the research centre, I was mainly responsible for applying relatively mature technologies to the enterprise's product... I don't think they [enterprise] have substantive innovation, but from their perspective, this is certainly innovation in product performance and application as long as existing technologies are applied to improve the functions of their systems." (UNI-CS-P5)

Nevertheless, UNI-MatS-P6, UNI-ECE-P3, UNI-PHY-P2, and UNI-CS-P5 cautioned that enterprises were heterogeneous. Large enterprises (LEs) with national missions or high-tech SMEs tended to be more innovation-oriented and were more likely to collaborate with academia in advanced research and technological development. Some large enterprises even led sci-tech innovation in industries that were central to national development and security, as noted by academics such as UNI-GEO-P1, UNI-NE-P1, UNI-ECE-P3, UNI-ECE-P9, and UNI-ECE-P10, who had (or had attempted to build) collaborative partnerships with enterprises in electric power, nuclear power, and telecommunication industries.

Beyond the simplified perception of wholly survival-driven, risk-averse, and short-sighted entities among most academics, enterprise and government participants contended that the major drives, activities, and allocation of resources in enterprises revolved around the endeavour to gain a strategic balance between survival and prospective development. This balance sought to combine short-term development and long-term competitiveness, and in part corroborated what was mentioned above by a few academics. It took into account the heterogeneous nature and mission of the enterprise as well as the cost, time, and capacities required. As IND-P10 stated:

> "Besides using inventions to forge distinctiveness and barriers to tackle external pressures, enterprise's innovation needs to review and rediscover the value of things in the past to balance enterprise competitiveness. Whether invention or innovation is dominant depends on the nature of enterprise or the optimal solutions taking into account cost and time." (IND-P10)

Striving to pursue leadership in the commercialisation of IoT Technologies, IND-P3 also pinpointed that:

> "Enterprise needs to survive, so we use engineering technologies to address some survival problems. However, technological research needs to consider the cutting edges of technological development, and the accumulation of technological bases. Therefore, our research consists of two parts: one is forward-looking technologies...the other is research concerning engineering technologies and industrial implementation. Only the combination and balance of both make it possible to persist in the path we are taking." (IND-P3)

Government participants also highlighted that innovation was indispensable to the enterprise's survival at present and long-term viability thereafter amid fierce competition and rapid societal changes. As GOV-P1 noted, the enterprise was increasingly evaluated by the "forwardness" of products and the extent to which they cater to market demands. Though in a dilemma of balancing the two ends, more and more enterprises strove to develop "independent scientific and technological innovation capacity". Similarly, in the remarks of GOV-P2:

> "Without innovation, there is no future for the enterprise. If you look at the high-tech enterprises that I am currently encouraging to upload their innovative achievements, R&D investment is the key. Having R&D means the enterprise looks into the future, and has innovation...without innovation, it is very difficult to accumulate or even survive in China...for large or small enterprises, the whole innovation landscape is changing rapidly." (GOV-P2)

From a governmental perspective, the enterprise, as the principal market entity and innovation actor, had supported the technological and economic development in China throughout different stages. Notably, in the early stage of building up of national innovation capacities, enterprises had oriented to the catch-up development of innovation through effective import, imitation, and learning from developed economies of cutting-edge technologies. Thereafter, there were continuous efforts in forging core competitiveness through innovation in science, technology, and organisational development trajectories. As GOV-P2 explains:

> "The initial innovation in China...revolved around sales and trading. In fact, at that time, we had neither talent nor technology. Just try to learn and trial slowly, so perhaps there were some so-called copycats. It was the particular experience of the time...but now we have passed the time of barbaric growth, and innovation has become the key to forging core competitiveness." (GOV-P2)

Similarly, UNI-CS-P2 asserted the principal role of the enterprise and industry in innovation, particularly in creating value for human production. UNI-MatS-P4, UNI-PHY-P2, and UNI-CS-P2 stated that academic innovation should be closely associated with the development of the production chain. Taking the Autostereoscopy industry as an example, UNI-PHY-P2 explicated that some professors had attempted to establish companies and commercialise their achievements, but were mostly unsuccessful because the industry was nascent, the limited scale of which failed to support the investment of these companies.

> "For value creation, the principal innovation actor should be the industry, rather than universities....University can't run a company and can't make it listed even if there is one...The re-combination of productive forces and relations of production, namely business models, commercialisation, and eventually monetisation, all hinge on the industry." (UNI-CS-P2)

By contrast, UNI-MatS-P5 and UNI-PHY-P2 indicated that university teachers were the overarching actors of innovation, or at least so before the enterprise had developed sufficient independent innovation capacity:

> "As university teachers, innovation mostly depends on ourselves. We

discover something innovative in both scientific and practical senses through years of accumulation, some of which have certain market prospects. Then we strive to bring them to market." (UNI-MatS-P5)

> "At the current stage, the support of universities is still indispensable to enterprises' development. This is because the application in the Autostereoscopy domain still demands something highly professional and specialised. Therefore, even large enterprises are looking for supportive research teams to conduct experiments from many universities." (UNI-PHY-P2)

6.2. Government: the macro organiser, regulator, and facilitator

Governmental innovation was commonly perceived as "macro", "broader", and "multifaceted" than innovation in the university and the enterprise. It took into account political, economic, cultural, scientific, and technological dimensions (UNI-LS-P2, UNI-PHY-P2, UNI-MGT-P2, UNI-ECE-P4) and values "innovative elements and dynamics of all sorts" (GOV-P2). Government strove to incentivise and facilitate the innovation of all social actors, 'mass entrepreneurship and innovation' in particular. On top of this, both the university and government sides underlined government's macro role in facilitating sci-tech development, social stability, and the well-being of people. As GOV-P2, UNI-LS-P2, and UNI-ECE-P4 expounded:

> "Innovation involves all walks of life, not just enterprise. Even a cook can invent a new cuisine...so it is important to identify innovative elements, drives, and dynamics of all sorts...to innovate centred on the changing demands of people since that's primary drive of social progress...the society encourages everyone to partake in innovative and entrepreneurial activities." (GOV-P2)

> "Governmental innovation is broader, meaning that all industries and actors strive to innovate, dedicate, and better our institutions and products in their own positions...allow people to lead a more comfortable life." (UNI-LS-P2)

> "We [university teachers] evaluate innovation more from technological perspective, but government and enterprise consider not only technological factors...government may have political considerations, say institutional innovation, stability, the livelihood and well-being of people, the innovativeness of policy or something like that." (UNI-ECE-P4)

6.2.1. Policy and institutional innovation

Regarding innovation in government, most industrial interviewees specified its multifaceted feature as the multiple levels, functions, and goals of government divisions as well as the heterogeneous and complex local realities, sectors, industries, or enterprises that different divisions needed to tackle. It was difficult to reveal and articulate the full spectrum of governmental involvement in innovation.

For instance, when asked about the potential influence of government on the enterprise's innovation, IND-P1 expressed uncertainties regarding the level of specificity to go into, since government was involved in "too many domains" and issued many guiding documents for different domains. IND-P4 also stated that government departments had "different functions and goals to achieve." Nevertheless, the multiplicity of government divisions and the complexity of local realities also made it possible for discretion in the formulation, intersection, and enactment of policies, where government sought innovative approaches to address development priorities at different levels and for different localities. This is considered a crucial form of governmental innovation by IND-P7 and IND-P9:

> "Things in China are very complicated. Every place is different. Even the top-down enactment of central policies varies...There are discretion and characteristic adaptations in policy enactment, and intersections between different policies. Perhaps Credit Investigation Policy will take the first part from one policy and then get the second from another...the governmental support that each enterprise needs also differs." (IND-P7)

> "Addressing key and core problems requires the guidance of high-level government, like supporting scientific research with national-level policies. Provincial governments can make arrangements based on the demands of local industries and their future plans and aptly lean towards these priorities." (IND-P9)

Despite noting the variances in local policies, UNI-LS-P2, UNI-MatS-P7, and GOV-P2, whose remark were relevant to this line of thinking, did not associate such variances with innovation. Alternatively, GOV-P2 stated that policies were largely similar across districts, in line with what issued by higher-level government, though there could be differences in the key local industries receiving support. Instead of focusing on different policies, UNI-MatS-P7 argued that what remained crucial was the "actual implementation". In similar vein, IND-P10 stated that the change of policies and rules were not innovations due to the lack of operational systems, though UNI-MGT-P2 argued that filling in the "policy lacuna" brought about by specific emerging issues constituted a form of governmental innovation.

6.2.2. Digital governance

However, IND-P10 and academics such as UNI-PHY-P2 and UNI-GEO-P3 shared a similar view that institutional innovation was another form of governmental innovation. Typical examples were "digital governance", the digitalisation of administrative work; and improvements in the formulation process of policies or the management of funded projects, such as the Chinese government's shift from extensive investment to a currently more selective open funding mechanism, as observed by UNI-PHY-P2 and IND-P8. Finally, IND-P10 added that government could also innovate with "open ears", absorbing and "filtering social voices" with the aim to augment diverse forms of wealth and the overall benefits of society. These two forms of innovation were in part corroborated by GOV-P2, who stated that government strove to keep pace with societal and economic changes, particularly the evolving demands of people, by balancing various agendas and priorities of innovative development and coordinating the "professional work" of different departments every year.

6.2.3. Public funders and venture capitalists

Interviewees across academia, industry and government contended that the role of government in leading, regulating and facilitating the innovation across sectors through funding, directional guidance, policy and institutional support, and service provision. Governmental funding remained overarching to basic research, the fundamental source of innovation. As GOV-P1 and GOV-P2 noted, the uncertainties and long development cycle of basic research determined that it was mostly funded by government, particularly at the national level. The significance of governmental funding was also corroborated by most university academics. The vertical projects (纵向课题) funded by government were the overarching support for academic research across different disciplines, besides those in basic science. This support was crucial for faculty whose academic research was interest-driven and possibly went far beyond the current demands of enterprises or social development. Typically expressed in the words of GOV-P1, GOV-P2, and UNI-ECE-P5:

> "Every year, the major fiscal, science, and technological spending of our country is on basic research, which is mostly undertaken by higher education institutions and research institutes." (GOV-P1)

> "Basic research demands patience. You can't invest today and think of the returns tomorrow. Let alone three to five years, even several decades is not necessarily enough for any disruption or breakthrough in basic science to emerge. Therefore, basic research can't rely on social resources. It's invested by nation-states." (GOV-P2)

> "We [university academics] don't just consider the enterprise's demands. Most of our research funding sources from national government, supporting the scientific exploration that interests us...like now, no one knows how the detection of gravitational waves is going to be useful...perhaps not even after billions of light years, but science is still about exploring something new." (UNI-ECE-P5)

Similarly, a few industrial interviewees, who applied for or had undertaken funded innovative projects, also underlined the role of government funding, which was not limited to basic research. IND-P3 and IND-P4 noted that government sponsored an array of research projects, and invested in the construction of innovation demonstration zones through the coordination of fiscal and financial policies. Both lines of policy provided enterprises with opportunities to develop novel technologies through trial-and-error.

6.2.4. The baton of administration

Although it was barely mentioned by the government, both the enterprise and university participants underlined the importance of directional guidance or the baton of administrative power. The common expectation of the baton was to signal a further movement away from the extant publication-oriented assessment and indicate more effective alternatives. Another expectation from the university academics was that official guiding documents should clarify the boundaries of academics' involvement in entrepreneurial activities. This was typically expressed by UNI-CS-P3:

> "Besides offering some convenience or incentives, government should clearly define things concerning industrial collaboration or starting business in policy documents. Otherwise, everyone [university academics] might dread." (UNI-CS-P3)

The enterprise side emphasised guidance in making macro planning, arrangement, and adjustment in aspects such as development of core technologies, cutting-edge research areas, and key industries, guiding all innovation actors to develop in line with these layouts and deployments. For instance, IND-P2 stated that:

> "We normally reference to government's innovation directories to find out what's in urgent demand. Picking tracks in this way makes it easier to gain policy support." (IND-P2)

Taken further, IND-P9 noted that the macro planning and guiding role of government remained very significant to the long-term development of the country and industry. Many bottlenecks China was currently faced with, such as the shortages of silicons and chips, resulted from a lack of in-advance arrangements, which had influenced the stability of various industries. Ideally, as IND-P9 illuminated:

> "Government should learn more proactively about the status quo of industries in depth, knowing where the areas of weakness lies, and what according policy support can be...need to take innovation as something to foster in the long run, instead of wishing for intensive production of large achievements within a short period of time...it is crucial to have early layout and

deployment, and then balanced development, supporting research across relevant disciplines and sub-fields." (IND-P9)

Two types of policy support were discussed: incentivising policies and regulatory policies. Incentivising policies that were deemed more relevant to the enterprise were tax reduction and financial subsidy. According to IND-P9, tax reduction had more direct impacts in attracting key innovative industries to cluster in particular localities,. The aggregation of capitals, facilities, and personnel led to lower cost and increased the supply of core resources and technologies. Funding and financial subsidy enabled the kick-starting of many innovative projects (IND-P7). On the side of government and university, incentives were mainly discussed in relation to the external rewards for academics who took part in commercialising innovative achievements. As GOV-P2 explicated:

> "Just a few professors have genuine interests in transforming their achievements...but government is promoting this, hoping to formulate a benefit-based incentivising scheme with some policies, so that professors can gain more economic benefits from the transformation...and we are indeed seeing some positive results now." (GOV-P2)

Regulatory policies were merely discussed by participants from the enterprise and government. As IND-P1 implied, regulatory policies monitored and assessed innovation activities, which often entailed monitoring the implementation of other policies and regulations such as energy safety policy and environmental regulations. These policies set out to assure that innovation activities were undertaken 'in the right direction' by penalising violations. The process of seeking solutions to fulfill regulatory requirements could lead to spillover innovation since 'anything can't be completed with existing solutions all necessitates innovation, being scientific, technological, or managerial' (IND-P1). GOV-P2 also underscored the regulation of innovation activities, but emphasised protecting IPRs and the establishment of a credit system. In the words of GOV-P2:

> "In contemporary society, government attaches remarkable significance to the establishment of credit system. Any infringement of intellectual property rights is detrimental to enterprise development. This depends on government regulation...any enterprise attempting to 'innovate' with copycats and infringe property rights needs to undertake legal consequences." (GOV-P2)

6.2.5. The "resource and service provider" and central coordinator

Government was also commonly construed as a "resource and service provider". This included fostering innovation-facilitating and coordinating policies, institutions, and mechanisms to serve the innovation activities of different actors. For government, an innovation-facilitating environment was where resources and forces of all sorts, including but not limited to that of universities and research institutes, were drawn to serve the innovation of enterprise and the improvement of productivity. In part resonating with the governmental perspective, however, the enterprise participants further expected such an environment to be open to trial and error. This was similar to the academic expectation of a facilitating environment that enabled interest-driven explorations, many of which were also experimental.

Despite the facts that funding and subsidies help kick start innovation, IND-P7 cautioned that policy coordination was more crucial to sustaining innovation. For instance, besides professional development, the demands of innovative talents for living facilities and children's schooling could only be addressed by coordinating policies across Science, Technology, Human Resources, Housing, and Education. Similarly, it was noted by GOV-P1 and GOV-P2 that favourable living and working environments were central to attracting and retaining innovative personnel, the critical assets of innovation. Moreover, as IND-P3, IND-P4, IND-P7 and IND-P8 underscored, coordinating institutional support was also significant, which could be achieved in several ways: a) setting institutions and mechanisms that specified the timeline and requirements of, for instance, the tender process of novel technologies; b) opening up more application settings and demonstration zones to test and improve innovations; c) establishing service organisations for innovation. As IND-P7 explained:

> "For the demonstrative guidance of some novel technologies, government needs to establish particular and clarified institutions because when a novel technology emerges, the tender process can take a year or a half...AI applied technologies usually become outdated after half a year. Therefore, government support that goes in line with the development pace of technologies still require joint efforts...funding is merely for kicking start; to persist, you need to scaffold the demonstration of Metauniverse's application." (IND-P7)

Said IND-P3, whose enterprise manages to accelerate mass commercialisation of technologies through the application settings opened by government:

> "There are many trial-and-error mechanisms, and open enterprise and government application settings for experimenting novel technologies and broadening the horizons of enterprises...We work on Smart City, our proprietor is mostly government at different levels. Now they are willing to open settings for enterprises to deploy the application of Smart City...this requires substantial resolution and investment from government." (IND-P3)

Working in an innovation service organisation founded by the Bureau of Human Resource and Social Security and guided by the Science and Industrial department, IND-P4 stated that the organisation provided enterprises with investment suggestions, innovation and entrepreneurship training, venues for Roadshow, and fast-track personnel and legal services on site,. These facilities originally needed to be handled by various government bureaus. GOV-P2, who guided and supervised this organisation, corroborated that the organisation had been a significant ‘platform’ enabling innovation-oriented collaboration across sectors and ‘a bridge between enterprises and social capitals and resources. Bridging the collaboration between enterprises and other innovators was also deemed the focus of GOV-P1’s work.

6.2.6. Challenges in strategic foresight and systemic orchestration

Despite government’s intention to play a prominent role in leading innovation, there were shared concerns from both the university and enterprise sides that government lacked the expertise in and dedication to identifying the overarching areas of innovation, supporting the whole process of transforming innovative achievements, and examining the value of these achievements independently. Government oftentimes relied on experts’ and scholars’ reviews. Similar to IND-P9’s earlier remarks, IND-P8, UNI-PHY-P2 and UNI-MatS-P4 indicated that in-advance layouts of innovative development and many innovative projects such as that in Autostereoscopy were highly specialised, which added to the challenges for government in claiming leadership. As UNI-PHY-P2 explains:

> “Government always wants to play a role, performing some leadership and funding projects. In fact, our government has invested substantially in Autostereoscopy for over a decade, perhaps having invested billions, but saw scant achievement...this is because when the industry was yet to take off, extensive investment and overspeed in development would incur many issues.” (UNI-PHY-P2)

Another challenge, as IND-P8, UNI-PHY-P2, and UNI-MatS-P4 explicated, was inherent in the collective structure of Chinese government. While there was yet to be any individuals or a department targeting the transformation of innovative achievements, the collective decision-making mechanism necessitated the participation of experts and scholars, the reviews of whom potentially became the means to avert or transfer the responsibilities of making decisions. Such review was not necessarily effective, in part because of the existence of ‘circle culture’ among some policymakers and experts, as well as the reality that many academic experts could not necessarily fully determine the quality of innovative achievements, particularly those involving practicality. In the words of IND-P8, UNI-PHY-P2, and UNI-MatS-P4:

> “None is working exclusively on innovation or the transformation of sci-tech achievements. Government in fact consists of officials at different levels. Civil servants are limited by their own knowledge and the whole mechanism of governance. Most are just fulfilling their duties.” (IND-P8)

> “The team in charge of sci-tech policies used to have a ‘circle culture’. Those

inside the circle did not take the funded projects seriously enough...few carried it through to the end...now to improve efficiency, the open competition mechanism is implemented to select the best candidates to undertake key research projects. Invest 30 million in a particular domain and allow the entire nation to put in applications. There are clear application requirements and indexes." (UNI-PHY-P2)

"Chinese government adopts collective decision-making., and nobody needs to take actual responsibility. So eventually we turn to the so-called experts and scholars. However, few scholars can solve practical problems. Those who currently have strong say in the administration like the president of university or deans all rely on reading and writing papers." (UNI-MatS-P4)

Chapter 7 Universities amid multisectoral innovation collaborations

In response to RQ3, this chapter illuminates how universities and academics engage in innovation-oriented interactions with industry, government, and civil society across subsystem, organisational, project and individual levels. Individual interviewees, departments and institutions act as nodes of different collaborative networks within or/and spanning higher education, industry and government. Despite potential hybridisation among university, industry and government spheres, each retains its distinct institutional core and independent network with priorities and interests that potentially create tensions in cross-sectoral collaboration.

This chapter is structured into five sections, presenting key interaction models, actors, collaborative activities, opportunities, and challenges, illustrated through interviewees' cases and supplemented with institutional documents and official media. The first section briefly discusses multi-sectoral interactions in relation to Quadruple/Triple helix and highlights the need for a 'post-Triple-Helix' approach to the heterogeneous and dynamic roles of each helice across different projects and specific fabrics of connections, particularly given the political, institutional and cultural heterogeneity of the GBA. The following sections illustrate interaction models across the domains of a) business and entrepreneurship; b) power and energy; and c) medical and pharmaceutical sciences. Each domain is illustrated with collaborative cases, with different constellations of actors and patterns of interactions with constituencies based on interviewee retrospective accounts, although not all actors depicted have been interviewed. These models seek to capture the snapshots of major actors but do not cover all actors and institutions or fully capture the evolving demands and interactions.

7.1. Subsystem-level Triple and Quadruple Helix configurations

Interviewees across academia, industry and government note the Party-state and central government' pervasive role as the overarching funder of innovation projects, guardian of ideologies, and of innovation priorities and their institutionalisation, and central organiser of innovation activities steering multi-sectoral interaction. Unlike Etzkowitz and Leydesdorff (2000)'s simplified statist configuration, interviewees observed a blend of central directives and local devolution, where mainland local government constituted a distinct sub-sphere within the central state's domain (Cai & Liu, 2015; Cai, 2018). Local governments adapt central directives into policies addressing local development priorities, serving as regulators, facilitators and potential partners of collaborative innovation. Some successful initiatives, starting between municipal local governments and academics, draw central attention and escalate into national platforms.

7.1.1. Guangdong: the statist-fading, local government-led Triple Helix

As depicted in Figure 7.1, as the pilot and demonstration zone for reform and opening-up[18], Guangdong's innovation system features a statist-fading Triple Helix

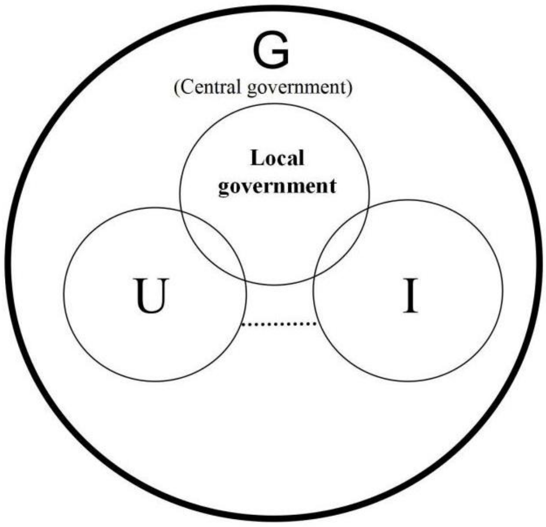
[18] https://www.gd.gov.cn/zwgk/zfgzbg/content/post_4359472.html

model marked by enhancing local government leadership. According to interviewees across sectors, local governments in Guangdong strategically mobilised the mix of policy tools such as tax incentives, land allocation, infrastructure investment, and public procurement to stimulate innovation demand. On the supply side, they adopted a dual strategy of attraction and cultivation for innovation actors (e.g., universities, high-tech industries) while actively organising and facilitating collaborative innovation across sectors. Guangdong also leveraged policy experimentation to pioneer local solutions that potentially scaled up to or inform national initiatives.

Guangdong governments engaged directly with the industry through activities such as enterprise visits, business-government meetings and policy promotion events (IND-P1, IND-P2, IND-P3, IND-P4, GOV-P1, GOV-P2, GOV-P3). Aside from key-node faculties who hold advisory roles, provide cadre training for officials and lead government commissioned projects, the university-government relationship was generally perceived as distant. Connection was limited to standardised funding application online and compliance with central directives of strategic innovation domains, institutional development, programme setting, and student admission (e.g., UNI-CHE-P1, UNI-ECE-P2, UNI-ES-P1). Universities and industries in Guangdong operated under distinct institutional logics, leading to a structural disconnect. Higher education had traditionally prioritised teaching and basic research, with research-intensive universities concentrated in core cities (e.g., Guangzhou, Shenzhen, Zhuhai) whereas others remained underdeveloped in research and technology transfer.

Besides the under-supply of universities, the disconnection also stemmed from constrained industrial absorptive capacity. Guangdong hosted a comprehensive industrial chain encompassing manufacturing, strategic emerging industries, and modern services. However, industrial innovation capacity followed a “pyramid” structure: leading firms, mainly SOEs drive industrial upgrading and cross-sector collaboration, as notably seen in the power and energy sector (IND-P1, IND-P8, IND-P9, UNI-NE-P1). While many remaining SMEs perform well in manufacturing and some qualify as high-tech, they often lacked innovation capacity and university-industry collaboration, with survival pressures remaining a key concern (UNI-CS-P3, UNI-MatS-P2). U-I alignment remained sporadic and difficult to sustain without government intervention and mediation from key-node individuals and the leading enterprises whose practices cross-cut institutional spheres (“dotted connections”). The intermediary bridge at the sub-regional and institutional levels notable in the Shanghai Tongji Cluster (Cai &Liu, 2015) remained largely lacking in the GBA.

Figure 7.1 Guangdong: statist-fading, local government-led Triple Helix



Source: Author's adaption from Etzkowitz & Leydesdorff (2000) based on integrated analyses of interviews, academic literature and documents

Amid the dotted bottom-up connections with the industry, university interviewees were involved in technology transfer, joint technology development, technological services and consultancy. Beyond contractual partnerships, some became shareholders and launch spin-offs to retain greater autonomy in strategising the commercialisation of their IPs and innovation pathways (UNI-MatS-P4, UNI-CS-P2, UNI-ECE-P1, UNI-PHY-P2, UNI-PHA-P3). While addressing operational stability and financial viability, the "academic heartland" remains central to these enterprises (Marginson & Considine, 2000; Clark, 2001), where faculties enhanced the social value of academic projects, improved publication quality, and amplified scholarly reputation. The competitive advantages of these SMEs were largely built on academic innovation and re-capitalisation on research capacities other than profit extraction, though the persistence of this trajectory remained contested and tentative.

By taking the roles of "academic entrepreneur" and "entrepreneurial scientist", university interviewees multiplied project funding, particularly those targeting commercialisable innovation. As industrial representatives, they engaged more directly with local governments through enterprise symposiums and negotiations for locating spin-offs in industrial parks where local governments acted as "public venture capitalists" and place-branders alongside regulators, attracting enterprises with preferential policies, subsidies and investments (Etzkowitz & Zhou, 2019, p.374). These synergistic roles augmented their standing as polymath exemplars within universities, advisors on government expert panels for innovation projects, and mentors for provincial/national-level innovation and entrepreneurship contests.

Besides fulfilling the "third mission", synergistic resources and capabilities feed back to research and teaching. Spin-outs, application scenarios, and user feedback inspire new scientific inquiry while providing students with real-world projects to work on and improve employment prospects, with some securing full-time positions in spin-offs upon graduation. This kind of student apprenticeship not only reduced operational and staffing costs, but also supplied spin-offs with graduates who were more likely to become trusted partners and employees, aligning more closely with the research groups' cultural practices and intended trajectory of academic entrepreneurship than would externally-hired staff.

Adaptive capabilities were developed to coordinate hybrid institutional priorities and responsibilities and sustain cross-sectoral practices with finite time, energy and sociability. Many university interviewees initially established spin-offs in university parks for convenience of commuting while eyeing the possibility of moving to larger, more affordable industrial spaces as the ventures took off. Noting the de facto constraints on faculties' industrial appointments, imposed by university administration, despite their stipulated support in policies, some became "institutional entrepreneurs" seeking leeway to maneuver institutional rules (Abdelnour et al., 2017, p. 1776; Ma & Cai, 2021, p.912) and retaining negotiating autonomy in relation to executive control. This autonomy increased as they accumulated success and reputation from cross-sectoral practices. Their lived experiences served to blur the institutional boundaries and potentially expand the property relations of academic space, where science parks and infrastructures supportive of commercialisation were appropriated as universities' "expanded developmental periphery" (Clark, 1998).

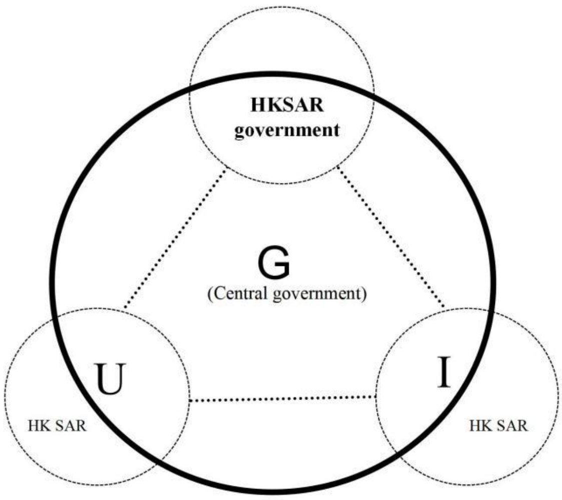
Some dotted connections were also facilitated by industrial interviewees, who took the "role of the other" (Etzkowitz, 2004) as adjunct lecturers and supervisors at universities while engaging in research and co-authoring publications at facilities jointly established with university partners. These bottom-up connections, despite limitations in scale, assisted a transition towards a balancing Triple Helix configuration, particularly when connections gained institutional endorsements from universities and governments. As interviewees across the different sectors noted, this transition necessitated plural strategies and pathways. Intermediaries (e.g., public/private research institutes, government agencies, service organisations), though deemed largely replaceable by hyrbrid organisations and integrative "boundary spaces" in Triple Helix (Etzkowitz & Zhou, 2019, p.367), remained essential for brokering different logics, priorities, and extant 'structural holes' in connections and functions across institutional spheres and borders within the GBA. Reaching the ideal triparite balance observed by Cai (2018) even in sub-centres as Guangzhou and Shenzhen, remained elusive given the long-standing university-industry separation and mismatches in absorptive and provisional capacities.

7.1.2. HKSAR: Laissez-faire Triple Helix

As summarised in Chapter 1, SARs enjoyed significant autonomy under the "one country, two systems" framework, managing internal legal, administrative, and financial affairs, as well as external economic and cultural engagements. This partial autonomy was illustrated in Figure 7.2. Despite aligning with central Party-state directives, HK universities and industries were administered and funded independently by the HKSAR government. As interviewees from both SARs and Guangdong observe,d the university-industry-government relationship of HK, with its non-interventionist government tradition, generally indicated a laissez-faire model where sectors remained largely disconnected. This persisted despite scholarly expectations of transition toward a balanced quadruple helix model that includes civil society as the fourth pillar (Mok & Jiang, 2020).

The HKSAR government's path-dependency in relation to a finance-led economy and foreign supply for public construction and procurement limited its capacity to transform HK into an innovation-driven model. HK academia had long lacked direction in relation to R&D innovations that contributed directly to industrial and social development or national capacity-building. HK industry, limited in scale and predominantly service-oriented, also exhibited constrained absorptive capacities and incentives for academic innovation. While "dotted connections" were moderately facilitated by faculties, their industrial partners, and bureaucrats in pertinent departments, even key-node interviewees holding positions in the HK Legislative Council and government committee,s noted difficulties in having their advice "heard" and acted upon by the HKSAR government. This inertia, which was perceived as demanding greater endeavour to shift, contrasted with the adaptive governments in Guangdong.

Figure 7.2. HKSAR: Laissez-faire Triple Helix



Note. Dotted circles indicate partial autonomy the central government of the P.R.C. Dotted lines between institutional spheres indicate largely separate boundaries with unsystematic, sporadic bottom-up connections.

Source: Author's adaption from Etzkowitz & Leydesdorff (2000) based on integrated analyses of interviews, academic literature and documents

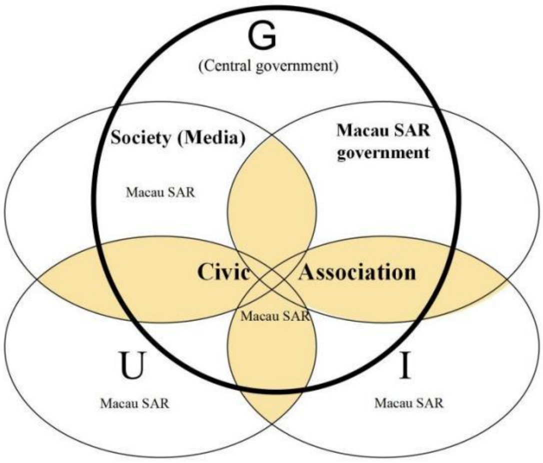
7.1.3. Macau SAR: Balanced Quadruple Helix

Macau SAR also enjoyed partial autonomy from the central Party-state, though with a more embracing attitude towards mainland policies and practices than HK, as noted by interviewees from both SARs and Guangdong. According to Macau interviewees, Figure 7.3 illustrates Macau SAR's balanced quadruple helix configuration where civic associations played a "quasi-governance" role in mediating interactions, fostering consensus-building, and enhancing social cohesion across sectors and society. The Macau government collaborated with civic associations—such as trade unions and chambers of commerce—to co-develop innovation policies, select leadership, identify policy needs, and deliver services. However, long-term reliance on such partnerships had weakened the government's own policymaking capability (Macau Basic Law Promotion Association, 2021; Lou, 2024). University faculties engaged in multisectoral collaborations by assuming roles in civic associations with varying specialisation, and established connections with particular communities, sectors, and government departments. They compiled demands from academia and beyond into proposals submitted to the government while facilitating public communication of government policies and stakeholder concerns on media.

Multisectoral interactions were further advanced by the close-knit interpersonal relationships within such a "small" community, where university faculties, even without institutional roles, can recommend partners across sectors, who were essentially their acquaintances (UNI-DS-P1, UNI-CT-P2, UNI-ECE-P9, UNI-EE-P1). Besides the influence of communities and media, the society pillar was also perceived as increasing massive participation in innovation, reflected in government-funded projects that were being opened to applications from Macau residents, not just HEIs (UNI-CT-P2). These small community and "civic association society" interaction mechanisms were highlighted as key attributes in achieving societal consensus on policies and development agenda concerning and beyond innovation, noted by a native Macau interviewee:

> "Unlike HKSAR, Macau doesn't have political parties. Civic associations coordinate governance...so the government seeks support or advice from pertinent associations when promoting different policies...such interactions are very harmonious...Connections rarely extend beyond 'three layers'. Even if I don't know you, I may be the friend of your friend." (UNI-ECE-P9)

Figure 7.3. Macau SAR: Balanced Quadruple Helix



Source: Author's adaption from Etzkowitz & Leydesdorff (2000) based on integrated analyses of interviews, academic literature and documents

Although Figure 7.1-7.3 illustrate interaction patterns in local innovation systems across Guangdong, HK, and Macau based on interviewees' accounts, faculties and stakeholders in different projects and networks held varying roles and primacy, capitalising on different sets of resources and capabilities. Depending on the demands of collaboration and the attributes of connections, each helice can be the initiator, central organiser, facilitator or participant of innovation activities. Some domains for instance, are notably industry-driven while others are led by cutting-edge academic innovation. In existing literature, the fourth pillar in quadruple helix is mainly conceptualised civil society (CS), manifesting as citizens, communities, "media and culture-based public" as well as intermediary organisations and demand sides such as users (Carayannis & Campbell, 2009; González-Martinez et al., 2021).

Context-specific configurations across projects, partnerships, and domains, particularly where sectoral networks with varying attributes intertwine and potentially reshape local innovation systems, remain under-discussed in extant helix models and innovation system approaches. Hospitals, for instance, constitute the fourth pillar in medical and pharmaceutical domains as both demand and supply sides. Civic associations, government-owned enterprises and research institutes of varying ownership structures can all serve as intermediary organisations. Hence, the following sections will demonstrate the interaction configurations of key-node faculties and stakeholders across various projects and domains.

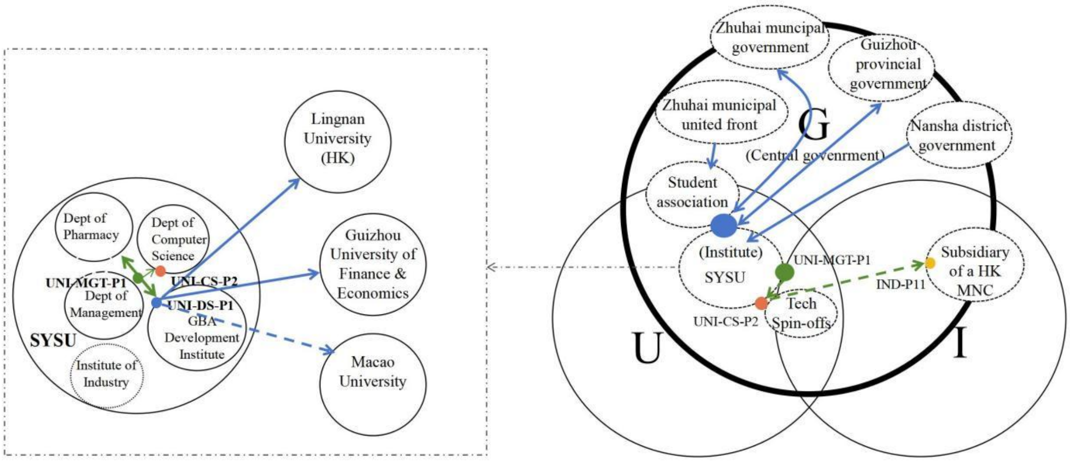
7.2. U-I-G-CS collaborations in business and entrepreneurship

Figure 7.4 and Figure 7.5 respectively demonstrate multi-sectoral interactions led by university faculties and by quasi-government agencies and industrial stakeholders. Despite a similar focus on expanding innovation and entrepreneurship, they differ in drivers, priorities, and ways of forging collaborations.

7.2.1. Collaborations driven by the academic network entrepreneurs

Figure 7.4 demonstrates the collaborative networks of UNI-MGT-P1 and UNI-DS-P1 and the multi-departmental collaborations they jointly led in incubating academic innovation and entrepreneurship. The relative size of interviewee nodes indicates their significance in brokering connections, initiating collaborations, and influencing outcomes, with key nodes such as UNI-DS-P1 and IND-P10 represented by larger nodes. Government autonomy varies across municipalities and districts in Guangdong. In this case, Zhuhai, with its Hengqin zone where the University of Macau is located, was entrusted with autonomy for experimentation and demonstration of deep cooperation with Macau. Similarly, the Nanshan District of Guangzhou, as a Free Trade Zone, enjoyed notable autonomy in directly allocating research funds to SARs and approving cross-border movement of research essentials[19].

