Thesis submitted in partial fulfilment of the requirements for the degree of

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The Co-constitution of Technologies, Organisations, and Institutions in the Process of Commercialisation – The Case of CRISPR –

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ABSTRACT

This thesis addresses how new technology and organisations are co-constituted through practices of commercialisation in emerging organisations. It is a response to the neglect within contemporary organisational literature of the structuring role of technology in its own constitution, as pertinent institutional theory addresses only instances where some structure is already in place. A significant blind spot in the institutionalists' perspective is the earliest moment of activity from which both organisational and technological structures emerge. Through the lens of practice driven institutionalism this research advances existing bottom-up practice-driven theorising of institutional logics by integrating 'technology' as part of its theoretical framework. Examining occasions where the development of new technology is a central ingredient to the emergence of organisations, this study finds that when people interact with a new technology in their ongoing practices this very interaction constitutes the emergent structures of both organisation and technology. Different interactions result in variation between organisational structures and technological applications.

The theoretical understanding is based upon an inductive empirical-comparative multiple case study on the commercialisation of the genomic technology CRISPR as applied in the development of human therapeutics. CRISPR is a multi-purpose biotechnology that has a potentially unlimited amount of applications of which only a limited number actually materialise. The emergence of thirteen organisations developing CRISPR applications was compared over a five-year period between the three geographical settings of the US East Coast Boston area, the UK's Golden Triangle (Oxford – London – Cambridge), and the Netherlands. This comparison creates an understanding of how some CRISPR applications for human health become a material reality following commercialisation, and others may not.

Keywords: Institutional theory, institutional logics, practice driven institutionalism, institutional complexity, hybrid organisations, co-constitution, technology, technology-as-practice, practitioners, commercialisation, materialisation, CRISPR, entrepreneurship

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To my parents

for their love & support

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1. INTRODUCTION

"There is enormous power in this genetic tool, which affects us all. It has not only revolutionised basic science, but … will lead to ground-breaking new medical treatments."

– *Claes Gustafsson, Chair of the Nobel Committee for Chemistry*

At the heart of my research are issues of how new technologies emerge and become relevant to our society. An awareness is needed of the wonders of nature – and of the technology that will increasingly affect how nature and society work. Technologies can be of incredible benefit to our human race, but in order to make sure that they are used wisely it is important for people to understand them – and how they evolve within the fabric of our society. My curiosity of the impact of new technology and social organisation motivated this research.

1.1 Commercialising CRISPR technology

This thesis addresses the research problem of how new technology and organisation are co-constituted through practices of commercialisation, in emerging organisations. In order to explore instances where the development of new technology is a central ingredient to the emergence of organisations, a lens of practice-driven institutionalism (Smets, Morris, and Greenwood, 2012) is adopted for examining the role that practices of commercialisation play in the materialisation of new technology applications and uses. The lens is used to scrutinize how people, as they interact with a technology in their ongoing practices, constitute structures which shape their

emergent and situated use of that technology. This research finds that when people interact with a new technology in their ongoing practices this very interaction constitutes the emergent structures of both organisation and technology. Although existing literature already addresses the constitutive role of social practices in the adoption, use, and development of technologies throughout the workplace (cf. Orlikowski, 2000; Leonardi and Barley, 2010) a significant blind spot was observed in institutional theory in that it only addresses instances where structure is already in place, thereby neglecting the structuring role of technology in its own emergence. This thesis therefore proposes to integrate a structuring notion of 'technology' into the theoretical framework of practice-driven institutionalism (Smets et al., 2012), which conceives of institutional logics and change from a bottom-up practice-driven perspective.

The research problem is explored by an inductive empirical-comparative multiple case study on the commercialisation of the precision genome-editing technology of CRISPR as applied in the development of human therapeutics. CRISPR is a multi-purpose biotechnology that has a potentially unlimited amount of applications of which only a limited number actually materialise. Using a comparative case study creates an understanding of how some CRISPR applications for human health become a material reality following commercialisation by emerging organisations, and others may not. The analysis makes further contributions by identifying forces of multi-level and multi-dimensional 'institutional complexity' (Greenwood, Raynard, Kodeih et al., 2011) exercised throughout the commercialisation process, as it observes the

dynamics between the individual, the organisation, and the field; as well as tensions between the belief systems (logics) of academia and commerce, different scientific disciplines, and between that of fields in different geographical settings.

1.2 Methodology

An empirical inductive qualitative multiple-case study was used to address the research problem (Yin, 2009; Gehman, Glaser, Eisenhardt et al., 2018). The sample consisted of thirteen emerging CRISPR businesses compared over a five-year period between 2013 and 2018. The thirteen businesses are based out of three geographical settings: the US East Coast Boston area, the UK's Golden Triangle (Oxford – London – Cambridge), and the Netherlands.

Data collection occurred through 110 qualitative interviews with 88 interviewees, archival/documentary data, and observations. The sample of interviewees consisted of different individuals, occupying various roles such as scientist, entrepreneur, investor, policy maker, or professional manager – each and everyone shaped by their education and career history that mediated understanding, motivations, and, consequently, behaviours. These interviews constituted the primary data source as it allowed for collecting sensitive information about the inner workings of the organisations, their technology development, and the institutions in which they are embedded, providing an in-depth insight when linked to different findings from observed dynamics and written sources. Observations were made at field events, company tours, and laboratory visits, and helped to capture impressions that contributed to an understanding of common practices, organisations, and the context

of the academic and industry settings in which CRISPR-based organisations operate. Documentary evidence helped with triangulating findings across data sources and connected practitioners' behaviour and organisational structures to wider institutional contexts. This multi-method approach allowed for theorising dynamics at the level of the practice, organisation, and field, as well as their multi-level interactions.