Figure 7.4. Collaborations Driven by the Academic network entrepreneurs



Note. Linkages share the same colour with initiating nodes. Arrows point from leading/initiating to involved entities. Bi-directional arrows indicate mutual interactions. Direction, formal involvements are presented in solid arrows whereas dashed arrows represent personal connections, attemptive collaborations or mediating interactions such as the occasion where UNI-DS-P1 facilitated collaboration without direct involvement. The left diagram zooms out the multi-departmental and institutional collaboration in the university sphere, where the dotted circle indicates the Institute of Industry under construction.

Source: Author's conceptualisation based on interviewees' accounts and pertinent secondary data

As an experienced mentor and panel expert in innovation and entrepreneurship events overseen by Guangdong governments, UNI-MGT-P1 was tasked by SYSU leadership with cherrypicking and training university teams for the China "Internet+" College Student Innovation and Entrepreneurship Contest. Through different formal events and informal networking, UNI-MGT-P1 introduced various departments, faculties and projects to industrial stakeholders and venture capitalists. UNI-DS-P1 initially intended to connect UNI-CS-P2, who has spin-offs and substantial industrial

[19] This autonomy is stipulated in the *Overall Plan of Nansha of Guangzhou for Deepening Comprehensive Global Cooperation among Guangdong, Hong Kong, and Macao*, and the *Nansha Regulations* on top of the GBA initiative.

experiences, with IND-P11, a SYSU alumnus and subsidiary manager of a HK Multinational Corporation, to form a contest team.

This attempt was suspended as UNI-CS-P2 was concerned about conflicts of interests and objections from his shareholders regarding presentation to other investors. Meanwhile, the Department of Pharmacy, led by its head and Communist Party branch, invited UNI-MGT-P1 to their Project Consultation Meeting. Under the MOE's "paired-up" supporting scheme, the department had partnered with counties in Yunnan province to apply their academic innovations to extend local industrial chains and product value, for instance by co-establishing pharmaceutical production bases and improving cultivation techniques. Many projects presented in the Consultation were based on these partnerships' achievements and plans.

UNI-MGT-P1 was invited to guide the department's contest entries, and provide feedback on project presentations, and brought management students to polish these presentations and business plans. As the departmental Party Secretary, UNI-MGT-P1 emphasised the significance of Communist Party branches in channeling university resources for industrial development and innovation in impoverished areas and this Party-led approach as a distinct Chinese innovation model. Additionally, to connect the department's new projects to broader entrepreneurial opportunities, UNI-MGT-P1 invited UNI-DS-P1, a Macau researcher at the Institute of GBA development with extensive networks beyond academia, to evaluate project feasibility and recommend collaborative resources.

UNI-DS-P1 promptly introduced the preferential policies associated with launching these projects in Zhuhai and a cross-departmental partnership was established since then. Beyond the Contest, the partnership continually capitalised on strategic decisions in project selection and outlining pathways for spin-outs. After months of internal deliberations and UNI-DS-P1's negotiations with the Zhuhai government, a foundational company structure was crafted, and the government agreed to provide initial funding for Project A to launch in Zhuhai, while in return retaining its equity shares. Nevertheless, the collaboration encountered a setback as the project's leader attempted to redirect the funding to another project, the replacement of which UNI-DS-P1 deemed to be lacking in integrity.

To preserve the partnership, UNI-DS-P1 diligently mediated between the Pharmacy Department's head and the Zhuhai government, eventually leading to an agreement on selecting alternative projects from the department. To facilitate systematic collaboration across different projects, UNI-DS-P1 started involving SYSU's university leadership to elevate partnerships to a university-wide level where negotiations were underway for establishing the Institute of Industry at SYSU's Zhuhai campus. The Zhuhai government had been an active public venture capitalist and partner, endorsing the establishment of a new SYSU institute and spin-offs in Zhuhai.

Besides brokering cross-institutional collaborations, UNI-DS-P1 leveraged personal connections with senior Macaunese academics to facilitate SYSU colleagues' appointments as visiting professors at Macao universities, fostering joint Ph.D. training and regular academic exchanges. In a personal capacity, UNI-DS-P1 collaborated with the Hengqin government in developing a school curriculum aligning with central party-state's ideologies, for which the government acquired the copyright. Interactions with wider universities and governmental networks were also enhanced through civil organisations. For instance, as an advisor to the Association of Mainland Students in Macau Higher Education, UNI-DS-P1 participated in talent acquisition, academic exchanges, and student career development activities hosted by the Zhuhai municipal United Front.

Beyond the designated "9+2" cities in the GBA initiative, UNI-DS-P1 mobilised resources and connections in Guizhou province. Levering board membership in the Guizhou Overseas Association and part-time professorship at a Guizhou University, UNI-DS-P1 formed an advisory group to assist the Guizhou government localise policies in line with central directives while identifying strategic opportunities for involving in the GBA agenda, particularly by strengthening connections with Macau. To navigate the prevailing preference for "seniority" and established "credentials" within China's academic system, particularly after an unsuccessful application, UNI-DS-P1 invited senior leaders at Lingnan University to endorse the application of funding from the Guizhou government while acting as the executive leader who oversaw project completion and mentored the Guizhou University students involved.

Plural identities, roles and networks were cross-fertilising. UNI-DS-P1 attributed competitive advantages as an academic network entrepreneur to the synergistic value of "Macaunese identity", top-tier university "credentials", and persistent network-building within and beyond academia since undergraduate studies. These factors enabled a deep understanding and management of the "temperaments and external relationship approaches" of both Macau and stakeholders from mainland China. Despite this, UNI-DS-P1 maintained a primary allegiance to Macaunese identity and built credibility on a personal level rather than acting purely as an institutional emissary (although two roles potentially converged). With Macau as a "foothold", UNI-DS-P1 conscientiously enhanced agility in collaborations and across different networks, with independence from any institutional affiliations, including SYSU.

UNI-DS-P1's key-node position had also been reinforced by the credentials and policy-making expertise attained from SYSU GBA Development Institute, facilitating participation in government projects such as advisory roles for the Nansha District government in Guangzhou.

> "I am the liaison between Macau and Guizhou. I've levered my Macaunese identity to validate my foothold in Guizhou. For me, SYSU is merely a place to accumulate credentials. I don't need professional titles nor particular favour from SYSU...I can offer them [Guizhou government] policy recommendations and bilateral collaboration [Macau and SYSU]. What I can gain from SYSU is learning how to craft a policy well and turn it into local policy documents." (UNI-DS-P1)

UNI-DS-P1 was both confident and cautious in maintaining network advantages and brokerage status. Across collaborative activities, UNI-DS-P1 insisted on the significance of responsible, high-quality innovation partnerships, where candid communication, mutual trust were indispensable. Positions within the Institute of Industry would only be undertaken if the endeavour "proved successful", and any undertakings that might risk standing or erode personal and institutional reputational trust within networks were promptly called off, as evidenced in the collaboration between SYSU and the Zhuhai government:

> "Out of personal desires, the professor attempted to swap Project A with her own staff. This is a deceitful acquisition of government resources, so I decided not to proceed with it. I am responsible to the government, right? They trust me. I can't let them down...also I believe we shouldn't tarnish the university's reputation like that." (UNI-DS-P1)

In these faculty-driven innovation endeavours, the university, with its academic credentials and expertise, was deemed the most robust leader in U-I-G collaborations by university interviewees. The autonomy to shape commercialisation trajectories or to find the right partners to maximise the impact of academic innovations remains a central priority. Second to the university, local governments were construed as resource-providers, supporting the "exploratory development" of academia beyond the capacities of single institutions; public venture shareholders focusing on broader industrial development than immediate financial returns; and "well-funded" partners with knowledge asymmetries that necessitate faculties to be "patient" in communication.

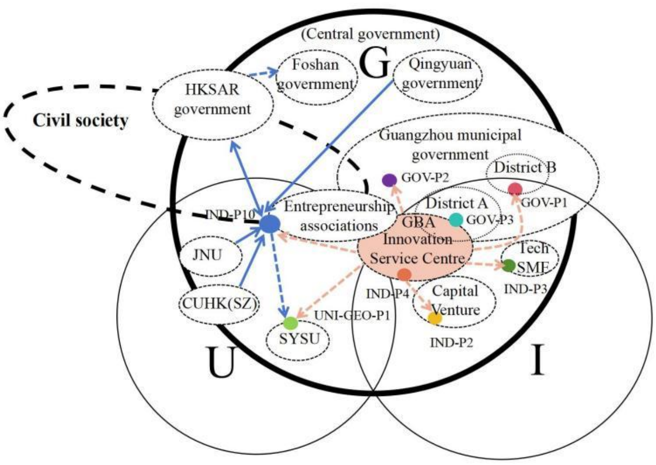
Enterprises were perceived as situated at the "lower end" of innovation that often approached universities and governments for resources and support. Industrial engagements orienting towards financial returns and value extraction diverged from the intellectual and social missions of academic scholarship. Hence, the industrial engagements of key-node faculties revolved around catalysing university spin-offs and increasingly became spillovers of U-G collaborations. Notwithstanding co-founding a consulting firm that addressed policy and financial integration issues in the GBA's diverse political systems and tariff zones, UNI-DS-P1 remained "self-sufficient" with resource-rich U-I networks and attached least importance to the "reputation, equity, and funding" that enterprise partnerships could offer.

High-quality collaborations were bottom-up, granting greater agency in shaping the collaboration's trajectories and desired outcomes and greater potentiality to become partnership-centric and self-perpetuating. As they took shape, top-down endorsement from universities or government bodies could systematise them with guidelines, funding, and institutional support. Comparatively, top-down collaborations, such as the Nansha case in UNI-DS-P1's perspective, diverged from what qualified as "collaboration with the government", in contrast to the partnerships with the Zhuhai and Macau governments. These were typically responses to open government tenders where the government acted as the primary entity, selecting universities through competitive processes based on due diligence. Such U-G relationship were contractual by nature, featuring stringent project deadlines and unidirectional communication. The Institute, as the commissioned party, received little feedback before the final approval of outputs, which were subsequently forwarded to higher-level governments. Many top-down frameworks emerging from these periodic contracts remain "rudimentary" and "superficial", the implementation of which often got disrupted by turnovers in leadership. The collective capabilities and resources of involved parties tend to be underplayed.

7.2.2. Government and industry-led interactions

While academic-driven collaborations were mostly initiated by key-node faculties with their institutional roles and multi-sectoral networks, Figure 7.5 depicts the top-down interactions led by a quasi-government agency — the 'GBA Innovation Service Centre' and bottom-up interactions facilitated by an industrial key node holding roles across universities, civic organisations, and government (IND-P10).

Figure 7.5 Government and Industry-led Interactions



Note. Linkages share the same colour with initiating nodes. Arrows point from leading/initiating to involved entities. The Innovation Service Centre is the convenuing node spreading arrows (orange) to multisectoral stakeholders. Dotted circles indicate partial autonomy from the P.R.C. government (big G-circle), with more outside space signifying greater autonomy. Solid arrows denote established collaborations. Dashed arrows represent attemptive collaboration or interactions that are yet to develop into partnerships.

Source: Author's conceptualisation based on interviewees' accounts and pertinent secondary data

The Centre is a hybrid organisation derived from a university science park and now jointly owned by municipal investment entities and private shareholders, sitting in the intersections of university, industry, and local government spheres. It functions as both an "innovation space" for promoting innovation policies, initiatives and awards while providing institutional, financial, and service support for technology transfer, commercialisation, and entrepreneurship, particularly those startups and SMEs based at the Centre; and a "consensus space" where different sectors convene to discuss innovation agendas and develop partnerships and alliances.

In Figure 7.5, the orange arrows depict the Centre's outreach to multisectoral spheres through diverse programs and activities. Some for instance, focus on sci-tech innovation where Science, Technology and Industry officials from Guangzhou municipal (GOV-P2) and district levels (GOV-P1, GOV-P2), academics and industrial shareholders such leadership from a technology SME (IND-P3), were invited to the launch of an enterprise listing program and deliver keynote addresses and partake in a roundtable on core technology innovation. Others strategically targeted uniting youth and entrepreneurs from Guangdong, HK and Macau, involving stakeholders such as the Centre's operational manager (IND-P4), a representative from its shareholder capital venture (IND-P2), a Hongkongnese director of an Youth Innovation & Entrepreneurship association based at the centre (IND-P10), and Hongkongnese faculty from SYSU (UNI-GEO-P1).

These interactions were yet to evolve into collaborations (by the time of interviews), for which stakeholders held varying priorities and expectations. Most university interviewees considered these top-down, generic networking as ineffective. Successful collaborations came from targeted reaching-out and recommendation from "closure network" of colleagues and acquaintances who had clear demands for their expertise. By contrast, industrial attendees tended to leverage these occasions to expand networks rich in "structural holes" and "non-redundant" information while increasing their exposure to potential clients, technology managers, and venture capitalists, who selected high investment-value projects. New connections could be leveraged for different purposes, but direct communication of demands with academics was crucial for achieving outcomes that aligned more closely with industrial expectations.

For instance, to strengthen the profile of his civic association, IND-P10 invited UNI-GEO-P1 to sit as an academic member. For those invited by government officials or whose major clients were governments such as IND-P3, these were opportunities to accumulate government goodwill in opening more application scenarios to enterprises. As IND-P2 notes, the Centre enabled the demonstration of diverse innovative projects, particularly the "competitive tracks more likely to receive favorable policy support". Besides selecting projects, IND-P4 also sought to identify enterprises' demands in R&D, financing, training, and services—information crucial to the Centre's initiative of building a large-scale U-I-G collaboration platform.

For government interviewees, overseeing the performance of the Centre and enterprises involved, and providing official endorsement for their activities were integral responsibilities in boosting industrial innovation capacities, the "principal innovation actor" stipulated in STI policies. Beyond regulatory roles, local officials increasingly engaged in private-public partnerships to incubate innovation and entrepreneurship, building alliances of techno-economic bureaucracy across government agencies and key enterprises. These engagements strengthened their "policy authority" in supporting claims of superior understanding and strategies for boosting local STI development amid inter/intra-regional co-opetition and to demonstrate these contributions to central regimes (Wang, 2024).

This demonstrative emphasis was also evident in provincial Department of Science and Technology's official report, where the Centre was submitted to the MOST as a "model case of science and technological reform" and the Centre's achievements, such as winning the "China Industry-Academia-Research Collaboration Innovation and Promotion Award", transactions from "industry-academia-research agreements", and the number of hosted STI events, were presented as government key performance achievements[20]. It was also observed by industrial interviewees, who viewed the combination of government steering and bottom-up initiatives as an established trajectory for innovation in China:

> "In China, both bottom-up and top-down approaches must go hand in hand. Once we've laid the groundwork from the bottom, we report to the leadership. If they find it favourable, we can then move forward." (IND-P3)

> "We work with several government departments, primarily Human Resources and Social Security, Industry and Information Technology, and the Science and Technology Bureau. Each has different functional goals to achieve, and they provide corresponding guidance, oversight, and KPIs for us." (IND-P4)

Figure 7.5 also illustrates the multisectoral connections of IND-P10, an industrial network entrepreneur building Innovation & Entrepreneurship (I&E) alliances through civic associations and universities' I&E Centres. For IND-P10, initial collaboration with mainland academia and government started with providing consultancy to HK-mainland cooperation in import and export trading when IND-P10 also acted as a liaison for the HK business association in Guangdong. This led IND-P10 to seek assistance from SYSU's Business School for documentation, but the

[20] Full report accessible at [in Chinese]: https://gdstc.gd.gov.cn/kjzx_n/gdkj_n/content/post_4394735.html

paperwork was seen as underutilising the school's expertise. Alternatively, the school head proposed jointly establishing an MBA program for HK, but no consensus was reached as IND-P10 felt that partnerships with more established universities, such as Peking or Tsinghua, would be better received in HK. Eventually, IND-P10 collaborated with a vocational college in Guangzhou for documentation and has since served as the director of their HK office.

Despite starting as an entrepreneur and investor, IND-P10 had increasingly shifted focus from industry to universities and civic associations, undertaking roles as a mentor and panel expert for innovation & entrepreneurial contests and research co-investigator in higher education. These engagements were exemplified by his invitation from the Chinese University of Hong Kong, Shenzhen (CUHK-SZ) to serve as a judge in the Shenzhen Startup Competition and involvement in research projects on GBA youth innovation, entrepreneurship, and education. After working for decades in HK Youth I&E Association, IND-P10 co-founded the GBA Youth I&E Centre and assumed a leadership role. In this capacity, IND-P10 gathered university students across the GBA to form teams for I&E contests, mentors, and connected them with venture capitalists while routinely visiting (potential) member organisations for I&E alliances.

With synergistic roles as Hongkongese entrepreneur, civic association leader, and university I&E director, IND-P10 was also appointed advisory positions (e.g., Qingyuan municipal government) and facilitated interactions between HKSAR and Guangdong governments. On notable case in point was the attempted collaboration between the HK Productivity Council and Foshan municipal government in creating management training programs for SMEs in Foshan. The collaboration was suspended due to divergent priorities — while HK prioritised high-tech industries, where its expertise lies, Foshan insisted on serving its dominant manufacturing sector, which HK lacks specialisation in. Another instance involved IND-P10 coordinating official visits between HK and Guangdong, arranging itineraries, and securing necessary endorsements from both sides.

While UNI-GEO-P1 did not perceive HK identity as an advantage in Guangdong, IND-P10 and UNI-DS-P1 emphasised their identity capitals of being SAR natives with political allegiance to the mainland as crucial for gaining trust from SAR and mainland governments, as well as stakeholders leveraging SAR involvement in GBA innovation projects. For IND-P10, HK identity also provided leeway to distance from hierarchical relations with Chinese bureaucrats, enabling more "straightforward" communication with municipal governments in Guangdong:

> "The key to collaborating with the mainland is having a solid foothold and demonstrating your distinctiveness. People see me in multiple roles and identities: as an association leadership with credentials and experiences at recognised mainland universities and as a native Hongkongese with broader

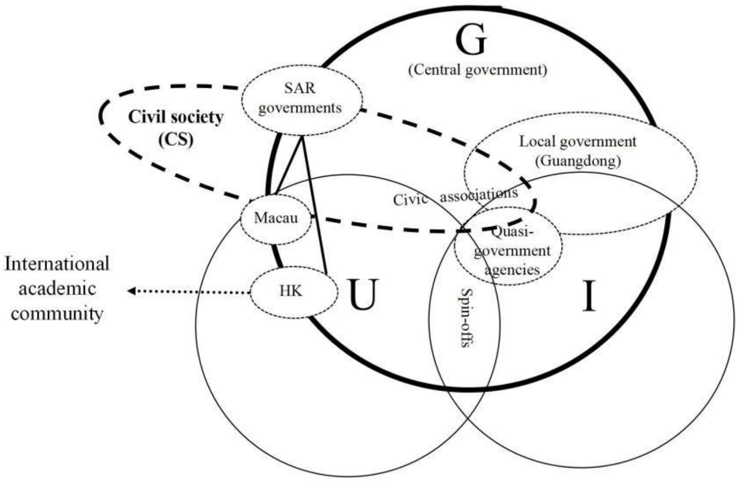
> resources than other HK natives...they know my positionality: the people I bring are politically correct." (IND-P10)

While UNI-DS-P1 developed credibility on a personal level, IND-P10 considered institutional affiliations as crucial "standing" for establishing reputational trust and and connecting with the government through various "purposes" in the capacity of professional groups instead of personal relationships.

7.2.3. The domain-summative model: the U-I-G(-CS) configuration in business and entrepreneurship

Figure 7.6 presents an overview of U-I-G(CS) interactions in business and entrepreneurship. Besides the guardian, funder and central innovation organiser roles, interviewees from government, university and industry note that local governments are procurers of resources and services from different sectors, public venture capitalists and partners of I&E projects, and service providers in support of innovative development.

Figure 7.6 U-I-G(-CS) Configuration in Business and Entrepreneurship



Source: author's conceptualisation

Procurement and public-private partnerships serve government's "urban entrepreneurialism" in planning and constructing industrial, high-tech development zones. However, the rule-making role, especially in border control, market and institutional regulation, such as permit approvals for institutes and alliances under the "GBA" framework, was more pronounced among interviewees from mainland China, including those who had migrated to SARs or SAR natives relocated to the mainland (UNI-MGT-P3, UNI-CT-P2, IND-P2, IND-P4, IND-P10). Service provider and partnership roles were highlighted by district-level officials from science, technology and industry departments in Guangdong (GOV-P1, GOV-P2) as well as SAR interviewees, especially regarding SAR governments (UNI-DS-P1, IND-P10).

At the intersection of local government and industry, quasi-government agencies orchestrated interactions among academia, industry, government, and finance. Civic associations, especially those focused on business, I&E, and youth development, also strove to facilitate U-I-G interactions and participate in innovation activities hosted across sectors as panelists, investors, and alliance members while forming mentoring partnerships with university I&E centres. These roles were particularly pronounced in SARs as part of the civil society sphere, with practices being brought to the mainland by SAR network entrepreneurs. Local governments and universities interacted through activities organised by Communist Party branches, which often involved student association activities led by the united front or collaboration between grassroots governments (e.g., at the township and county levels) and “paired up” university teams in supporting underdeveloped areas[21].

In the U-sphere, HK served as a pivotal nexus for connecting the GBA university alliances with international academic community, enhancing their influence and facilitates on-site interactions with globally-renowned academics—opportunities that mainland universities within the alliance find less accessible. However, at the individual level, there was concern regarding the lack of mutual interests for reasons such as the perceived lower rank of Guangdong universities by HK academia and the disinterest of HK students in teaching contents pertinent to the mainland. Limited by the scale of higher education, Macau faced shortages in faculties and teaching capacities in emerging domains such as cultural and creative industries. To address the demands of new educational programs, rising student enrollment and the ambition for enhancing academic profiles, Macau universities, particularly the private ones transitioning from vocational collages, actively recruited academics from the GBA to become adjunct lecturers and supervisors given their convenience of cross-border travels. However, the viability of such collaborations was challenged by the commuting costs, faculties’ finite commitment, and increasing cross-border restrictions for those who hold administrative roles (UNI-MGT-P2, UNI-MGT-P3, UNI-CT-P1, UNI-CT-P2).

The current configuration was produced based on interviewees’ experiences. Some of them were SAR natives and residents adept at leveraging the civil society sphere for cross-sectoral interactions and their SAR identities to create positional advantages in collaborative networks across the GBA (UNI-CT-P2, UNI-DS-P1, IND-P10). Although civil associations mediated some U-I-G interactions in the mainland, their influence was not yet comparable to that in Macau. The civil society sphere was not presented in some subsequent cases, particularly those driven by the mainland, where interviewees did not involve civic organisations in collaborations.

7.3. U-RI-I-G interactions in power and energy

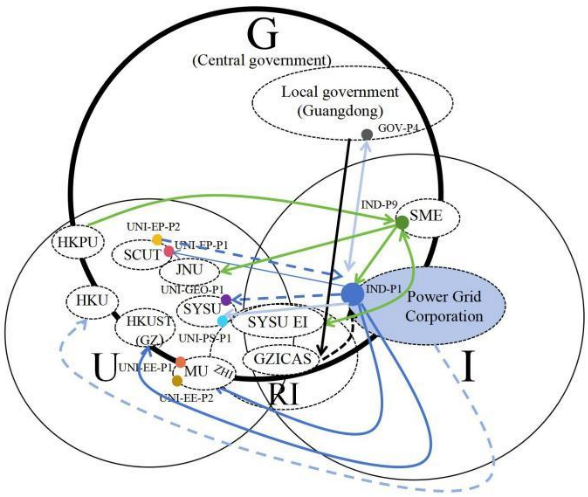
[21] MOE’s Guideline on Targeted Poverty Alleviation by Universities directly under MOE: https://www.gov.cn/zhengce/zhengceku/2019-10/23/content_5444003.htm

Figure 7.7 illuminates the collaborative networks among university interviewees from SYSU (UNI-PS-P1, UNI-GEO-P1), SCUT (UNI-EP-P1, UNI-EP-P2), MU (UNI-EE-P1, UNI-EE-P2), and their industrial partners (IND-P1, IND-P9). In this industry-driven domain, the Grid Corporation and IND-P1, an engineer with a liaison role therein, both serve as key nodes linking intra-industrial and U-I-G networks. The following sections illuminate how IND-P1 fulfills these key-node functions at both institutional and individual levels, along with IND-P1's (potential) collaborators' cross-sectoral networks.

7.3.1. The SOE leader and network entrepreneurs in the power sector

Both university and industry interviewees (e.g., IND-P1, UNI-EP-P1, UNI-EP-P2) noted that the Grid Corporation adeptly consolidated resources from academia, industry and government to fulfill corporate interests and social responsibilities. The Grid primarily collaborated with the Department of Industry and Information Technology (DoIIT) and the Development and Reform Commission (DRC) across various governmental levels. It holds "strategic negotiating" power in shaping the formulation, promotion and leading the implementation of policies and regulations in areas such as energy storage development, carbon peaking and neutrality, and grid operation; project evaluation; and providing support to users and the industry. This autonomy involved navigating the tensions between enterprise interests and social responsibilities and the balancing act upon government performance demands, which could be occasionally in tensions with broader societal benefit (IND-P1).

Figure 7.7 Industry-Driven U-I-RI-G Collaboration in the Power Sector



Note. The size of U-I-RI-G circles indicates relative sectoral influence. The notably larger I-sphere indicates that this domain is industry-driven, where enterprises house the majority of innovation capacity.

Source: Author's conceptualisation based on interviewees' accounts and pertinent secondary data

In a liaison role within the Grid, IND-P1 engaged closely with government departments through activities such as hosting governmental visits, presenting project overviews and policy implementations, and supplying documents for policymaking (e.g., industry reports, standards, implementation cases, speech drafts for leaders). These efforts were geared towards accumulating "political goodwill" for the Grid in coordinating pilot projects and various institutions, leveraging governmental power in initiating innovation policies and facilitating cross-industrial actions. However, goodwill was maneuvered judiciously against its potential cost on the "strategic negotiating" relationship between the Grid and government. The timescale of industry-government collaborations was usually shaped by government's schedules and administrative procedures, which sometimes involved "unrealistic or impractical" requirements for accelerated innovation. These motivations and challenges, especially regarding innovation, were illuminated by IND-P1 as follows:

> "We usually reach out to industrial partners first and turn to government only if necessary...when the government demands rapid completion, innovative projects risk being wrapped up in low quality. The government's slow response, insensitivity to industrial demands and how innovation works as well as conservatism in policy-making and implementing innovation-related measures can all slow down progress." (IND-P1)

The Grid had assembled a diverse group of experts, predominantly in power and energy sciences. UNI-PS-P1 was an exception, offering strategic consultation regarding the power transmission planning to the SARs from a social science perspective. Besides this core group, as noted by IND-P1 who had been involved in many of these collaborations, the Grid actively sought new academic collaborations, inviting experts to join review panels, industry conferences, application for S&T innovation projects and awards, often leveraging academic publications to strengthen its competitive standing. Project reviews and industry conferences often served as the Consensus Space where universities, research institutes, industry and government entities convened to evaluate innovation achievements and strategise for future developments, although the leading sphere in these spaces varies.

In government-commissioned project reviews, the government typically led the session, with IND-P1 representing the Grid in presenting or evaluating projects, depending on who the commissioned party is. IND-P1 was once an expert reviewer in a municipal government involving departments such as DoIIT, Housing and Urban-Rural Development, and Environmental Protection of a report by GZICAS (a DRC Think Tank) regarding sustainable, high-quality local socio-economic development. Hence, as depicted in Figure 7.7, this connection between IND-P1 and GZICAS was orchestrated by local government, the "host" in this space.

At the individual level, IND-P1 also managed collaboration with multiple universities. Collaborations with HKUST (GZ) and MU were institutionally driven by the Grid, with IND-P1 as a primary contact whereas those with SYSU and SCUT were mainly initiated by IND-P1. In IND-P1's experiences, SARs universities were "down-to-earth" partners that proposed funding requirements based on "actual need". Before the GBA Initiative, the Grid's R&D department had engaged in discussions with HKU research teams and MU leadership, leading to joint applications for the Guangdong-Macau Joint Funding. However, these early collaborations were limited due to the nascent "regulatory compliance" across administrative jurisdictions and considerable efforts required to familiarise SARs collaborators with mainland contracting and biding processes. More institutionalised collaborations were largely facilitated post-pandemic, by the municipal government and the resumption of cross-border mobility within the GBA. This facilitated organised site visits to HKUST (GZ) and MU's Zhuhai Science & Technology Research Institute (ZHI). ZSTRI was established as a private non-enterprise entity to compete for China's natural science funding and to enhance the academic recognition of MU, with all its members being MU faculties[22].

During on-site visits, faculty members from various departments presented their expertise, followed by further discussions between IND-P1 and research teams whose expertise align with the Grid's specific demands. IND-P1 decided to initiate a project collaboration with several professors from HKUST (GZ) who proposed exploratory yet innovative approaches. IND-P1 had been guiding them in drafting proposals and preparing for Grid's reviews. Meanwhile, the Grid had established the Carbon Neutrality and Smart Energy Power Joint Laboratory with MU, with a significant portion of these collaborative efforts being channeled through ZHI. MU and its ZHI are entrusted with developing smart urban grid solutions by addressing scientific inquiries, conducting experimental simulations and validations, and building endogenous databases in line with the Grid's requirement. The Grid focused on technological breakthroughs in current direction, prototype development and integrated solution design for the GBA. The lab served as a more structured platform to streamline earlier collaborations and provide additional industrial funding for MU. Both collaborations were expected to produce prototypes or patents within two years as a "trial run" that assessed the feasibility and effectiveness of the partnerships. The initiation of these collaborations involved a comprehensive review of funding requirements, resulting in a reduction in HKUST (GZ)'s proposed budget.

IND-P1 and MU partners (UNI-EE-P1 and UNI-EE-P2), alongside the Guangdong government leadership (GOV-P4) who oversaw the Grid's performative report, concurred that the collaboration was driven by mainland industry and policies, but SAR status provides geopolitical advantages in securing projects targeting SARs. Besides funding, the collaboration provided UNI-EE-P1 and UNI-EE-P2 with access to industry-specific technical challenges that were not publicly disclosed and less available in Macau given its limited industrial scope in power and energy. This stimulated research innovation that was unattainable solely through academic papers.

[22] https://www.gov.mo/zh-hant/news/131149/

While early project meetings were often online, on-site interactions were crucial for establishing trust and understanding potential collaborators' institutional environment and expertise, particularly for SAR faculties to grasp the roles, concerns, and demands of mainland enterprises. UNI-EE-P2, a Macau native, elucidated that these visits improved Mandarin proficiency and familiarised them with mainland practices. However, cross-border travel for official purposes posed challenges for state-owned enterprise staff due to the extensive multi-level administrative approvals, as IND-P1 experienced in missing a Macau award ceremony. Additionally, SAR university faculties also faced time constraints due to on-campus teaching commitments and the significant travel time required to reach the mainland.

Despite these similar views on the opportunities and challenges of cross-border collaborations, IND-P1 and MU partners differed in perspectives on the key attributes driving their collaborations. UNI-EE-P1 and UNI-EE-P2 largely credited their SAR status and academic expertise for securing the collaboration. They emphasised that joint funding applications with research institutes, including those of the enterprise, were effective starting points where each side independently applied for funding without financial transfers and had paved the way for current cross-administrative border collaborations. Regulatory disparities, including differences in project application and management, diminished with increased mainland interactions. In contrast, IND-P1 contended that collaborations with HKUST (GZ) and MU's ZHI in particular, were feasible starting points for engaging with SAR academia primarily due to their mainland locations that brought convenience to the legal, financial coordination and on-site communication.

Expectations of academic collaborators' innovation capabilities and their future trajectories also varied. While alignment with industrial demand was deemed the collaboration foundation by both university and industry interviewees, IND-P1 highlighted that these collaborations were driven more by the Grid's social responsibility in supporting the national GBA strategy and aiding the development of SARs while expanding its R&D capacity in basic research through engagement with a broader range of academic partners. Collaborations with SAR universities were tentative. It remained to determine how their expertise differed from that of mainland university counterparts, though the earnest and serious attitude demonstrated by the SAR university partners so far remained a notably valued aspect of these partnerships. While IND-P1 viewed academia's key strength as highly-specialised and niche research expertise, which industry cannot feasibly develop, UNI-EE-P2 contended that the specific demands of industry collaborations could restrict the scope for more theoretical research and tended to be too practical for high-ranking academic publications.

As UNI-EE-P1 and UNI-EE-P2 highlighted, Macau academia generally welcomed collaborations under the GBA Initiative for the multiplying opportunities and resources it offered. However, these benefits were supplementary as Macau academia was already self-sufficient with the generous salaries funded by the SAR government, which far exceeded those in mainland. However, there were differing faculty views on Macau's positioning in these collaborations. UNI-EE-P1, originally from mainland China, perceived Macau's third-place positioning in the "Guangdong-Hongkong-Macau GBA" as justifiable, considering Macau's smaller scale in area, population, higher education and technological development. In contrast, UNI-EE-P2, a native Macaunese, argued that Macau held an equal and distinctive position in regional collaborations and development through its connections with Lusophone countries.

At the institutional level, the Grid had a long-term partnership with SCUT in student internships given SCUT's specialisation in power and energy. Nevertheless, in IND-P1's case, interactions with SCUT and SYSU faculties were directly initiated through personal recommendations. As indicated in Model Ia, IND-P1's interactions with UNI-EP-P2 and UNI-GEO-P1 remain informal and did not progress to collaborations (dashed arrows) whereas that with UNI-EP-P1 and IND-P9, though differing in depth and scope, developed into actual collaborations. UNI-EP-P1, an Electric Power professor from SCUT, was introduced to IND-P1 by a Grid colleague and SCUT alumnus. IND-P1 then invited UNI-EP-P1 to the expert panel for the Grid's project reviews. UNI-EP-P2, who was a SCUT researcher and start-up founder at the time of the interview and had since become IND-P1's colleague, approached IND-P1 for assistance in gaining entry permissions to the Grid and network recommendations for his start-up. Additionally, IND-P1 also noted that collaborations with other SCUT faculties (not interviewed for this study), whose major contribution was in completing paperwork for project application, areas where industrial partners were less adept, besides providing policy consultation and developing small-scale prototypes.

While IND-P1's acquaintance with many SCUT faculties was yet to yield successful project collaborations, interactions with SYSU appeared more occasional and sporadic, especially due to the absence of a School of Electric Power. IND-P1 encountered UNI-GEO-P1 in a meeting with other SYSU colleagues, which led to an unsuccessful project application. However, the collaboration with IND-P9 was an exception given IND-P9's solid expertise and industry experience, as perceived by IND-P1. Through his SME, IND-P9 collaborated with IND-P1 to marketise innovative products in compliance with the Grid's policy of selling employee innovations through external industrial partners. Collaborating with universities to enhance enterprise profile remained one similar motivation for IND-P1 and IND-P9 that IND-P9 had been collaborating with SYSU and JNU to enhance the company's application portfolio, particularly for national-level applications that necessitate leadership from distinguished academics.

Different from IND-P1's liaison role, IND-P9's collaborations with academia were notably driven by the goal of listing his SME, long-standing connections with SYSU as a former employee and PhD graduate from the Energy Institute, and a passion for teaching. IND-P9 taught a course and mentored two master's students annually as an adjunct professor at JNU. This passion was nurtured during IND-P9's full-time work at the Institute, when he involved in joint student training and research projects with SYSU's School of Physics and several German universities. IND-P9 considered the Institute as more "practical and grounded" than universities. Co-established by the municipal government and SYSU as an independently administered public institution, the Institute operated in the hybrid university-industry space, as depicted in Model Ia. It employed its own full-time staff, separate from SYSU faculty, with a focus on commercialising energy innovations.

IND-P9 noted that the Institute remained distanced from practical application, constrained by the publish-or-perish culture. This led him to establish his own SME, with a corporate research institute housing most of the innovation capacity. Unlike the Grid, SMEs faced intense competition for national projects. Partnerships with top-tier universities, along with IND-P9's role as an alumnus and industry partner of SYSU, were seen as key endorsements to enhance the SME's profile for securing national projects. These collaborations also reflected IND-P9's personal aspiration to ground research and teaching in practical demands and cultivate graduates who were highly pragmatic and sought-after in the industry. In IND-P9 words:

> "We have our corporate research institute and know what we need technically and practically...but competition for national projects is fierce, especially for a company like ours...I've always dreamed of teaching. I often joke that if one day I can't continue with my business, I would return to academia and become a professor, bringing financial resources, experience, and expertise to deliver practically grounded teaching." (IND-P9)

Similar to IND-P1's SAR collaborators seeking mainland partners for application resources, IND-P9 was initially recruited as a postdoc by Hong Kong Polytechnic University (HKPU) professors seeking mainland students with industry experience, though this was later changed to a short-term visiting scholarship due to HKPU's institutional decisions. However, perceptions of HK partners differed between IND-P1 and IND-P9, owing to nature of connections and aims of collaborations. For IND-P9, it was a personal pursuit for receiving systematic training in scientific research where HK was favourable for international exchanges and its non-hierarchical, open academic culture.

University faculties specialising in power and energy engaged in similar cross-sectoral practices as other domains, including founding spin-offs, collaborative research, training projects, serving on review panels and providing consultancy, often without direct government interaction (UNI-EE-P1, UNI-EE-P2, UNI-EP-P1, UNI-EP-P2). Nevertheless, in such highly industry-driven domains, access to the real-world production challenges, apprenticeship opportunities, and mega-projects from the industry, held comparatively strong weight in advancing the frontier of academic innovation and professional influence within the field. For instance, UNI-EP-P1 actively engaged with Grid's production line leaders, brings SCUT students for practical experience and offering free consultancy despite the lack of funded collaborative projects. Most of these opportunities arose through personal connections, SCUT alumni networks, or direct approaches from the industry, as noted by UNI-EP-P1:

> "Many SCUT alumni businesses contact us to help solve their problems...Over 90% of these are through personal recommendations...we often attend review committees out of courtesy to assist project teams. These meetings, especially now with many being conducted online, do not effectively expand our network...more importantly, in Guangdong, people value more about practicality, how things are done. My interactions, like those I've worked with at the Guangzhou Bureau on many projects, regard me as highly pragmatic and delivering outcomes. This is like making friends through work, which actually happens more often." (UNI-EP-P1)

Both university and industry interviewees identified the primary challenges in university-industry collaborations as the limited motivation and capacity of faculties to produce work at the quality expected by the industry. This was largely attributed to the fact that faculties were self-sufficient with funding and salaries from the government and are predominantly assessed by academic publications instead of industrial collaborations. IND-P1 and UNI-EP-P2 also noted that university faculties' spin-outs were usually small-scale since profit-seeking was not their priority. Some entrepreneurial faculties who were deeply involved in business and political networking often exploit repetitive research to maximise financial returns.