The data analysis is a synthesis of the comparative research approach allowing for inducting findings from empirical observations for theory building (Eisenhardt and Graebner, 2007; Eisenhardt, 1989). The presented theoretical framework emerged from the data analysis and was not derived from a prior theory guiding the data collection (Strauss and Corbin, 1990; Glaser and Strauss, 1967). Instead, a process of gradual abstraction through constant comparison between sample data and emerging analysis made analytical generalisation possible (Suddaby, 2006; Strauss and Corbin, 1990). The focus was on building empirical evidence into a mid-range theory contributing to an institutional perspective on technology and practice. The on-going analytical efforts typical of this kind of inductive exploratory research pervaded the entire research process making it an inherently flexible and iterative endeavour. Nonetheless, in the interest of clarity this thesis is structured in an orthodox linear fashion highlighting where it does not accurately reflect the flexibility of the actual research process.

Clarity serves the purpose of theory building (Eisenhardt, 1989) but when reading this thesis it is important to remember that the empirical phenomenon central in this study is contemporary and emergent in real life. The following chapters provide findings induced and generalised from a time bound consideration of a highly complex, messy, and on-going situation. Behind the abstract concepts that summarise the observed dynamics are real people. They are the producers of activities and the carriers of practices (Whittington, 2006; Reckwitz, 2002). Although sometimes we would like to think otherwise, human activity is cluttered by nature and permeated with all sorts of dynamics that reflect – amongst others – norms, values, and beliefs (Deephouse and Suchman, 2008; Suchman, 1995), legitimacy (Nicolini, Reinecke, and Ismail, 2020), meanings (Schatzki, 2002) and perceptions (Weick, 1995), power struggles (Foucault, 1997), taken-for-granted habits, skills, styles, and tastes (Bourdieu, 1990), as well as irrational but rationalised behaviour (Browne, 1978) – all highly interdependent on the specific contexts in which activity takes place (Sandberg and Pinnington, 2009; Gherardi, 2000; Schatzki 2006; 2012). While acknowledging the rich diversity of activities, human achievements as the total sum of them, are best explained by looking at the expression of overall tendencies in both social structures and human agency (cf. Giddens 1984; Whittington, 2019). However, human activity relies on practices, supported by (institutional) rules and resources that are structural by token of their enduring and pervasive nature. With many angles to choose from the structural practice central to this thesis aims to imbue (and introduce) what has traditionally been an inert element in the contemporary study of institutions and practices: *Technology-as-Practice*. As people organise themselves to further develop

applications with the genome editing technology of CRISPR, technology becomes a central reason and a common ground for people to come together and interact with each other on the basis of everyday work. It is their collective performance of practices that constitute the CRISPR organisations (Schatzki, 2001), their structures (cf. Giddens, 1984), and ultimately the institutional field in which they operate (Smets et al., 2012). In empirically focussing on technology related practices that constitute the structures of newly emerging CRISPR organisations, this study joins others in management research in a more general turn to adopting the 'practice' label: for instance, Strategy-as-Practice (Whittington, 2006), Entrepreneurship-as-Practice (Thompson et al., 2020), Leadership-as-Practice (Raelin, 2016), Marketing-as-Practice (Skålén and Hackley, 2011), Accounting-as-Practice (Ahrens and Chapman, 2007), and now also "Technology-as-Practice".

1.3 Research Context and Case Study

This study starts with the phenomenon: A new, understudied, and highly complex empirical context of an on-going contemporary social phenomenon within a real life setting over which no control can be exercised by the investigator. The research studied in real-time how new technology and organisations can be co-constituted by commercialisation. The empirical case addressed in this thesis is the commercialisation of the emerging precision genome-editing technology 'CRISPR' as applied in the development of human therapeutics. CRISPR is an easy-to-use precision genome editing technique that allows for proactive modification and sequencing of DNA. A bacterial defence system to fight viruses, the technology was discovered in nature before it evolved over several decades into a biotechnological tool to be first

commercialised in 2013. In 2020 two CRISPR pioneers, Emmanuelle Charpentier and Jennifer Doudna, were awarded the Nobel Prize in chemistry for their contributions to the development of the technology (Ledford and Callaway, 2020).

CRISPR is a multi-purpose biotechnology that has potentially an unlimited amount of applications such as a treatment to sickle-cell anaemia, cancers, and blindness. It is acknowledged for its significant potential to change our society and identified as one of the technologies driving the fourth industrial revolution (George et al., 2016). The stories behind the scientific as well as commercial advances of CRISPR can educate us about how biomedical progress takes place and what structures are created and enacted by related practices. The emergence of CRISPR is a rich narrative far beyond the laboratory bench involving serendipity and planning, pure curiosity and practical application, hypothesis-free and hypothesis-driven science, individuals and teams, fresh perspectives and deep expertise, technical protocols and the development of laboratory equipment, the filing of patents and intellectual property claims, novel business models and investment schemes, corporate strategies and commercial mentorship, and regulations and new policy frameworks. These efforts show a serious interest in translating CRISPR from progressive research laboratories into applications directly relevant to society at large.

CRISPR has made available new capabilities for rewriting the genetic code of cells and organisms (Jinek et al., 2012). The Nobel Prize committee for chemistry described the technology as “genetic scissors, [that are] a tool for rewriting the code of life” (2020).

The technology is more accessible than preceding genomic technologies as one only needs a standard level of skills in molecular biology to be able to use it. This significantly lowers the economic cost of genome-editing as expensively trained specialists are no longer a requirement, whilst increasing the pool of potential users (cf. Kozubek, 2018). The types of users have already extended to include non-specialists and even amateur enthusiasts such as biohackers (Nascimento, Pereira, and Ghezzi, 2014). While the CRISPR system is undergoing continuous refinement, the implications of being able to alter the code of life are far-reaching and also trigger questions of ethics.