However, university interviewees also tended to associate the "limited motivation" to meet industrial demands with academic autonomy in pursuing curiosity-driven innovation. They conceptualised "capacity" as the lack of industrial experiences and resources, compounded by the pressures of teaching and research duties, rather than the constraints of innovation capabilities noted by industrial interviewees. While the review panel was commonly perceived as a responsibility to enable further collaborations, IND-P1 perceived this as an opportunity for UNI-EP-P1 to gain consulting fees and influence in the domain, whereas UNI-EP-P1 considered it more as a socially obliged favour with limited networking benefits. IND-P1 attributed UNI-EE-P2's transitions between SCUT and the Grid to changing opportunities for promotion at the Grid. UNI-EE-P2 highlighted that joining SCUT was driven by a desire for more independent exploration time, distinctively available in the university environment:

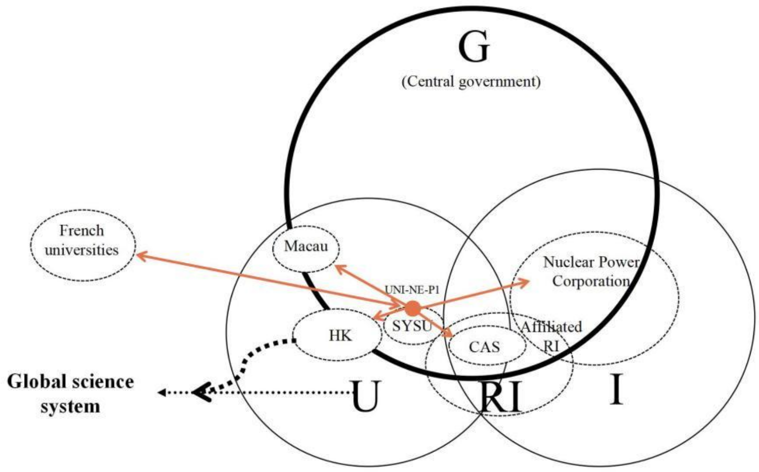
> "The Grid's work is management-oriented. There's usually not enough time to fully understand the issues at hand. That's why I came to SCUT...seeking 'independent time' to sort things out, and then there may be changes in career choices. I think these are different stages." (UNI-EP-P2)

Perceived challenges also varied by specific collaborators, particularly given the Grid's significant influence in choosing from a wide array of collaborators. As previously depicted, collaborations with SARs universities were tentative in evaluating their comparative advantages and the institutional differences involved. However, a key concern with SCUT was the request for funding that exceeds the value of their contributions, along with a previously observed lack of motivation. Collaborations with SYSU faculties who were identified by IND-P1 as earnest and meticulous and as having aligned expertise, faced a recurrent challenge that their joint project applications had yet to become a priority in the Grid's strategic planning, which in part reflected a discrepancy between individual understanding of institutional priorities and the institution's final decisions. Hence, the timescale of industry-academia collaborations was determined not only by project-specific demands and administrative processes, but also how partnerships were positioned within institutional strategic priorities—whether they were seen as trial initiatives or mature projects ready to deliver outcomes.

7.3.2. U-I-RI-G collaboration in nuclear energy

Academia-industry relation in nuclear energy—where academia and industry respectively excelled—hold more equal weight compared to the industry-driven nature of power energy. The CAS' Institute of High Energy Physics was perceived as a research collaborator with a competitive edge in basic research. While the power energy domain remained largely proprietary and exclusive to national contexts, the nuclear domain hinges on innovation in basic science that benefits from international collaborations. Hence, as distinct from obtaining application scenarios for engineering innovation, universities enjoyed greater autonomy in advancing basic scientific innovation with international partners, leading the industry and nation-state to surpass the dominance of developed countries in the forefront of the global science.

Figure 7.8 U-I-RI-G Collaboration in Nuclear Energy



Note. The thicker dotted arrow from HK U-sphere to indicates a larger role in connecting to the global science system.

Source: Author's conceptualisation based on interviewees' accounts and pertinent secondary data

Figure 7.8 illuminates UNI-NE-P1's interactions with industry and academia as a departmental leader at SYSU. The Nuclear Power Corporation is also a state-owned giant with its own R&D and RI wielding considerable influence on government and industrial sector. UNI-NE-P1's department was co-established by SYSU and French partner universities with joint teaching and mentorship. It leveraged its proximity with the corporation to foster nuclear engineering education and obtain industrial insights as well as collaborative projects with the corporation and its RI.

As UNI-NE-P1 highlighted, in a domain so deeply influenced by national ambitions and ultimate goals of humanity, universities navigate "split personalities" to balance academic and industrial priorities. Collaborations with SAR universities were constrained not only by their limited capacity in upholding large-scale infrastructures and R&D, but the prevailing colonial and trading culture that constrained "vision" for long-term scientific progress and societal development:

> "HK and Macau maintain close connections with European academia, enjoying certain advantages in information and academic activities. However, given their limited scale and 'small culture' that is trade-centric and influenced by colonial histories, there is a noticeable prioritisation on short-term interests and societal 'vision' is lacking...In contrast, the mainland possesses the grand ideal of achieving communism." (UNI-NE-P1)

7.3.3. The domain-summative model: U-I-RI-G collaboration in power and energy

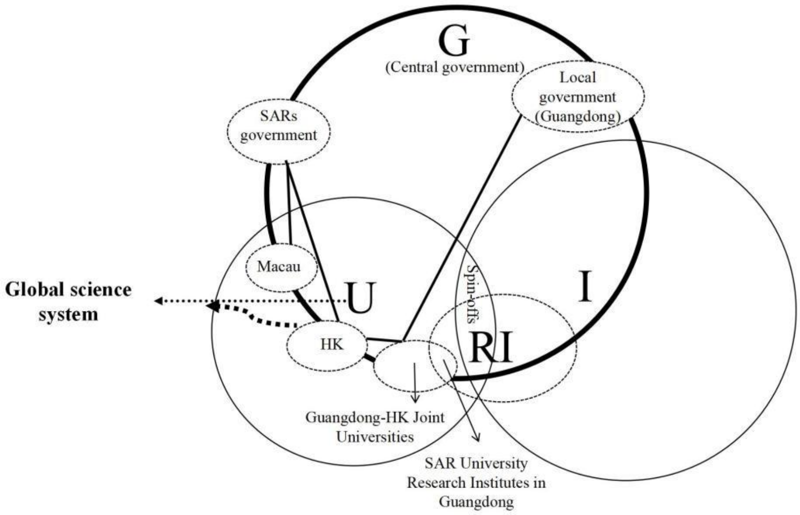
Similar to the conceptualisations of interviewees from aforementioned domains, interviewees involved in power and energy noted the central and local governments' directive roles in strategic planning, policy formulation, framework building and resource endorsement, typically through R&D projects and significant scientific infrastructures. Nevertheless, in power and energy, there was a distinct emphasis on the central government's pivotal role in establishing a common "grand vision" for society, one that bolsters domestic cohesion to elevate China's international standing. Aligning national vision with local realities, local governments assumed more direct roles in redistributing resources to substantiate central frameworks, address local industry demands and coordinate interactions among local innovation actors.

Another distinctive feature emphasised by both university and industry interviewees was the industry's overwhelming control of R&D and production capacities, led by a select group of large SOEs with "strategic or domain status (江湖地位, *jiang hu di wei,* UNI-NE-P1)". Besides serving as nexuses of R&D, professional talent development and employment (UNI-GEO-P1, UNI-NE-P1, UNI-EP-P1,UNI-EP-P2), they were crucial in national strategic planning, policy implementation, taxation and sharing governmental responsibilities in promoting "public welfare and societal development", leading to a "strategic negotiating relationship" between industry and government (IND-P1). As IND-P1 illuminated:

> "In power industry, grid corporations, as SOEs, maintain a 'strategic negotiating relationship' with both local and central governments. They are relied upon by most of the industry...They serve the government for social responsibilities and the maintenance of local relations...and political goodwill. Local governments offer limited support, mainly overseeing local enterprises. Grid corporations' profits are predominantly channeled to the central government. Only a small portion of taxes benefit local governments. Hence, local governments expect them to assume greater responsibility over profit generation." (IND-P1)

These dynamics grant significant autonomy to state-owned giants from the government, with their negotiating power often perceived as even more pronounced in dealings with local governments, as depicted in the non-overlapping sphere and dotted-I circle in Figure 7.9. Comparatively, only a few universities and academics had expertise relevant to power and energy, an expertise that tended to be niche and revolving around highly basic scientific areas. Accordingly, in Figure 7.9, the university sphere s smaller than the industry. Despite government steering for U-I collaboration and the associated benefits of gaining funding, projects and firsthand technological challenges for research innovation, universities retained autonomy in determining research foci, pursuing collaborations in global science and generating impact beyond the region (UNI-GEO-P1, UNI-EP-P1, UNI-EP-P2, UNI-EE-P1, UNI-EE-P2). In particular, as UNI-NE-P1 and IND-P9 highlighted, the energy domain "thrives on international collaboration" and long-term cumulative efforts of human societies.

Figure 7.9. U-I-RI-G Configurations in Power and Energy



Source: author's conceptualistion

Universities in HK and Macau exhibited greater autonomy from the central government as they operated under SAR institutional and cultural structures distinct from mainland China and received funding and the appointment of personnel from the SAR governments (UNI-NE-P1, UNI-EE-P1, UNI-EE-P2, IND-P1, IND-P9). Both mainland and SARs interviewees concur that these differences provided a foundation for complementary collaborations with mainland universities and industries while also limiting their scope and depth. Given their constrained land size and population, HK and Macau were not suited for large-scale engineering projects and lack the platforms and application scenarios or demands for transforming academic innovation. As potential collaborators within China's extensive pool of universities, their expertise in power and energy was yet to differentiate significantly from mainland counterparts, with Macau institutions being even less visible than HK due to limited expertise, number of universities and academic accumulation.

In mainland-led domains, SARs universities remained distanced from mainland industries and universities. The "window" status of HK academia appeared less prominent despite HK still being recognised for its international alignment with global science (IND-P9). However, following the mainland government's strategic directives for mainland-SARs cooperation, mainland universities and industries persisted in seeking more effective ways of collaborating. In strengthening connections with HK, HK-mainland joint universities, operating under the joint administration of their parent HK universities and municipal governments in Guangdong that invested in them, were currently perceived as more feasible and efficient mediating institutions, with HK institutional identity.

Similar to the other domains discussed above, there were hybrid organisations such as university spin-offs, but a notable distinction in power and energy was the recurring involvement of RIs as collaborators. RIs spanned the university and industry spheres, varying by ownership, primary funding, organisational missions and key innovation activities, though their classification — whether as part of the university, broader academia, industry, or constituting a separate helix remains contested among interviewees. RIs within the U-sphere were university-owned and administrated. Their innovation activities centred on non-profit academic research funded by the government. Hybrid RIs situating in the university-industry overlapping sphere, possessed independent legal person statuses despite university affiliations, typically those co-established by local governments and universities. Some RIs were entirely corporate and have an overarching priority on profitability.

Figure 7.9 remains limited in reflecting the heterogeneity and evolving nature of autonomy. While universities from HK, Macau, and HK-mainland joint universities are illustrated as distinct sub-spheres, these small U-circles do not capture the full range of autonomy and connections. Notably, some universities in SARs, particularly those with relatively high international standing, strong academic profiles that align more closely with the demands of mainland partners or have leaderships with substantial mainland influence, tend to possess more autonomy in collaborations and in shaping the outcomes. Among HK-mainland joint universities, HKUST (GZ) is considered having greater autonomy than CUHK(SZ) in administration, staff recruitment, and remuneration, exceptionally offering Hong Kong-level salaries despite being located on the mainland. According to IND-P1, the administrative functions of grid corporations had been gradually transferring back to the government amid state-owned enterprise privatisation reforms, re-shifting corporate management's focus on internal strategies and operations.

The distance between SAR universities and mainland collaborators was also evolving. University interviewees from both SARs and the mainland agreed that cultural and institutional similarities facilitated communication between HK and Macau, increasing interactions, especially through initiatives aimed at institutional innovation and in-depth cooperation zones, will reduce the distance of academia and industry in between (UNI-EE-P1, UNI-EE-P2, UNI-NE-P1).

7.4. U-I-H-G interactions in medical and pharmaceutical sciences

Figure 7.10-7.12 demonstrate the collaborative networks of key-node faculties specialising in medical and pharmaceutical sciences. Beyond tentative ventures to broaden research applications, their collaborations with government and industries are long-term commitments to synthesising demands across production chain and systematic innovation of standards, institutions, and products. Figure 7.13 illustrates the collaborations of faculties in related domains such as biomaterials and medical technologies, who mostly play a facilitating role in serving the demands of hospitals and industries. As interviewees across these cases emphasised, U-I-H collaborations should begin at an idea-forming stage. Ongoing interactions fostered trust and reciprocal learning of each other's "mindset", "habitus", "language" and resource repertoires, and helped reduce information asymmetry, thereby enhancing the efficiency of collaboration and the feasibility and social value of collaborative outcomes. The significance of an "empowerment" mindset, ongoing reciprocal learning, and consensus-building was typically noted by UNI-CS-P7 and UNI-MedS-P1:

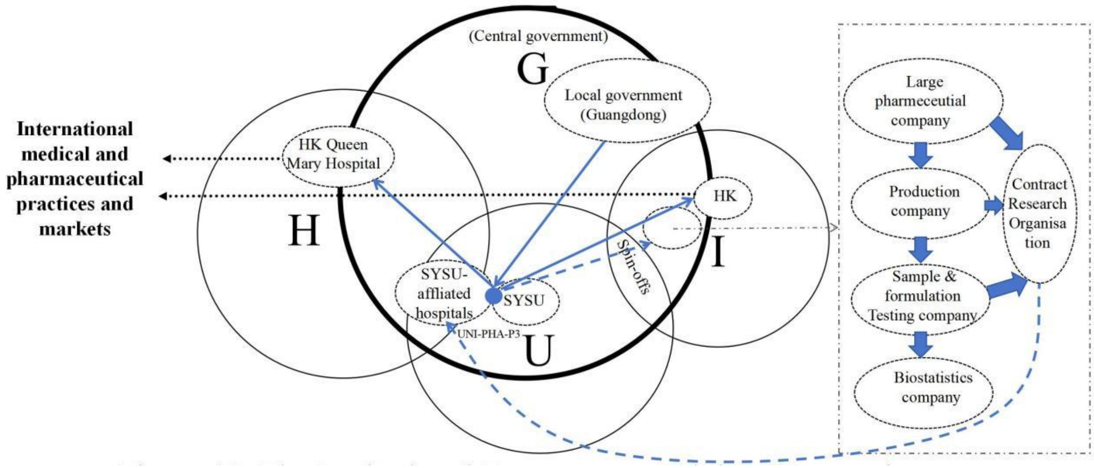
> "Initially, you are merely a teacher or scholar in Materials. Yet through continuous interactions, you may find yourself gradually adopting a mindset reminiscent of a doctor or entrepreneur...Through this reciprocal learning process, valuable ideas and products emerge. They should be pursued and adapted for clinical application, with all entities [U-I-H] collaboratively striving towards this shared goal." (UNI-MedS-P1)

> "Collaborations with hospitals and companies involve mutual understanding of each other's language and ways of thinking...We encounter few challenges as we always consider ourselves as the facilitative 'leaf'...We simply enhance the efficiency of this domain [medical science]...we are not the major entity, so what we do is actually empowerment, meaning that we need to attach to something and we are not the dominant force." (UNI-CS-P7)

7.4.1. The institutional entrepreneur driving systemic innovation in the U-I-H-G pharmaceutical innovation chain

Figure 7.10 presents the cross-sectoral networks of UNI-PHA-P3, a key node linking the whole pharmaceutical value chain from R&D to market launch. UNI-PHA-P3 established clinical trial centres as a distinguished professor at several SYSU affiliated hospitals and actively collaborated with large pharmaceutical companies to secure funding for front-end research. While representing the hospitals, UNI-PHA-P3 observed significant challenges within China's pharmaceutical industry, such as poor drug quality and fierce competition in the generic drug market intensified by drastic price cuts in local bidding and national procurement. Public hospitals, with evaluations largely based on research publications, considered new drug evaluations as low-profit, peripheral tasks burdened by substantial administrative and regulatory risks.

Figure 7.10 The institutional entrepreneur driving systemic innovation in the U-I-H-G pharmaceutical innovation chain



Note. The size of U-I-H circles indicates relative sectoral influence, with the Hospital, followed by the university, predominantly driving innovation in this domain. The right-hand side provides an simplified view of the innovation value chain coordinated by UNI-PHA-P3.

Source: Author's conceptualisation based on interviewees' accounts and pertinent secondary data

Recognising existing gaps, UNI-PHA-P3 began leading companies spanning the entire pharmaceutical value chain as an advisory shareholder rather than as a nominal founder, as indicated by the dashed arrow in Figure 7.10. This strategic approach allowed UNI-PHA-P3 to maintain independence as a public servant while legitimately facilitating connections between these companies and SYSU-affiliated hospitals in support of new drug market launch. UNI-PHA-P3's dual roles and experiences in academia and hospitals also led to appointments as a Good Clinical Practice Inspector and consulting expert for National Medical Products Administration (NMPA). In these capacities, UNI-PHA-P3 represented the regulatory authority in inspections and participates in drafting policies for the MOST and national guidelines for enhancing the standardisation, scientific integrity and ethics as well as innovation efficiency of the national pharmaceutical system.

To conduct clinical trials recognised internationally, UNI-PHA-P3sought collaborations with Queen Mary Hospital and enterprises in HK. Nevertheless, implementation stagnated due to differences in management systems and clinical trial requirements. As foreign entities in mainland China, HK organisations had to comply with Genetic Office procedures, which complicated the process for trials considered foreign. This was further compounded by stringent licensing standards and a scarcity of clinical cases that increased trial costs. Hence, collaborations remained in the stage of mutual data recognition in practice by initiating plans and procedures with HK collaborators, but UNI-PHA-P3 stressed that individual efforts were limited and effective cross-border collaborations required centralised institutional support:

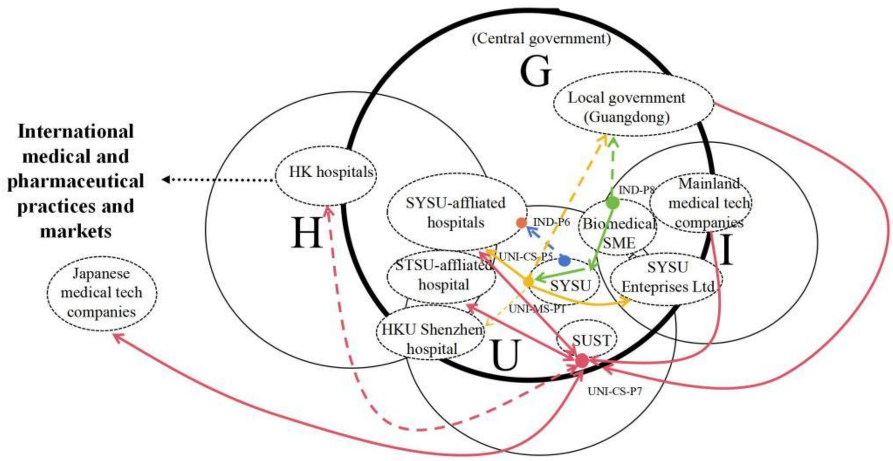
> "Ideally, intra-regional collaboration of the GBA should leverage HK's advanced management systems, but this is not something to expect alone

from HK or Guangdong. It requires the NMPA and the Genetic Office to harmonise policies and legislation between the two regions like the Pharmaceutical Administration Law, which is difficult to amend. Others are policy-sensitive, adhering to national will and will not change for individuals.” (UNI-PHA-P3)

7.4.2. The “empowering auxiliary”: U-I-H-G collaboration in biomedical materials and technologies

Figure 7.11 depict the collaborations between university faculties and “niche peers (小同行, *xiao tong hang*)” in hospitals and companies in medical technologies and biomaterials. Through a colleague’s recommendation, UNI-CS-P5 began collaborating with IND-P6, a doctor at a SYSU-affiliated hospital, on joint research funding applications, shared student mentorship, and co-authoring publications and patents around AI’s clinical applications. While both UNI-CS-P5 and UNI-CS-P7 collaborated with hospital partners to find “market outlets” for academic innovations, UNI-CS-P7 identified “medical application (医学采用, *yi xue cai yong*)” as a “close-looped ecosystem” where endogenous interactions among academia, hospitals and industries are compressed across “glonacal” scales.

Figure 7.11 The “empowering auxiliary”: U-I-H-G collaboration in biomedical materials and technologies



Source: Author’s conceptualisation based on interviewees’ accounts and pertinent secondary data

UNI-CS-P7 collaborated with medical technological companies’ R&D departments and hospitals such as the STSU-affiliated hospital and SYSU’s Ophthalmology Centre through joint-laboratories for clinical demand-based development of algorithms, technological licensing, transfer. Early partnerships were mutually established with top-tier Japanese companies and mainland hospitals before UNI-CS-P7’s relocation to China whereas local partnerships were mainly initiated by mainland companies, particularly those employing graduated students. Interactions with HK hospitals, though also mutually initiated before relocation, remained personal and exploratory for complementary research.

However, collaboration was constrained by factors such as the short-notice application from the mainland government versus the established administrative timeline of HK partners as well as increasing pressure from local data protection laws. Despite not being interested in engaging with the government network, UNI-CS-P7 was invited to serve as an expert representative on Shenzhen Science and Technology Innovation committee and a GBA medical intelligence and innovation research institute co-established by SUST and its affiliated hospital. For UNI-CS-P7, these roles were social responsibilities. The institute's GBA framework, while broader than current initiatives, served as an umbrella to incentivise ambitions for the "greater good" beyond Shenzhen.

UNI-MatS-P1 and IND-P8 worked at a SYSU bio-material group under the mentorship of the same supervisor. During postgraduate studies, IND-P8 was the group's liaison for industrial and hospital collaborators before UNI-MatS-P1 joined the team as an associate professor. Leveraging the experiences, connections, and resources accumulated during that time, IND-P8 founded a biotechnology SME post-graduation and extensively connects with academia at and beyond SYSU with due diligence of aligning R&D and manufacturing services with industrial client demands. Interactions with UNI-MatS-P1 are part of these processes.

Both UNI-MatS-P1 and IND-P8 underscored the valuable synergy between traditional disciplines and medical applications at SYSU and the significance of academically-grounded "sedimentation" for driving clinical and industrial innovations. However, their individual attributes and positions within institutional networks led to different proximity and interaction patterns with stakeholders in biomaterials and technologies. IND-P8 perceived academia as a conventional trajectory and considered academia-industry brokerage as strategic in creating values through more effective syntheses of capabilities and resources across sectors, which also involved proactive government interactions to stay attuned to investment and funding opportunities. UNI-MatS-P1's contact with the government remained limited and was oftentimes mediated by industrial collaborators. UNI-MatS-P1 considered industrial research commissioned by the Development and Reform Commission challenging due to a perceived lack of understanding of the industry and research for policymaking.

Taking over the liaison role from IND-P8, UNI-MatS-P1 transitioned into more applied domain and accumulated clinical experiences by working with doctors from SYSU-affiliated hospitals, the users of biomaterials, in developing products, co-authorship and funding applications. These doctors introduced UNI-MatS-P1 to a collaborator from HKU Shenzhen hospital. The collaboration began with UNI-MatS-P1's visits to the shenzhen hospital to discuss join applications for

Guangdong-Hong Kong-Macau collaborative projects, leading to mutual visits before the pandemic. Later interactions were restricted to online meetings and material samples sent to the hospital faced preservation challenges. For UNI-MatS-P1, doctors were pivotal collaborators who had decisive say in the commercialisation and entrepreneurship opportunities stemming from their collaborations. If sequence indicates significance, proximity and initiation of interactions, UNI-MatS-P1's networks featured U-H-I-G pattern and differs from the more balanced and mutual H-I interactions in UNI-CS-P7's case or UNI-PHA-P3's H-I-G interactions.

7.4.3. The institutional entrepreneur at the cross-border university-hospital nexus: cross-fertilising U-I-H-G networks of Shenzhen and HK

Figure 7.12 presents the collaborative networks of UNI-MedS-P1, an HKU professor who primarily serves as the leader of HKU Shenzhen Hospital (hereafter noted as "the Hospital"). UNI-MedS-P1 brokered connections from various HKU departments and external institutions to advance the Hospital and HKU's innovation capabilities. Collaborations were largely bottom-up, leveraging both UNI-MedS-P1's reputation and personal connections accumulated over two decades and the Hospital' strategic position as the pilot site channeling medical funds from the HKSAR government and permitting the use of HK-registered drugs and medical devices without MPA registration[23] and its combined strengths from HKU's internationally established institutions and wealth of talent and expertise.

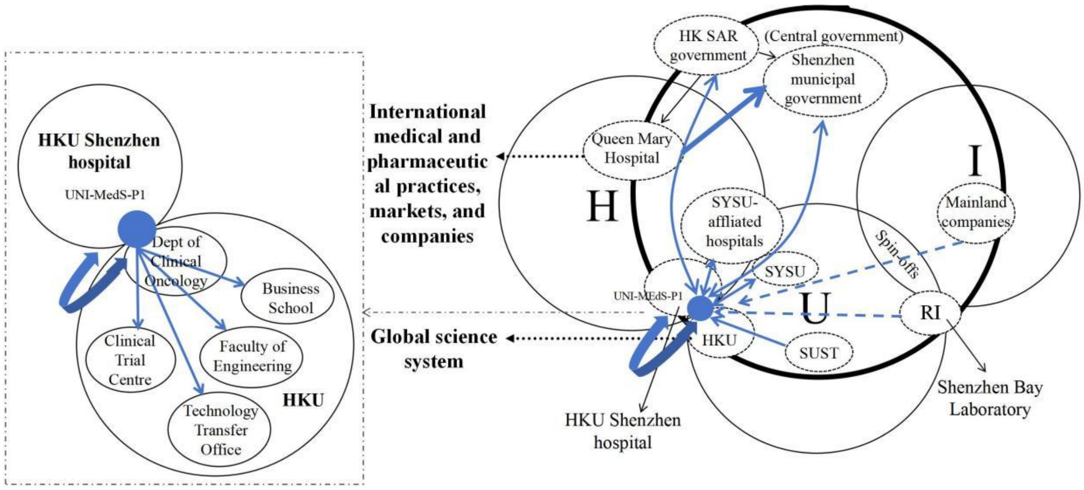
Academic collaborations, especially those formed before UNI-MedS-P1 joined the Hospital, often began on a personal basis, some of which evolved into institutional cross-sectoral partnerships. The bi-directional arrow UNI-MedS-P1 and SYSU and its affiliated hospitals indicate the mutual interactions that evolved with individual and institutional demands, though Figure 7.12 as a snapshot, is limited in capturing such dynamics. SYSU was UNI-MedS-P1's earliest collaborators from mainland China, beginning with UNI-MedS-P1's visiting professorship in the 1990s. Initially, the collaborations were driven by SYSU's aim to import advanced technologies and concepts from HK, while UNI-MedS-P1 sought access to local samples.

Over two decades, as SYSU's ability to recruit talented individuals improves, the reliance on imported expertise decreased. However, the established relationship facilitates ongoing collaboration, which had matured into a more "reciprocally balanced and complementary" partnership. More recent collaborations were exemplified by the joint doctoral education between SUST and UNI-MedS-P1, initiated through personal connections by SUST faculty. This partnership, which successfully co-trained three PhDs with funding from the Shenzhen government, addressed SUST's temporary lack of doctoral degree-granting authority pending government approval. Similarly, Shenzhen Bay Laboratory also recently reached out to UNI-MedS-P1 to explore potential co-training opportunities.

[23] In HKSAR, drugs and medical devices must be registered through MPA of mainland China or an equivalent to the FDA, as there is no local authority for this purpose.

The U-shaped arrows depict how UNI-MedS-P1 had actively recruited colleagues and doctors from HKU, SYSU and their affiliated hospitals to establish a core professional team for the Hospital, many of whom have collaborated with UNI-MedS-P1 in research and clinical trials. To enhance personnel mobility between HK and the Hospital, UNI-MedS-P1 proactively acquired and shared knowledge on the utilisation and transfer of funding and medical samples between HK and Shenzhen with HKU colleagues. Meanwhile, UNI-MedS-P1 actively mediated negotiations to secure HKU's approval for colleagues to work at the Hospital while ensuring the Shenzhen government covers the HR costs. Hence, the bi-directional U-shaped arrows and arrows from UNI-MedS-P1 to various departments and units illustrate how UNI-MedS-P1 leveraged HKU's institutional strengths to support the design of the Hospital's infrastructures through multi-departmental collaborations.

Figure 7.12 The institutional entrepreneur at the cross-border university-hospital nexus: cross-fertilising U-I-H-G networks of Shenzhen and HK



Note. The U-shaoe arrow depicts how UNI-MedS-P1 brokers connections, resources, and flows between HKU and its Shenzhen hospital, illuminated further in the left diagram.

Source: Author's conceptualisation based on interviewees' accounts and pertinent secondary data

UNI-MedS-P1 collaborated with the HKU Clinical Centre to design and institutionalise the Hospital's clinical centre while engaging the Business School to explore investment and incubation strategies for commercialising innovative products within the Hospital's framework and to develop EMBA programs for medical professionals and management. UNI-MedS-P1 also discussed with the Engineering Faculty the potential medical applications of their robotics and other innovations at the Hospital. The bilateral feature of U-shaped arrows indicates a reciprocal relationship rather than exploitation of university resources. UNI-MedS-P1 bolstered HKU's innovation capabilities by enabling research collaborations, such as providing Hospital samples for HKU medical research and supporting departments to integrate their expertise into the Hospital's practical applications.

When signing external collaboration agreements, UNI-MedS-P1 utilised the technical and legal consulting services from HKU's TTO's to reduce the risk of trademark infringement while elevating these partnerships to the university level. This institutional support was essential for successful external partnerships as the dashed arrows from mainland companies to UNI-MedS-P1 indicated that potential collaborators approach UNI-MedS-P1 to commercialise innovative products at HKU and the Hospital. However, some negotiations stalled because HKU perceived the IPs as undervalued. Conversely, the arrow from foreign companies through HKU to the Hospital illustrated that capitalising on HKU's global prestige and connections helped establish trust between the Hospital and international collaborators. Moreover, recognising that HKU's TTO aligned well with international standards, UNI-MedS-P1 was exploring opportunities for the TTO to conduct training in mainland China where TTO still remained nascent to support the integration and regional innovation of the GBA.

The bi-directional arrows between UNI-MedS-P1 and both the HKSAR Government and Shenzhen Municipal Government demonstrate the combination of bottom-up and top-down U-I-H-G collaborations. The bottom-up approach typically started with UNI-MedS-P1 initiating proposals at the Hospital regarding issues such as infrastructures, funding, and cross-border medical policies. These discussions extended to HKU, Queen Mary Hospital, or the HK Hospital Authority and progress to the Shenzhen Municipal Government once a consensus was reached among all parties. A prominent case involved persuading the Shenzhen government to invest in the Hospital's facilities such as the Clinical Trial Centre, big data and AI Centre and a Medical Research Translation Centre in the Hetao Shenzhen-Hong Kong Science and Technology Innovation Cooperation Zone[24], which have garnered institutional support through multi-departmental collaborations at HKU. In discussions with the Shenzhen government, UNI-MedS-P1 highlighted that these collaborations were mutually beneficial—HK lacked sufficient space and patient volume to host pilot clinical trials while Shenzhen sought to import HK's medical talents and technologies to raise its medical standards.

Another ongoing discussion concerned the Shenzhen government's sponsorship of HKU graduate programs. UNI-MedS-P1 had already collaborated with HKU in recruitment for two years, but the Hospital bore considerable training costs. Hence, UNI-MedS-P1 aimed to persuade the Shenzhen government to benchmark against Guangzhou's government sponsorship for HKUST (GZ), leveraging its superior fiscal capacity. As UNI-MedS-P1 emphasised, the key to achieving consensus was enabling collaborators to recognise the reciprocity and viability of proposed ideas and their agentic role in forging these collaborations. This approach was especially relevant in negotiations with local governments, which sometimes necessitate stimulation of the

[24] Original policy document see: https://www.gov.cn/zhengce/content/202308/content_6900742.htm

political entrepreneurship or the co-opetitive spirit of local bureaucrats to outperform city-regions with comparable competitive standings:

> "Being win-win is important. I convince them [Shenzhen government] of our capabilities to meet their requirements, ensuring that they understand the logic...Collaborating with our hospital naturally draws ten top talents given our affiliation with a medical school. Once they realise they are the ones seeking us, not the other way around, it excites them...Next, I'll persuade them: 'Look, the Guangzhou government has already sponsored HKUST(GZ). Shenzhen has even better fiscal capacity. Why not supporting us?'" (UNI-MedS-P1)

Top-down interactions were typically initiated through government official visits and government-led U-I collaborations. The Hospital's strategic significance in the GBA, as recognised by the central government, translated into visit missions for government departments in Guangdong Province and Shenzhen. UNI-MedS-P1 usually hosted these visits, presenting the Hospital's current status and discussing potential collaborations. Additionally, UNI-MedS-P1 led a hospital delegation to industry-academia-research contract signing ceremonies organised by the Guangdong provincial government, where institutions with shortlisted commercialisable projects were invited.

HKSAR government designated the Hospital as the authorised institution to accept healthcare vouchers from HK elderly citizens. To enhance convenience for these citizens, especially amid pandemic mobility restrictions, UNI-MedS-P1 proposed that the HKSAR government permit direct medication dispensation at the Hospital with ad-hoc reimbursement, turning the Hospital into the pilot channel for HK-mainland medical funds and products. Meanwhile, the former Hospital head and HKU faculty, now leader of the HK Health Bureau, also became a crucial gatekeeper in facilitating interactions between UNI-MedS-P1 and the Shenzhen government. The leader frequently visited the Shenzhen Health Commission to discuss medical integration and promote the Hospital's engagement in cross-border collaborations. This mediating role was illustrated by the thickened arrow branching from the UNI-MedS-P1-HK government bi-directional link towards the Shenzhen government.

UNI-MedS-P1 perceived top-down interactions not as de facto "cross-sectoral practices" but as part of the managerial responsibilities at the Hospital, whereas bottom-up U-I-H-G interactions were more effective to perpetuate in future practices, especially those involving policymaking. All these brokerages were driven by a strong "sense of duty", with facilitating intra-regional collaborations between Guangdong and HK essential for leveraging their complementary advantages and mutual benefits deemed instrumental to fulfilling such duty. In UNI-MedS-P1's words:

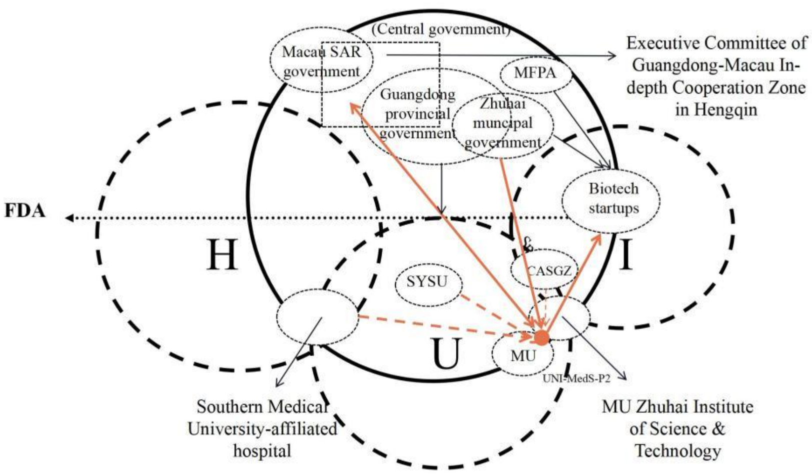
> "HK's institutional system is well-established and effective in many places, but it sometimes lacks the efficiency of Shenzhen, where many things are done more quickly." (UNI-MedS-P1)

Figure 7.12 has limitations in capturing the dynamic interactions, roles and perceived challenges amid shifting institutional contexts. Before joining the Hospital, UNI-MedS-P1 more directly interacted with the industry in negotiating IPs transfers and sponsorship under HKU's reserved commercialisation policies. Later, in a managerial capacity, UNI-MedS-P1 primarily oversaw and reduces barriers for the Hospital staff's external collaborations, supported by HKU's increasingly open commercialisation policies and established TTO services. Given UNI-MedS-P1's experience with U-I-H-G interactions, tensions arising from differences in institutional logics and priorities or multiple responsibilities (e.g., teaching, research and hospital management) were increasingly considered minor. Challenges were mainly operational issues within proposed partnerships.

7.4.4. The academic and Institutional Entrepreneur mobilising U-I-G collaboration across Macau and Hengqin Cooperation Zone

Figure 7.13 illustrates the collaborative network of UNI-MedS-P2, a MU professor with departmental leadership position and roles in MU's Biotech Ethics committee and Zhuhai Institute. After relocating to Macau from the US, UNI-MedS-P2 established a biotech company in the Guangdong-Macau In-depth Cooperation Zone (hereafter referred to as "the Cooperation Zone"), based on the initial US company whose IPs were already approved by the FDA, though the new company is administrated by MFPA.

Figure 7.13 The academic and institutional entrepreneur mobilising U-I-G collaboration across Macau and Hengqin Cooperation Zone



Note. The dotted rectangle indicates co-governance structure within the Hengqin Cooperation Zone.