The story of CRISPR provides an inherently complex and unique setting. Further advancement of science is costly and many CRISPR applications for human health become a material reality following commercialisation. CRISPR companies grapple with all kinds of technical, ethical, societal, and business challenges. Such challenges are accompanied with profound and persistent uncertainty as the effects of a business' R&D process can have far reaching implications. These implications are highly uncertain and much greater than commonly seen in other kinds of organisations (Pisano, 2006); not only because the commercialisation process of the technology becomes crucial for the development of specific applications, but also because of the implications the developed applications may have on society. As we are entering a new era it is imperative to improve our understanding of how technology and organisation emerge through commercialisation.

There are many different ways for academic engagement with commercialisation ranging from strongly research-related informed motives such as joint research, contract research and consulting to more commercially motivated patenting or spin-off formation (Klepper, 2016). Perkmann, Tartari, and McKelvey et al. (2013) categorised this engagement in two channels. First, via academic entrepreneurship an organisation may be founded with the objective to commercially exploit a patented invention or a body of unpatented expertise (Perkman et al., 2013; Pisano, 2006; Shane, 2004). Alternatively, a patented or similarly protected invention can be licensed out against a contracted receipt of fees, royalties, or (convertible) equity (e.g. Jensen and Thursby, 2001). In the case of both channels, patenting is likely to be a preliminary step as it supports a disposition on the part of the academic actor towards some kind of exploitation. Secondly, the process of commercialisation entails that an academic invention is exploited with the objective to reap financial rewards. However, academic engagement with commercialisation is of a broader nature and serves the pursuance of varying objectives. Although monetisation is eventually needed to make an organisation viable, the initial motivation for commercialisation is not necessarily of a capitalist nature. It was found that most of the academics who are *incentivised* to engage in commercialisation to further their research rather than to monetise their knowledge (cf. D'Este and Perkmann, 2011; McGivern and Dopson, 2010; Pisano, 2006), as commercialisation presents opportunities that might be difficult to obtain within academic settings. For instance, it enables the development of CRISPR applications from laboratory bench to patient's bedside as it allows for

supporting costly R&D trajectories, standardisation, scaling, and society-wide adoption.

1.4 Contributions and Document Outline

The main contribution of this thesis is the observation that as a new technology emerges, technology and organisation are co-constituted. How technology is developed, adopted, implemented, and used shapes how organisations emerge, replicate, and change. To make sense of dynamics at the macro level practices need to be better understood from the micro level upwards (Demer and Grond, 2020; Smets et al., 2017; Pache and Santos, 2013; Powell and Colyvas, 2009; Hallett and Ventresca, 2006). Studying how structures take shape following the emergence of new practices between micro (the individual) as well as macro (the field) helps to explain the role of technology in the dynamics of organising. Such an understanding encourages organisational theorists to recognise technologies to be more than tools. This thesis serves as a reminder of how the material partly constitutes the belief systems, or logics, that structure our every day behaviour and social reality (Thornton and Ocasio, 1999).

To date, if organisational institutional literature included technology it addressed instances where some structure was already in place (cf. Leonardi and Barley, 2010; Orlikowski, 2000), even though we may call them nascent, but organisations or institutional arrangements are rarely studied as they are brought into existence. Exceptions are Smets et al. (2012) and Gumusay, Smets, and Morris (2020). Their perspective is further advanced throughout this thesis by looking at the earliest

moments of emergence of both organisational and technological structures. Observing these practices, this thesis emphasises the importance of including the notion of 'technology' not only in the theoretical framework of practice-driven institutionalism, but to also recognise a more profound role for technology in institutional theory as this offers a window into how everyday technology related practices constitute organisation and institution. The remainder of this document is organised as follows:

Chapter two reviews the institutional theory literature to which this study aims to contribute. With the help of existing literature it identifies theoretical approaches on the interplay between structure and agency within organisation and technology. It demonstrates how the various existing approaches overlook aspects of the interplay between structures of organisation and technology.

Chapter three elaborates the methodology of this study. It explains how the underlying empirical research was conducted. The different sections justify the choice of a comparative multi-case study research strategy, explain the sampling of the cases, and how data was collected. It describes how the data analysis evolved and how abstract concepts were subtracted for the formulation of the data-to-theory connections.

Chapter four discusses the research context. It shows how tensions come into play as aspects of academia and commerce are merged within the organisations. It explains

how commercialisation takes place as a process of hybridisation and how this forms the foundation for the following chapters. Subsequently three discussion chapters build further on this chapter, each offering their own theoretical contributions:

The theoretical contribution of chapter five *'Balancing Logics at the Level of the Practitioner'* is the interplay between the mechanisms of '*organisational differentiation'* and *'personal integration'* as a way to understand how practitioners navigate competing demands and pre-empt conflict. So far, the literature has focused *either* on structural organisational solutions (cf. Besharov and Smith, 2014), *or* the practices of individuals (cf. Whittington, 2006) but not on the interplay between them. The insight offered here is that attention should be directed at this interplay as it allows us to see new dynamics: Through adjusting and internalising competing demands – like that from academia and commerce – practice and practitioner can be reinvented, allowing to construct organisational structures that pre-empt the conflict that is commonly seen in contested hybrids (Besharov and Smith, 2014). This chapter is presented in the format of a stand-alone article.

The theoretical contribution of chapter six *'The Co-Constitution of Organisation and Technology'* is that the development of various CRISPR applications is identified as being driven by the dynamics of three conceptual approaches that determine which priorities are spearheaded and how tensions that emerge from competing institutional demands are dealt with, namely: the *'technology led approach'*, the *'organisation led approach'*, and the *'institution led approach'*. These approaches give

rise to different emphases in the development of CRISPR applications and hence shape the process of co-constitution of technology and organisation. In their recent empirical work institutionalists have focussed more on fields than on organisational dynamics (Smets et al., 2017) and studying the technology of CRISPR opens up new insights that help to progress toward a more comprehensive and dynamic understanding of how institutional influences (logics) interact with organisational life and the associated practices within (Whittington, 2006).

The theoretical contribution of chapter seven *'Strategic Field Location: A Multilevel Model of the Materialisation of CRISPR through Commercialisation across Different Fields'* is that organisations may use strategic approaches to not only tap into their own local institutional field, but also align themselves with other favourable institutional fields through the strategic field relocation (Faulconbridge and Muzio, 2016). Different strategies can be adopted by an organisation to navigate the richness/bareness of the field they are situated in by switching between institutional fields, and to construct institutional fields while doing so, namely: *the institutional configurator approach*, *the institutional builder approach*, and *the institutional exploiter approach*. It was observed that these strategic approaches give rise to a divergent (and not isomorphic) set of organisations that develop a diverse set of CRISPR applications. In order to understand how CRISPR technologies and organisations emerge and take shape, one ought to look at interactions with the field. It is broadly understood in institutional theory that organisations are embedded within institutional (field) structures that constrain action (Giddens, 1984; Barley and

Tolbert, 1997; Battilana et al., 2009; Lawrence and Suddaby, 2006; Meyer, 2008; Powell and Colyvas, 2008; Scott, 2013; Thornton et al., 2012; Cardinale, 2017). However, instead of understanding the institutional field as a structure to which the organisation needs to adapt (DiMaggio and Powell, 1983), this chapter contributes to the understanding that organisations can utilise fields (McPherson and Sauder, 2013), strategically navigate them, and also construct them through practice driven field construction that flows from these interactions.

Chapter eight concludes this thesis. The practice driven institutional perspective (Smets et al., 2012) is further developed to enable institutional theorists to refine explanations of structuring in the emergence of organisation and technology. The comparative analysis of situated activity between three different geographical institutional field settings helps to examine how individuals and their organisations construct, navigate, and negotiate tensions that arise from various institutional demands as they develop novel CRISPR applications. Different interactions lead to different organisational structures and various CRISPR applications. This chapter extends the discussion by abstracting and bundling the general arguments made in this research about the co-constitution of technology and organisation and the different dynamics at play – as they emerge. The theoretical gaps to which this inductive exploratory research contributes are specifically addressed and summarised. The final sections discuss the limitations of this research, outline an agenda for future research, and points out potential policy and practice implications.

1.5 Summary

This introductory chapter presented an overview of my research framing, the main contributions made by this thesis, and the structure. Chapter two provides a literature overview, followed by chapter three the methodology, chapter four discusses the research context, chapter five discusses empirical findings and theoretical inductions on the level of the practitioner, chapter six presents empirical findings and theoretical inductions on the level of the organisation, and chapter seven presents empirical findings and theoretical inductions on the level of the field, followed by the conclusion that addresses policy and practice implications as well as a research outlook.

2. LITERATURE REVIEW

2.1 Introduction

Why do organisations in their social context look the way they do, behave the way they do, and with what consequences? These are the central questions scholars of Organisational Institutionalism grapple with (Greenwood, Oliver, Sahlin, and Suddaby, 2008). The social context is a specific setting in which social interactions takes place between people (Given, 2008). In understanding and studying organisations, 'Institutional theory' is the most dominant approach. Institutional theory *"…considers the processes by which structures, including schemas, rules, norms, and routines, become established as authoritative guidelines for social behaviour"* (Scott, 2005, p.2). The theoretical approach of institutional theory pertains to deeper aspects that constitute the 'social', which can be understood through the identification and analysis of 'social structures'. Social structures can be understood as *"…abstract, formal relations that constrain day-to-day action in social settings"* (Barley, 1986, p.78). In essence structures are conceptualised as processes rather than as entities. They consist of sets of rules that specify parameters of acceptable conduct, but are also modified by the actions they inform, similar to languages being altered over time through everyday speech (Barley and Tolbert, 1997). These dynamics exist at the level of the 'individual', the 'organisation', and the 'field'. Some of these structures and actions not only relate to organisations, but also to technologies. Several scholars reflected that institutional theory has yet to fully address the relation between organisations and technology, leaving room at the intersection of both realities to increase our understanding of the social and the physical aspects of technology and

their role in institutional theory (cf. Czarniawaska, 2008; Leonardi and Barley, 2008; Goodman and Sproull, 1990).

The focus of this literature review is how organisation and technology can co-evolve. Unpacking the relationship between the two, various authors have tried to systematise their thinking by considering both organisation and technology as 'social structure', revealing similarity between institutional scholars (cf. Greenwood et al., 2008; Heugens and Landers, 2009) and scholars of technology (cf. Bijker, Hughes, and Pinch, 2012; Klein and Kleinman 2002). The structures can be *emergent* and disputed, or *stable* and established. Different combinations of how the relationship between organisation and technology are understood can be observed. Four semi-coherent perspectives are differentiated that dominate institutional scholarship on this topic. Table 2.1 summarises these perspectives, their take on the structuring of organisation and technology, and the key underlying theoretical concepts essential for this thesis. Each institutional perspective on organisation and technology is characterised by the emphasis institutional theorists put on the direction of structuring capacities of either organisation, technology, or both.