Source: Author's conceptualisation based on interviewees' accounts and pertinent secondary data

UNI-MedS-P2's biomedical expertise and commercialisation experiences attracted a colleague who formed a team consisting of research institute, company, hospital and universities for a MOST project and appointed UNI-MedS-P2 as the project leader. As depicted by the dotted arrows, SYSU, the affiliated hospital of Southern Medical University and CASGZ were all linked to UNI-MedS-P2 through the facilitation of personal relationship (university and industrial collaborators outside the GBA was not demonstrated). The project team was not only complementary in expertise, but also in know-how around navigating project evaluations in mainland China, which are unfamiliar to UNI-MedS-P2. The collaboration was both strategic and operational, with mainland partners playing crucial roles in negotiating the legitimacy and competitiveness of the project with key stakeholders amid UNI-MedS-P2's restrictions in identity, physical mobility and familiarity with mainland norms, protocols and social practices:

> "You must 'pay your respects' (拜码头, *bai ma tou*) to key stakeholders of MOST projects...Personally, I don't have this habit, because I never did it in the US or Macau...neither do I have the funding to do so...I couldn't even pass the border to mainland during the pandemic...My entry to the project defense venue was initially denied. Coming from Macau with an American passport made me highly suspicious...Then my collaborators made many calls and even to the MOST, explaining that we were a special case and I had to go in... That was how it succeeded." (UNI-MedS-P2)

The project's strategic significance elevated UNI-MedS-P2's reputation with the Zhuhai government, leading to an expert position in the Cooperation Zone's Executive Committee. In this role, UNI-MedS-P2 proposed recommendations to facilitate mobility between MU's Macau and Hengqin campuses for faculty with different types of identity documents; to streamline regulatory processes for transferring samples from the mainland to SARs, which currently requires approval from MOST, SAR Medical authorities to Customs; and to direct MOST funding to the Zhuhai Institute for efficient distribution to mainland collaborators, reducing transactional costs resulting from currency exchange. Recommendations were informed by both UNI-MedS-P2's personal experiences with foreign passport restrictions and funding logistics and a survey of MU colleagues' expectations for the Cooperation Zone.

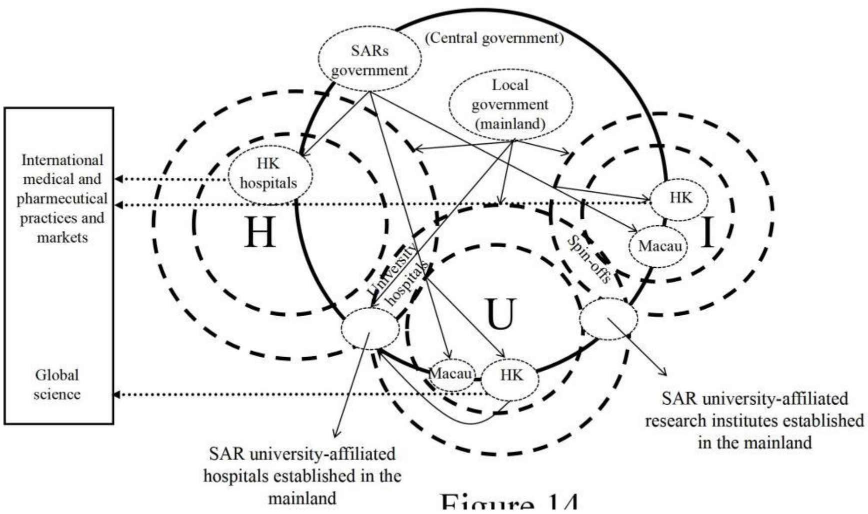
These cross-sectoral roles were perceived as integral to administrative responsibilities in addressing collegiate concerns that are also pertinent to UNI-MedS-P2's own interests, but the effectiveness of fulfilling these primary responsibilities also hinged on addressing the institutional priorities of industry and government. For instance, albeit primarily aiming at facilitating faculty mobility, UNI-MedS-P2 sought to address governmental concerns for policy fairness and thus discussed with legal experts for regulations or policies applicable to all Macau residents, rather than solely providing special policies for academia.

7.4.5. The domain-summative model: U-I-H-G interaction in medical and pharmaceutical sciences

Figure 7.14 illuminates the interaction dynamics among universities, industries, hospitals and governments according to the experiences of interviewees from medical and pharmaceutical sciences, including related interdisciplinary domains such as biomedical materials (UNI-PHA-P1, UNI-PHA-P2, UNI-PHA-P3, UNI-MatS-P1, UNI-MatS-P2, UNI-ECE-P8, UNI-MedS-P1, UNI-MedS-P2, IND-P6, IND-P8).

In U-I-H collaborations, doctors are users of these products that play a crucial role in identifying innovation demands and providing feedback throughout the whole development processes of products. University serves as the major source of fundamental research innovation, some of which are conducted based on the demands proposed by doctors. Industrial players assume varied roles in the innovation chain: venture capitals and large pharmaceutical companies finance R&D and the translation of their outputs; biotechnology and pharmaceutical companies refine prototypes and advance R&D towards practical applications; manufacturers convert these prototypes into market-ready products; firms specialising in the testing of new samples and formulations as well as Contract Research Organisation (CROs) that coordinate the entire process. However, in China, hospitals remain strictly independent from the industry. CROs are prohibited from direct connections with hospitals. To partake in the U-I-H collaborations, CROs communicate with the hospitals through the medium of the university.

Figure 7.14 U-I-H-G interaction in medical and pharmaceutical sciences



Source: author's conceptualisation

Hospitals and universities house the majority of capacities in R&D and medical services. Leading hospitals are well-regarded for their wealth of national projects, experts and facilities. This draws not only a substantial influx of patients that enriches the pool of clinical data, but also academic and industrial collaborators across R&D,

clinical trials, translation and commercialisation of innovation. The industry largely depends on adhering to advanced international standards and lacks the capacity to absorb academic innovations. Universities and hospitals interact most closely through university-affiliated hospitals in their intersecting sphere, which is a prime case for SYSU and its ten affiliated hospitals[25]. Affiliated hospitals are indispensable teaching and clinical training bases for the university's Medical Department while the hospitals' research serves as the cornerstone of the university's First-Class Discipline evaluation in Clinical Science[26]. In this study ,some faculty members with pharmaceutical and medical sciences expertise held dual appointments at affiliated hospitals while many medical professionals from these hospitals also had distinguished appointments from SYSU.

Due to the similarity in research evaluation systems, shared university affiliation and the fact that both entities are public institutions, university faculties and doctors acknowledged that aligning goals in collaborations typically presents fewer challenges compared to those with industry and government. These internal connections provide more channels to collaborate for innovation, expand interdisciplinary expertise and facilitate the translation of research output. They also enhanced SYSU's overall capacity to amass diverse resources such as funding, platform qualifications, projects, prospective talents and collaborators. Both university and industrial interviewees highlighted strong medical science profile and hospital resources as key factors in their decisions to join or collaborate with SYSU (e.g., UNI-CS-P5, UNI-MatS-P2, UNI-ECE-P8, UNI-PHA-P3, UNI-MedS-P1, IND-P6, IND-P8). As both SYSU's current faculty and industrial alumni collaborator emphasised:

> "I started my master's studies five years after the campus merger, when the South Campus's traditional academic strengths were integrated into medical applications at the North Campus. Material science is at the forefront while medical science provides application scenarios, which is a perfect match for S&T innovations." (IND-P8)

> "When SYSU offered me a position, I was drawn by its long-established and concentrated strengths in medical science across Southern China, convening multiple affiliated hospitals...Given these advantages, I decided to shift my research towards medical applications...my previous work abroad was fundamental and left me uncertain about application prospects." (UNI-MatS-P1)

The mainland government was paternalistic as the central organiser that provided policy support and funding for innovation across different stages (e.g., support for

[25] https://www.sysu.edu.cn/yxsz/fsyy.htm
[26] http://www.syshospital.com/basic/453

R&D, CRO platform construction and subsidies for hospitals); market regulator that drives the standardisation and professionalisation of healthcare and pharmaceutical sectors; and the "baton of administration" in reforming institutional and talent assessment standards. The prevailing promotion criteria within hospitals and universities were predominantly oriented towards scholarly publications and government-funded projects, which often marginalises collaboration with stakeholders and individuals engaged in new drug development.

Each government department played a specific role in fulfilling these objectives and fostering U-I-H collaboration and innovation. The MPFA granted production licenses, and used permits and clinical application certificates before production and sales could formally commerce. The SAR governments autonomously administrated SAR hospitals, academia and industries, but key central governmental bodies, particularly the Human Genetic Resource Administration of China, MOST and MPFA, remained respectively crucial in regulating and complying the exchange of medical data, products and samples across the borders of HK, Macau, and mainland China.

Hospitals in HK were perceived as aligning closely with international standards, particularly FDA's recognition, while the foreign enterprises in HK were integrated into the global market. A few Hong Kong universities were recognised for their advanced research capabilities and international publications. These comparative advantages incentivised collaborations between the mainland and SARs in this domain. However, actual collaborations remain constrained by restrictions on cross-border data and sample transfers. To navigate these challenges, SAR universities often formed partnerships with mainland universities or establish affiliated hospitals in the mainland under the administration and investment of local governments. Macau hospitals were not discussed in this domain as interviewees highlighted the limited scale and visibility of Macau therein and did not report any interactions with that SAR.

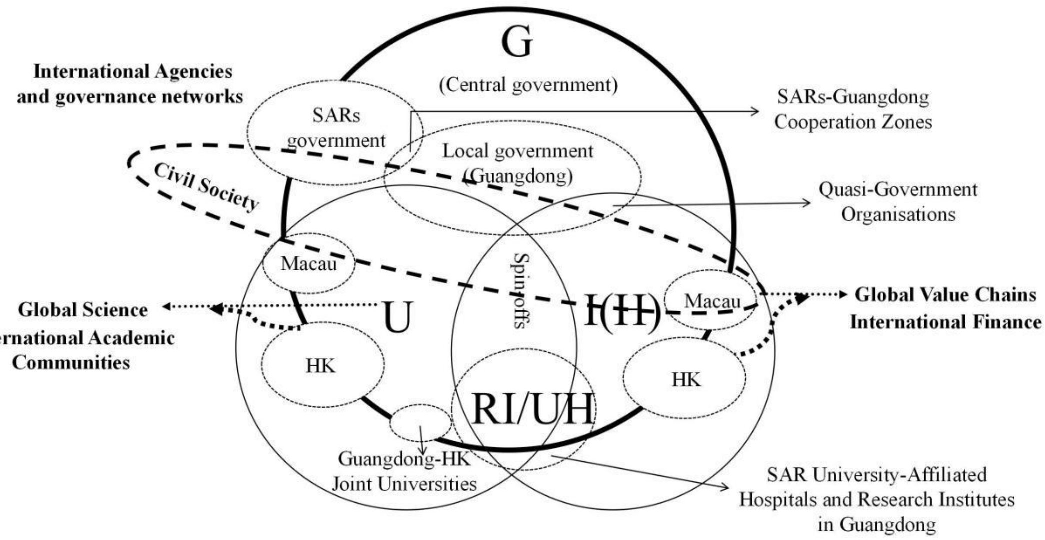
7.5. The GBA innovation system in remix: towards cross-fertilising synergies and balanced quadruple helix

Figure 7.15 illustrates the provisional GBA innovation system configuration based on the integrated analyses of aforementioned subsystems (i.e., Guangdong, HK, Macau) and collaborative cases. In this overview, the central party-state and its ministries remain pervasive guardians that steer ideological orientation, innovation priorities and their institutionalisation, including the kick-starting of the innovation-centric GBA initiative. Nevertheless, under the confluence of "One Country, Two Systems", reform and opening up as well as the GBA initiative, local governments of the GBA held a strategically distinctive discretion to reinvent pathways for fostering innovation networks and capacities, pilot policy and institutional innovations, and scale successful local experiments into national practices. Such interplay reveals an overall pattern of rising local agency and reduced state intervention, a characteristic "statist-fading" system exemplified by Shenzhen (Cai & Liu, 2018).

The increasing interconnection and mutual embeddedness of innovation subsystems, each with distinct capacities and degrees of autonomy, fostered the pluralisation of local government agentic roles and strategic integration of top-down strategic direction with bottom-up innovation practices and multi-scalar network-building. Local governments served as intermediate regulators, public venture capitalists, organisers, facilitators and partners, according to the specific demand of interaction and the power dynamics among collaborators across sectors and localities. These interconnections had already facilitated, and could bec expected to continue to enable the emergence of institutional innovation and new, often hybrid, organisational forms, including SAR- Guangdong joint institutions, cooperative governance committees, and evolving GBA alliances across scales and domains, contributing to a regional governance layer mediating between central and local levels.

Quasi-government organisations include government research establishments (e.g., national and provincial labs) at the U-G intersection, and SOEs and public institutions (*e.g.,* government-owned science parks and incubators, municipal-investment enterprises, productivity promotion centre) at the I-G intersection. Spin-offs from public-private partnerships typically emerge within the intersection between local government and the U-I spin-off sphere. Government-endorsed civic associations and alliances, such as the Guangdong-Hong Kong-Macao University Alliance, operate at the intersection between government and civil society.

Figure 7.15 The GBA regional innovation system: statist-fading and cross-fertilising synergies towards a balanced Quadruple Helix



Source: author's conceptualisation

The cross-fertilisation of innovation networks also encouraged and enabled the formation of a potentially self-perpetuating GBA innovation system that transcended geographically bounded configurations (e.g., municipal or SAR-based Triple Helix models) towards a new equilibrium of supply and demand attuned to the national Dual circulation Strategy. As more universities, research institutes, and enterprises took on expanded and overlapping roles, the pluralisation of intermediary organisations such as quasi-governmental bodies, commercial technology transfer enterprises, and civic associations, often facilitated by SAR stakeholders, together weaved a denser web of innovation networks and increasingly balanced quadruple helix across the GBA.

While the integration of innovation networks across the GBA was concurrently driven by top-down policy coordination and bottom-up network-building initiated by key-node individuals and institutions, achieving sustained regional synergy would require continuous systematic support for multi-scalar innovation activities and pathways, transforming scattered bottom-up initiatives into institutionalised, self-sustaining practices. Challenges remain in reconciling tensions between agency and structural constraints at multiple levels, such as the central-local autonomy and divergent institutional priorities across sectors and jurisdictions. Cross-border activity remains disperse in strength and directionality, can will continue to shift over time.

Notably, interviewees from both the mainland and SARs suggested that, as mainland R&D capacities strengthen and the GBA's multi-subcentre strategy matures (e.g., Nanshan and Donguan become more co-opetitive city-region of SARs), the strategic imperative and demand for mainland-SAR collaboration may decline (IND-P1, IND-P8, UNI-MedS-P1, GOV-P2). While cross-border practices and interactions are notably active in STEM and medical sciences, SSHA domains reveal less engagement, where SAR academics might have less incentives to involve in the GBA initiative (UNI-DS-P1, UNI-EE-P1, UNI-ECE-P9, UNI-CT-P1). The conceptual figures presented in this chapter also do not capture the significant connections and interactions beyond the GBA that warrant further exploration. Collaborations within the GBA extend beyond the policy-mandated circle, with city-regions, organisations, and individuals outside the designated '9+2' also seeking to engage (are engaging) with the GBA initiative, or instance, exemplified in UNI-DS-P1's collaboration with Guizhou and SYSU School of Pharmacy's partnership with Yunnan province.

7.6. Concluding remarks

In each project, collaborators brought in different resources, capabilities and demands, requiring the network brokers to navigate resources, bridge interaction, align interests and coordinate implementation, influencing the configurations of collaborations. The intensity, depth and outcome of the same interaction model differed across specific cases and time. Expectations for partnership varied notably among interviewees, contingent on factors such as the role of, manners of communication and power relationships among collaborative entities. Even for similar types of collaboration such as commissioned government projects, some interviewees considered them as partnerships whereas others perceived them as top-down commands from "primary entities". Research institutes could be categorised into different institutional spheres (e.g., university institutes, non-profit social enterprises, business entities) by their organisational ownership.

Depending on the nature of connections, university interviewees acted as mentors, partners, and core research team members of innovation and entrepreneurship projects; startup founders, advisors and network brokers building connections across individual, departmental, and university levels. Government of different municipalities and districts served as public venture capitalists and partners in some instances while being “primary entities” seeking consultancy and public procurement in others. In instances where university and governmental interviewees had both personal and professional connections as well as mutual communication or where university interviewees perceiving themselves as key nodes, local governments were often regarded as equal partners closely engaged in the collaborations. By contrast, government-commissioned projects were typically not considered as “collaborations” or “partnerships” given their top-down, uni-directional nature. Governments served more as “clients” or the “primary entities”. Key-node positions, both within and across sectoral networks, enabled extensive referrals and due diligence on potential suppliers, clients, collaborators, financing and interactive models (Burt, 2002).

Chapter 8 Factors shaping regional innovation systems: the GBA experiences

This chapter explores the key factors shaping the GBA's innovation system (RQ4). It first analyses macro-level factors regarding the broader geopolitical and economic landscape, central party-state apparatus, policies, funding and incentives, along with distinctive institutional, economic and social environments of the GBA, which have been frequently cited as favorable for innovation given its "high quality of life" and "pragmatic/down-to-earth culture" (e.g., UNI-EE-P1, UNI-GEO-P3, UNI-NE-P1, IND-P1, IND-P10). Next, the chapter discusses the system-level characteristics, particularly the configurations of capacities and relationships among innovation actors at both national and local levels. It then explores the meso-level factors revolving around the influence of bureaucracy. organisational structures, regulations, strategies and priorities before delving into micro factors regarding individual network-building, strategic autonomy and enterprising attributes. The chapter concludes by integrating the additional factors highlighted in policy and institutional documents into a synthetic innovation factor-framework.

8.1. Macro-level factors

8.1.1. Janus-faced geopolitical landscape

The tensions between China and other major economic entities, exemplified by the Sino-US trade war, have restricted China's imports and exports in critical materials and bottleneck technologies for innovation and international partnerships. The trends of deglobalisation, protectionism, and unilateralism were further complicated by quarantines and economic slowdowns during the pandemic. Nevertheless, both STI policies and interviewees' accounts present these constraints as an opportune catalyst for collective efforts towards greater reliance on domestic innovation systems and ownership for endogenous innovation, reshaping China's resilience and competitiveness amid the changing global innovation landscape.

According to industrial and university interviewees (UNI-CS-P2, UNI-MatS-P4, UNI-MatS-P6, UNI-ECE-P4, IND-P8, IND-P9), geopolitical tensions have led the Chinese government to bolster supply-side policies for domestic innovation capacity-building, which manifest as targeted projects, funding allocation and establishments of national and provincial labs in STI policies (D-13-NI, D-14-PSTI, D-14-PSED, D-14-CSTI). China's stable production capacity continuously drives export growth while funding constraints have also led to more strategic support for proprietary original innovations that do not always manifest as patents or publications, thereby demystifying the 'bubbles' of speculative achievements.

These tensions have also heightened the sense of urgency within Chinese industries to capitalise on ownership of in-house innovation and enhance international influence in setting technological standards. Academics and scientists working in domains related to crucial materials, processes and technologies reveal a notable sense of social-intellectual responsibility in addressing bottlenecks and enterprising ethos to harness rewarding opportunities from national deployment and the growing demands of Chinese industries to build a reserve of strategic assets derived from scientific and technological innovation. The janus-faced impacts of geopolitical tensions on innovation are typically illuminated as follows:

> "The current Sino-US trade war, critical bottlenecks, and limitations in industry-academia-research collaboration, all urge us to shift our strategy towards prioritising owning intellectual property and securing core materials as crucial leverages. They present opportunities in unleashing demands for endogenous development of materials like semiconductors. Despite short-term 'pains' and impacts on market profitability, once a supportive innovation ecosystem is established, we can gradually become self-sufficient in the long run." (UNI-MatS-P6)

> "Diligence and a strong sense of collective honour to sacrifice personal gain for the greater good are core strengths of Chinese…We don't need to spar with others [in building 'international allies'], but focus on doing what we should do." (IND-P8)

Geopolitical changes are not positioned as deterministic but turning points for forging strategic regionalisation and multi-lateral international partnerships in both STI policies and by stakeholders. As IND-P8's remarks illuminated, rather than being disrupted by external 'noises', it is essential to concentrate on internal strengths and resilience in both mindset and capacity. The key priority consists in strengthening the GBA's regional innovation system with diverse local-global nexuses that effectively leverage their unique innovation attributes and international networks. This for instance, includes fostering a regional ecosystem captalising on the HK stock market to increase its liquidity amid restricted access to the US market, noted by an academic entrepreneur who co-founded and listed a startup in HK (UNI-CS-P2). Macau's connections with Lusophone countries were also emphasised by Macau interviewees (UNI-MedS-P2, UNI-EE-P1, UNI-EE-P2, UNI-CT-P1, UNI-ECE-P9) and emerging policy initiatives aimed at establishing Sino-Portuguese STI and Trade Cooperation Platforms in Macau and the Guangdong-Macau Hengqin Cooperation Zone (Economic Development Bureau of Guangdong-Macao In-Depth Cooperation Zone in Hengqin, 2024).

The GBA initiative, further discussed in the subsequent section, is recognised by both SARs and mainland interviewees as a timely subnational regionalisation strategy to mitigate local tensions in HK, economic slowdown and geopolitical restrictions (UNI-DS-P2, GOV-P2). Despite the strategic emphasis on SARs, GOV-P2, an STI official from Guangdong, notes the significance of promoting the resilience of endogenous innovation capacity and rebalancing the reliance on SARs as the sole international gateways with a multi-centre strategy that develops Hengqin, Nansha and Qianhai into innovative cooperative zones, particularly given the influences of geopolitical forces on SARs.

The importance of building “an innovation ecosystem based on domestically substituted technologies or products” is also underlined in Guangdong STI policies, which highlight Guangdong as both “the frontline in Sino-US economic and trade war” and “national pilot demonstration zone” for forging first-mover advantages in innovation before key technological breakthroughs occur (D-14-PSTI). In central policies, there is a further emphasis on balancing endogenous innovation system with strategic openness and multi-polar international partnerships (e.g., ASEAN, Belt-and-Road). These policies caution against tendencies toward autarky or cold war, advocating instead for enriching the innovation dimensions of major-power relationships and easing geopolitical tensions through the “soft power” of dialogue and interaction in science, technologies, markets, capitals and culture (D-13-NSTI).

8.1.2. Central Party-state apparatus

The party-state apparatus shapes how innovation is valorised, organised, and supported. It is ideological in advancing the central vision and social cohesion towards the “great rejuvenation of the Chinese nation” and asserting increasing strategic leadership in global innovation competition and public goods through the “revolutionary forces and lever” of STI (D-13-NI). Besides consensus-building, it also serves as policy, fiscal and budgetary instruments to optimise the supply-demand equilibrium of innovation, thus enhancing the systemic efficiency of innovation-driven development. The combination of top-down endorsement and bottom-up initiatives, which iteratively influence each other, is construed by many as a distinctly effective approach to development and innovation in China (e.g., GOV-P1, GOV-P2, IND-P1, IND-P3, UNI-EE-P1, UNI-ECE-P1).

While the party-state apparatus encompasses a broad taxonomy spanning macro and meso levels, such as the diplomatic strategies in navigating geopolitical tensions and control of production for innovation through SOEs and universities, this section does not seek to scrutinise the entire spectrum, but focuses on key party-state agency and governmental instruments identified by interviewees as crucial to innovation system-building.

8.1.2.1. Party leadership and central deployment

The innovation expertise and governance capabilities of party leaders are critical across different levels and sectors of the innovation system. While this is primarily emphasised in STI policies, interviewees from academia, industry, and government, who are also party cadres, corroborate the importance of party-building and leadership in innovation system-building.

The central party-state apparatus focuses on top-down deployment and application orientation based on large teams and mega-science infrastructure construction. This developmental concentration is perceived as particularly conducive to latecomer strategic capacity-building in applied science and engineering, though some returnee interviewees noted that the exploratory culture of knowledge exchange and small team organisation in countries such as the UK and Canada, is more favourable for basic scientific innovation, where emerging ideas are continuously honed (UNI-ECE-P1, UNI-CHE-P1, UNI-GEO-P1, UNI-GEO-P3, UNI-ECE-P4, UNI-CS-P1, UNI-CHE-P1).

Party directives and government policies have served as powerful frames of reference shaping the institutional logics of universities and academics, as reflected in the concurrent shifting ethos from "big and complete" to "big and strong" (SYSU News, 2025a; MOE, 2025). Implementation is marked by intrinsic complexities and discrepancies in interpretation among stakeholders, compounded by the ambiguity and occasional mixed messages embedded within these normative directives (Han, 2017). The directives often result in delayed effects that persist over time, and in some cases, "an over-correction of the original intent"—manifesting notably in certain sectors through excessive investment and overcapacity (UNI-PHA-P3, UNI-MatS-P8, UNI-ECE-P4, IND-P7, IND-P8, IND-P9).

Moreover, the planning deposition of the central party-state and the ideology that economy can be designed according to central visions, are diffused to SARs and retooled to engineer their pathways to economic modernisation in relation to the broad national development agenda. Interviewees from both the mainland and SARs highlighted the party-state's positioning of SARs as China's international gateways —HK as a "super connector" and Macau as "one centre, one platform, one base" (UNI-MedS-P1, UNI-MedS-P2, UNI-ECE-P8, UNI-DS-P3, UNI-EE-P1, UNI-EE-P2). Guangdong province, and now the GBA enjoys significantly more autonomy in experimenting with its own model and trajectory of innovation. The supportive attitude and administrative flexibility of its civil servants are seen as key enablers of innovation (UNI-GEO-P6, UNI-NE-P1, UNI-MatS-P8, GOV-P4, IND-P3).

However, long-term collective "visions" and enabling "soil" for innovation remains work in progress. SARs' trading, survival-focused colonial legacies, while conducing to incremental innovations that meet the practical demands of everyday life and mass entrepreneurship, limits the development of long-term, large-scale innovations (UNI-NE-P1, UNI-EE-P2, IND-P8, IND-P10). Under market-led innovation system configurations, SAR governments have largely adopted a laissez-faire approach to innovation deployment and actor coordination. SAR academics, particularly those in STEM, become increasingly active in contributing to national mega-science projects, which offer substantial funding and access to large-scale scientific infrastructure unavailable locally (UNI-MedS-P1, UNI-EE-P1, UNI-ECE-P9).

Limitations in governance leadership foresight were also noted, particularly regarding the potential to enhance expertise in identifying high-quality innovation projects while strengthening regulatory capacity to curb rent-seeking and opportunistic practices (IND-P1, IND-P8, IND-P9, GOV-P2, UNI-PHY-P2, UNI-MatS-P4). Many innovation bottlenecks, such as the shortage of critical semiconductors currently faced by China, were seen as the result of imbalanced deployment and constraints of foresight in strategic allocation (IND-P8, IND-P9, UNI-MatS-P6, UNI-PHY-P2). This foresight is not only crucial to technology sovereignty—a nation-state's ability to sustain innovation capacity and avoid over-reliance on external supply and demand—but also to local political entrepreneurship, where there is co-opetition in attracting and nurturing critical innovation industries and infrastructures.

SOEs, government labs and quasi-government organisations are all evolving administrative and functional institutions integral to the party-state apparatus. CAS headquarters remains a state-level research administration body, setting national standards and policies, such as the CAS journal ranking system.

8.1.2.2. Government funding and incentives

Government science and technology projects, infrastructural investment, public procurement, and policies (e.g., subsidies, tax incentives) all serve as macro regulatory instruments for driving innovation capacity-building. Government projects, besides being a stable source of funding, foster agglomeration in innovation investment and practices towards gradual decrease of overall R&D and production costs and increased efficiency in valorised domains.

Funding distribution valorises the commitment to, and capacity for various innovation activities and outcomes. According to returnee interviewees, China's approach to selectivity and scale funding per project balances support for exploratory innovation with projects aimed at national and local strategic demands. This contrasts with Canada's more egalitarian model that features a high sponsor rate but relatively less funding per project, and the US's selective model, where higher amounts funding are concentrated on fewer projects (UNI-CHE-P1, UNI-GEO-P6). Perceived autonomy and exploratory freedom vary significantly across different funding sources. Nationally sponsored research funding is generally considered more exploratory than provincial and municipal government funding, which is often aligned with local strategic priorities.

Some interviewees also note the importance of aligning proposals with specific government departmental objectives. For instance, projects that balance between exploratory innovations typically funded by general research grants and highly technology promotion-oriented innovations favored by the Industrial and Information Department are more likely to secure funding from the Science and Technology Department. Industrial funding is typically the most targeted and demand-specific. However, in academic evaluations at both national and institutional levels, the recognition of importance is inversely related while application-specific demands also appear challenging for many academics, particularly in achieving the readiness levels required by funders. Consequently, academics often prioritise securing national government research funding, staying within their "comfort zone" of practices.

Government funding requiring joint applications from universities and industry promotes t collaborative team activities, either involving new “weak-tie” collaborators who partner mainly to secure funding or by strengthening resources for existing partnerships. Nevertheless, such funding tends to equate as return on corporate taxes in support of “ready-innovations” in enterprises’ pre-given roadmaps. It is often allocated to established partners and proposals, some of whom are “funding or subsidy entrepreneurs” (UNI-PHA-P1, IND-P8, IND-P9). Hence, funding-driven collaborations remain constrained in sustaining partnerships and alter the entrenched U-I divide, and the minimal role industry plays in funding innovation. Despite bolstering R&D and the industry’s absorptive capacity, the reliance on a paternalistic government approach continues to perpetuate the path dependency within China’s statist innovation model.

The government funding model still sees space for improvement in the orientation and valuation of innovative projects. While advancing national competitiveness through high-profile publications remains crucial, greater support is needed for valorisation and application-driven innovation, particularly in areas serving the public good (e.g., critical medicines for public health) or involving risks and investment scales too large for industry to undertake alone (UNI-PHA-P2).

8.1.2.3. The GBA initiative

The GBA initiative integrates multiple logics and strategies to foster innovation and regional synergy. It is strategic in both enhancing innovation-driven economic development and facilitating the integration of Guangdong, HK and Macau SARs into China’s national development agenda through institutional and social innovation.

Interviewees generally reveal an optimistic view of GBA’s role in shaping a collective vision for building the region as a “world-class innovation cluster” (State Council, 2019). This vision guides strategic deployment of key innovation domains, endorses innovation network-building while pooling resources for infrastructures and programs critical to strengthening the region’s innovation capacity in science, technology and industry. Rather than being a panacea policy, the GBA initiative was considered a catalyst for long-term experimentation and pioneering practices that reduce barriers to intra-regional interactions, harness heterogeneity to build synergistic innovation capacity, and ideally lead to a distinctive model of economic and institutional innovation/solution to the “one country, two systems” (UNI-MedS-P1, UNI-DS-P3, GOV-P2). It incentivises and supports emerging grassroots innovation initiatives while scaling up existing bottom-up practices woven into its framework.

Beyond the path-dependencies and contingent constraints of local innovation systems, the academic, industrial and governmental networks of Guangdong, HK and Macau SARs are expected to be (also having some progresses in) cross-fertilising, driving both demand and supply-led innovations and multiplying innovation trajectories. Notably, SARs academia are tapping into the larger mainland's demand for innovation by launching startups in Guangdong and boosting the STI capacity of local industrial partners. By collaborating with mainland government, academia and industry because of their strengths in engineering, SARs governments may also enhance their innovation capacities in civil construction, public procurement and service delivery. Furthermore, through central directives and inter-governmental collaborations, the GBA facilitates more strategic innovation deployment and supply-driven innovation in the SARs, though mainland interviewees and SARs academics who closely collaborate with the mainland.

Cross-fertilising networks are expected to drive endogenous innovation and growth that as noted, are increasingly essential in offsetting constraints from geopolitical tensions and the trend of structural economic decline, while reinforcing pan-national strategic international partnerships through the local-global nexus of the GBA innovation cluster. These practices and perceptions are typically noted by key-node university interviewees who are actively involved in building the innovation infrastructures, institutions, resources and networks for the GBA, shaping its strategic priorities and conceiving it as a social space in the making. Comparatively, those who do not directly engage with the initiative tend to perceive the GBA as a political imaginary or an economic reality preemptive of its establishment.

Despite not considering themselves as direct beneficiaries, most still recognise the GBA's potential to improve economic vibrancy, reputation, and living conditions for businesses and talents. At the individual level, the initiative provides some guidelines for faculties to harness funding opportunities and institutional support for strategised domains. At the university level, it also incentivises universities to align their spatial strategies, such as the expansion or creation of new campuses, departments, and institutes, with the innovation priorities and industrial strengths of the city-regions where they currently operate or plan to expand. While acknowledging the motivations behind innovation-oriented collaborations with the mainland in STEM, some SARs interviewees from the social sciences and humanities express reservations about their raison d'être for collaboration and highlight concerns over ideological and epistemic divergences that could have constrained their intellectual innovation.

Industrial and government stakeholders also tended to perceive different strategic priorities from the initiative. For government interviewees and their university collaborators in urban planning, building multi-polar innovation sub-centres in Guangdong (e.g., Hengqin Deep Cooperation Zone, Qianhai Shenzhen-Hong Kong Modern Service Industry Cooperation Zone, Nanshan Free Trade Zone) is strategic not only for promoting innovation-driven economic development but also for enhancing Guangdong's strategic position in bridging partnerships and networks from pan-national to global scales (UNI-GEO-P2, UNI-GEO-P4, UNI-CT-P2, GOV-P1, GOV-P2). This serves as a complement to relying solely on HK and Macau's heritage international connections, which show certain signs of decline.

> "The core of the GBA strategy is Guangdong achieving integrated development with HK and Macau. First comes intra-regional integration, then globalisation. This must be sustained, whether for reform and opening-up or improving our domestic development environment. HK and Macau are highly international, but Nansha is now developing stepwise, since China faces a complex, changing international environment…HK and Macau's geographic advantages are waning, but the state hopes they'll continue progressing in tandem with the mainland's pace." (GOV-P2)

As GOV-P2's remark indicated, the GBA initiative is strategic to aligning innovation agenda across local, national and global levels. It enables Guangdong to unleash its political entrepreneurship to strengthen local STI capacity while advancing the party-state's aim of supporting SARs sustain competitive advantages. Though industrial interviewees also acknowledged the strategic priority of subnational regionalisation and some from SOEs, also shared the mission of collaborating with SARs, their primarily viewed the GBA's impact in terms of creating a more open and inclusive environment for business and further unleash the potentiality of market, where Guangdong authorities are increasingly committed to providing public application scenarios and experimental platforms for the trial and error of STI (e.g., digital governance, smart city), alongside developing institutional frameworks more responsive to changing demands (IND-P1, IND-P3, IND-P7, IND-P11, IND-P13).

Nevertheless, the initiative's impacts are delayed and comes with unintended consequences. For example, newly articulated regulations (e.g., data security) that address previous "grey areas" impose more constraints on collaboration until compliance and coordination frameworks are fully established (UNI-Med-P1, UNI-PHA-P3, IND-P6). The favorable conditions created by the initiative may lead to excessively high tolerance for errors, resulting in opportunistic behaviours that exploit policy incentives and low survival rates of startups and businesses in high-tech/cooperative zones with preferential policies.

8.1.2.4. The DFC Initiative

Among interviewees from academia, industry, and government, DFC is generally construed as a government evaluation instrument that aims at prioritising support for top performers while maintaining satisfactory standards in research, education, and impact through its dynamic five-year evaluation cycle, steering universities to stay above the "exclusion" threshold. It is more auditing and redistributive than innovation-oriented, albeit a notable steering process in relation to the valorised type of innovation in higher education. Increased funding and reputation from DFC accreditation are expected to facilitate the innovation capacities of universities and their regions by attracting talented academics and students, the overarching human resources for innovation, and supporting them with better-funded facilities.

University interviewees value DFC recognition mainly for enhancing both the quantity and quality of faculty and student recruitment. This enables the formation of top-tier teams working on various stages of academic innovation, and potential quality student projects that lead to spin-outs and graduate startups. DFC has elevated universities to a comparable level of influence in academic research and innovation to the academies, which were traditionally dominant, as noted by interviewees transitioning from the academies to universities. These changes may also strengthen the culture of learning and scholarship in southern China, which has traditionally been more focused on a trading and "money-making culture" that limits the long-term vision and commitment for innovation.

For industrial interviewees, DFC serves more as a general reference for selecting partners with competitive innovation capacity. However, there appears to solidification of institutional status where the 985 and 211 universities are still viewed as more reliable indicators of academic strength from long-term accumulation compared to a single five-year evaluation (IND-P4). Actual decisions of collaborations still hinge on demand alignment and domain-specific reputations. Comparatively, government interviewees from STI departments tend to highlight the DFC initiative as a strategic instrument to improve the efficiency of resource allocation, and the importance of increasing the number of DFC universities to raise local innovation capacity and attractiveness. While acknowledging that these inputs do not necessarily guarantee talent retention or improved innovation performance, they maintain a positive projection that "the more DFC universities, the better", in closing the gap and eventually outperform the other mega-centres—Shanghai and Beijing. In contrast, university interviewees remain critical of this compressed developmental approach and latecomer strategy of hastily introducing and expanding universities in Guangdong.

Nevertheless, challenges persist in balancing the evaluation cycle to incentivise continuous improvement while allowing sufficient autonomy for exploratory,intellectually driven innovation as well as in developing effective instruments to support and recognise quality innovation across institutions, disciplines, and individuals. Both university and industry interviewees remain reserved about the effectiveness of DFC initiative in fostering academic innovation that delivers genuine value for scientific inquiry, production, or national capacity-building, as well as reducing opportunistic or performative 'innovation'. Policy implementation often faces countermeasures, particularly since quality innovation is more challenging to achieve than conformative outputs. Despite attempts to break Five-Onlys, the DFC initiative remains oriented towards scientific innovation in high-profile publications while industrial engagements and innovation in teaching and curriculum are still undervalued. This orientation pressures academics, including those in applied domains, to conform to cutting-edge upstream hotspots, which tend to diverge from their disciplinary priorities and intellectual interests.

University interviewees additionally highlight concerns that DFC's auditing pressures translate into administrative workload for compiling performance data, which faculties, including those with administrative roles, find to be of limited relevance to their own innovation practices, This is particularly the case since DFC resources are internally redistributed by universities, while the auditing pressures may, in fact, constrain their capacity for exploratory, groundbreaking innovation that requires long-term commitment behind the scenes. There is a shared ethos of reducing performative evaluations in favour of trust in formative peer review within the academic community. Research evaluation over a longer time frame and broader recognition of co-authorship (e.g., not just recognition of first authorship in collaborations) provide a more autonomous and supportive environment for substantive innovation and collaborations.