Table 2.1		Organisation	
		Stable	*Emergent*
Technology	*Stable*	**Technological determinism** (1) *Stable organisation / stable technology* Shared understanding of technology established; shared understanding of organisation established. *What is negotiated/contested:* - internal structures: Relationships / structures (conflicted interests, values, & power) *What is fixed:* - organisation - technology - field structures *Tech as opportunity for social structuring; Innovation studies; determinism*	**Institutional complexity** (2) *Emergent organisation / stable technology* Shared understanding of technology established; no shared understanding of organisation established. *What is negotiated/contested:* - organisational design - field structures (following blending logics) *What is fixed:* - technology - logics are fixed (how does that work if the field is emerging?) *(blended) institutional logics, hybrids, amphibious entrepreneurs*
	Emergent	**Social construction** (3) *Stable organisation / emergent technology* No shared understanding of technology established; consensus on meaning of organisation established. *What is negotiated/contested:* - Technology + activity (praxis) *What is fixed:* - field structures - organisation - (institutional context / logics are fixed) *social construction, practice, technology-in-practice*	**Practice driven institutionalism** (4) *emergent organisation / emergent technology* No shared understanding of technology established; no shared understanding of organisation established. *What is negotiated/contested:* - *practice (activity + logic together)* - technology - organisation - field structures *What is fixed:* - logics *Practice-driven-institutionalism; 'Technology-as-practice'*

The structuring dynamics of each perspective can be understood through the notions of '*field*', '*logic*', and *'institutional complexity'* that are central to this thesis: A 'field' is *"…a community of organisations that partakes of a common meaning system and whose participants interact more frequently and faithfully with one another than with actors outside the field"* (Scott, 1995, p.56; see for a review Wooten and Hoffman, 2008). Early institutional theory posited the field's social influence predominantly as

'top-down', with norms, rules, or shared beliefs affecting organisations through forces of institutional logics. A 'logic' can be understood as a *"…socially constructed, historical pattern of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality"* (Thornton and Ocasio, 1999, p.804). Thus, logics are part of every practice, organisation, and institutional context. Logics provide distinct forms of rationality that inform the behaviour of different kinds of practices within or by actors, organisations, fields, or contexts, and facilitate variation in how organisations respond to the growing allure of a particular kind of practice. When multiple logics are at play this results in 'institutional complexity'. Institutional complexity occurs when an organisation is confronted with multiple institutional prescriptions following from a diverse set of logics with incompatible demands (Schildt and Perkmann, 2017; Zietsma et al., 2016; Greenwood, Raynard, Kodeih, et al., 2017).

The afore table serves as an outline of the following sections of this review. First, the axes of the table are discussed in the light of the structure-agency debate: organisation as social structure and technology as social structure. Then, using the four perspectives as roadmap, it is discussed how institutionalists have arrived at their current understandings of the relationship between organisation and technology. The review is concluded by identifying a gap in terms of opportunity for exploring the co-constitution between organisation and technology, and the opportunity to re-emphasise the importance of technology in organisation institutionalism; allowing for

re-balancing the dualism in institutional theory of how organisation and technology emerge and structure.

2.2 Organisations as social structure

Like other sociologist and organisation theorists, institutional scholars have taken part in the broader structure-agency debate that has been on-going since the mid-20th century (cf. Hirsch and Lounsbury, 1997). The structure-agency debate is concerned with the rational and structural determinants of human action, and tries to understand whether social action occurs independently and freely, or whether it is dictated by arrangements of social structure. At the centre of different generations of institutional theory sits the question of whether organisational behaviour is the product of structure or agency (Heugens and Lander, 2009). Each generation tries to correct assumptions of human determinism or voluntarism, in their own manner (Leonardi and Barley, 2010). Both views, structuralist and agency, are broadly discussed in the following sections.

2.2.1 Structure

The beginning of the 'study of organisations' as 'distinct social forms' can be dated to the period between 1937 and 1947 (March, 1965/2013). The conceptual foundations of the framework of institutional theory were constructed later around the mid-19th century (Meyer and Rowan, 1977; Hannan and Freeman, 1977; Pfeffer and Salancik, 1978; DiMaggio and Powell, 1983). Building further on the foundations laid by earlier social theorists such as Durkheim (1912/1961), Weber (1924/1968), and Berger and Luckmann (1967), Meyer (1970) proposed the social order to be a product of social

rules and norms that constitute certain kinds of actors, as well as the specific ways through which they produce their activities. Their behaviours are not so much socially influenced as socially constructed. Early institutional theory posited models of social influence predominantly as 'top-down'. Scholars have studied the various manners in which norms, rules, or shared beliefs affected organisations. Such an approach is understandable considering that drawing attention to the importance of institutions is to demonstrate their influence on organisations. The language used was, however, predominantly one of 'institutional effects'. *"As if a given set of environmental forces was able to exert influence in a unilateral manner on compliant organisations"* (Scott, 2005, p.11). Since then, this theoretical tradition considering the interplay of organisations and institutions has well advanced.

Today, new institutionalism is the prevailing approach. New institutionalism, or neo-institutionalism, is a stream in sociological literature that focuses on institutions and the way they interact and affect society. It aims at explaining why and how institutions emerge in a certain way, given a specific context and studies how institutions shape the behaviour of actors, for instance, people, organisations, and governments (Powell and DiMaggio, 2012). New-institutionalism seeks to explain culturally and cognitively organisational and social phenomena by using units of analysis that are not reduced to the direct consequences of individuals' attributes or motives. In turn, such broader contexts can facilitate cognitive, normative, cultural, and regulative pressures shaping organisational behaviour (Scott, 1995). In sum, the structuralist camp holds the "master hypothesis" (Hoffman and Ventresca, 2004) that

organisations have the tendency to gradually assimilate their peers, a process known as 'isomorphism' (DiMaggio and Powell, 1983). It entails that organisations collectively incorporate characteristics for organising from their institutional environments, or field, with the purpose of gaining legitimacy through similarity (cf. Tolbert and Zucker, 1983). Legitimacy entails obtaining normative support through alignment with predominant rules, laws, and cultural norms (Scott, 2001). More recently it is understood that interactions can also occur between fields, acknowledging the agency of organisations in actively choosing between what aspects to adopt from multiple institutional environments (cf. Zietsma, Groenewegen, Logue, and Hinings, 2016; Smets et al., 2015).

2.2.2 Agency

It can be observed that over time the understanding of the relationship between organisation, technology, and institution has shifted, moving from institutional top-down and technological deterministic views (cf. DiMaggio and Powell, 1983) to agentic approaches emphasising social structuring (cf. Orlikowski, 2000). This sets the stage for the contemporary emphasis on social structuring as being dominant over technological influences. Moving along this *"relative swing between agency and embeddedness"* (Seo and Creed, 2002, p.231) different combinations of how the relationship between organisation and technology are understood can be observed. Agency theoreticians challenge the structuralist position and consider it overly deterministic (Heugens and Lander, 2009). They argue that organisations have different experiences in responding to institutional pressures, and that institutional environments are not simply to be understood as monolithic (Scott, 2005). Instead,

organisations are often considered to be varied and conflicted and organisational behaviour cannot be determined by social structures (Washington and Ventresca, 2004; Hoffman, 1999) as institutionalisation may actually even lead to deviation (cf. Oliver, 1991; DiMaggio, 1988).

Over the past few decades important work has been done which aids in unpacking the multiplicity of institutional arrangements, both within and between specified fields, examining the intersection of structures, and recording the transposability of schemas, as actors and ideas would flow across the boundaries of fields (Lounsbury, 2007; Fligstein and McAdam, 2012; Sewell 1992; Friedland and Alford 1991). Empirical studies conducted on these processes are various and discussed, for instance, the effects of the fragmentation of U.S. state structures (Abzug and Mezias 1993; Meyer, Scott and Strang 1987); to competition among alternative professional models (DiMaggio, 1991) as well as their variation across borders (Smets et al., 2012); to tensions between fading and emergent regimes, for instance, that of the introduction of market models in socialist states (Campbell and Pedersen 2007; 1996; Stark 1996); or, the divergence between geographical settings (Lounsbury, 2007). It has become apparent that competing rules or structures allow for bargaining and choice between the actors that are subject to them. Basically, agency scholars see social structures as enabling platforms for organisations to use as springboards for autonomous and agentic behaviour (e.g. Heugens and Lander, 2009; Giddens, 1979).

In sum, both structure and agency positions consider the relationship between institutional forces and the behavioural autonomy of organisations. Nonetheless, at least historically, the majority of research using institutional theory has embraced structure rather than agency. Although 'institutional' is still often considered as a structure argument, it is today increasingly considered as one of agency (Heugens and Lander, 2009; Scott, 2001).

2.3 Technology as social structure

'Technology' is a slippery term. It can refer to a Neolithic stone axe or a satellite system in orbit around planet earth. With technology and technological change permeating every aspect of our society, concepts such as 'technological development' or 'technological change' can be perceived through many different interpretations. Within Organisation Studies technology remains under-theorised (Leonardi and Barley, 2008; Zamutto, Griffith, Majchrzak et al., 2007; Orlikowski and Iacono, 2001; Garud and Rappa, 1994), making a seemingly simple question elusive (Garud and Rappa, 1994): How do new technologies emerge and materialise? It is relevant to understand what is meant by 'technology' from an institutional perspective, and how this perception has shifted from top-down determinism (structure) to bottom-up social construction (agency). A broad understanding of both views is provided in the following sections.

2.3.1 Structure

Over the past couple of decades it was possible to observe the development of a number of structurational models of technology. These models have given us many

insights regarding the influence and role of technologies in organisations (Poole and DeSanctis, 1990; 1992; Orlikowski and Robey, 1991; Jones and Karsten, 2008; Orlikowski, 1992; Walsham, 2006; Powell and Sandholtz, 2012a; 2012b), such as technology as an occasion for structuring (Barley, 1986) or technology having structures in its own right moderated by social practices (DeSanctis and Poole, 1994). Technological determinism holds that in society technological changes determine the development of social structures and cultural values (e.g. Marx and Engels, 1848; Kurzweil, 1999; see also Wyatt, 2008). Technological change can be considered an 'exogenous shock' (Scott, 2008a), thereby linking the technological argument with the institutional. Social determinism takes one step further and holds that technologies structure, but that what really matters are the social and economic systems in which they are embedded (e.g. Winner, 2001). The models portray technology as embodying structures that were built in by designers during the process of technological 'development' (Orlikowski, 2000). The users then appropriate the structures whilst they use the 'deployed' technology. In these models human action is a central aspect. Especially highlighted are those actions associated with embedding structures within a technology during its development, as well as those associated with appropriating those structures during the use of deployed technology (Jones and Karsten, 2008; Walsham 2006; DeSanctis and Poole 1994; Orlikowski 1992; DeSanctis, 1992; 1990; Orlikowski and Robey, 1991).

With this in mind, in the early days of organisational studies 'technology' meant something quite different than what most contemporary scholars of technology and

organisation think of when using the term today. Technology was considered by contingency theorists as part of what industrial engineers would refer to as a production system (e.g. Woodward, 1965; Perrow, 1967). It would be comprised of people, processes, and machines. All of these had to be coordinated with the purpose of transforming inputs into outputs. Specific artefacts (such as hardware and software) or the identifiable material properties of artefacts' were not considered. Instead the focus was on interdependences in work processes needed in organisations when managing a specific type of production system (Perrow, 1970; Thompson, 1967; Woodward, 1965). For instance, in a study on the different types of production systems in British manufacturing firms, Woodward (1958, p.16) defined technology as a ''system of techniques". Perrow (1967, p. 194) saw it as the ''work done in organisations". Technology was defined so broadly that by these measures one could only assess whether an organisation was operating in the service or in the manufacturing sector (Leonardi and Barley, 2008).