Albeit being a national agenda for building WCUs in policies (MOE, 2017, 2022a), DFC is not equivalent to the broader WCU agenda, which seeks comprehensive enhancement in attracting global talent and fostering an institutional environment for internationally-recognised innovations beyond what the DFC can achieve. While the DFC initiative includes aspects of internationalisation, its primary focus is on a national auditing mechanism and capacity-building towards being "world-class". Similarly, global university rankings are often seen as performative comparative tools that, while useful for benchmarking and facilitating the compressed growth of latecomers in higher education, may limit exploratory, original innovation and the cultivation of world-class/master scholars. In contrast, WCU allows plural agential imaginings of what qualifies as world-class innovation from individuals and institutions. Most interviewees suggest that rankings, being global or national, should not be the core metric. Rather, universities should concentrate on cultivating their "distinctive identities and core competitiveness" in innovation (e.g., UNI-MatS-P4, UNI-CHE-P1, IND-P1, IND-P8).

8.1.3. Regional environment for innovation

The GBA's attractiveness as an innovation-friendly region is widely perceived as a result of the interplay between its strategic role as China's hub for opening-up and innovation and its unique historical, economic, social, and cultural conditions. It was frequently cited as a magnet for talent and businesses due to its economic vibrancy, well-established industrial chains in Guangdong, pragmatic and service-oriented government, high urban livability, and distinctive Cantonese culture characterised by entrepreneurialism, practicality, and a focus on personal quality of life, qualities often contrasted with northern China. Key enablers include its strong fiscal capacity, higher GDP per capita, robust consumption levels, relatively open market and business environment, and government officials' service-oriented approach and open-mindedness (e.g., piloting policy experiments, creating application scenarios for industries, and fostering public-private partnerships). These factors collectively enhance industrial innovation capabilities and productive interactions among government, markets, and users.

8.2. Meso-level factors

8.2.1. Innovation system-level characteristics

The configurations of national and local innovation systems, particularly the contingent relationships between academia, industry, and government, significantly shape the allocation and flow of resources, the capacity-building of innovation actors, and their interactions. As interviewees commonly noted, the statist model of national and local innovation systems in China is both an historical legacy and ongoing configurations of contemporary legitimacy and reality. The long-standing separation between academia and industry, coupled with their mutual reliance on a strong government presence, holding the majority of resources and systemic power, presents a path dependency that continues to affect the division of innovative roles and the synergistic value of collaborations.

8.2.1.1. Underdeveloped industrial innovation capacity and academia-industry separation

Industry absorptive capacity determines the intrinsic demands of and the extent to which enterprises prioritise development of in-house innovation capability and valorise innovation generated from industry-university partnerships. Under a statist system where central party-state and government wields overarching power over industry and te under-developed market, large SOEs are the major forces of industrial R&D. The private sector remains in the developmental stage of R&D, where innovation has yet to become a strategic priority. Many viable enterprise models are still resource-intensive and labor-intensive or reliant on surplus value derived from processing, export and moderate technological advancement following a late-comer strategy. Except for emerging industrial giants and unicorns, most lack intrinsic motivation and sufficient capacity to invest in and deploy scientific and technological innovations, particularly those in early or pilot-production stages.

Innovation originating from academia often remains too advanced for private sector or preliminary/upstream for enterprises with commensurate absorptive capacity (GOV-P1, IND-P9, IND-P11). This misalignment is exacerbated by academia's priorities in frontier research and knowledge production for national strategic demands, recognition within the academic community, and the intellectual ethos of scholarship, alongside fostering an exploratory environment for talent cultivation and intellectual growth. These priorities translate into meeting evaluation criteria for securing funding and career advancement at the individual level. As state-funded public goods, academic innovations do not necessarily align with industry's profitability goals (UNI-CHE-P1). Academia's institutional priorities and structure—characterised by public institutions and faculties as civil servants—remain largely independent from industry.

Some interviewees such as IND-P8 also note, the long-standing decoupling between academia and industry reflects not only a misalignment of demand and incentives but also a historical legacy of Confucian societal hierarchy, where "商" (business) and "学" (scholarship) were mutually prejudiced, and respectively dismissed each other as "wealthy but uncultured" and of low social status; and "impoverished intellectuals".

8.2.1.2. Co-opetitive universities and research institutions (RIs)

The innovation capacities and roles of universities and research institutions are evolving from a relatively parallel division of labour, where universities focused on teaching while research was primarily conducted within the Chinese Academy of (Social) Sciences, to an increasingly co-opetitive relationship. The innovation capacities of both are enhancing, with each balancing teaching and research innovation according to distinct priorities: universities increasingly taking on research and valorisation whereas RIs, particularly CAS, expand their teaching functions, recruit postgraduate students, and form innovative partnerships with government and industry through local institutes. Nevertheless, the flow of talent from RIs to universities remains predominantly unidirectional as universities have significantly enhanced their innovation facilities, resources, funding, salary competitiveness, and overall capacity following the implementation of WCU agenda, including the former 985 and 211 projects and the current DFC. This dynamic fosters stimulating competition in talent attraction and research resource development.

According to interviewees who were trained in or formerly worked in the Academy (UNI-MatS-P2, UNI-MatS-P4, UNI-MatS-P7, UNI-MatS-P8, UNI-GEO-P2), CAS leverages their dominance in undertaking national key research projects and missions alongside an increasingly competitive, performance-based management system. Principal Investigators (PIs) act as manager-leaders and funding entrepreneurs maintaining strong stakeholder relationships and accountability for their research teams' viability. PIs have comparatively greater oversight in shaping their teams' capacity repertoires and strategic directions. University research teams are often structured for administrative purposes, with members operating autonomously in terms of salary and funding applications, though the extent to which the large-team system grants PIs decisive leadership authority also varies across universities. CAS is also advantaged in putting its full strength into research and commercialisation because of its comparatively lesser responsibility in undergraduate education. Especially within the basic research and commercialisation pipeline, graduate students are a notably stronger force in terms of human capitals. Hence, CAS, particularly its local research institutes, sometimes becomes a competitor of universities in garnering innovation opportunities and resources from government and industry.

> "Not burdened with teaching, CAS is advantageous in industry-academia-research collaboration...However, close ties with enterprises often align research with practical demands, limiting support for basic research or high-impact publications. I prefer to maintain distance...otherwise, the scope of work becomes unnecessarily narrow and

> specific while basic research is central to long-term development." (UNI-MatS-P7)

Labour mobility from the Academy to universities brings expertise in diversifying external funding and commercialising academic innovation. This has been a key strategy for SYSU in rapidly developing its engineering disciplines to meet emerging application demand and strengthening its capacity to compete for key innovation projects, as distinct from expanding publication records. Many academics who transition to universities seek a balance between exploratory innovation and practicality, particularly more autonomy and "distance" from the utilitarian demands of enterprises and the CAS's pressure to secure external funding and deliver quick returns within an increasingly corporatised institutional culture. These differing priorities create distinct pathways for intellectual and professional aspirations that collectively contribute to innovation system-building, as highlighted by UNI-MatS-P2 and UNI-MatS-P7, who spent over a decade in a CAS's local institute:

> "[CAS] sometimes went to another extreme that over-emphasised the practicality of everything it does...Society operates on division of labour and collaboration: some should focus on steadfastly advancing core technological innovation whereas others dedicate to commercialising them." (UNI-MatS-P2)

CAS's project and funding entrepreneurship leads it to potential intermediary positions for addressing government and industry innovation demands, as well as for commercialising academic research that universities cannot fully undertake. Being resource-abundant and an agglomerate of local research institutes with varying specialisation, there are concerns regarding the capacity of the institutes to complete these missions with due quality. For academics pursuing commercialisation, CAS remains distant from application scenarios and offers lower compensation compared to industry positions (UNI-PHA-P1, UNI-MatS-P7). Projects are commissioned to CAS for mixed reasons, partly because of its professional expertise and partly because of the status of its institutes as national research institutions, but some of these projects are eventually outsourced to universities, noted by university and industrial interviewees who have collaborated with them (UNI-ES-P1, UNI-ECE-P1, IND-P1, IND-P9, IND-P10).

These co-opetitive dynamics are shaping China' s innovation system, within which the GBA is embedded, driving the redistribution of resources such as funding and talent. Beyond universities and CAS, new innovation actors—government labs and enterprise R&D institutes of high-tech companies—are gaining prominence in knowledge and technology innovation. These emerging forces in part dilute CAS's traditional role in applied innovation and university-industry brokerage, potentially leaving its local subsidiaries to adopt an in between position—less competitive than universities in basic research, education, and reputation, yet less effective than industry in applied innovation and commercialisation (UNI-CS-P1, UNI-PHA-P1). Hence, some CAS local institutes are striving for greater institutional entrepreneurship and autonomy, securing municipal and industrial support to establish universities, invest in innovation projects, and develop joint educational and research programs (UNI-LS-P1, UNI-LS-P2). establishing new-type research institutes as private non-profit entities to enhance stakeholder collaboration, commercialisation, and entrepreneurship. Despite variations in their institutional attributes, these research institutes serve as intermediaries, brokering innovation networks and resources.

8.2.1.3. Local innovation systems in the GBA

Industrial innovation and absorptive capacity are disparate across places and change time. Due to the locality-specific attributes of industrial structures, the geographical distribution of sectors and the contingencies of university locations, faculties cannot always find suitable industrial partners within the GBA. For example, UNI-MatS-P6, despite working at SYSU, primarily collaborates with semiconductor industries clustering in the Jiangsu-Zhejiang-Shanghai region.

Academia-industry demand alignment is also complicated by the long-standing "money-making" ethos in the GBA, especially among businesses. As highlighted by a Cantonese native faculty:

> "Basic research is a costly endeavor valued and funded by the state. For companies, however, 'money-burning' is a sin...They [Academia and industry] are not on the same page, particularly in Guangdong, where companies are primarily profit-driven, which fundamentally conflicts with basic research." (UNI-CHE-P1)

Guangdong's industrial structure, traditionally centred on manufacturing and international trade and seen as the "world factory", is deemed a crucial factor in the lack of industrial absorptive capacity and demand for academic innovation. Although gradually reshaped by industrial upgrading initiatives, this path dependency remains influential among many local industrial stakeholders and government officials (e.g., the attempted collaboration between Foshan and HKSAR government, who respectively insisted on providing training for manufacturing, and high-tech industries), affecting their priority-setting and conceptualisations of innovation.

Path dependency in local contingencies, such as sectoral relationships and structural attributes, influence the directionality of innovation flows and network-building, and hence the potentials for synergy in innovation systems. In HK and Macau SARs, path dependencies in finance and service sectors have resulted in monolithic industrial chains and underdeveloped engineering and high-tech industries. This not only limits demand and supply chain capacity for scientific and technological innovation but also, as noted by SAR interviewees and some returnees who have worked in SARs, exacerbates the conservative institutional environment for STI, which is known for stringent procedural integrity. The constraints of land, market and supply chain have prompted many SARs academics to collaborate with mainland industry and establish their companies in Guangdong. Comparatively, Guangdong interviewees revealed a significant degree of self-sufficiency in innovation resources and networks within Guangdong and the broader mainland (UNI-MatS-P4, UNI-CS-P7, UNI-ECE-P1, UNI-MGT-P1).

The limited local demand for applications is seen as a double-edged sword, fostering exploratory innovation and disruptive thinking in the absence of practical constraints, with potential to excel beyond what the current market holds (UNI-EE-P1). Flows and incentives for collaboration between HK and Macau remain constrained, as both HK and Macau interviewees noted. HK's higher education is seen as superior in scale and reputation.

Enterprises of different sizes also vary in demand for innovation, which influences the types of activities and outcomes from university-industry collaboration. For SMEs, it is generally challenging to afford the additional R&D costs of university partnerships while struggling to meet the bottom line. High operational costs for enterprises based on tangible IPs and the need for physical organisational space are also concerns for faculties in establishing startups. Academic innovation is often perceived as distant from market demands and profit generation, leading SMEs to favour licensing, imitation or adaptation of existing technologies as a more practical approach, rather than joint development. Successful U-I collaboration relies on connections with trusted acquaintance and the goodwill of academic partners through pro-bono contributions.

From university interviewees' perspectives, collaborating with SMEs often involves risks of know-how exploitation and challenges in aligning goals, expectations about the level of innovativeness or technological sophistication, and readiness for commercialisation Industrial interviewees from SMEs also note the misalignment of goals with academics, citing a lack of incentives and sometimes capability to produce applicable innovations. This misalignment is attributed to divergent priorities driven by the academic evaluation system and, in part, to a perceived "arrogance" of intellectuals in Confucian society.

Large enterprises tend to have more funding for different innovation pipelines and partnerships with teams of multiple expertise across the university. Partnerships can be based on projects, joint platforms and frameworks for both application-oriented and exploratory innovation. Although LEs possess comparatively strong financial and absorptive capacity to support U-I collaborations, they are motivated both to accelerate multiple innovation lines through partnerships and to build long-term competitiveness from core R&D collaborations with universities, while also enhancing endogenous innovation capabilities by keeping key technologies in-house (e.g., corporate R&D centres and research institutes). Particularly in industry-driven domains, academics face significant pressure to deliver quality innovation expected by LEs and establish expertise beyond being mere "partners" included for publications or paperwork. As mentioned earlier, SOEs are a key component of the central party-state apparatus, driving innovation demand and supply across both public and private sectors for the sake of political achievements and societal benefits even at the cost of economic returns.

However, absorptive capacity is non-static. Persistence of the viability of industrial partners shapes the time frame of U-I collaborations. Capital and investors value innovative IPs and tolerance for trial and error.

8.2.2. Bureaucracy

Bureaucracy is pervasive in academia, industry, and government, shaping strategic priorities for innovation and the organisation of innovation activities, practices, and outcomes. Some decisions that hinder innovation are driven by bureaucratic demands to meet KPIs and demonstrate political achievements. For example, in universities, leadership often faces bureaucratic pressures to maximise publication volume per unit, with aggressive expansion and compartmentalisation of departments. Management needs to be improved, including the reduction of tasks that do not contribute to innovation productivity, or even hinder it, while respecting the development principles of discipline and talent.

Academic-managerial relationships influence the perceived importance, efficiency and quality of different innovation activities and their deliverables. Interviewees from Guangdong universities indicate that their research services and technology transfer offices largely function as administrative units wielding "bureaucratic authority (官威)" over collegiality. The procedures for contracting and documentation oftentimes slow down and even delay the establishment of innovation partnerships. This not only diverts the energy that faculty members could have devoted to innovative activities but also causes some industrial stakeholders to forego collaboration, considering the protracted process versus time sensitivity of technological innovation. Such issues are notably more acute in multiversities that remain traditionally academic-focused and less nimble in managing external partnerships, compared to institutions specialised in applied sciences and engineering. Outsourcing professional services (e.g., contracting, licensing, valuation) to separate organisations while research offices managing only core administrative approvals, is seen as conducive to streamlining administrative processes and enhancing efficiency and professionalism (UNI-PHA-P1).

Within SOEs and collaborations with government, differing strategic priorities across various managerial levels often result in confusion and even tensions. The bureaucracy involved in communicating and implementing these priorities can also compromise how innovative ideas are received and how innovation practices are incentivised and recognised.

> "Government projects are mostly fussy and 'under-priced', involving complicated bureaucratic procedures and factors beyond the technical, but projects from the Ministry of Science and Technology are still worthy...the Ministry has its own considerations for what projects to prioritise and approve for. Getting successful application also needs a stout tree of social ties, including those within the system and in the government, plus substantial amount of resource exchange. Many processes of national projects may be intervened and ossified. Perhaps for a one-year research project, you may spend several months dealing with all sorts of report...These projects have higher degree of recognition, especially those led by academicians or academician candidates." (IND-P1)

In line with Zhang and Wang (2024), party-state and government often issue policy signals with ambiguity, leaving lower-level bureaucrats to interpret and implement them under significant pressure to meet policy goals. The combination of policy uncertainty and broad directives often leads to the widespread practice of intensification at each administrative level, which is notably the case in many public institutions as well. Universities and their faculties responded by imposing increasingly stringent publication criteria for academic staff evaluations. Elite Chinese universities, such as SYSU, have introduced 'up-or-out' tenure and promotion systems that heavily emphasize the quantity of SSCI- and SCI-indexed publications, often with more stringent requirements than those found in Western institutions. Many SYSU faculties, graduates and external partners highlighted how the previous university leadership's emphasis on meeting political KPIs in publications and government-funded projects intensified these pressures, steering faculty across diverse disciplinary traditions and intellectual interests into a homogenising publish-or-perish trajectory, a particularly distorting trend for those in engineering and applied sciences (e.g., UNI-PHA-P3, UNI-MatS-P4, UNI-ECE-P1, UNI-GEO-P1, UNI-CS-P2, IND-P8, IND-P9).

8.2.3. University governance and strategic priorities

When U-I collaborations or commercialisation of academic innovation are pushed further, they lead to academic entrepreneurship, a 'grey area' due to systematic institutional dilemmas. While the central government encourages academic industrial engagements and entrepreneurship to drive productivity and economic development and facilitate industrial sponsorship of innovation, industrial and academic interviewees note the institutional challenge of operationalising central directives. Due to their ownership structure as public institutions, universities face challenges in becoming shareholders of spin-outs. University shareholding is perceived as a notable restriction on spin-outs going public, deterring private, particularly foreign investors and venture capitalists.

Consequently, most universities adopt a permissive or hands-off stance toward faculty appointments in industry and startup ventures. 'Non-opposition as consent' has also become a tacit strategic approach for faculties, regardless of the extent of their involvement in cross-sectoral practices. Instead of being spin-outs, many faculties prefer to establish startups or buy out all university equity shares (non-university affiliation, UNI-PHA-P3, UNI-ECE-P1, UNI-ECE-P4, UNI-CS-P4). Both university interviewees and industrial stakeholders recognised that the valorised U-I collaborations were technology transfer and contract- or project-based engagements, and at the university level, there were more explicit constraints on faculties' shareholding or taking formal positions in companies.

The consistency of university policies and initiatives regarding faculty innovation and collaboration with external stakeholders is further complicated by university leadership shifts and their strategic priorities. Many interviewees from SYSU remark that the university was more supportive in fostering UIG collaborations before the leadership of the most recent president, who has since left. This previous administration shifted the focus towards prioritising only high-profile publications and restricting industrial engagements with auditing. This abrupt change in priorities, narrow recognition and stringent environment for innovation activities are perceived as deviations from the university's exploratory tradition and culture of academic freedom, leaving many faculties, especially those in applied sciences and engineering or those with established collaborative partnerships, feeling uncertain and conflicted. This constrained faculty capabilities both in producing original scientific breakthroughs and in fostering innovations with application prospects, while focusing on performative publications.

Industrial and academic interviewees highlight the potential of university regulations (e.g., faculty secondments, sabbatical leave, long-vacation external appointments) to enable cross-sector personnel and knowledge exchange, particularly in enabling academic innovation to better integrate industrial state-of-the-art and application scenarios.

8.2.3.1. Institutional policies and incentives

As interviewees from various universities noted, IP policies notably influence the incentives for commercialisation and academic entrepreneurship. The general trend is toward increasing the proportion of IP retained by research teams to provide more incentives. Some universities retain merely a low percentage for overheads. The processes of patenting, licensing, and creating spinouts require legal, financial, and operational support, which often exceeds the expertise of faculty members and the capacity of universities' research and professional services. Consequently, universities establish subsidiaries for asset management and technology transfer. However, valuing and supporting intellectual property, particularly in understanding the core innovations and developing appropriate patenting strategies, presents technical challenges given the broad range of domains involved.

Many efforts to valorise academic innovation require significant personal commitment, as university TTOs or asset management companies often lack the incentives, clear accountability, and capacity to become involved in the early stage (e.g., idea generation, prototype testing, and pitching to investors) or later stage (e.g., forming spinout teams and launching businesses). On the industrial side, effective measures to track and assess the actual value or benefit of academic innovations have yet to be developed, with current practices relying on idealised estimates for performative reporting (IND-P1).

Aligning with the central ethos of mega-science and large-team research organization, many universities are adopting the PI system, encouraging faculty at different career stages to form teams, share research facilities, collaborate on funding applications, and jointly supervise students. However, the effectiveness of this structure in achieving its intended efficiency and innovation output remains contested. At SYSU, many interviewees perceive large research teams as primarily administrative units, where members often work independently or entirely separately. In practice, team leaders typically lack executive authority over members' funding and career advancement, unless they are funding entrepreneurs, granting them greater influence, which is deemed a more typical case at SCUT and new research universities.

The prevailing evaluation system, which prioritises research over teaching, inherently discourages faculty engagement in pedagogical innovation, while students, influenced by exam-oriented mindsets and a focus on graduation requirements over process, exhibit limited enthusiasm for participating in innovation-driven education and interdisciplinary projects, particularly those with aspirations for further academic pursuits or careers in academia.

The increasing casualisation of the academic workforce—particularly job precarity, work-life conflicts, and survival pressure under the up-or-out tenure system—forces ECRs to resort to short-term, low-risk "innovation" directions leading to measurable outcomes within assessment cycles. Within a system shaped by temporary transitions, independent creativity, collaborative mentorship, and employer-dependent funding, ECRs face imbalanced rights and responsibilities, labour exploitation in knowledge production, and identity struggles in role construction, posing significant challenges to their professional development.

8.2.3.2. Institutional structures and strategies

Departmental reorganisation at SYSU has facilitated a stronger application-oriented focus in some faculties, such as the separation of Computer Science from the Mathematics department. The expansion into five campuses across three central city-regions (Guangzhou, Shenzhen, Zhuhai) has enabled SYSU to increase its enrollment capacity, refine its academic structure, and leverage the advantageous industries of its city locations for disciplinary deployment, talent development, partnership building, and localising research commercialization. However, managing such extensive scale and diversity of disciplines at a multiversity like

SYSU potentially reduces organizational agility and flexibility, particularly in relation to time-sensitive innovation.

This inflexibility is further complicated by the path dependencies in establishing academic standing through cutting-edge scientific innovation and liberal arts inquiry, which traditionally remain distanced from industry, more exploratory and time-taking. Diffused responsibility exacerbates the burden of administrative procedures, resulting in patentable and licensable innovations becoming outdated, or industrial partners being unable to afford the wait. In contrast, younger universities specialising in applied science and engineering such as SCUT tend to hold more embracing strategies and managerial approaches for valorisation of academic innovation and entrepreneurship. Administration is generally more standardised, streamlined, and efficient. Innovation activities in patenting, licensing, and U-I partnerships are active among faculties and in university science parks. In either type of university, disciplines that are not aligning with the university's specialty often find their contributions to innovation marginalised and sometimes even hindered. For example, many multiversity interviewees in engineering consider SCUT more conducive to their innovation.

Largely in line with DFC initiatives, universities remarkably weighed towards publication and government grants and research funding in recruitment and promotional practices. As a result, industrial stakeholders sometimes turn to second and third-tier universities and vocational colleges that prioritise application-oriented innovation and value industrial partnerships and social impact in their evaluations. Those with strong in-house innovation capabilities consistently perform due diligence to identify top-tier universities within and beyond the GBA that excel in both capability and motivation.

At the department level, innovation is often supported by recruiting faculty with diverse disciplinary and innovation backgrounds, including academic publishing, technology transfer, and industrial collaboration. Faculty with cross-sectoral experiences are generally more inclined and equipped to engage in external knowledge exchange, impact and engagement activities. This is evident among university interviewees with industry or research institute experiences, where business partnerships and industrial funding are crucial for sustaining organisational and individual career viability, as well as among industrial interviewees who have pursued doctoral or postdoctoral training and hold mentoring roles at universities.

Amid funding cuts and increasing re-prioritisation toward STEM, the once-strong SSH have been marginalised, accompanied by the faltering of a scholarly culture that fosters critical inquiry. The "up-or-out" faculty employment reform has also deviated in practice to varying degrees, lacking a clear career development framework and incurring unintended consequences, such as heightened professional anxiety and brain drain among early-career faculty. In response, universities are pursuing Break

Five Only reform, adopting a "representative work" evaluation system, establishing "general divisions" to promote interdisciplinarity, and restructuring research organisation models (UNI-ECE-P4, UNI-PHA-P3).

8.2.3.3. University tradition and alumni network

University traditions influence strategies for organising, producing, and recognising innovation; cultivating human capital for innovation; and forging collaborations. At SYSU, a multiversity with a strong liberal arts legacy, priorities include cutting-edge scientific and technological advancements across diverse disciplines, fostering innovative approaches to socioeconomic development, generating academic critiques and discourses, driving cultural changes. Compared to SCUT that places greater emphasis on applied innovation and engineering, SYSU's contributions to local innovation system is less about engaging in commercialisable innovation and producing spinouts.

As discussed earlier, students' academic work is both an innovation in its own right and crucial to the innovation capacity of the university's innovation talent pool. However, high student turnover challenges the sustainability of talent pools for innovation partnerships, as innovation cycles often exceed the duration of (under)graduate education. This creates a high-investment, low-output dilemma that can discourage commitment to student innovation and entrepreneurship contests (UNI-ECE-P4, UNI-PHA-P1).

Alumni networks directly provide resources and collaborative opportunities for university innovation activities and are essential to enhance the university's reputation for cultivating human capital for innovation. Alumni working across various sectors and organisations often serve as mentors or providers of entrepreneurship and innovation opportunities for current students; act as stakeholders, partners, and network brokers in innovation projects and spinouts; and contribute to infrastructure and facility-building for innovation. As human capital contributes to the innovation capacity of various sectors, their collective efforts foster a new equilibrium of innovative development across the entire innovation system, including universities.

8.2.4. Hybrid organisations

Hybrid organisations such as government labs, research institutes and quasi-government intermediary organisations act as mediators in the division of labour between universities—which focus on public-funded medium to long-term innovation—and industry, which prioritises short-term R&D and commercialisation. Innovations with short-term commercial value and critical to national security and public welfare are entrusted to quasi-government R&D institutions. These institutions also facilitate downstream enterprises to implement these innovations locally. The mission of local research institutes is to serve local industries and governments, who are the primary beneficiaries setting the priorities for innovation. However, the "co-opetitive" relationship between universities and RIs, such as conflicts over first authorship recognition, both enables and constrains innovation collaborations.

According to university interviewees, university science parks are adjacent venues for them and their students to traverse between campuses and companies or incubators, but provide limited benefits, with rents and services comparable to those offered to external companies. Despite advertised services and benefits, most interviewees who had worked or are working in university parks perceived limited tangible advantage. Some considered relocating to spaces with lower rents, larger capacity or closer proximity to market as their companies stabilised and began to scale up (UNI-PHY-P2, UNI-PHA-P3).

Intermediary organisations are typically seen as underdeveloped, products of a latecomer catch-up stage. Patenting institutions often specialise in packaging outputs to pass novelty checks and meet the performative requirements of innovation, even for those unable to produce scientific and practical value. Some lack professional expertise in patent scientific or technological mechanisms, as observed by inventors who, after multiple failed attempts with third-party patent organisations, succeeded when managing the process internally (IND-P1, IND-P9).

8.3. Micro-level factors

8.3.1. Collaboration-specific features

Different types of collaboration influence innovation priorities, timescales, and outcomes. While industry collaboration is generally perceived as “short-term and fast-paced”, activities like patent buyouts, licensing, and consultancy are viewed as relatively short-term than R&D collaborations for strategically developing and monopolising innovative IPs (UNI-ECE-P4). Strategic planning documents tend to focus on “forward-thinkingness” whereas action plans demand more practicality, though the two often have tensions that need to be balanced (UNI-GEO-P2).

8.3.2. Agentic network-building and strategic autonomy

The capability of faculties to innovate is significantly influenced by their teams. In universities with high-quality student intake, students’ academic work is often recognised as innovation in its own right (e.g., UNI-ECE-P2, UNI-MatS-P1, UNI-PHA-P1). Students are the primary drivers of innovative projects and spin-out activities. Graduates are especially valued as reliable successors and trusted partners for their supervisors’ startups, who are less likely to sell out the IPs or divest the intended innovation trajectory or roadmap. Despite the primary mission of higher education being the education of human talent, the high mobility of students, particularly when compared to enterprises, often results in brain drain and challenges to the continuity of innovation projects and their impacts. Some interviewees also note that their students lack sufficient motivation for innovation under a graduation-driven mindset and mixed interests in valorisable innovation under the prevailing publication-oriented evaluation system and culture.

Strategic decisions regarding university choice are influenced by considerations such as the level of academic freedom, institutional culture, leeway in external appointments, and the degree of autonomy in entrepreneurial activities, including IP ownership and operational independence. Due to the constraints of institutional regulations and changing leadership's priorities, many university interviewees emphasize the importance of individual agency in sustaining personal passions (academic and beyond) and developing strategies to navigate or seek leeway from institutional and contextual constraints (UNI-PHY-P2, UNI-PHA-P3).

Faculty members act as institutional and network entrepreneurs, attaining greater autonomy in academic entrepreneurship and external appointments despite administrative limitations. For instance, while UNI-CS-P2 successfully balances full-time roles in renowned companies and his own startup, UNI-ECE-P1 faces greater challenges in securing university approval to allocate more time to entrepreneurial activities. Similarly, UNI-MatS-P4 highlights the university-industry divide, having forged an "academic entrepreneur" identity by dedicating equal efforts to both sectors. However, universities' equity stakes in faculty startups often limit the companies' ability to go public, leading many academics to acquire patents from their universities to secure full operational autonomy.

8.3.3. Enterprising attributes

Foresight for innovation, adaptability to uncertainty, and strategic know-how or resourcefulness to leverage different priorities, capabilities and resource repertoires of innovation actors are perceived as essential enterprising attributes for innovators across sectors, given the pioneering and agile nature of innovation and the concerted, systematic efforts required for success. However, "enterprising" manifests differently across institutional spheres and present varying opportunities and challenges due to the intersectional influences of institutional logic, individual career stage, disciplinary expertise, professional background, intellectual interests, cross-sectoral experiences, networks and reputation.

For university interviewees, acquiring the operational and technological capabilities to engage in ventures and industrial partnerships, particularly navigating the ambiguities and potential risks involved, mean stepping out of the comparatively exploratory and stable comfort zone of universities — the very reasons many choose to work in academia (GOV-P1, GOV-P2, UNI-MatS-P4, UNI-ECE-P1, UNI-PHY-P2, IND-P1, IND-P8, IND-P9). Faculties engaged in cross-sectoral practices are notably enterprising in promoting the commercial and societal value of academic innovations. Academic entrepreneurs who establish their own ventures hold a strong commitment to commercialising and re-investing in innovations along self-devised trajectories, seeking strategic autonomy and proprietary advantage less attainable through licensing or partnerships. These individuals are often mid-to-late career researchers with intellectual interests, experiences and reputation in valorising academic work, typically accumulated through pre-academic industrial experiences or hands-on learning in industrial partnerships.

As noted by faculties across career stages (e.g., UNI-GEO-P1, UNI-LS-P1, UNI-CS-P2), tenured professorships enable greater capacity in terms of time, energy and sociability to engage in later-stage innovation activities, such as commercialisation and spin-out creation. The more common trajectory involves establishing academic credibility through publications and funding before engaging in cross-sectoral practices. ECRs often face the pressure of securing tenure and adapting to teaching and research responsibilities, though alternative perspectives suggest that ECRs appear less 'molded' by the traditional academic progression pathway and thus possess greater flexibility for cross-sectoral practices (UNI-PHY-P1, IND-P8). Aside from disciplines such as management and public policy that are notably active in knowledge exchange and engagement, most enterprising faculties specialise in science and engineering, where IPs tend to be readily patentable and commercialisable.

Despite varying readiness across disciplinary domains, intellectual interest remains the overarching motivator. Even interviewees from more theoretically and research-focused institutions and disciplines that concentrate on frontier publishable innovation and potential paradigmatic shifts, still find pathways to valorisation. Such cross-sectoral engagements lead to cumulative effects in cross-sectoral networks, reputation, and future rewarding opportunities. Many also attribute innovation practices to entrepreneurial traits such as "venture-seeking", "agility" and "market acumen" and the ability to manage split and/or hybrid identities of academic and entrepreneur (e.g., UNI-CS-P2, UNI-MatS-P1, UNI-NE-P1). These traits are uncommon in academia, particularly given the reluctance to profit from academic work and the historically social disdain for business in Confucian society, where scholars held higher social status than businessmen. Combining academic acumen with market demands and establishing trust for collaborations necessitate humility and respect to learn from industrial stakeholders, setting aside the pride of public intellectuals.

Hence, the enterprising qualities of university interviewees are largely situated within the "academic heartland" where social prestige and resources that feed back to research and teaching are pursued with great confidence in their ventures' innovativeness, value creation and contributions to the public good (Clark, 2001; Marginson & Considine, 2000). These goals are deemed less achievable in industry where innovation is oftentimes compromised by short-term viability, survival concerns and value extraction, particularly during nascent and developmental stages. Being enterprising requires resilience and adaptability to navigate the frictions between institutional structures and personal agency, though the focus of this negotiation varies across career stages and individual instances.

Among industrial interviewees (IND-P3, IND-P7), being enterprising or entrepreneurial involves notable commercial and financial risks and personal costs in venturing along new pathways, sometimes even starting a new career and life. Financial viability, operational stability and agility to market demands remain overarching to balance against any innovative endeavours. Government directives, particularly leaderships' innovation foresight, play a critical role in shaping the strategic deployment of innovation across different scales and the resources/input allocated to innovation capacity-building. Being enterprising demands 'standing tall and visioning afar', with both a broad understanding of the positioning of local innovation systems within the national, international and global landscapes, and forward-looking vision able to identify the direction of innovation deployment before predictable paradigmatic shifts occur (IND-P1, IND-P2, IND-P8, IND-P9).

Age and experience contribute to combinational or integrated innovation, while disruptive innovation often relies on junior scholars who are less entrenched in established knowledge systems and innovation paradigms, and lack the "burden of knowledge" or the inertia of established academic echelons (UNI-PHY-P1). However, negotiating individual intellectual aspirations with the established orientations and cultures of academic ecology and universities potentially leads to internal friction, particularly for ECRs who typically face dual constraints in students, research facilities, and funding while under high "up or out" pressure to maximise high-profile publications, pursuing application-driven innovation at personal cost.

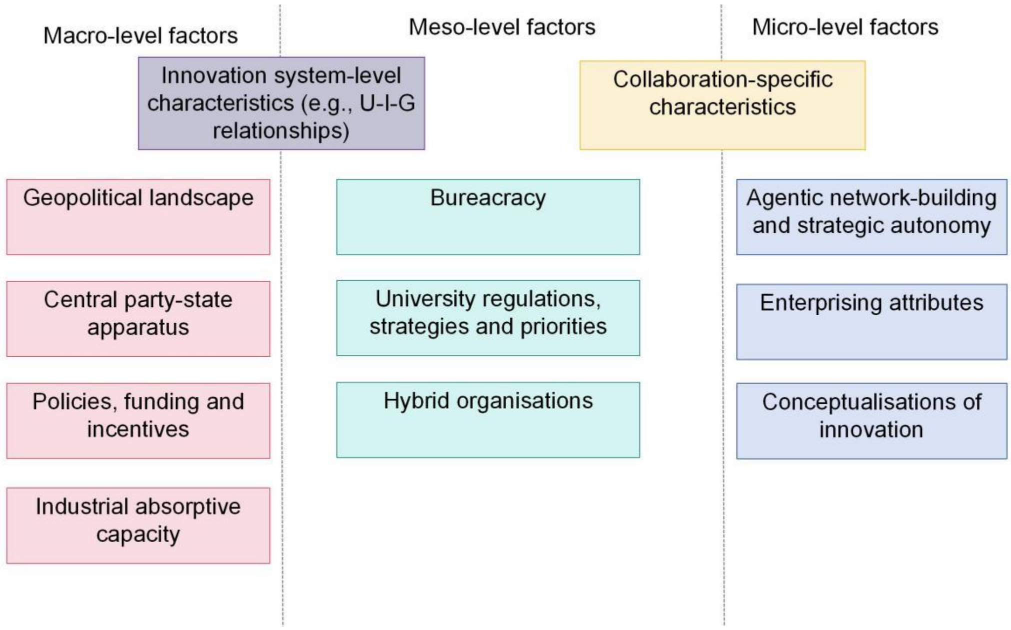
8.3.4. Conceptualisation of innovation

Conceptualisations of innovation (e.g., what it is, which is more important, why it is important, how it should be developed and evaluated) influence innovation policies and practices across national, local, institutional, disciplinary, and individual levels. National policies and initiatives such as the DFC serve both as normative devices—particularly in articulating a long-term collective ambition for original, endogenous innovation—and as incentive and evaluation mechanisms that channel personnel and resources toward valorised forms of innovation. Through strategic deployment, innovation policies steer institutions and individuals to conceptualize and engage with key innovation domains as outlined by national priorities. Evaluation programs like the DFC further shape understandings of innovation by establishing indicators (e.g., publications, technology transfer) and embedding principles and logics that concentrate support in disciplines with established innovation capacities.

Varying by disciplinary traditions and intellectual interests, conceptualisation of innovation by its source, type, purpose, priority, outcome and beneficiary also direct stakeholders towards engaging in diverse types of innovation activities, practices, and collaborations (e..g, theoretical vs application-oriented innovation). A stigmatised perception of commercialisation and gaining financial returns from academic innovation, while allowing academics to concentrate on their core missions of teaching and research, also constrain their willingness and capability to engage further in cross-sectoral practices and advance along the innovation and entrepreneurship trajectory. The valorised sources and purposes of innovation also significantly influence the internal strategies and collaborative decisions of innovation actors. University and industry interviewees who attribute innovation to "sedimented" theoretical innovation and cross-disciplinary integration tend to engage in interdisciplinary domains and actively broker collaborations between academics with deep theoretical expertise and their potential beneficiaries (e.g., UNI-MatS-P1, IND-P8).

The dominant conceptualisation of innovation as limited to for-profit commercialisation contributes to academics' reluctance or hesitation to valorise their research and engage in industrial partnerships. Many perceive the idea of profiting from research as conflicting with their core ideals of being scholars and their roles as civil servants.

Figure 8.1. An illustration of multi-level factors influencing the GBA's innovation system



Source: author's conceptualisation based on integrated analysis of interviews and documents

Chapter 9 Discussion

This chapter discusses the current and possible contributions of universities to the GBA's regional innovation system in comparison to the literature on the enterprise university, entrepreneurial university and multiversity, to the contexts of worldwide pursuit of (sub-) national innovation system, the WCU agenda, and the increasing emphasis on universities' enterprising role in fostering social and economic innovation. It starts by integrating evidence of both SYSU's institutional strategies and practices and sub-system level participation to shed light on a unified understanding of the university's contribution. Within the GBA, universities' core contribution is perceived as cultivation of talents, and creation, transmission and dissemination of knowledge through teaching and research. Resting on such intrinsic core, universities are expected to spearhead cutting-edge research that facilitates national and industrial innovation, collaborate closely with industry and government for transforming academic innovation, boost local employment and stability, and effect cultural radiance and attraction of talents and resources, facilitating intra-regional mobility, exchange and integration.

The study finds that institutional, social and economic innovation are well under way in the GBA. There are increasing expectations for universities to assert more engaged and constructive roles in innovation, economic and social development, and national rejuvenation, staying relevant to new conditions, which requires closer ties to other research institutions, the industry, and public sector. Like universities in many other countries, those in the GBA are influenced by the trend of "market bureaucracy" in public organisations, where quasi-economic competition shapes resource allocation and funding policy serves as a key instrument of institutional convergence (Marginson & Considine, 2000, p.21). Though varying in form, timing and extent, there appears to be government-inspired, management-driven convergence in building research-intensive multiversities. Universities and scholarships vary in their enterprising efforts to achieve demonstrable performance and secure competitive advantages for institutional and social prestige. They are embedded within broader political and social projects that position higher education as a collective endeavour—serving both the communities in which they operate and the goals of an innovation-driven nation-state, while engaging diverse disciplines, staff, and student groups whose talents they aim to cultivate and extend.

9.1. Universities within the GBA's innovation system

In line with the comparative literature review on the WCU, the Chinese imaginary of universities is ontologically open, exhibiting both reproductive and productive characters (Cai, 2020). Enterprising universities in the GBA progress valorisation towards a research-intensive multiversity. As the *Enterprise University* (Marginson & Considine, 2000) suggests, more attention should be placed on the creative power of the academic disciplines, the collegiate cultures and networks in shaping the future of the university (p. 16) and its contribution to innovation systems. There are movements from discipline-based academic departments to interdisciplinary divisions/hubs and research centres where resources are subject to a high degree of selection and top-down restructuring, exemplified by the establishment of General Education Departments at SYSU and the interdisciplinary society and hub structure at HKUST(GZ).

The increasingly engaged and developmental character and growing emphasis on the merit principle in university organisation serve to disguise the shift from collegiality to executive power concentrated in university leadership and administration. This executive core is increasingly seen as bureaucrats accountable for national performance mandates and auditing pressures, striving to enhance political careers through distinctive institutional strategies and practices, which sometimes diverge from the actual needs of the "academic heartland" for innovation, such as maintaining trust for academic sensitivity and fostering inclusive and tolerant environment for innovation. Among faculty-collectives, there is cautious distancing from the faltering of academic identity and growing external expectations for economic responsiveness, particularly the reliance on money as the meta-measure of value. Despite being involved in multisectoral innovation practices and academic entrepreneurship, many remain wary of the constraints of existing industrial demand and innovation agenda in being short-term and narrowly focused.

Regional spatial reinvention is leveraged for innovation capacity-building by expanding campuses and affiliated hospitals that broadens disciplinary profiles and enhances access to innovation resources, including funding, infrastructure, new partnerships, and increased student catchment. New campuses receive direct construction funding from the municipal governments of their host cities and leverage local resources for differentiated establishment of faculties and laboratories, though differentiation remains contested in practice. Multiversities contribute not only to education, employment, and economic growth but also to scientific and technological advancements, creative solutions to local challenges, and business and reputational capital, enhancing the attractiveness of their host localities. Such spatial strategies also drive the continuous growth of research-intensive multiversities, attracting more funding, talent, and innovation output to build a larger, more competitive portfolio for DFC evaluation. Success in securing DFC further enables internal resource redistribution within universities.

Establishing medical schools and university-affiliated hospitals is strategic to enhancing both institutional innovation capacity and potentiality to draw innovation resources. Medical and related biological sciences attract significant research funding, resources and talents while biomedicine and biotechnology have great commercial potentiality. Their public-good dimension draws prestige and attentional resources from local governments, while they are also significant in attracting talents to the region they are situated in. Both of these factors are notably exemplified by SYSU's well-established Medical Science discipline and over ten university hospitals (the number is still on the rise with emerging university-government partnerships), alongside MU and HKU's cross-border expansion of medical faculties, research centres, and university hospitals.

To better prepare for increasing external engagement and academic entrepreneurship, universities have professionalised administration in managing external contracting, licensing, and IP equity (e.g., SYSU's establishment of a research management unit for horizontal projects), along with intermediary organisations and spaces (e.g., university science parks and university asset management companies). However, these adjustments remain distant from institutional innovation and the concept of a productive TTO that plays a central role in incubating academic entrepreneurship and fostering an innovation ecosystem around the university, as stipulated in the entrepreneurial university model.

Notably, SYSU strives to align its desire for academic excellence and prestige with societal expectations concerning the intrinsic core of the university. While preserving a central multiversity character with "layered sediment" in academic research (UNI-GEO-P3, UNI-PHA-P3, UNI-CS-P3, UNI-MatS-P8, UNI-ECE-P1, UNI-ECE-P4, UNI-ECE-P7, UNI-PHY-P1, IND-P8, IND-P9), SYSU cautiously ventures into broadening enterprising roles, for instance, in expanding engineering departments and connections with other academic institutions, government, and the industry within and beyond the GBA. However, internal expectations diverge in relation to balancing these intrinsic and extrinsic purposes. Some faculties advocate for greater institutional support for university-industry collaboration and academic entrepreneurship, while others favor enhanced autonomy and a stronger commitment to basic research. This internal diversity is further complicated by the occasional misalignment of the university leadership's imaginaries of WCU and their endorsement of flagship institutional strategies and practices during their tenure.

Besides being key innovation actors, universities and their faculties also act as network brokers, synthesising the institutional priorities, resources, and capabilities across academia, industry, and government. They can potentially take a leadership role in forging multi-sectoral alliances within the GBA, bridging cross-fertilising innovation networks across SARs and Guangdong. Despite being largely top-down and framework-based, universities, particularly SYSU, which claims leadership in forging GBA alliances across multiple disciplines, create space for innovation agenda-setting and institutionalised partnerships. Alliances are perceived as of certain symbolic/strategic importance in uniting innovation forces and actors for the sake of the GBA and legitimise bottom-up innovation activities when opportunity arises. Through their connectivity with international academic communities and stakeholders, universities serve as strategic interfaces in "glonacal" innovation, with expectations of them playing a larger role in positioning the GBA as a local-global nexus for enhancing national and global connectivity, particularly amid the increasing geopolitical tensions.

Higher education systems vary significantly across and within national contexts, with universities differing in the scope of knowledge they offer, spanning STEM and SSHA disciplines (Winters, 2014); in their aspirations and spatial trajectories that shape involvement in innovation activities, practices, networks; and in their roles within the innovation system. Research-intensive multiversities, such as SYSU, tend to prioritise broad-base innovation with potentiality to drive frontier scientific and technological advancements and social cultural changes, making significant contributions to global knowledge production. This strategy often comes with a higher intellectual threshold for industrial collaboration and funding, and spin-outs. In contrast, universities with a stronger emphasis on STEM, such as SCUT, adopt institutional strategies that place greater weight on industrial funding and commercialisable innovations, and a more embracing approach to spin-outs of varying levels, whether these are high-tech or not.

Unlike the enterprise universities in many western countries, commitment to entrepreneurial activity is not a strategic priority t. Neither is private income generation from fee-based education, given that tuition fees and student quotas are still determined by provincial-level governments, in coordination with education and finance departments. The emerging "neo-type research universities" (新型研究型大学), particularly those jointly established with foreign partners such as HKUST(GZ) and CUHK(SZ), share similarities with the enterprise university model. They integrate education, research, and entrepreneurial activities to enhance advanced STI capabilities, promote academic-management synergy, and diversify funding through entrepreneurial initiatives and fee-based international education. The Chinese characteristics of enterprise universities, however, are valorised by harnessing the creative potential of academic disciplines and interdisciplinarity to tackle complex innovation challenges for the global community and academic collegiality and autonomy in innovation, beyond the constraints of performative evaluation (MOE, 2021).

The sources of enterprising universities in the GBA's regional innovation system can be understood as taking two forms. The first is exemplified by SYSU, which brokers multisectoral innovation networks across the GBA, synthesising diverse, cross-fertilising resources and capabilities. This role is largely enabled by the GBA's unique innovation system configurations, rather than the university's institutional model. The second comes from institutional and organisational innovation within universities, notably SARs-mainland cooperative institutions like HKUST(GZ), which adopt proactive management structures and strategies to integrate teaching, research, and the third mission, leveraging hybrid institutional statuses, resources, capabilities, and prestige.

Finally, this study also attests to China's predominantly public and state-led higher education system, with private institutions playing a supplementary role, underscoring the higher education sector's strong policy responsiveness and participatory function.

The top-down administrative structure and the quasi-governmental nature of universities shape an operational model characterised by government steering and university compliance, where institutions primarily function as policy implementer within the national higher education framework (Zhuo, 2025). However, institutional and academic autonomy remain ambiguous and contextually dependent.

9.2. The roles of government in GBA's innovation system

9.2.1. Central Party-state apparatus

Central party-state and ministries remain the pervasive guardians that steers ideological orientation, innovation priorities and their institutionalisation. The mainland government is "paternalistic" as the central organiser that provides policy support and funding for innovation across different stages; market regulator that drives the standardisation and professionalisation of healthcare and pharmaceutical sectors; and the "baton of administration" in reforming institutional and talent assessment standards (UNI-GEO-P4, UNI-CS-P2, UNI-PHA-P2, UNI-PHA-P3, UNI-ECE-P1, UNI-ECE-P4, UNI-CE-P1, UNI-PHY-P2, UNI-MedS-P1, UNI-MatS-P4).

The central party-state plays a leadership role in steering innovation with a structured, top-down approach involving strategic planning and targeted resource allocation, including identification and strategic deployment in relation to innovation bottlenecks, to strengthen the country's ability to maintain overall innovation capacity and reduce reliance on one-sided external supply and demand. Government STI projects, infrastructural investments, public procurement, and policies act as macro-regulatory tools to enhance innovation capacity-building. These initiatives provide a stable funding source and generate agglomeration effects in innovation, ultimately driving down R&D and production costs while improving efficiency in valorised sectors. Locally-driven experiments that manage to demonstrate an appealing rubric of initiatives or experiments are legitimatised and scaled up into the national agenda. The combination of top-down steering and bottom-up initiatives, which mutually influence each other in an iterative process, has been a defining characteristic of the Chinese party-state approach.

Besides direct leadership in innovation ideologies, policies, and strategic directives, performance auditing and the appointment of institutional leaders aligned with its ethos are another increasingly recentralising approach that is employed by the party-state. Through instruments such as DFC and STI project funding, the party-state directs innovation performance and outcomes through auditing of metrics closely tied to funding and resource allocation, leading to restructuring of disciplines and strategic priorities voluntarily enacted by universities and enterprises. This has, in part, led to institutional isomorphism towards the multiversity model, driven by its perceived stronger capacity (or potential) to absorb innovation resources and generate a larger pool of innovation outputs conducive to securing competitive advantages (perceptions by universities themselves and possible also the municipalities they belong to/admin under).

Besides SYSU, most first-tier universities initially based in Guangzhou such as SCUT, JNU, and SCNU, are also expanding their campuses and disciplinary profiles across multiple districts and municipalities in Guangdong, where education remains under-supplied. Part of the institutional isomorphism has been mitigated by the recent directives to promote the construction of "neo-type research universities" and "classification-based reform and development of higher education" (MOE, 2024). "Neo-type research universities" with STEM-focused orientations, including those jointly established with SARs partners, have emerged as experimental models envisioned to operate with greater institutional autonomy and concentrated capacity to drive strategic, interdisciplinary innovation, gaining leapfrog momentum in global science and technology frontiers.

Their development trajectories remain exploratory, and at times, discursive. Both challenges and opportunities are ahead in distinguishing themselves from traditional universities in autonomy, strategic positioning, and institutional identity, and maintaining these advantages. This involves ongoing negotiations of legitimacy with stakeholders involving parent universities, local governments, party committees, students and their families. Examples include attempts to maintain the SAR university governance structure without a party committee and ideological education and efforts to ensure that their quality and recognition match and prospectively surpass those of the parent SAR universities.

In many Western countries, university reforms are often subject to institutional arrangements such as university boards of trustees and various interest groups. However, China's current arrangement indicates that the power is highly consolidated at the university level in the president and party secretary's hands with the departments subject to their decision-making power (Han, 2017). Leadership in public universities and SOEs (increasingly, also the party secretaries in private enterprises) is embedded within the party-state's administrative ranking system and bureaucracy, incentivising local leaders to pursue political achievements visible to the central authority, seeking rewarding opportunities for political careers.

Public academic institutions, SOEs, government labs, and quasi-governmental organisations are integral administrative and functional arms of the party-state apparatus for creating innovation, knowledge, and consensus space. The CAS headquarters, for example, remain a key state-level research body, responsible for setting national standards and policies, such as the CAS journal ranking system. The party-states power is institutionalised through the dual-governance structure of "presidential responsibility under Party Committee leadership" legitimised by the *Higher Education Law,* which blurs decision-making boundaries and serves as a key mechanism for sustained state influence in Chinese universities (Han & Xu, 2019).

While concerns regarding Party dominance over academic autonomy persist (Zha, 2012), academic-administrative synergy is increasingly facilitated by the appointment of Party secretaries with strong or comparable academic credentials to university presidents. This enhances the academic legitimacy of Party leadership, alongside the political authority embedded within the academic core, since most faculty and academic leaders are also Party members or cadres. Both the SYSU President and Party Secretary play active roles in facilitating innovation agreements and launching collaborative platforms. The two most recent Party secretaries at SYSU have held PhDs, with the former originally a professor of history.

Academic-administrative synergy is further reinforced by the growing integration of Party-building and cadre training with STI and academic agendas, marking a broader shift toward embedding ideological leadership within the pragmatic governance and coordination of STI and higher education. Party-building has become an expanding force in steering innovation, fostering innovation-oriented interaction among Party branches across intra- and inter-institutional levels. This expands the channels of interaction, where previously innovation initiatives may have been led primarily by university leadership, departments, or research offices, Party branches at multiple institutional levels can now pair up to foster shared understanding and co-create spaces for innovation and entrepreneurship. This shift also reflects a growing orientation in Party-building toward combining ideological guidance with practical, innovation-driven governance, and promoting "a mutually advantaged state-scholar nexus", a consensual and productive system that works with a growing talent pool in STI (Marginson, 2021, p. 1).

Moving beyond the central party-state in China as an abstract force shaping innovation systems, this project has critically engaged with the concrete social and organisational networks the party-state embodies in practice: not with an exhaustive taxonomy of the state apparatus, but by identifying what is deemed influential by stakeholders. The central party-state shapes social consensus (e.g., ownership, sectoral relationships, legitimate/valorised activities) that enables production and exchange to function on a stable basis and "secures conditions of production" by directing investment in innovation and production in both private and public sectors; and also demand for innovation, including but not limited to the social consumption of mega scientific infrastructures, parks and research facilities to ensure the reproduction of the labour force (Clark & Dear, 2021, p.43). State power takes on a concrete form through the mediating functions of state apparatuses. State apparatuses crystallise the materiality, inertia and efficacy of innovation systems, to some extent independently from current state policies and social relations. Para-apparatuses (e.g., quasi-government organisations) increasingly penetrate the social fabric, extending state power over spatially expansive and heterogeneous jurisdictions.

9.2.2. Co-opetitive local governments: innovation organisers, political entrepreneurs, public venture capitalists and procurers

Local governments serve as intermediate regulators, facilitators and potential partners, contingent on the nature and demands of interaction, particularly the power dynamics among collaborators across sectoral spheres and localities. Notably, the SAR governments in HK and Macau are occasionally perceived as retaining some leeway or distinct spheres of influence from the central government.

In instances where university and governmental interviewees have both personal and professional connections as well as mutual communication, or where university interviewees perceive themselves as key nodes, local governments are often regarded as equal partners who are closely engaged in the collaborations. By contrast, government-commissioned projects are typically not considered as “collaborations” or “partnerships” given their top-down, uni-directional nature. Here governments serve more as “clients” or the “primary entities”. Key-node positions, both within and across sectoral networks, enable extensive referrals and due diligence on potential suppliers, clients, collaborators, financing and interactive models (Burt, 2002). Governments of different municipalities and districts serve as public venture capitalists and partners in some instances while being “primary entities” seeking consultancy and public procurement in others.

9.3. The roles of industry in GBA’s innovation system

9.3.1. Innovation supply chain

Enterprises play a central role in the innovation supply chain, primarily responsible for translating university-generated prototypes and semi-products into scalable, market-ready products. Given academia’s distance from market demands and the limitations of small-scale, experimental research, enterprises, particularly LEs and SOEs, actively filter, refine, and commercialise innovations. SMEs often face challenges in sustaining university collaborations due to constrained resources, preferring licensing, imitation, or adaptation over co-development. Despite varying innovation capacities, large firms possess stronger financial and absorptive capacities, enabling both exploratory and application-oriented innovation through strategic university partnerships. Their motivations include accelerating multiple innovation pipelines and fostering long-term competitiveness through core R&D activities. However, academia’s innovation is often too upstream or advanced for immediate enterprise adoption, leading to ongoing misalignments in expectations and capabilities.

9.3.2. Employment, training and apprenticeship

Industry significantly influences employment, training, and apprenticeship through direct collaborations and university spin-offs. Enterprises provide vital real-world scenarios and challenges for student apprenticeships, enhancing graduates' employability. Faculty-led spin-offs often offer students practical experience, aligning graduates’ skills closely with entrepreneurial and industry needs. This reduces staffing costs and provides spin-offs with personnel culturally attuned to their trajectory. Large enterprises, especially in industry-driven domains such as power, energy, and nuclear technology, frequently collaborate with universities for professional talent development, internship placements, and joint training programs. Such partnerships allow academia to engage directly in industrial practices, shaping curricula and research agendas to better reflect industry demands.

9.3.3. Hybrid/brokering organisations and public-private partnerships

Industry actors, particularly large SOEs and individual key nodes, often function as brokers, bridging academia, government, and other innovation actors. They serve as advisors, mentors, and participants in innovation contests, government expert panels, and quasi-governmental initiatives. Enterprises collaborate closely with local governments in public-private partnerships, leveraging preferential policies, subsidies, and investment opportunities. Quasi-governmental agencies and civic associations facilitate interactions across sectors, promoting networking and collaboration. Industrial representatives actively engage with these hybrid entities, shaping policy, strategic planning, and innovation frameworks. Nonetheless, successful collaborations generally emerge bottom-up through trusted relationships rather than generic, government-led networking. Enterprises also strategically use their roles in public-private alliances to consolidate political goodwill, influencing government policymaking and resource allocation, thereby strengthening their negotiating position and capacity to guide regional innovation trajectories.

9.4. Contribution

9.4.1. Conceptualisations of innovation: triangulation of policy and multi-stakeholder perspectives

The study attests to the significance of taking a more fluid and accommodating approach to researching innovation. By comparing how innovation is conceptualised in policies and by interviewees across academia, industry, and government, the study finds that policies focus on strengthening China’s indigenous innovation capability and global innovation leadership through productive cross-scale intersections of innovation, national system thinking and synergistic instruments for deployment and implementation. The study has advanced the understanding of innovation as a contested concept, beset by philosophical, practical and political tensions. It has also provided insights into the governance, policy and practice of innovation across plural disciplines, domains and institutional spaces.

The policies’ emphases on “tolerating failure” and encouraging “trial-and-error” potentially help to mitigate “risk-averse impact reporting [that] can lead to favouring quantitative indicators of short-term reach and outcomes over qualitative accounts of longer-term and collective significance and influence” (Oancea, Florez-Petour & Atkinson, 2018). The meaning of innovation can stretch from short-term, bounded activity, parsed into projects on grounds of external funding, into durable individual habitus, career-long endeavour, or to the collective tradition of inquiry. Conceptualisation of innovation as both process and outcome makes it possible to tap into the richer, more subtle and long-term contribution of innovation.

The emphasis of existing research is on using instead of theorising "innovation", with much resting in the neo-economic Schumpeterian theoretisation. This study has examined the shared attributes, types, and manner of creation of innovation. Innovation is by no means a neutral or natural process. Rather, it is infused with power tensions between globalisation, internationalisation, Westernisation, (neo)-colonisation and indigenisation/endogenisation. This echoes previous research, that innovation in some disciplines is primarily global in epistemic form whereas some develop in "national conversations paralleled across the world", constituting the "primary source of national-cultural variations in the contributions of higher education" (Marginson, 2022d, p.29).

While these dynamics partly echo Schumpeter (1947)'s conceptualisation of capitalism as an inherently dynamic, disequilibrium system where innovation and the agency of individual entrepreneurs drive "creative destruction", this study moves beyond the methodological individualism and economic determinism underlying Schumpeterian thought. Instead, it foregrounds how stakeholders' conceptualisations of innovation emerge through both individual and collective agency, and often at the strategic interface between the two.

University interviewees, despite acknowledging the need to align with national priorities, market demands, and entrepreneurial opportunities, continue to anchor innovation in the pursuit of truth, curiosity-driven knowledge production, and societal responsibility. This reflects a continued commitment to intellectual freedom, scholarly rigour, and societal responsibility, as also noted by scholars in the GBA in Zhu and Yang's (2024) study. The collective ethos of patriotism and public service through research, innovation and entrepreneurship was also expressed by some industrial and governmental interviewees. This collective agency operates at multiple scales—national and local. Notably, interviewees observed that pragmatism, particularly centred on the pursuit of individual happiness, is more pronounced in the GBA, shaped by its commercial legacy and Lingnan cultural traditions, in contrast to the stronger emphasis on national and social responsibility typically observed in northern China.

Contrasting with previous research that typically defines innovation through the synthesis of academic discourses in literature reviews (Tierney & Lanford, 2016; Cai, 2017), this study demonstrates how the conceptualisation of innovation activities, practices and networks can be qualitatively researched to understand how innovation is locally, intellectually worked out and operationalised by stakeholders in their day-to-day practices while ideologically (re)produced in policy contexts. It sheds significant light on the epistemological components of innovation and the ways innovation agenda is identified, defined, organised and evaluated, and the methodologies appropriate for indigenously generating knowledge and connections (Amir & Nugroho, 2013). There are potential cultural barriers related to local embeddedness that necessitate rearrangement of innovation activities and practices in ways more permeable to local realities.

9.4.2. Multi-scalar network approach to innovation system and Triple/Quadruple Helix

While innovation systems and triple helix theory continues to hold significant currency in policymaking and practices worldwide, they are largely grounded in Western contexts and offer a intelligible yet simplified conceptulisations of multisectoral relations and universities' roles therein. This thesis advances the state-of-art in research, innovation and higher education by providing a heuristic tool to analyse the context-specific configurations of how universities interact with other innovation actors or helix in local innovation systems.

As observed in many empirical studies, local innovation systems exhibit structural regularities from past knowledge accumulation and learning" that shape innovation activities, systematic relationships among innovation actors and growth opportunities (Iammarino 2005, p. 503; Ferretti & Parmentola, 2015). Helix configurations are reproducible across innovation sub-system, institutional, individual and project levels, though with varying relative weight, divisional roles, directionality and strength of interactions.

Guangdong's innovation system is characterised by a statist-fading, local government-led Triple Helix model that is gradually shifting towards more balanced configurations within its enterprising subsystems (e.g., Shenzhen, Guangzhou) where universities and industry progressively enhance their innovation capacities, synergistic interactions in an increasingly self-sustaining manner. As suggested by Liu and Cai (2018) in their analysis of Shenzhen's evolving Triple Helix, local governments in Guangdong benefit from significant discretion due to the province's pioneering role in China's reform and opening-up, as well as its designation as a national demonstration zone from the central government's shift towardsdecentralisation, the transition from a centrally planned to a market-oriented economy, and the growing emphasis on innovation and learning in the knowledge society.

Guangdong governments directly engage with industry, acting as "public venture capitalists" and place-branders alongside regulators, drawing enterprises with preferential policies, subsidies and investments (Etzkowitz & Zhou, 2019, p.374). However, the intermediary sub-regional and institutional levels, seen in the Shanghai Tongji Cluster (Cai & Liu, 2015), remain underdeveloped in the GBA. Reaching the ideal triparite balance observed by Cai (2018) even in sub-centres as Guangzhou and Shenzhen remains elusive given the long-standing university-industry separation and mismatches in absorptive and provisional capacities. Addressing this historically rooted structural decoupling between academia and industry requires time and continued government facilitation before the current sporadic, grassroot initiatives of boundary-spanning individuals, such as academic entrepreneurs, entrepreneurial scientists, practice professors, or industrial adjuncts can be institutionalised into systemic interaction (Etzkowitz & Zhou, 2019).

With a non-interventionist government tradition, HK SAR generally indicates a laissez-faire model where sectors remain largely disconnected, despite scholarly expectations of transition toward a balanced quadruple helix model that includes civil society as the fourth pillar (Mok & Jiang, 2020). Macau SAR constitutes a balanced quadruple helix configuration where civic associations play a "quasi-governance" role in mediating interactions, fostering consensus-building, and enhancing social cohesion across sectors and society.

This study contributes to a nested networked multi-scalar approach to conceptualising multisectoral interaction in local innovation systems. The context-specific configurations across projects, partnerships, and domains, particularly where sectoral networks with varying attributes intertwine and potentially reshape local innovation systems, remain under-discussed in extant helix models and innovation system approaches. In existing literature, the fourth pillar in quadruple helix is mainly conceptualised civil society, manifesting as citizens, communities, "media and culture-based public" as well as intermediary organisations and demand sides such as users (Carayannis & Campbell, 2009; González-Martinez et al., 2021). Hospitals constitute the fourth pillar in medical and pharmaceutical domains as both demand and supply sides. Civic associations, government-owned enterprises and research institutes of varying ownership structures can all serve as intermediary organisations.

Intermediaries (e.g., public/private research institutes, government agencies, service organisations), notwithstanding deemed largely replaceable by hybrid organisations and integrative "boundary spaces" in Triple Helix model (Etzkowitz & Zhou, 2019, p.367), remain essential for brokering different logics, priorities, and extant "structural holes" in connections and functions across institutional spheres and borders within the GBA. In universities, where knowledge production and research are central, technology transfer offices remain peripheral, with limited funding and weak institutional standing, hindering resource coordination. External commercialisation agencies offer shared spaces and funding but lack specialised expertise in technology, markets, and policy, limiting effective research translation into marketable products (Wu, Yan & Chen, 2023).

While geographical concentration is a key feature of regional innovation systems, this thesis contributes to understanding the multi-scalar production of innovation activities and networks. By examining the GBA's strategic role as a local-global nexus, it highlights how innovation network-building, collective learning, and diffusion of innovation practices, though originating in a specific location, often extend beyond local, regional, and national boundaries. This study contributes to understanding the evolving GBA innovation system as a dynamic, multi-actor configuration marked by heterogeneity and emergent balance. As integration deepens across Hong Kong, Macau, and Guangdong, institutional innovation is increasingly characterized by two-way empowerment: top-down strategic design from the central government and bottom-up feedback from cross-border innovation practices. The integration of HK and Macau's international regulatory experience with Guangdong's experimental policy capacity is fostering a hybrid governance paradigm that is both globally aligned and distinctly Chinese.

Policy coordination across the three regions is giving rise to hybrid organisations such as new research universities and R&D institutions that function as critical intermediaries, linking actors across the innovation chain and stabilizing the system. Cross-border university-industry-government collaboration is reshaping regional value networks: HK and Macau's strength in basic research complements Guangdong's industrial base, accelerating the translation of innovation into application. At the same time, universities in the SARs support local governance through research and social services. HK's financial capital and international talent facilitate Guangdong's technology commercialisation and global outreach, while Guangdong's manufacturing capabilities and market scale address industrial gaps in the SARs, enhancing supply-side autonomy and reducing external dependence.

While the GBA remains primarily a geographical and policy-driven construct, the gradual pluralisation of intra-regional innovation networks is largely propelled by bottom-up experiments and iterative trial-and-error processes that lay the groundwork for systemic transformation. The intentional ambiguity of central directives creates "strategic space" for operational discretion and development of locally produced knowledge and solutions, but the central party-state retains ultimate authority to select, endorse, and scale successful local experiments (Han, 2017).

9.5. Enterprising universities in the GBA and broader contexts of regional innovation

Universities play increasingly enterprising roles in the reproduction of GBA's regional innovation spaces. Their spatialising strategies represent a confluence of policy-driven, market-oriented, and higher education–specific rationales, highlighting their evolving role as enterprising agents in the GBA's innovation system. The three primary logics are: (1) central and local policy imperatives, (2) the capital logic of urban economic expansion, and (3) higher education's own needs for expansion, prestige, and sustained resource accumulation.

Universities are deeply embedded in national and local policy agendas, aligning their spatial strategies with governmental STI objectives. The GBA's policy frameworks emphasise cross-border collaboration, industrial upgrading, and technology transfer, prompting universities to expand their research infrastructure, industry linkages, and cross-jurisdictional educational initiatives. The central government's DFC initiative and regional policies such as the Guangdong-Hong Kong-Macao Innovation Corridor encourage universities to take on more enterprising roles in knowledge production and applied research. Local governments, in turn, strategically incorporate university-led innovation hubs into their broader urban and economic planning efforts.

The expansion of multiversities is also underpinned by the capital logic of urban economic expansion, in which they are positioned and position themselves as regional growth machines, attracting high-skilled talent, foreign investment, and emerging industries. The integration of university-led innovation ecosystems into urban planning strategies reflects a broader entrepreneurial turn in higher education, whereby universities become instruments of land valorisation, technology commercialisation, and regional economic upgrading. Spatialising strategies reflect their own internal institutional logics related to enrollment expansion, prestige accumulation, and resource acquisition.

By expanding their physical and institutional presence, universities gain access to new student markets, research funding streams, innovation facilities, collaborative and entrepreneurial opportunities. The emergence of “neo-type research universities”, such as HKUST(GZ) and CUHK(SZ), exemplifies how institutions position themselves within global academic hierarchies while simultaneously embedding within the GBA’s innovation landscape. Moreover, universities leverage their spatial expansions to attract public and private investments, often through university science parks, joint research centres, and incubator programs. These efforts reinforce their roles not only as educational institutions but also as entrepreneurial actors in regional innovation governance.

Chapter 10 Conclusion

10.1. Summary conclusion

As empirical, context-sensitive study, this thesis presents an ontologically open inquiry into universities' contributions to innovation and how such contributions are conceptualised, valorised and enacted in the day-to-day realities of organisations and individuals. The study offers valuable insights into the wider implications of that university's contributions to regional innovative development through both its own central innovation capacity and its interactions with government, industry, civil society, and other academic institutions within a nested innovation network in the GBA. Significant gaps remain understanding both the actual and potential roles of universities. This not only results in their contributions being undervalued but also leads to narrow, and at times counterproductive, expectations around participation and outputs.

In the GBA, universities' core contribution is perceived as the education of students and creation, transmission and dissemination of knowledge through teaching and research. Resting on this intrinsic core, universities are expected to spearhead cutting-edge research that facilitates national and industrial innovation, collaborate closely with industry and government in transforming academic innovation, boost local employment and stability, and exert a magnetic cultural influence, attracting talent and resources and facilitating intra-regional mobility and integration.

Notably, SYSU aligns its demand for academic excellence and prestige with societal expectations for the intrinsic core. However, internal divergences persist regarding the balance of intrinsic and extrinsic purposes. Some faculties advocate for greater institutional support for university-industry collaboration and academic entrepreneurship, while others favour enhanced autonomy and a stronger commitment to fundamental research. Unlike a static statist model, roles within Triple Helix are dynamic, varying across innovation-oriented collaborations and influenced by factors including regional environment, institutional incentives, university structures and practices, disciplinary focuses, and individual factors such as personality, social ties and professional interests.

An embedded understanding of collaborations at both meso (sub-system and institutional) and micro-levels (project and individual) is crucial for future research, policymaking, and practice in multisectoral collaboration. Individuals, departments, and institutions act as nodes of innovation networks within or/and spanning academia, industry and government. The exact interaction model in play, including which sector or actor plays the primary role, varies across networks and projects. Despite potential hybridisation among academia, industry and government, each retains its distinct institutional core and priorities that potentially create tensions in collaborations. This will advances state-of-the-art forward by retheorising university–society–state–industry relations within a distinct social framing with capacity for building more coordinated, multi-scalar systems. It advances a more inclusive global dialogue by illuminating how globally influential agendas—such as innovation system-building, enterprise, and the WCU model—are locally interpreted and practised.

The implications from the GBA innovation system are particularly noteworthy due to their strategic status relative to the PRC, their dynamic presence and potential for social and economic innovation that are arguably distinct from other leading global innovation clusters such as the Silicon Valley and Tokyo Bay Area. These insights hold significant value for regions worldwide striving to strengthen the role of higher education in innovation and regional collaborations.

10.2. Limitation and future studies

The study has several methodological and contextual limitations. In a single nested case study focusing on innovation conceptualisations, networks and practices, it was not possible to collect conclusive data on systemic-level multisectoral interactions or cross-case comparisons of universities. While the case study of SYSU offers valuable insights into how a mainland multiversity engages in multi-scalar innovation activities, it does not fully reflect the diversity of higher education institutions in the region, which warrants more future studies. Key academic innovation actors such as research institutes, particularly local branches of the CAS, which have played a central role in China's STI policy (Cai et al., 2018), were also left under-explored despite being identified by interviewees as critical collaborators.

However, this study, by advancing an illustrative, nested networked approach to analysing innovation activities at micro and meso levels, lays the groundwork for future research with broader and more diverse case representation. Future studies should expand to a wider range of higher education institutions and local innovation systems to explore how university strategies, network-building, and system participation vary by institutional mission, ranking, disciplinary profile, and university-locality relations. This is particularly relevant as more emerging universities strive to become new research-intensive or entrepreneurial universities, and more cities across Guangdong emerge as innovation players under the GBA initiative.

Supported by extensive stakeholder interviews and documentary analysis, this study enables a multifaceted exploration of complex innovation dynamics, integrating historical-phenomenological and empirical perspectives. However, as discussed in Chapter 3, data collection encountered practical constraints due to pandemic-related travel limitations and institutional gatekeeping. Response rates remained low, particularly among female faculty, those in administrative roles, and scholars in theoretically-oriented disciplines. Securing referrals for industry and government participants also proved challenging, resulting in a limited number of fully collaborative cases. These were disproportionately concentrated in entrepreneurship and the power and energy sectors, with underrepresentation in other domains. SSHA scholars were notably underrepresented, often perceiving themselves as peripheral to innovation agendas. Understanding how diverse academic fields engage with innovation is vital for a comprehensive account of universities' regional roles.

With more structured sampling and strategic access to gatekeepers of multisectoral partnerships, future research may draw on a richer bricolage of evidence such as systematic data on innovation initiatives, network mapping, and performance indicators in patents and publications, to support triangulation and trace the historical evolution of institutional roles and helix configurations.

Future research should also better integrate SSHA perspectives to capture the full spectrum of innovation contributions across disciplines, institutional roles, and genders. Preliminary findings from SSHA interviewees in business, management science, geography, and political science suggest that SSH fields contribute not only as collaborators in multidisciplinary STEM-led innovation but also in their own right through entrepreneurial training, spinouts and social ventures, stakeholder brokerage, and inclusive innovation for social and economic development. Their underrepresentation risks reinforcing a narrow, STEM-centric innovation agenda that overlooks broader societal, cultural, and environmental priorities. A more inclusive approach is needed to reflect, recognise, and support the diversity of innovation contributions and pathways within regional higher education and innovation systems. Future research would also benefit from a more thorough examination of higher education's role in skill formation as well as cultivation and retention of human capital—areas that remain under-discussed in context of research and innovation.

10.3. Policy implications

High-order spatial planning, combined with multi-scalar bottom-up initiatives, has fostered a wide array of infrastructures, resources, and institutions supportive of multi-sectoral innovation activities and network-building. Recent policies such as the Outline of the Plan for Building China into a Strong Education Country (2024－2035), tend to continously underscore the growing strategic importance of education in local and national innovation system-building (State Council, 2025). However, multi-scalar coordination, particularly driven by key-node individuals and organisations has been crucial in constructing the intermediary level still largely absent at the (sub)system scale. It remains to see how these centrally deployed and locally iterated efforts can evolve into systemic transformation, allowing the GBA to move beyond a predominantly policy-driven and geographical construct.

Positioned between the SARs and the mainland, Guangdong, with its relative openness, autonomy, and entrepreneurial culture as a demonstration zone for China's opening-up and reform, offers a promising foundation for regional synergy and innovation. While HK and Macau were once treated uniformly in national strategies, the GBA initiative increasingly emphasises their differentiated strengths and contributions to the region and China's national development agenda: Guangdong's advanced manufacturing and high-tech clusters, HK's international finance, and Macau's exhibitions and tourism sectors (State Council, 2019). Transforming the GBA from a political imaginary into a social reality will depend on whether these heterogeneous strategies, modes of production, and productive forces can synergistically contribute to a distinct model of institutional, economic, and social innovation. Cross-fertilising multi-sectoral networks within and beyond the GBA hold significant potential to strengthen "domestic circulation as the mainstay, with domestic and international circulations mutually reinforcing" (NDRC, 2023).

References

Abdelnour, S., Hasselbladh, H., & Kallinikos, J. (2017). Agency and institutions in organization studies. *Organization studies*, *38*(12), 1775-1792.

Afonso, O., Monteiro, S., & Thompson, M. (2012). A growth model for the quadruple helix. *Journal of Business Economics and Management*, *13*(5), 849-865.

Altbach, P. (2003). The costs and benefits of world-class universities. *International higher education*, (33).

Amir, S., & Nugroho, Y. (2013). Beyond the triple helix: framing STS in the developmental context. *Bulletin of Science, Technology & Society*, *33*(3-4), 115-126.