By contrast, contemporary scholars of technology and organisation typically define their object of study particularly narrowly, concretely, and precisely. Instead of trying to define technology in general terms, or to distinguish technology from science for that matter (or indeed from any other activity), it seems preferable to work from a set of empirical cases that seem intuitively paradigmatic. Rather than to operationalise technology as a constellation of techniques, processes, and work practices, more contemporary scholars mainly study identifiable 'artefacts' like electric lighting (Hargadon and Douglas, 2001), DNA synthesizing and sequencing (Powell, Koput, and Smith-Doerr, 1996), email systems, groupware technologies, enterprise resource

planning (ERP) systems (Orlikowski, 2000), integrative IT (Boudreau and Robey, 2005), wind energy turbines (York, Hargrave, and Pacheco, 2016), or artificial intelligence (Gregory, Henfridsson, Kaganer, and Kyriakou, 2020). Such 'technological artefacts' are defined by Orlikowski (2000, p.408) as *''bundles of material and symbol properties packaged in some socially recognisable form, e.g., hardware, software"*. In the case of Orlikowski, the studied artefacts are information technologies rather than solid physical objects. It may seem peculiar to state that information technologies have 'material properties'. But, as pointed out by Leonardi and Barley (2008, p.162): *"…when material properties are construed as features that provide opportunities for or constraints on action, the metaphor seems warranted… The important point is that information technology, or for that matter any artefact, has materiality in a concrete sense…".* What they also point out is that there is a persistent tendency by organisational scholars to overlook the important difference between how the term 'technology' is understood by contingency theorists and contemporary scholars. As a consequence, contingency theory's stance that there is a deterministic relationship between technology and organising is frequently still adopted.

2.3.2 Agency

Leonardi and Barley (2008) observed how in the 1980s sociologists of science showed how attending to agency and associated social dynamics can be compatible with appreciating material constraints and affordances (see also Latour and Woolgar, 1986). Similar to the work on technology and organising, sociologists of science had turned towards the notion of 'social construction'. As a result of this turn a contingent

of scholars warmed to the idea of explaining change in terms of social structures rather than material-inspired activities (Knorr-Cetina and Mulkay, 1983). Eventually, however, scholars cautioned that such an orientation might be misguided since material phenomena (both naturally and technically) can accomplish things that might not be attributed solely to social practice (Fujimura, 2006; Pickering, 2001; Hutchby, 2001).

Pickering (1995) offers a helpful example: He makes a persuasive argument that physical phenomena can resist a scientist's efforts to manipulate them and that this resistance is, in fact, part of the interaction between scientist and object that may result in scientists altering their methods and theories. Technology can resist, in such a way that users are not allowed to do whatever they want to (cf. Lawrence et al. 2013; Lawrence and Suddaby, 2006). Yet if technology resist, it does not mean that users are at its mercy, but only that activities need to be adapted accordingly (Knorr-Cetina, 1999; Pickering, 1995; Clarke and Fujimura, 1992). For instance, an auditorium shaped setup of a lecture theatre regulates where the audience sits and where the professor stands when teaching. That way "…materiality structure(s) what actions can and might be carried out when, where, how, and for what ends" (Schatzki, 2010, p.136; see also Nicolini et al., 2020). In this manner features of particular artefacts can become part of the activities of people's day-to-day work (Bijker et al., 2012; Jones and Massa, 2013; Patriotta et al., 2011; Lanzara and Patriotta, 2007), thereby shaping and being shaped through these interactions. In addition to examining social dynamics such as perception, interpretation, or structuring, this means one should

also pay attention to what technology lets users do, or what it does not let them do, and how this shapes the development of the social dynamics – and in turn the technology itself. Pickering's example is particularly relevant for the empirical case addressed in this thesis. The technology of CRISPR concerns the deployment and manipulation of combined tools used by bacteria to defend themselves from viruses. Although CRISPR is man-made, it is based on tools and techniques that exist within physical phenomena found in nature. The technology can be developed and exercised by scientists, but they can also experience natural physical limitations in doing so.

Thus, a technology is a multifaceted phenomenon. Apart from its materiality, a technology is: a product of negotiations (Constantinides and Barrett, 2006; Orlikowski, 1992), human agency (Boudreau and Robey, 2005; Vaast and Walsham, 2005; Poole and DeSanctis, 2004;) or personal interest (Scott and Wagner, 2003; Markus and Benjamin, 1996;). Accordingly, scholars recognised organising to revolve around interactions between machines and people (Mohr, 1971; Thompson and Bates, 1957), technical and social sub-systems (Barley, 1990; Scott, 1998; Trist, 1981), as well as material and social practices (Orlikowski, 2002; Schatzki, 2005; 2010; Nicolini et al., 2020). With this in mind, the definition of technology in this thesis is characterised by a combination of three layers (MacKenzie and Wajcman, in Bijker, Hughes, and Pinch, 2012, p.xli-xlii, underlining added for emphasis):

> *"First there is the level of 'physical objects' and 'artifacts', for example, bicycles, lamps, and Bakelite. Second "technology" may refer to 'activities' or 'processes', such as steel making or molding. Third, "technology" can refer to what people 'know' as well as what they do; an example is the "know-how" that goes into designing a bicycle or operating an ultrasound device in the obstetrics clinic"*

– thus one layer material, two of them social. Technology as beliefs or know-how can be understood as a combination of *"the activity of knowing: the acquisition, organization, and use of knowledge"* (Neisser, 1976, p.1); physical 'artefacts' address the form through the dimensional shape and material of construction, and the functional characteristics over time of a technology (Sahal 1981a; 1981b; Constant, 1987); 'evaluation routines' or 'processes' constitute the technology to become institutionalised throughout researchers' communities (Garud and Rappa, 1994; Jagtenberg, 1983; Latour and Woolgar 1979; Fleck, 1935). These evaluations, then, form the basis for constructing individual reality, with technological claims only to be perceived as relevant by those who employ the same routines while appearing as noise to those who employ different routines.

In sum, a general consensus exists that technology and organisation both arise at the intersection of social and material phenomena (Leonardi and Barley, 2008). Technology is simultaneously a social as well as a physical artefact (Orlikowski and Barley, 2001). Hence, neither a strictly materialist nor a constructivist stance is adequate for studying technology and organisation. Nonetheless, what remains contested is the ontological and epistemological nature that constitutes the relationship between the social and the material and, thus, how technologies and organising are intertwined and take shape in this interactive process.