Bamberger, A., & Morris, P. (2024). Critical perspectives on internationalization in higher education: commercialization, global citizenship, or postcolonial imperialism?. *Critical Studies in Education*, *65*(2), 128-146.

Barbieri, E., Di Tommaso, M. R., & Huang, M. (2010). Industrial development policy and innovation in southern China: government targets and firms' behaviour. *European Planning Studies*, *18*(1), 83-105.

Beecher, B., Streitwieser, B., & Zhou, J. (2020). Charting a new path toward economic prosperity: Comparing policies for higher education hubs in Hong Kong and South Korea. *Industry and Higher Education*, *34*(2), 80-90.

Benneworth, P., Pinheiro, R., & Karlsen, J. (2017). Strategic agency and institutional change: Investigating the role of universities in regional innovation systems (RISs). *Regional studies*, *51*(2), 235-248.

Berger, R. (2015). Now I see it, now I don't: Researcher's position and reflexivity in qualitative research. *Qualitative research*, *15*(2), 219-234.

Berlie, J. A., & Hung, S. (2020). The Greater Bay Area and the Role of Hong Kong and Macau SARs in the Belt and Road Initiative. In *China's Globalization and the Belt and Road Initiative* (pp. 77-100). Palgrave Macmillan, Cham.

Bhaskar, R. (2014). *The possibility of naturalism: A philosophical critique of the contemporary human sciences*. Routledge.

Biernacki, P., & Waldorf, D. (1981). Snowball sampling: Problems and techniques of chain referral sampling. *Sociological methods & research*, *10*(2), 141-163.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative research journal*, *9*(2), 27-40.

Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative research in sport, exercise and health*, *11*(4), 589-597.

Bray, M., & Kwo, O. (2003). Higher education in small territories: Political transition and development in Macau. *Higher Education Policy*, *16*(4), 413-432.

Breznitz, S. M., & Feldman, M. P. (2012). The engaged university. *The Journal of Technology Transfer*, 37(2), 139–157. https://doi.org/10.1007/s10961-010-9183-6

Brislin, R. W. (1970). Back-translation for cross-cultural research. *Journal of cross-cultural psychology*, *1*(3), 185-216.

Burt, R. S. (2000). The network structure of social capital. *Research in organizational behavior*, *22*, 345-423.

Cai, Y. (2014). Implementing the Triple Helix model in a non-Western context: an institutional logics perspective. *Triple Helix*, *1*(1), 1-20.

Cai, Y. (2015). What contextual factors shape 'innovation in innovation'? Integration of insights from the Triple Helix and the institutional logics perspective. *Social Science Information*, *54*(3), 299-326.

Cai, Y., & Liu, C. (2015). The roles of universities in fostering knowledge-intensive clusters in Chinese regional innovation systems. *Science and Public Policy*, *42*(1), 15-29.

Cai, Y. (2017). From an analytical framework for understanding the innovation process in higher education to an emerging research field of innovations in higher education. *The Review of Higher Education*, *40*(4), 585-616.

Cai, Y., Normann, R., Pinheiro, R., & Sotarauta, M. (2018). Economic specialization and diversification at the country and regional level: introducing a conceptual framework to study innovation policy logics. *European Planning Studies*, *26*(12), 2407-2426.

Cai, W.L. (2020). *The World-Class Universities Imaginaries: A Comparative Systematic Review of Research Discourses in the Chinese-Medium and English-Medium Academic Literature.* (Master dissertation, University of Oxford).

Cantner, U., Graf, H., & Rothgang, M. (2019). Geographical clustering and the evaluation of cluster policies: introduction. *The Journal of Technology Transfer*, *44*(6), 1665-1672.

Carayannis, E. G., & Campbell, D. F. (2009). 'Mode 3'and'Quadruple Helix': toward a 21st century fractal innovation ecosystem. *International journal of technology management*, *46*(3-4), 201-234.

Cardinale, R., Landoni, M., & Mi, Z. (2024). Global state-owned enterprises in the 21st century: Rethinking their contribution to structural change, innovation, and public policy. *Structural Change and Economic Dynamics*, *68*, 468-472.

Chan, D., & Ng, P. T. (2008). Developing transnational higher education: Comparing the approaches of Hong Kong and Singapore. *International Journal of Educational Reform*, *17*(3), 291-307.

Chatterton, P., & Goddard, J. (2000). The response of higher education institutions to regional needs. *European Journal of Education*, *35*(4), 475-496.

Chavez, C. (2008). Conceptualizing from the inside: Advantages, complications, and demands on insider positionality. *The qualitative report*, *13*(3), 474-494.

Cheng, Y. C., Cheung, A. C. K., & Yuen, T. W. W. (2016). Developing Hong Kong as a regional education hub: functions, modes, and requirements. In *Internationalization of Higher Education* (pp. 21-42). Springer, Singapore.

Clark, B. R. (1998). The entrepreneurial university: Demand and response. *Tertiary Education and management*, *4*(1), 5-16.

Clark, B. (2001). The entrepreneurial university: New foundations for collegiality, autonomy, and achievement. *Higher education management*, *13*(2).

Clark, G. L., & Dear, M. (2021). *State apparatus: Structures and language of legitimacy*. Routledge.

Coates-Ulrichsen, T. (2023). *Universities at the heart of an innovation-led recovery* (IRC Policy Briefing 005). University of Cambridge.

Corcoran, J., & Faggian, A. (2017). Graduate migration and regional development: An international perspective. In J. Corcoran & A. Faggian (Eds.), *Graduate migration and regional development.* Edward Elgar.

Dakhli, M., & De Clercq, D. (2004). Human capital, social capital, and innovation: a multi-country study. *Entrepreneurship & regional development*, *16*(2), 107-128.

Danson, M., & Todeva, E. (2016). Government and governance of regional Triple Helix interactions. *Industry and Higher Education*, *30*(1), 13-26.

Datta, S., Saad, M., & Sarpong, D. (2019). National systems of innovation, innovation niches, and diversity in university systems. *Technological Forecasting and Social Change*, *143*(C), 27-36.

David, S. A., & Motala, S. (2017). Can BRICS build ivory towers of excellence? Giving new meaning to world-class universities. *Research in Comparative and International Education*, *12*(4), 512-528.

Deem, R., Mok, K. H., & Lucas, L. (2008). Transforming higher education in whose image? Exploring the concept of the 'world-class' university in Europe and Asia. *Higher education policy*, *21*, 83-97.

Department of Education of Guangdong Province (2017). 关于安排 2017 年世界一流大学和一流学科建设资金的公示 [Announcement on arranging the construction funds for World-Class Universities and First-Class Disciplines in 2017]. Available from: http://edu.gd.gov.cn/zwgknew/gsgg/content/post_3420886.html retrieved Feb 04 2023.

Dey, I. (1993). *Qualitative data analysis: A user-friendly guide for social scientists*. London: Routledge.

Dwyer, S. C., & Buckle, J. L. (2009). The space between: On being an insider-outsider in qualitative research. *International journal of qualitative methods*, *8*(1), 54-63.

Easton, G. (2010). Critical realism in case study research. *Industrial marketing management*, *39*(1), 118-128.

Edquist, C. (2013). *Systems of innovation: technologies, institutions and organizations*. Routledge.

Etzkowitz, H., & Leydesdorff, L. (1999). The future location of research and technology transfer. *The Journal of Technology Transfer*, *24*(2), 111-123.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research policy*, *29*(2), 109-123.

Etzkowitz, H. (2004). The evolution of the entrepreneurial university. *International Journal of Technology and Globalisation*, *1*(1), 64-77.

Etzkowitz, H., & Dzisah, J. (2008). Rethinking development: circulation in the triple helix. *Technology Analysis & Strategic Management*, *20*(6), 653-666.

Etzkowitz, H. (2013). Anatomy of the entrepreneurial university. *Social science* *information*, *52*(3), 486-511.

Etzkowitz, H. (2016). The entrepreneurial university: vision and metrics. *Industry and Higher Education*, *30*(2), 83-97.

Etzkowitz, H., & Zhou, C. (2017). *The triple helix: University–industry–government innovation and entrepreneurship*. Routledge.

Faggian, A., Modrego, F., & MaCann, P. (2019). Human capital and regional development. In R. Capello & P. Nijkamp (Eds.), *Handbook of regional growth and development theories* (2nd Ed.) (pp.149–171). https://doi.org/10.4337/9781788970020.00015

Ferretti, M., & Parmentola, A. (2015). *The creation of local innovation systems in emerging countries: the role of governments, firms and universities*. Springer.

Fleetwood, S. (2004). *An ontology for organisation and management studies* in Fleetwood, S., & Ackroyd, S. (Eds.). (2004). *Critical realist applications in organisation and management studies* (Vol. 11). Psychology Press, 25-50.

Freeman, C. (2002). Continental, national and sub-national innovation systems—complementarity and economic growth. *Research policy*, *31*(2), 191-211.

Godin, B. (2009). National innovation system: The system approach in historical perspective. *Science, Technology, & Human Values*, *34*(4), 476-501.

González-Martinez, P., García-Pérez-De-Lema, D., Castillo-Vergara, M., & Bent Hansen, P. (2021). Systematic review of the literature on the concept of civil society in the quadruple helix framework. *Journal of technology management & innovation*, *16*(4), 85-95.

Gorsky, M., & Mold, A. (2020). Documentary analysis. *Qualitative research in health care* Gorsky, M., & Mold, A. (2020). Documentary analysis. *Qualitative research in health care*, 83-96.

Guangdong-Hong Kong-Macau University Alliance. (2022). 联盟成员[Members of the Alliance]. Available from: https://eao.sysu.edu.cn/ghmua/zh-hans/basic/84. retrieved Jan 23 2023.

Guangdong Provincial Government. (2022, February 15). 广东 8 所高校入选“双一流” 新增华南农业大学、广州医科大学和南方科技大学 [Eight Guangdong universities selected for “Double First-Class”: South China Agricultural University, Guangzhou Medical University, and Southern University of Science and Technology added]. Guangdong Provincial Government. Available from:

https://www.gd.gov.cn/gdywdt/bmdt/content/post_3814345.html retrieved April 24, 2025.

Guangdong Provincial Government. (2024, May 29). 粤港澳大湾区高等教育合作交流工作情况报告出炉 广东高校在读港澳生 1.5 万人 [Report on higher education cooperation and exchange in the Guangdong–Hong Kong–Macao Greater Bay Area: 15,000 Hong Kong and Macao students enrolled in Guangdong universities]. Guangdong Provincial Government. Available from: https://www.gd.gov.cn/zwgk/zdlyxxgkzl/jy/content/post_4432519.html retrieved April 24, 2025.

Guangzhou Municipal Government. (2003). *Guangzhou National Economic and Social Development 11th Five-Year Plan* [《广州市国民经济和社会发展十一五规划》]. Guangzhou Municipal Government. Accessible at: https://www.gz.gov.cn/zwgk/ghjh/fzgh/sw/ghgy/content/post_2847660.html retrieved Jan 23 2023.

Guangzhou Municipal Government. (2006). *Guangzhou National Economic and Social Development 11th Five-Year Plan* [《广州市国民经济和社会发展十一五规划》]. Guangzhou Municipal Government. Accessible at: https://www.gz.gov.cn/zwgk/ghjh/fzgh/syw/ghgy/content/post_2847662.html retrieved Jan 23 2023.

Grünberg, L. (2000). *The mystery of values: Studies in axiology* (Vol. 95). Rodopi.

Gunasekara, C. (2006). The generative and developmental roles of universities in regional innovation systems. *Science and public policy*, *33*(2), 137-150.

Han, S. (2017). *Policy experimentation and institutional power dynamics in China's higher education reforms* (Doctoral dissertation, University of Oxford).

Han, S., & Xu, X. (2019). How far has the state 'stepped back': An exploratory study of the changing governance of higher education in China (1978–2018). *Higher Education*, *78*(5), 931-946.

Han, S., Zha, Q., & Xie, J. (2023). Understanding Chinese universities' strategic responses to the 'Double First-class' initiative and the potential outcome on higher education diversity: an exploratory study. *Studies in Higher Education*, *48*(11), 1624-1638.

Hao, Z. (2016). In search of a professional identity: higher education in Macau and the academic role of faculty. *Higher Education*, *72*(1), 101-113.

Harrion, D., & Easton, G. (2004). *Temporally embedded case comparison in industrial marketing research* in Fleetwood, S., & Ackroyd, S. (Eds.). (2004). *Critical realist applications in organisation and management studies* (Vol. 11). Psychology Press, 179-192.

HKSAR Government. (2021). Greater Bay Area education. Accessible at: https://www.bayarea.gov.hk/
en/opportunities/mainpoints-education.html retrieved 10 Apr 2025

Holland, B. A. (2001). Toward a definition and characterization of the engaged campus: Six cases. *Metropolitan Universities*, *12*(3), 20-29.

Huang, F. (2015). Building the world-class research universities: A case study of China. *Higher Education*, 70(2), 203–215. https://doi.org/10.1007/s10734-015-9876-8

Ivanova, I. (2014). Quadruple helix systems and symmetry: a step towards helix innovation system classification. *Journal of the Knowledge Economy*, *5*(2), 357-369.

Ivanova, I. A., & Leydesdorff, L. (2014). Rotational symmetry and the transformation of innovation systems in a Triple Helix of university–industry–government relations. *Technological Forecasting and Social Change*, *86*, 143-156.

Jasanoff, S. (2002). New modernities: Reimagining science, technology and development. *Environmental Values*, *11*, 253-276.

Kang, Y., & Jiang, J. (2020). Revisiting the innovation systems of cross-border cities: the role of higher education institution and cross-boundary cooperation in Hong Kong and Shenzhen. *Journal of Higher Education Policy and Management*, *42*(2), 213-229.

Kanuha, V. K. (2000). “Being” native versus “going native”: Conducting social work research as an insider. *Social work*, *45*(5), 439-447.

Karppinen, K., & Moe, H. (2012). What we talk about when we talk about document analysis. *Trends in communication policy research: New theories, methods and subjects*, 177-193.

Kelly S. (2010) Qualitative interviewing techniques and styles. In: Bourgeault I, Dingwall R, de Vries R. (eds) *The Sage Handbook of Qualitative Methods in Health Research*, Thousand Oaks: Sage Publications.

Kerr, C. (2001). *The uses of the university* (Vol. 29). Harvard University Press.

Kim, K., & Nam, S. (2007). The making of a world-class university at the periphery. *World class worldwide: Transforming research universities in Asia and*

Latin America, 122-139.

Kim, D., Song, Q., Liu, J., Liu, Q., & Grimm, A. (2018). Building world class universities in China: Exploring faculty's perceptions, interpretations of and struggles with global forces in higher education. *Compare: A Journal of Comparative and International Education*, 48(1), 92–109. https://doi.org/10.1080/03057925.2017.1292846

Kim, G. (2022). Sociocultural contexts and power dynamics in research interviews: Methodological considerations in Confucian society. *Qualitative Research*, *0(0)*, 1–18.

Kim, S. (2024). Intersectional positionalities across gender, race, ethnicity and immigrant status in qualitative interviews. *International Journal of Qualitative Studies in Education*, *37*(6), 1687-1703.

Kimatu, J. N. (2016). Evolution of strategic interactions from the triple to quad helix innovation models for sustainable development in the era of globalization. *Journal of Innovation and Entrepreneurship*, *5*(1), 1-7.

Kleibert, J. M. (2021). Geographies of marketization in higher education: Branch campuses as territorial and symbolic fixes. *Economic Geography*, *97*(4), 315-337.

Kruss, G., McGrath, S., Petersen, I. H., & Gastrow, M. (2015). Higher education and economic development: The importance of building technological capabilities. *International Journal of Educational Development*, *43*, 22-31.

Lai, A., & Maclean, R. (2011). Managing human capital in world cities: The development of Hong Kong into an education hub. *Asia Pacific Journal of Education*, *31*(3), 249-262. https://doi.org/10.1080/02188791.2011.594418.

Lam, W. M. (2010). Promoting hybridity: The politics of the new Macau identity. *The China Quarterly*, 656-674.

Lam, C., (2018). The 2018 Policy Address: Striving Ahead, Rekindling Hope. Government Printer, Hong Kong. Accessible at: https://www.policyaddress.gov.hk/2018/eng/pdf/PA2018.pdf retrieved Jan 23 2025.

Leutert, W. (2020). State-owned enterprises in contemporary China. In *The Routledge handbook of state-owned enterprises* (pp. 201-212). Routledge.

Leydesdorff, L. (2012). The triple helix, quadruple helix,…, and an N-tuple of helices: explanatory models for analyzing the knowledge-based economy?. *Journal of the knowledge economy*, *3*(1), 25-35.

Li, M., & Bray, M. (2007). Cross-border flows of students for higher education: Push–pull factors and motivations of mainland Chinese students in Hong Kong and Macau. *Higher education*, *53*(6), 791-818.

Li, J., & Wu, Q.Y. (2021). 深圳经济特区高等教育简史——40 年沿革与探索[A brief history of higher education in Shenzhen Special Economic Zone—40 years of evolution and exploration]. *Higher Education Exploration*, 7, 109–115. https://CNKI:SUN:GJTA.0. 2021-07-015.

Li, S., & Li, L. (2022). 粤港澳大湾区高等教育发展：从不平衡到平衡 [The development of higher education in the Guangdong-Hong Kong-Macao Greater Bay Area: From imbalance to balance]. *Journal of Higher Education*, *43*(8), 102-115.

Li, H., Tessone, C. J., & Zeng, A. (2024). Productive scientists are associated with lower disruption in scientific publishing. *Proceedings of the National Academy of Sciences*, 121(21), e2322462121.

Liu, A. (2023). 三螺旋理论与广东省科技创新的实践——企业、大学和政府的视角 [Triple Helix theory and the practice of technological innovation in Guangdong Province: Perspectives of industry, universities, and government]. *Industrial Innovation Research*, 24, 40-55.

Liu, C., & Cai, Y. (2018). Triple Helix model and institutional logics in Shenzhen special economic zone. *Science and Public Policy*, *45*(2), 221-231.

Liu, N. C., Wang, Q., & Cheng, Y. (2011). *Paths to a world-class university*. SensePublishers.

Liu, X. (2018). The “Double First Class” initiative under top-level design. *ECNU Review of Education*, 1(1), 147–152. https://doi.org/10.30926/ecnuroe2018010109

Lo, C. P. (1994). Economic reforms and socialist city structure: a case study of Guangzhou, China. *Urban Geography*, *15*(2), 128-149.

Lo, W. Y. W. (2018). After globalisation: A reconceptualisation of transnational Higher Education governance in Singapore and Hong Kong. *Higher Education Quarterly*, *72*(1), 3-14.

Lo, W.Y.W. and Tang, H.H.H. (2020), “Chasing phantoms? Innovation policy, higher education and the pursuit of a knowledge economy in Hong Kong”, *Journal of Higher Education Policy and Management*, Vol. 42 No. 2, pp. 178-193.

Lo, W. Y. W., & Wan, C. D. (2021). Revisiting the Asian regulatory regimes in transnational education: How local politics (re) oriented higher education policy in Malaysia, Singapore and Hong Kong. *Policy Reviews in Higher Education*, *5*(2), 113-130.

Lo, W. Y. W., Lee, J. T., & Abdrasheva, D. (2022). Global pedigree and national imperative: Hong Kong universities' response to China's grand strategies. *Higher Education*, *84*(1), 141-157.

Lo, W. Y. W., & Li, D. (2023). Reimagining the notion of Hong Kong as an education hub: National imperative for higher education policy. *International Journal of Educational Development*, *103*, 102938.

Lou, S. H. (2024). 澳门社团组织的公共治理参与 [Public governance participation of Macao community organizations]. *Journal of South China Normal University (Social Science Edition),* (5), 92-105.

Lundvall, B. A. (1992). National systems of innovation: Towards a theory of innovation and interactive learning. *Francis Printer*.

Ma, J., & Cai, Y. (2021). Innovations in an institutionalised higher education system: the role of embedded agency. *Higher Education*, *82*(5), 897-915.

Marginson, S. (2022a). 'All things are in flux': China in global science. *Higher Education*, 1-30.

Marginson, S. (2022b). What drives global science? The four competing narratives. *Studies in higher education*, *47*(8), 1566-1584.

Marginson, S. (2022c). Global science and national comparisons: Beyond bibliometrics and scientometrics. *Comparative Education*, *58*(2), 125-146.

Marginson, S. (2022d). Space and scale in higher education: The glonacal agency heuristic revisited. *Higher Education*, *84*(6), 1365-1395.

Martynovich, M. (2017). The role of local embeddedness and non-local knowledge in entrepreneurial activity. *Small Business Economics*, 49 (4), 741–762. https://doi.org/10.1007/s11187-017-9871-9

Mayring, P. (2014). Qualitative content analysis: theoretical foundation, basic procedures and software solution.

MOE. (1993). 中国教育发展和改革发展纲要 [The Outline of China's Education Development and Reform]. Ministry of Education of the People's Republic of China.

Available from: http://www.moe.gov.cn/jyb_sjzl/moe_177/tnull_2484.html retrieved Jun 23 2021.

MOE (2005). “211 工程” 学校名单 [“211 Project” University List]. Available from: http://www.moe.gov.cn/srcsite/A22/s7065/200512/t20051223_82762.html retrieved Jan 23 2023.

MOE (2006). “985 工程” 学校名单 [“985 Project” University List] Available from: http://www.moe.gov.cn/srcsite/A22/s7065/200612/t20061206_128833.html retrieved Jan 23 2023.

MOE (2017). 教育部 财政部 国家发展改革委关于印发《统筹推进世界一流大学和一流学科建设实施办法（暂行）》的通知 [*Notice of the Ministry of Education, Ministry of Finance, and the National Development and Reform Commission on Announcing the Implementation Measures for Coordinating and Promoting the Building of World-Class Universities and First-Class Disciplines (Provisional)]*. Available from:http://www.moe.gov.cn/srcsite/A22/moe_843/201701/t20170125_295701.html retrieved Jan 23 2023.

MOE (n.d.).关于“211 工程”与“985 工程”[About “211 Project” and “985 Project”] Available from: http://www.moe.gov.cn/jyb_xwfb/xw_fbh/moe_2606/moe_2074/moe_2438/moe_2442/tnull_39607.html retrieved Jan 23 2023.

MOE. (2021, March 23). *教育部关于印发《普通高等学校本科教育教学审核评估实施方案（2021—2025 年）》的通知* [Notice from the Ministry of Education on the issuance of the implementation plan for the review and evaluation of undergraduate education and teaching in regular higher education institutions (2021–2025)]. http://www.moe.gov.cn/jyb_xwfb/moe_2082/2021/2021_zl22/202103/t20210323_521955.html retrieved Jan 23 2025.

MOE (2022a, February). 教育部 财政部 国家发展改革委关于公布第二轮“双一流”建设高校及建设学科名单的通知 [*Notice of the Ministry of Education, Ministry of Finance, and the National Development and Reform Commission on Announcing the List of Universities and Disciplines for Second Round of ‘Double First-Class Construction’.*] Available from: http://www.moe.gov.cn/srcsite/A22/s7065/202202/t20220211_598710.html retrieved Jan 23 2023.

MOE. (2022b, February). 服务创新发展，完善管理机制，推动高层次人才培养与高水平科学研究相互促进 [Serve innovation development, refine management structure: Co-building high-level talents cultivation and high-level scientific research]. Accessible at:

http://www.moe.gov.cn/jyb_xwfb/s271/202202/t20220214_599080.html retrieved Mar 20 2025.

MOE. (2022c, April). 中华人民共和国高等教育法[Higher Education Law of the People's Republic of China] Accessible at: http://www.moe.gov.cn/jyb_sjzl/sjzl_zcfg/zcfg_jyfl/202204/t20220421_620257.html retrieved Mar 20 2025.

MOE. (2025, Jan). 中共中央 国务院印发《教育强国建设规划纲要（2024—2035年）》[The Communist Party of China Central Committee and the State Council Issued the Outline of the Plan for Building a Strong Education Nation (2024–2035)] Accessible at: http://www.moe.gov.cn/jyb_xxgk/moe_1777/moe_1778/202501/t20250119_1176193.html retrieved Mar 20 2025.

Mok, K. H. (2016). The quest for regional education hub status: Challenges, possibilities and search for new governance in Hong Kong. In *Internationalization of higher education* (pp. 43-62). Springer, Singapore.

Mok, K. H., & Jiang, J. (2020). Towards corporatized collaborative governance: the multiple networks model and entrepreneurial universities in Hong Kong. *Studies in Higher Education*, *45*(10), 2110-2120.

Mok, K. H. (2022). The role of higher education, innovation, and entrepreneurship in bay areas: Challenges and opportunities. *Higher education, innovation and entrepreneurship from comparative perspectives: Reengineering China through the Greater Bay economy and development*, 1-14.

Montresor, S. (2001). Techno-globalism, techno-nationalism and technological systems: organizing the evidence. *Technovation*, *21*(7), 399-412.

Nelson, R. R. (Ed.). (1993). *National innovation systems: a comparative analysis*. Oxford university press.

NDRC. (2023, March 22). 统筹发挥国内大循环主体作用和国内国际双循环相互促进作用 [*Coordinating the main role of domestic circulation and mutual promotion of domestic and international dual circulation*]. Available from https://www.ndrc.gov.cn/wsdwhfz/202303/t20230322_1351592_ext.html etrieved April 20, 2024.

Noy, C. (2008). Sampling knowledge: The hermeneutics of snowball sampling in qualitative research. *International Journal of social research methodology*, *11*(4), 327-344.

Oancea, A., Florez-Petour, T., & Atkinson, J. (2018). The ecologies and economy of cultural value from research. *International Journal of Cultural Policy*, *24*(1), 1-24.

Oancea, A., Derrick, G., Robson, J., & Xin, X. (2022). The role of research and research assessment in higher education. *Centre for Global Higher Education*. Accessible at: https://www.researchcghe.org/wp-content/uploads/migrate/project-3-at-2022-cghe-conference-1.pdf#page=13.00. retrieved Apr 26, 2025.

OECD. (1995). The Implications of the Knowledge-Based Economy for Future Science and Technology Policies, *OCDE/GD, (95),* 136.

OECD. (2001). Innovative clusters: drivers of national innovation systems.

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and policy in mental health and mental health services research*, *42*, 533-544.

Parker, C., Scott, S., & Geddes, A. (2019). Snowball sampling. *SAGE research methods foundations*.

Pedersen, T. H. (2019, September). Innovation as a Social Phenomenon: Exploring the Past of PSI Studies. In *European Conference on Innovation and Entrepreneurship* (pp. 775-XXIII). Academic Conferences International Limited.

People's Government of Guangdong Province (2022). 广东 2022 年高等教育"冲一流、补短板、强特色"提升计划资金安排方案公示 [Announcement of the Funding Arrangement for Guangdong's 2022 Higher Education Improvement Plan of "Going First-Class, Bolstering Weaknesses, and Strengthening Characteristics"]. Available from: http://www.gd.gov.cn/gdywdt/bmdt/content/post_3776677.html retrieved Feb 04 2023.

Punch, K. F., & Oancea, A. (2014). Introduction to research methods in education.

Ranga, M., & Etzkowitz, H. (2015). Triple Helix systems: an analytical framework for innovation policy and practice in the Knowledge Society. *Entrepreneurship and knowledge exchange*, 117-158.Ruiz-Rodgers, N. (2011). The Role of Research University in the Third World. In *Paths to a World-Class University* (pp. 107-124). Sense Publishers.

Reichert, S. (2019). Innovation ecosystems: The role of universities in regional development. *European University Association.* Available from:

https://www.eua.eu/images/pdf/eua_innovation_ecosystem_report.pdf retrieved Feb 04 2025.

Rodriguez-Pomeda, J., & Casani, F. (2016). Legitimating the world-class university concept through the discourse of elite universities' presidents. *Higher Education Research & Development*, *35*(6), 1269-1283.

Saldaña, J. (2021). The coding manual for qualitative researchers. *The coding manual for qualitative researchers*, 1-440.

Salmi, J., & Froumin, I. (2013). Excellence initiatives to establish world-class universities: Evaluation of recent experiences. *Voprosy obrazovaniya/Educational Studies Moscow*, (1), 25-68.

Sands, R. G., & Roer-Strier, D. (2006). Using data triangulation of mother and daughter interviews to enhance research about families. *Qualitative Social Work*, *5*(2), 237-260.

Sayer, A. (2004). *Foreword* in Fleetwood, S., & Ackroyd, S. (Eds.). (2004). *Critical realist applications in organisation and management studies* (Vol. 11). Psychology Press, 6-19.

Scott, D. (2013). *Education, epistemology and critical realism*. Routledge.

Schumpeter, J. A. (1947). The creative response in economic history. *The journal of economic history*, *7*(2), 149-159.

Sharif, N. (2004). Contributions from the Sociology of Technology to the Study of Innovation Systems. *Knowledge, Technology & Policy*, *17*(3), 83-105.

Sharif, N. (2006). Emergence and development of the National Innovation Systems concept. *Research policy*, *35*(5), 745-766.

Sharif, N. (2015). Understanding the "National Innovation System" Conceptual Approach as a Social and Governmental Technology. *Tecnoscienza–Italian Journal of Science & Technology Studies*, *6*(1), 33-60.

Sharif, N. (2020), "Realizing Hong Kong's innovation potential in the Greater Bay Area (January 1, 2020)", HKUST IEMS Working Paper No. 36, available at: https://ssrn.com/abstract53522370 or http://dx.doi.org/10.2139/ssrn.3522370

Shenzhen Municipal Government. (2022, August 22). *深圳市前海深港现代服务业合作区管理局支持科技创新实施办法（试行）政策解读* [Interpretation of the Measures for Supporting Technological Innovation in the Qianhai Shenzhen-Hong

Kong Modern Service Industry Cooperation Zone (Trial)]. Shenzhen Municipal Government. Accessible at: https://www.sz.gov.cn/zfgb/zcjd/content/post_10042698.html retrieved Feb 04 2023.

Shore, C., & McLauchlan, L. (2012). 'Third mission'activities, commercialisation and academic entrepreneurs. *Social Anthropology/Anthropologie Sociale*, *20*(3), 267-286.

Smolentseva, A. (2010). In search of world-class universities: The case of Russia. *International Higher Education*, (58).

State Council. (2025, January 19). 教育强国（2024-2035） [Outline of the plan for building China into a strong education country (2024–2035)]. Xinhua News Agency. Retrieved July 27, 2025, from https://www.gov.cn/zhengce/202501/content_6999913.htm

Stenhouse, L. (1978). Case study and case records: towards a contemporary history of education. *British educational research journal*, *4*(2), 21-39.

Song, J. (2018). Creating world-class universities in China: Strategies and impacts at a renowned research university. *Higher Education*, *75*, 729-742.

SYSU Information Disclosure. (2022). 中山大学 2022 年度部门预算[Departmental budget of SYSU in 2022] Available from: https://xxgk.sysu.edu.cn/article/249 retrieved Feb 04 2023.

SYSU News. (2022). 我校获国家自然科学基金资助项目数连续两年突破千项 [The number of SYSU's projects funded by the NNSFC has exceeded 1,000 for two consecutive years] Available from: https://www.sysu.edu.cn/news/info/2161/715701.htm retrieved Jan 23 2023.

Tang, K. C., & Bray, M. (2000). Colonial models and the evolution of education systems-Centralization and decentralization in Hong Kong and Macau. *Journal of Educational Administration*.

Tang, L., & Horta, H. (2021). Women academics in Chinese universities: a historical perspective. *Higher Education*, 1-31.

Tang, H. H. H. (2022). The strategic role of world-class universities in regional innovation system: China's Greater Bay Area and Hong Kong's academic profession. *Asian Education and Development Studies*, *11*(1), 7-22.

Tierney, W. G., & Lanford, M. (2016). Conceptualizing innovation in higher education. In *Higher education: Handbook of theory and research* (pp. 1-40). Springer, Cham.

Tsang, Y.K., (2011). *The 2011–12 Policy Address: From Strength to Strength*. Government Printer, Hong Kong. Accessible at: https://www.policyaddress.gov.hk/11-12/eng/pdf/Policy11-12.pdf retrieved Aug 5 2024.

Tsoukas, H. (1989). The validity of idiographic research explanations. *Academy of management review*, *14*(4), 551-561.

Torch Centre of the Ministry of Science and Technology. (2022). 关于启动 2022 年度火炬科技成果直通车工作的通知[*Notice on launching the 2022 Torch Scientific and Technological Achievements Through-Train-Campaign*.] Available from: http://www.chinatorch.gov.cn/ retrieved Aug 5 2022.

Thomas, G. (2021). *How to do your case study*. Sage.

Tsoukas, H. (1989). The validity of idiographic research explanations. *Academy of management review*, *14*(4), 551-561.

Uyarra, E. (2010). Conceptualizing the regional roles of universities, implications and contradictions. *European Planning Studies*, *18*(8), 1227-1246.

Vallance, P., Blažek, J., Edwards, J., & Květoň, V. (2018). Smart specialisation in regions with less-developed research and innovation systems: A changing role for universities?. *Environment and Planning C: Politics and Space*, *36*(2), 219-238.

Wang, J. (2018). Innovation and government intervention: A comparison of Singapore and Hong Kong. *Research Policy*, *47*(2), 399-412.

Wang, Q. (2019). Yue gang ao da wan qu guo ji gao deng jiao yu shi fan qu nei han, ding wei, kun jing yu shi xian lu jing. *Higher Education Exploration*, (8), 62-67.

Wang, Y. (2024). *Markets with Bureaucratic Characteristics: How Economic Bureaucrats Make Policies and Remake the Chinese State*. Columbia University Press.

Wang, Z., & Lin, G. (2022). 交叉学科建设：第二轮"双一流"建设战略价值 [Vision on inter-disciplinary development and pathways (Dialogue)]. E*ducation Development Research,* 11(Special Issue), 1–4. https://doi.org/10.14121/j.cnki.1008-3855.2022.11.016

Waters, J. L., & Leung, M. W. (2017). Domesticating transnational education: discourses of social value, self-worth and the institutionalisation of failure in 'meritocratic' Hong Kong. *Transactions of the Institute of British Geographers*, *42*(2), 233-245.

Wei, Y., & Johnstone, C. (2020). Examining the race for world-class universities in China: a culture script analysis. *Higher Education*, *79*(3), 553-567.

Winters, J. V. (2014). STEM graduates, human capital externalities, and wages in the US. *Regional Science and Urban Economics*, 48, 190–198. https://doi.org/10.1016/j.regsciurbeco.2014.07.003

Wu, J., & Vong, S. K. (2017). Macau higher education expansion in flux: a critical spatial perspective. *Discourse: Studies in the Cultural Politics of Education*, *38*(6), 937-954.

Xie, X., Huang, Q., & Jung, J. (2022). Higher education and regional development of Shenzhen municipality in China's greater bay area. *International Journal of Chinese Education*, *11*(3).

Xiong, B. (2022). 第二轮"双一流"建设的"看点" ["Highlights" in the second round of "Double First-Class" university and discipline construction]. *Shanghai Journal of Educational Evaluation*, 11(2), 24–27. http://www.shjee.org.cn/shjypgyj/ch/reader/view_abstract.aspx?flag=1&file_no=2022020024&journal_id=shjypgyj

Xu, J., & Yeh, A. G. (2005). City repositioning and competitiveness building in regional development: New development strategies in Guangzhou, China. *International journal of urban and regional research*, *29*(2), 283-308.

Xu, C. Q., & Huang, Y. M. (2019). 制度变迁视角下粤港澳大湾区高等教育一体化发展研究 [Research on the Integrated Development of Higher Education in Guangdong-Hong Kong-Macao Greater Bay Area under the View of Institutional Change]. *China Higher Education Research*, 07, 25–32. https://doi.org/10.16298/j.cnki.1004-3667.2019.07.05.

Yan, X. (2017). A study of Macao tertiary students' language attitudes after the handover. *Language Awareness*, *26*(1), 25-40.

Yang, L., Yang, J., & Wang, C. (2021). The research-intensive university in a glonacal higher education system: The creation of the world-class university in China. *Journal of Higher Education Policy and Management*, 43(4), 415–434. https://doi.org/10.1080/1360080X.2021.1884512

Yang, R. (2012). Academic entrepreneurialism in a context of altered governance: Some reflections of higher education in Hong Kong. *Globalisation, Societies and Education*, *10*(3), 387-402.

Yang, Y., & Qin, N. (2024). 粤港澳大湾区真的产业结构趋同了吗?——基于制造业产业结构趋同与竞合关系视角 [Is the industrial structure of the Guangdong-Hong Kong-Macao Greater Bay Area really converging? — Based on the perspective of manufacturing industry structure convergence and the competition-cooperation relationship]. *Jinan Journal (Philosophy & Social Sciences)*, 306, 123-135.

Yigitcanlar, T. (2016). Understanding the multidimensional nature of innovation in the era of knowledge-based economy. *International Journal of Knowledge-Based Development*, *7*(3), 203-206.

Yin, R. K. (2018). Case study research and applications: Design and methods. (6th ed.) Sage publications.

Yoda, N., & Kuwashima, K. (2020). Triple helix of university–industry–government relations in Japan: Transitions of collaborations and interactions. *Journal of the Knowledge Economy*, *11*(3), 1120-1144.

Yu, H. (2021). The Guangdong-Hong Kong-Macau greater bay area in the making: Development plan and challenges. *Cambridge Review of International Affairs*, *34*(4), 481-509.

Zhang, M., & Cai, L. L. (2021). 粤港澳大湾区高校互补与合作研究[A study on the complementarity and cooperation of universities in the Guangdong-Hong Kong-Macao greater bay area]. *Journal of Higher Education*, 23, 23–26. https:// CNKI:SUN:GJXK.0.2021-23-007.

Zhang, X., & Wang, P. (2024). The politics of higher education in China: the signal–response mechanism, downward tiered pressure escalation, and the Double First-Class University Initiative. *Comparative Education*, 1-23.

Zheng, G., & Li, W. (2024). Critical policy analysis of the second round of the double first-class project in China. *ECNU Review of Education*, 20965311241265372.

Zhuo, Z., Yang, T., & Ma, Z. (2020). 高等教育改革如何促进区域协调发展——以京津冀、长三角和粤港澳大湾区为例 [How higher education reform promotes regional coordinated development — A case study of the Beijing-Tianjin-Hebei, Yangtze River Delta, and Guangdong-Hong Kong-Macao Greater Bay Area]. *Theoretical Exploration*, 12, 35-45. https://doi.org/10.13236/j.cnki.jshe.2020.12.007

Zhu, J. H., & Yang, R. (2024). The Chinese idea of a university in flux: academic freedom and institutional autonomy under entrepreneurial reforms in the GBA. *Studies in Higher Education*, 1-18.

Zhuo, Z. L., (2025). 研究型大学赋能区域创新发展的理论审思与策略——以粤港澳大湾区为例 [Theoretical Thinking and Transformation Strategies of Research Universities Empowering Regional Innovative Development:A Case Study of Guangdong-Hong Kong-Macao Greater Bay Area]. *Journal of East China Normal University: Educational Sciences*, (1), 67-80.

Zong, X., & Zhang, W. (2019). Establishing world-class universities in China: deploying a quasi-experimental design to evaluate the net effects of Project 985. *Studies in Higher Education*, *44*(3), 417-431.

Appendices

Appendix 1. List of provisional interview questions

<u>For university faculty/department leadership:</u>

1. How do you understand the meaning of "innovation"?
2. How do you perceive the respective roles of innovation for the university, industry and government?
3. What innovation-oriented collaboration are you/[or faculty/department, or group/project] currently engaged in? Are there any collaborative projects with the industry?
    3.1. What's the scale (long-term vs short-term) of these activities?
    3.2. How are these activities initiated and organised (top-down vs bottom up or both)?
    3.3. What roles do you/your research group play?How about that of your collaborative partners?
4. What motivates you/your department/research group to engage in these activities and practices? What opportunities and challenges have you encountered?
5. Are there any collaborative projects with government? Why collaborating? Who's involved and how? (same sub-questions as above)
6. What are the impacts of these innovation-oriented collaborations?
7. Are there any collaborations with other universities, particularly those from Hong Kong and Macau? How do you select you collaborators?
8. Transition from university to regional lens: How do you understand the current status of regional innovation in the Greater Bay Area?

9. What more can/should university do in order to foster regional innovation in the Greater Bay Area?

10. What is the relevance of the World-Class University/Double-First-Class Agenda and the Great Bay Area Initiative in encouraging universities to contribute to regional innovation development?

11. What factors do you find it particularly influential in shaping your innovation-oriented activities and their outcomes (individual, institutional, contextual level)?

12. Do you have anything more to say that did not cover?

<u>For industrial actors:</u>

1. How do you understand the meaning of "innovation"?
2. How do you perceive the respective roles of innovation for the university, industry and government?
3. What innovation-oriented collaboration are/have you engaged in with the university?
    3.1. What's the scale (long-term vs short-term) of these activities?
    3.2. How are these activities initiated and organised (top-down vs bottom up or both)? How do you select your collaborators?
    3.3. What roles do you/your research group play?How about that of your collaborative partners?
4. What motivates you/your company to engage in these activities and practices? What opportunities and challenges have you encountered?
5. Are there any collaborative projects with government? Why collaborating? Who's involved and how? (same sub-questions as above)
6. What are the impacts of these innovation-oriented collaborations?
7. Are there any collaborations with other universities, particularly those from Hong Kong and Macau? How do you select you collaborators?
8. Transition from university to regional lens: How do you understand the current status of regional innovation in the Greater Bay Area?
9. In your opinion, what more can/should university do in order to foster regional innovation in the Greater Bay Area?
10. What is the relevance of the World-Class University/Double-First-Class Agenda and the Great Bay Area Initiative in encouraging universities to contribute to regional innovation development? Is this your selection criteria for collaborators?
11. What factors do you find it particularly influential in shaping your innovation-oriented activities and their outcomes (individual, institutional, contextual level)?
12. Do you have anything more to say that did not cover?

<u>For government actors:</u>

1. How do you understand the meaning of “innovation”?

2. How do you perceive the respective roles of innovation for the university, industry and government? Who are the principal actors and why?

3. Based on your experience, what are the opportunities and challenges of fostering innovation-oriented collaboration among the university, industry and government? What’s your relevant experiences in fostering such collaboration (e.g., university-industry, university-government)?

4. Transition from university to regional lens: How do you understand the current role of university in the regional innovative development of the GBA? What more should be done?

5. What is the relevance of the World-Class University/Double-First-Class Agenda and the Great Bay Area Initiative in encouraging universities to contribute to regional innovation development?

6. What factors are influential in shaping these innovation-oriented activities and collaborations(individual, institutional, contextual level)?

7. Do you have anything more to say that did not cover?

Appendix 2. Participant Information Sheet

The contribution of universities to regional innovative development in the Great Bay Area of China

PARTICIPANT INFORMATION SHEET

Central University Research Ethics Committee Approval Reference: [CIA-21-281]

Introductory paragraph

You are being invited to take part in a research project. Before you decide to participate, it is important to understand why the research is being conducted and what your participation will entail. Please take time to read the following information carefully. Please ask if there is anything that is unclear or if you would like more information. Take time to decide whether you wish to take part.

Why is this research being conducted?

This research is a case study of the regional innovation system in the Great Bay Area (GBA) of China, a critical site for understanding the contribution of universities to regional innovation development. The project aims to gain an in-depth understanding of the innovation activities of a case universities located in Guangzhou and Shenzhen and its interactions with the industrial and government actors in innovative collaborations.

Why have I been invited to take part?

This research seeks to understand how the key stakeholders within the GBA perceive the role of universities in the regional innovation system. These stakeholders include academics and administrative staffs at the case universities; government officials and relevant industrial partners engaged in innovation-oriented collaborative activities with the case university. You have been identified as a key stakeholder in the university/industrial/government sector, who can provide crucial insights into the university/enterprise' s engagement in innovation activities and operational challenges of interacting with stakeholders across different sectors in the GBA.

Do I have to take part?

It is your decision to take part in this study. You can withdraw yourself from the study, without giving a reason, by advising me of this decision. The deadline by which you can withdraw any information you have contributed to the research is **30/05/2022**. If you have decided to withdraw, the data collected from you will be deleted from the researcher's devices and the University of Oxford's Onedrive facility as soon as possible.

How will I take part in the research?

To participate in the interview, you will first need to sign the consent form and return it back to the researcher through the same email address where the form is sent. The research will involve an one-hour interview scheduled between September and December 2021. The interview can take place either online via Microsoft Teams (if this is inaccessible or other means are preferred, please advise me of your preferred options) or in person preferably in a booked office/meeting room. You can provide the researcher with a list of available dates and time within this period and any preferable locations (if applicable). Based on this, the researcher will try to schedule the interview at your convenience.

The interview questions broadly relate to the innovation activities you/your department/your company engage in; the interactions with the government and the universities; and the contributions and challenges of such engagement and collaboration. There is no known sensitive questions in the interview. However, you do not need to answer questions that you do not wish to. With your consent, I would like to audio record our interview in order to have an accurate record of our conversation. If you wish not to be recorded, you may be contacted to review the interview transcripts sent by the researcher in encrypted files in order for accuracy confirmation.

What will happen to the results of this research?
The results of this research will form the basis of an Oxford doctoral thesis. A copy of the thesis which will be deposited both in print and online in the Oxford University Research Archive, being publicly available to facilitate its use in future research with restricted access. Some of the results may be published in academic journals concerning higher education, innovation studies and regional development.

Before public release, all data will be stored and accessed securely on the University of Oxford's Onedrive facility and protected by passwords throughout the research project following the University's requirements. You will be anonymised in the presentation of results. However, if you wish to be identifiable in this research, you may advise the researcher of this preference. Only the researcher and the researcher's supervisors will have access to the research data. If you wish to obtain a copy of the published results, please inform the researcher. The research will take place over the next two to three years after which time the published results will be publicly available.

What are the possible risks and benefits of taking part?
Every effort will be made to protect confidentiality, but as this cannot be fully guaranteed by the nature of this research, it is possible that you may be identified in the final report. Other than this, there is no known risk of participating in this research. Personally, you may benefit from a better understanding of the complexity involved in being more proactive in innovation-oriented activities in collaboration with the government and the universities. This understanding may help you and your organisation address the challenges of innovation more effectively and potentially benefiting more such strategic collaborations. Furthermore, your participation will also benefit those trying to formulate, understand or implement the innovation policies and practices in the GBA.

Data Protection
The University of Oxford is the data controller with respect to your personal data, and as such will determine how your personal data is used in the study. The University will process your personal data for the purpose of the research outlined above. Research is a task that is performed in the public interest. Further information about your rights with respect to your personal data is available from https://compliance.admin.ox.ac.uk/individual-rights.

Contacts for Further Information or Follow-up

If you would like to discuss the research with someone beforehand (or if you have questions afterwards), please contact:

Wanlin Cai, DPhil student,
Department of Education,
15 Norham Gardens, Oxford, OX2 6PY
wanlin.cai @education.ox.ac.uk

Appendix 3. Participation Consent Form

Consent to take part in the study “The contribution of universities to regional innovation development in the Great Bay Area of China”

Central University Research Ethics Committee (CUREC) approval reference: CIA-21-281

Purpose of Study: This project is a nested case study of the regional innovation system in the Great Bay Area (GBA) of China, a critical site for understanding the contribution of universities to regional innovation development. The project aims to gain an in-depth understanding of the innovation activities of eight case universities located in Guangzhou, Shenzhen and Hong Kong and their interactions with the industrial and government actors in innovative collaborations.

	Please initial each box if you agree with the statement
I confirm that I have read and understand the information sheet dated ________ for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
I understand that my participation is voluntary and that I am free to withdraw at any point **until 10/12/2021**, without giving any reason.	
I understand who will have access to personal data provided, how the data will be stored and what will happen to the data at the end of the project.	
I understand that I will (not) be/ the extent to which I could be identifiable from any publications.	
[**Optional**:] I consent to being audio recorded.	
I understand how audio recordings will be used in research outputs.	
Use of quotations: Please indicate your preference (select *one* option):	
a) I do not wish to be quoted. **or**	
b) I agree to the use of quotations in research outputs if I am not identifiable. **or**	
c) I agree to the use of direct quotations, attributed to my name, in research outputs.	

I give permission for you to contact me again to clarify information. ☐

I agree to take part in the study.[27] ☐

I understand how to raise a concern or make a complaint. ☐

Optional: I agree to my de-identified research data being used, for future research. ☐

Optional: I agree that my personal contact details can be retained in a secure database so that the researchers can contact me about future studies. ☐

______________________	___________________	______________________
Name of participant	Date	Signature
______________________	___________________	______________________
Name of person taking consent	Date[28]	Signature

[27] I hereby assign to the researcher all copyright in my contribution for use in all work stemming from this project and future projects.

[28] *To be signed and dated in the presence of the participant. Once this has been signed by both parties the participant should receive a copy of the signed and dated participant consent form. The original signed and dated consent form should be kept with the project's main documents which must be kept in a secure location.

Appendix 4. List of policy documents selected for documentary analysis

Policy type	Abbreviation	Document title	Issue time
Innovation policy (n=7)	D-11-NI	National Independent Innovation Ability Construction Plan During the '11th Five-Year Plan'	2008
	D-12-NI	National Independent Innovation Ability construction plan During the '12th Five-Year Plan'	2013
	D-12-NIR	Opinions on Deepening the Reform of the System and Mechanisms to Accelerate the Implementation of the Innovation-Driven Development Strategy	2015
	D-13-NI	Outline of the National Strategy of Innovation-Driven Development	2016
	D-13-PI	Decision of the Guangzhou Municipal Party Committee and the Guangzhou Municipal People's Government on Accelerating the Implementation of the Innovation-Driven Development Strategy	
	D-13-NMEI	State Council's Opinions on Promoting High-Quality Development of Innovation and Entrepreneurship and "Mass Entrepreneurship and Innovation" (Upgraded version)	2018
	D-13-PI	Regulations on Independent Innovation in Guangdong Province	2019
S&T policy (n=14)	D-11-NLSTD	National Medium- and Long-Term Program for Science and Technology Development (2006-2020)	2006
	D-11-NSTI	National Science and Technology Innovation Plan During the '11th Five-Year Plan'	
	D-11-PSTD	Guangdong Science and Technology Development Plan During the '11th Five-Year Plan'	
	D-11-DSTD-TH	Tianhe District Science and Technology Development Plan During the '11th Five-Year Plan'	
	D-12-NSTI	National Science and Technology Innovation Plan During the '12th Five-Year Plan'	2012
	D-12-PSTD	Guangdong Science and Technology Development Plan During the '12th Five-Year Plan'	
	D-12-CSTD	Guangzhou Science and Technology	

		Development Plan During the '12th Five-Year Plan'	
	D-12-PPSSD	Guangdong Philosophy and Social Sciences Development Plan During the '12th Five-Year Plan'	2016
	D-13-NSTI	National Science and Technology Innovation Plan During the '13th Five-Year Plan'	
	D-13-NSTISD	National Plan for Science and Technology Innovation in Social Development During the '13th Five-Year Plan'	
	D-13-PSTI	Guangdong Science and Technology Innovation Plan During the '13th Five-Year Plan'	
	D-13-CSTI	Guangzhou Science and Technology Innovation Plan During the '13th Five-Year Plan'	
	D-13-DSTIT-HZ	Haizhu District Science, Technology, Information Technology Development Plan During the '13th Five-Year Plan'	
	D-13-NIPSBR	Implementation Plan for Strengthening the '0 to 1' Basic Research	2018
	D-14-PSTI	Guangdong Science and Technology Innovation Plan During the '14th Five-Year Plan'	2021
	D-14-CSTI	Guangzhou Science and Technology Innovation Plan During the '14th Five-Year Plan'	
	D-14-DSTI-HZ	Haizhu District Science and Technology Innovation Plan During the '14th Five-Year Plan'	
Economic and social development policy (n=20)	D-11-NESD	Outline of the 11th Five-Year Plan for the National Economic and Social Development of the People's Republic of China	2006
	D-11-PESD	Outline of the 11th Five-Year Plan for the National Economic and Social Development of Guangdong	
	D-11-CESD	Outline of the 11th Five-Year Plan for the National Economic and Social Development of Guangzhou	
	D-11-DESD-HZ	Outline of the 11th Five-Year Plan for the National Economic and Social Development of Haizhu District	
	D-12-NESD	Outline of the 12th Five-Year Plan for the National Economic and Social Development	2011

		of the People's Republic of China	
	D-12-PESD	Outline of the 12th Five-Year Plan for the National Economic and Social Development of Guangdong Province	
	D-12-CESD	Outline of the 12th Five-Year Plan for the National Economic and Social Development of Guangzhou	
	D-12-DESD-HZ	Outline of the 12th Five-Year Plan for the National Economic and Social Development of Haizhu District	
	D-12-DESD-TH	Outline of the 12th Five-Year Plan for the National Economic and Social Development of Tianhe District	
	D-12-DMP-HZ	Haizhu District Master Plan (2015-2030)	2015
	D-13-NESD	Outline of the 13th Five-Year Plan for the National Economic and Social Development of the People's Republic of China	2016
	D-13-DPGIKV	Opinions on Implementing Distribution Policies Guided by the Increase in Knowledge Value	
	D-13-PESD	Outline of the 13th Five-Year Plan for the National Economic and Social Development of Guangdong Province	
	D-13-CESD	Outline of the 13th Five-Year Plan for the National Economic and Social Development of Guangzhou	
	D-13-DESD-HZ	Outline of the 13th Five-Year Plan for the National Economic and Social Development of Haizhu District	
	D-13-DESD-TH	Outline of the 13th Five-Year Plan for the National Economic and Social Development of Tianhe District	
	D-14-NESD	Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China	2021
	D-14-PESD	Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of Guangdong Province	
	D-14-CESD	Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of Guangzhou	

	D-14-DESD-HZ	Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of Haizhu District	
	D-14-DESD-TH	Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of Tianhe District	
Educational policies (n=26)	D-11-NLSTHE	Medium-and Long-Term Plan for the Development of Science and Technology in Higher Education (2006-2020)	2004
	D-11-NUSTPD	National University Science and Technology Park Development Plan Outline for the 11th Five-Year Plan Period	2006
	D-11-NIGE	Opinions of the Ministry of Education on Implementing the Innovative Plan for Graduate Education, Strengthening the Cultivation of Graduate Students' Innovative Ability, and Further Improving the Quality of Education	
	D-11-PED	Development Plan of Education in Guangdong Province during the 11th Five-Year Plan period	2007
	D-11-CED	Development Plan of Educational Science in Guangdong City during the 11th Five-Year Plan period	
	D-12-NLERD	National outline for medium and long-term educational reform and development (2010–2020)	2010
	D-11-PLERD	Outline for Medium and Long-term Educational Reform and Development of Guangdong Province	
	D-12-NUSTPD	National University Science and Technology Park Development Plan Outline for the 12th Five-Year Plan Period	2011
	D-12-NIPHEICIP	Implementation Plan for "Higher Education Institutions Innovation Capability Improvement Program"	
	D-12-PED	Development Plan of Education in Guangdong Province during the 12th Five-Year Plan period	
	D-12-CLERD	Outline for Medium and Long-term Educational Reform and Development of Guangdong City	

	D-12-NSTHE	Development Plan for Science and Technology in Higher Education Institutions during the 12th Five-Year Plan period	2012
	D-12-RSRBHE	Further Regulating Scientific Research Behaviour in Higher Education Institutions	
	D-12-CED	Development Plan for Education in Guangzhou City during the 12th Five-Year Plan period	
	D-12-NHEI	Opinions of the Ministry of Education and the Ministry of Finance on Implementing the Plan for Enhancing Innovation Capability in Higher Education Institutions	
	D-13-NSTHE	Development Plan for Science and Technology in Higher Education Institutions during the 13th Five-Year Plan period	2016
	D-13-NDPOIKI	Opinions on Implementing a Distribution Policy Oriented Towards Increasing Knowledge Value	
	D-13-NHETSTA	Notice of the General Office of the Ministry of Education on Further Promoting Higher Education Institutions to Implement Policies Related to the Transformation of Scientific and Technological Achievements	2017
	D-13-NDFC	Implementation Measures for Coordinating and Promoting the Construction of World-Class Universities and First-Class Disciplines	
	D-13-PE	Development Plan of Education in Guangdong Province during the 13th Five-Year Plan period	
	D-13-CE	Development Plan of Education in Guangzhou City during the 13th Five-Year Plan period	
	D-13-NSBSR	State Council's Opinions on Comprehensively Strengthening Basic Scientific Research	2018
	D-13-DE-HZ	Development Plan of Education in Guangzhou Haizhu District during the 13th Five-Year Plan period (2016-2020)	
	D-13-NEM	China's Education Modernisation 2035	2019
	D-14-PE	Development Plan of Education in Guangdong Province during the 14th Five-Year Plan period	2021
	D-14-PDFC	The Implementation Plan of Guangdong	

		Province's Higher Education Promotion of "Striving for First-Class, Filling the Gaps, and Strengthening Characteristics" (2021-2025)	
	D-14-DE-HZ	Development Plan of Education in Guangzhou Haizhu District during the 14th Five-Year Plan period	
	D-14-NDFC	Ministry of Education, Ministry of Finance, and National Development and Reform Commission's Opinions on Further Promoting the Construction of World-Class Universities and First-Class Disciplines	2022
	D-14-CE	Development Plan of Education in Guangzhou City during the 14th Five-Year Plan period	
	D-14-DE-TH	Development Plan of Education in Guangzhou Tianhe District during the 14th Five-Year Plan period	
Regional Development Outline	D-13-GBA	Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area	2019

	D-14-CE	Development Plan of Education in Guangzhou City during the 14th Five-Year Plan period	
	D-14-DE-TH	Development Plan of Education in Guangzhou Tianhe District during the 14th Five-Year Plan period	
Regional Development Outline	D-13-GBA	Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area	2019

Appendix 5. Definitions of overarching themes and top-level sub-themes from analysis of interviews and policy documents

Themes from policy documents

Themes (top-level nodes)	**Description**	**Sub-themes (nodes below root nodes)**
Globalisation of innovation (relations between scales and the indigenous)	This theme comprises 1) a reflection on how globalisation of innovation has led to global flows of innovative factors, networked innovation activities, economic restructuring, and innovation multipolarity; 2) China's positioning in the global innovation landscape that features deeper global participation and stronger initiative in winning global competition, gaining first-mover advantage, and establishing global innovation leadership in multiple dimensions (economic, S&T, culture, geopolitical); 3) internationalisation of innovation in the forms of steering international cooperation as well as meeting and setting international standards in various areas; 4) innovation's integration with regional diplomacy (e.g., Belt-and-Road Initiative)	-impacts of globalisation -global positioning -global participation -global expansion -global leadership -internationalisation -regional diplomacy
Systemhood of innovation: Holism, Capability, Interaction dynamics (e,g., network, chain, highland)	This theme underscores a systemhood conceptualisation of innovation comprising of 'holism', 'interaction dynamics', 'capability', and 'advanced deployment and planning'. 'Holism' or 'holistic innovation' refers to a wide variety of innovation by realms (e.g., S&T, education, culture) and forms (e.g., indigenous, integrated), and emphases (e.g., independent vs. introduction, digestion, absorption, and re-innovation, non-consensual vs. Common innovation). It reflects China's holistic approach to identify and integrate different types of innovation, where	Holistic innovation: S&T, management, business model, industrial, cultural innovation...

	indigenous innovation has been a priority and scientific and technological innovation plays a leading role in enabling indigenous and original innovation and the enhancement of productivity and national capacity. The theme also indicates that 'holistic innovation' relies on 'systematic implementation' and is conceived as an 'experimentation'. 'Interaction dynamics' indicates multiple ways in which innovation activities are organised and innovation actors interact with each other. An innovation 'system' represents a complex fabrication of 'actors', 'networks', 'chains', 'technologies', 'facilities', and physical spaces. It is expected to conduce to 'efficiency' and 'efficacy' through scientific 'innovation governance', concentrated deployment and allocation of resources and coordination of various actors and nodes in the 'innovation chain'. A highly efficient innovation (national/regional) system is deemed overarching to the construction of an 'innovation country', 'innovative province', and 'innovative city'. The 'network' perspective mainly underlines China's expected leadership role in the 'global innovation network of science and technology', and to lever the global flows of innovative resources (e.g., technologies, capitals, talents) to developing domestic networks that involves multiple actors, scalars (e.g., global, national, regional), and purposes (e.g., S&T achievement transformation, resource-sharing, coordinated research). 'Network' features openness and coordination. The coordination and integration of 'innovation, industry, finance, and service chains' create a sustainable innovation cycle and	Interaction -innovation systems at varying scales -innovation network -innovation chain -innovation community -innovation highland -innovative country/region/ province/city Capability (by iteration) -innovation capability (independent, original, convergent...) -national (e.g., national defense, healthcare) -regional (e.g., integrated innovation capability) -industrial capabilities (technological innovation/design/sustainab le development) -organisational (e.g., enterprise, university) -creation capability

	'ecosystem' led by various innovation actors (e.g., government, universities, enterprises, research institutes, service organisations, capitals) and is deemed essential to enhancing the hub/node status in the 'global innovation network'. 'Capability' contains the connotation of capacity-building and the ability to identify, mobilise, and utilise different resources for innovation and development. 'Capability of independent innovation' is most iterated, followed by other variants such as 'convergent innovation capability' and 'original innovation', and finally a wider range of 'capability' in creation, governance, resource allocation, nurturing talents, national defense...	-Talent-nurturing capability
Value (value chain, diversity and synergy of value, purpose and outcome indicator)	The themes indicates iterative emphases on pursuing 'added value' and a more advantageous position in the 'global value chain' through innovation or innovative capabilities of developing new technologies, designs, products, and services. The theme also includes various types of value of innovation or innovative products, and highlights 'value' as the purpose, outcome indicator, and incentive of innovation (innovation value needs to be fulfilled, maximised, assessed, fully demonstrated, and widely recognised).	-value chain -added value/value-added -value of innovation (factors) -application value -knowledge value -commercial value -brand value -scientific value -value of scientific trial-and-error exploration -technological value -economic value -social value -cultural value -excavation of cultural heritage value -value orientation -core socialist value -advocacy of innovation, entrepreneurship, and wealth creation
Demand	Demand is defined as the purpose of	-innovation demand

	innovation, and has been specified to different scales (e.g., global, national, local) and realms (e.g., national defense, health, environment & sustainability, market).	-(key) national demand -national defense -economic & social development -population health -environment & sustainability -scientific research demand -market demand -industry & enterprise demand
Competition	This theme underlines the increasing 'competition' of resource, technology, market, and talent at global scale and the urgency to forge 'competitiveness' at different scales (e.g., global, national, local) and in various domains (e.g., industry, S&T, national defense). 'Competitiveness' appears as part of the outcomes of value creation, not only in relation to market dynamics, but also in terms of China's ambition to attain global leadership. In order to gain 'first-mover advantage' in the race, 'competitiveness' needs to be concurrently forged through exploiting existing advantages, adopting 'asymmetric path' (非对称路径) or differentiated development strategies, and 'advanced planning and deployment' (提前部署布局).	-competition of resource, technology, market, and talent -competitiveness (global, national, industrial, enterprise, core vs. Comprehensive) -first-mover advantage
Evaluation outcomes (benefit. contribution, achievement, quality)	'Value', 'benefit', 'contribution', 'quality', and 'achievement' are all conceptualised under the frame of 'evaluation systems', but the distinctions or the different emphases each may contain remain under-discussed. A typical policy exemplar is that basic scientific research needs to be evaluated by 'research quality, scientific value, and actual contribution.'	
Era/time (integrate into globalisation)	'Time/era' is a recurrent theme in the contextualisation of innovation and development agenda. The identification of forceful 'trends', 'opportunities', and	-Era of 'Big Science'/ 'the Internet' -A critical period of building an innovative

	‘challenges’ in particular spatial-temporal contexts provide rationales and references for setting innovation and development directions. It is followed by the positioning of China against the large global-era context and the location of its own development stage.	country/worldwide ‘deep adjustment that relies on innovation to promote the prosperity of the real economy’ -New stage/period of development

Themes from the interviews

Themes (top-level nodes)	Description	Sub-themes (nodes below root nodes)
Features/indicators of innovation	This theme demonstrates how ‘novelty’ is phrased, theorised by components such as ‘breakthrough’, and ‘improving the extant’, and discussed in relation to its synonyms and antonyms.	-novelty -creativity -change -breakthrough -improvement of the extant -starting from scratch
Purpose of innovation: value creation	This theme underlines ‘value’ as an umbrella term. A variety of value notions (e.g., scientific value, social value) are mentioned, and ‘value’ creation is also discussed in relation to ‘demand’ fulfillment and ‘problem-solving’ as the purposes of innovation, and its essential indicators such as ‘usefulness’ and ‘meaningfulness’.	-value (scientific, social, humanity, commercial, application, engineering, technological, environmental & ecological) -problem-solving -usefulness (efficiency, efficacy, feasibility, user’s acceptance) -demand fulfillment -meaningfulness -benefit/contribution
Type of innovation	This theme indicates how innovation is categorised by nature, scale, and domain-dimension, followed by a discussion of division of labour between innovation in engineering and science.	-small vs. Large -practical/incremental vs disruptive -technological/scientific/institutional/research/education/business -pathway innovation -mass innovation & entrepreneurship -engineering vs science
Stage of innovation	This theme illustrates how interviewees conceptualise innovation by its different stages (i.e., to what stage is ‘innovation’ accounted as ‘an innovation’).	-idea -experiment -semi-products -pilot-testing -standardised production

		-commercialisation
Source of innovation	This theme highlights the sources of innovation that the interviewees identify and attach importance to. A large number of interviewees from academia place great importance on accumulation of disciplinary knowledge & expertise, including but not limited to reading previous papers. Some academics from engineering backgrounds or/and have practical experiences also consider 'engineering work' and the 'collaboration with the industry' as significant sources of attaining demands or inspiration for innovation.	-paper -accumulation of knowledge & expertise -engineering work -cross-boundary communication -emerging technologies & markets -production -mass entrepreneurship & innovation -implementation of central policies -people's welfare
Evaluation	This theme illuminates the ways of evaluating innovation that the interviewees find effective and appropriate.	-peer review (third-party) -self-evaluation (academics)

Appendix 6. Translation Glossary

Chinese	English Translation	Meaning of the Chinese term	Examples
新 n.	newness	the mere feature of being recently created or coming into existence	"*Newness* (*xin*) refers to something that does not exist yet" (UNI-MatS-P7)
	novelty	the quality of being new and unusual	"*Novelty* does not mean everything new is worthy of creation" (UNI-MatS-P1)
创新性 n.	innovativeness	the quality of being innovative	"The publication in domain top journals needs to be peer reviewed by the academic society in order to evaluate the *innovativeness* of academic work." (UNI-ECE-P3)
创造性 n.	creativity	the quality of being able to generate something novel and unusual	"Innovation needs *creativity* and feasibility." (UNI-ECE-P2)
领域 n.	domain	a specified field of activity or knowledge, potentially across the boundary of sector and/or discipline	"The identification of novelty depends on professional *domains*." (UNI-ES-P1)
	discipline	a specified field of study, especially in a higher education context	"Our materials may be improved based on existing ones, and are not that innovative from the aspect of Material Science *discipline*" (UNI-MatS-P1)
工业界 n.	industry	the sector where enterprises and activities revolve around production	"The innovation of *industry* means creating something with practicality" (UNI-GEO-P1)
产业化 n.	industrialisation	Scale up academic research to a level where it can be produced on a large scale in a factory or become an industry	"Academia and *industrialisation* are two different systems..." (UNI-PHA-P3)
学术/学术界 n.	academia	the activity of studying and pursuing systematic and scientific accumulation of knowledge	"*Academia* is not isolated, and should relate closely to application and innovation" (UNI-MatS-P4)
效果 n.	performance	how well someone or something (especially	"Technological innovation means having better

		new), performs an activity or fulfill an purpose	*performance* than extant technologies" (UNI-GEO-P2)
工艺 n.	technique	a way of performing skillful activities or the skills required to do so	There can be innovation in product design, technology, material, and *technique*.
验证 n./v.	Validation/ validate	Examine scientifically to make something officially approved or acceptable	Innovation can be *validated* through scientific experiments and peer review.
认可 n.	acceptance	people's willingness to use new products or services, or to believe a new idea, usually used in marketing	"Practicality needs to be examined by reality and by people's *acceptance*." (UNI-MatS-P4)
接受度 n.	acceptability	the extent to which something is deemed satisfactory and approved of	"Things that are too novel is difficult to be developed into products, considering *acceptability* and the time required for development" (UNI-MatS-P1)
可行性 n.	feasibility	the possibility of being made and achieved, can be something practical or theoretical	"The second step is to have practical *feasibility*" (UNI-MatS-P4)
实质的/实在的 adj.	substantive	Defined in a narrower sense but considered to have real importance or value, or closer to real facts	"*Substantive* innovation solves problems." (UNI-MatS-P2)
本质的 adj.	essential	associating with the most basic and important qualities	"Natural sciences should consider more *essential* and original issues." (UNI-CHE-P1)

急功近利	hustle for quick success and immediate benefits	"Excessive assessment will adversely give rise to *hustle for quick success and immediate benefits*..." (UNI-MatS-P7)
照本宣科	repeat the textbooks	"We can innovate our teaching in classes. Some teachers simply *repeat the textbooks*." (UNI-MatS-P2)
融会贯通	build connections across disciplinary knowledge	"Consolidating the foundation makes it possible for *building connections across disciplinary knowledge*" (UNI-MatS-P3)
与时俱进	advance with the times	"When teaching students, I think it is a must to *advance with the times*." (UNI-CS-P1)
另辟蹊径	break new ground	"Innovation means to *break new ground*."

		(UNI-ECE-P2)
中国名片	the brand-card of China	"More importantly, entrepreneurship lends us support and allows us to have *the brand-card of China*." (UNI-MGT-P1)
科研审美	taste in scientific research	"Whether it is more important to do novel or application-oriented research, it is more a matter of individual *taste in scientific research*." (UNI-ECE-P1)
圈子文化	circle culture	"The team in charge of sci-tech policies used to have a 'circle culture'. Those inside the circle did not take the funded projects seriously enough." (UNI-PHY-P2)
专利布局	patent portfolio	"Even our students can examine *patent portfolio*." (UNI-ECE-P6)
深入简出	profundity in plain manner	"...teaching with *profundity in plain manner* is also an innovation." (UNI-ECE-P6)
一竿子做到底	Carried...through to the end	"Few carried it through to the end." (UNI-PHY-P2)
提灯人	the lamp carrier	"Everyday we tread on a dark path as *the lamp carrier*." (UNI-CHE-P1)
门路	knack and channel	"Everyone in my team wants to do things right and publish good papers, but lacks the '*knack and channel*' for commercialisation." (UNI-LS-P3)
内卷	involution	"Now the post-90s generation are facing much greater *involution* than us [the 70s]." (UNI-LS-P3)
积淀	layered accumulation	"The upstream [industry] is a system requiring long-term *layered accumulation*." (UNI-MatS-P7)

Chinese term	**English Translation**	**Term in original text**	**Exemplary policy origin**
破五唯（分数、升学、文凭、论文、帽子）	Break five onlys/supremacies: grades, enrollment, diploma, papers, and titles	"*Break five onlys* is difficult to achieve because many of those in charge got there mainly by publishing papers." (UNI-MatS-P4)	Notice on a Special Action to Rectify the practices of "Only Paper, Only Titles, Only Professional Titles, Only Academic Qualifications, Only Awards" (2018)
指挥棒	Baton of administrative	"Once without the *baton of administrative power*,	Comprehensive Plan for Deepening

	power	supervisors will not pay attention to cultivating soft skills." (UNI-ECE-P3)	Education Evaluation Reform in the New Era (2020)
话语权	Discourse power	"Become a leader in several key areas and contributor to significant regulation-setting, increasing China's *discourse power* in global innovation governance.	National Science and Technology Innovation Plan During the "13th Five-Year Plan"
硬骨头	Cracking hard nuts	"They should undertake the responsibilities of *cracking hard nuts* and addressing *bottleneck problems*." (IND-P1)	Guiding Opinions of the General Office of the State Council on Supporting State-level New Areas in Deepening Reform and Innovation and Accelerating High-quality Development (2019)
卡 脖 子 问 题	Bottleneck problems		
揭榜挂帅	Open competition for the best candidates or research proposals	"Now *open competition for the best candidates or research proposals* is adopted to improve efficiency." (UNI-PHY-P2)	Report on the Work of the Government (2021)
应用场景	Application settings	"Some are difficult to understand or the models are perceived to be too complicated, but *application settings* may emerge in the future" (UNI-CS-P1)	
创新主体	Principal innovation actor	"Under many circumstances, the *principal innovation actor* should be the industry, rather than universities." (UNI-CS-P2)	National Science and Technology Innovation Plan During the "13th Five-Year Plan"

Source: Cambridge online dictionary;referred policy documents

Appendix 7. Excerpt of a back-translated English transcript

Original Chinese version:

受访者：创新更多就是创造一个新的东西嘛，还是要新，这个新我通常的理解是不是所有新的东西都值得去开发，我也经常这样跟学生讲。这个新的东西要有意义有用，在这么个前提之下，我这个思路偏工程或实用角度。

Translated English version:

Interviewee: Innovation is more about creating new things. They should be novel. However, as I understand, novelty does not mean everything that is new is worthy of creation, so as I always taught my students about. Novelty should be meaningful and useful. Premised on this, I incline to define innovation from an engineering or practical perspective.

Back-translated Chinese version:

受访者：创新更多是创造新东西。它们必须得是新的。不过，我的理解是，创新的新并不是说所有新的东西都是值得创造的，我也一直是这么教我的学生的。创新的新/原创必须是有意义的、有用的。假如说基于此，我倾向于从工程或实际/实用角度定义创新。

Appendix 8. Key areas of social value in national, international and global innovation objectives

Key areas of social value	National innovation objectives	International and global innovation objectives
Population aging and health	Achieve breakthroughs in precision medicine and other major disease prevention and control technologies for application in domestic healthcare; improve national drug quality and quality control levels	Promote the oversea expansion of generic drugs and garner international recognition for China's contribution to the preservation and development of traditional Chinese medicine and global disease prevention
Resource and environmental protection	Develop systematic solutions for major ecological and environmental issues, build a full-process pollution control and ecological restoration technology system, and promote the development of low-carbon circular economy and high-tech environmental protection industries	Respond to the characteristics of foreign water resources, oil and gas and minerals by developing proprietary technologies and equipment for resource development and utilisation, and enhance the international competitiveness of Chinese resource-based enterprises
Deep earth and polar regions	Advance theoretical research in deep earth and polar resource exploration and technological equipment, establish a multidisciplinary data source for polar regions, and improve China's polar research capabilities and technical support conditions	Establish large-scale international cooperation projects in polar observation, seabed resource development, and deep ice core drilling, promote the efficient use of shared human resources and elevate China's influence and discourse power in polar geopolitics.
Climate change	Achieve research, technological innovation and demonstration of green, low-carbon technologies in key sectors to enhance China's resilience to climate change	Undertake strategic studies on international negotiations and domestic green transition, establish a technology library covering all key areas of the sustainable development agenda to enhance China's discourse power in the international climate science and technology
Marine science	Achieve technological breakthroughs in marine resource exploration, disaster prevention, and maritime rights protection,	N/A

	challenging enduring foreign monopolies.	
Education	Merge innovation and talent development chains, establish enduring, talent-accessible innovation platforms and publicise scientific and innovative accomplishments, enhancing public scientific literacy; incorporate innovation resources into education, revamp curriculum, pedagogy and technologies, fostering scientific spirit, innovative thinking and creativity	Innovate international collaboration models, attract global innovative talent and resources, and expedite the internationalisation of China's higher education
Sustainable urbanisation	Innovate planning methodologies by integrating ecological capacity, historical inheritance and green low-carbon principles; lead urban planning, construction, and management through technological innovation; advance green construction to boost urban energy efficiency and improve living standards	N/A
Cultural and sport industries	Innovate technologies in smart museums and digital libraries to expand the depth and breadth of public cultural services; develop innovative solutions for sports training, health behaviour monitoring, and sports rehabilitation technologies in preparation for the 2022 Winter Olympics.	N/A
Public security	Improve the R&D level of public safety risk control and emergency technology; innovate key core technologies in information security, cyber security, biosecurity, counter-terrorism, and confidentiality	N/A