2.4 Institutional Perspectives on Organisation and Technology

Different strands of literature have addressed the emergence of either organisation or technology. Social structures are not external or independent of human agency; they are not 'out there,' simply waiting to be appropriated. Rather they are virtual, emerging from people's repeated and situated interactions. Social structures in 'use' can be perceived as stable, whereas social structures that are constituted 'from scratch' are emergent. To be more precise, a structure is *stable* when it entails a legitimate and socially recognised pattern of social action that it is repeatedly reinforced by a community (Feltman and Orlikowski, 2011; Levina and Orlikowski, 2009), at which point the patterns become treated as predetermined prescriptions for social action and as such may impede change. A structure is *emergent* when the community has not yet reached consensus and processes are still being negotiated (Latour, 1987; Woolgar and Grint, 1991; Orlikowski, 2000; Callon, 2007; 1984). At the same time that a structure is emergent, a technology can be 'emergent' or 'settled'. The various combinations of either organisation or technology being considered 'emergent' or 'stable' leads to the identification of four different semi-coherent perspectives within the literature: That of (1 - determinism) *'stable organisation / stable technology'*, with scholarship demonstrating how existing social structures interact with properties of existing technology (e.g. Barley, 1986; 1988; 1990); (2 - institutional complexity) *'emergent organisation / stable technology'* scholarship examines how new structures of organisations are created in order to adapt to a new technology. Researchers within this perspective are interested in how work systems such as organisation and field are organised around a technology as patterns of use

begin to form (e.g. Thornton, Ocasio, and Lounsbury, 2012; Battilana and Dorado, 2010; Powell and Sandholtz, 2012a; Pisano, 2006); (3 – social construction) *'stable organisation / emergent technology'* scholarship studies how people use technology and how practitioners within the social structures of organisations dictate its use (Orlikowksi, 2000); and, (4 – practice driven institutionalism) *'emergent organisation / emergent technology'* scholarship focuses on how individuals craft structures of technology and organisation through practices, through which both technology and organisation emerge at the same time (Smets et al., 2012). For this thesis the last quadrant that addresses co-evolvement of technology and organisation is of particular interest. The focus is on the practices by which both organisation and technology are co-constituted at the earliest moments of emergence.

2.4.1 Determinism: Stable organisation / Stable technology

Scholarship focussed on 'stable organisations' combined with 'stable technology' produces theory and research that pertaining to how existing social structures interact with established technology and its material properties. The anchor points are drawn from 'Technology as opportunity for social structuring' and basic innovation studies.

2.4.1.1 Key theoretical concepts

Technology as opportunity for social structuring

Focusing on social structures such as the organisation (Barley, 1986; Scott, Reuf, Mendel, and Caronna, 2000), the field (DiMaggio and Powell, 1983; Owen-Smith and Powell, 2008), but also the individuals within them (Owen-Smith, 2005), technology is

often considered as exogenous to the social processes being studied; differentiating between 'institutional environments' and ' technical environments' (Meyer and Scott, 1981), as a traditional distinction between administration and industry (Czarniawska, 2008). At the end of the 1980s it was understood as two forms of reality intersecting (Goodman and Sproull, 1990), in which technology was conceived of as an institutionalised organisational pattern (Joerges and Czarniawska, 1998) and to trust machinery was to have 'system trust' (Giddens, 1990). Other examples of such theoretical approaches range from 'technological determinism' and 'innovation studies', to literature on technology implementation (Barley 1986; 1988; 1990; Aiman-Smith and Green, 2017) and technology transfer (Powell and Colyvas, 2008). For instance, Barley (1986) saw technology as an opportunity for social structuring in established social structures and studied computerised imaging in radiology departments. The radiologists and technologists he studied produced the social order of radiology departments as they went about their daily routine, at the same time treating structures as though they are relatively fixed and embodied in technological artefacts; offering an occasion for the negotiation between the social structure and that of the technology. Although radiologists and technologists understood that they had renegotiated their respective roles around the use of specific technologies, it was not anticipated or intended that these developments would gradually split the radiology departments into two distinct social systems (Barley, 1990; Leonardi and Barley, 2008). This relates to the notion of designers building physical affordances and constraints into a technology to encourage certain patterns of use and behaviour. Users appropriate these features in ways that are either consistent or inconsistent

with designers' intentions (Poole and DeSanctis, 1990).

Innovation studies

Work by Powell (1998) and Powell, Koput, and Smith-Doerr (1996) discusses inter-organisational dynamics. They state that in innovation driven fields with rapid technological development (like that of the biotech industry) the locus of innovation is found within 'networks of learning' that exist between organisations that sustain a fluid and evolving community, allowing for organisations to facilitate collaboration across diverse communities (Perkmann, 2016). Innovation takes place through these networks when an industry's knowledge base is complex as well as expanding. Sources of expertise are widely dispersed instead of having a presence in a single organisation. The production and exploitation of knowledge, competence, and related intangibles have emerged as the key drivers of competitive advantage, not only because of the importance of knowledge itself, but rather the rapid expansion of goods and factor markets marks *intangible assets* as the main basis of competitive differentiation in the biotechnology sector (Teece, 1998). Knowledge and technology established as intellectual property, and the ability to quickly share it, plays an imperative role. Technology and know-how is distributed through interconnected innovation hubs, making knowledge widely accessible, allowing for rapid emergence and diffusion of developed innovations. With knowledge assets being created and exploited in a global context, the focus of organisations is on access to the network and the 'ready-made' knowledge it contains (Powell et al. 1996). Consequently,

knowledge production is not only confined within the tangible boundaries of established institutions but also by the network it plugs into.

Combining available technology and know-how to seek out new opportunities is at the core of 'Innovation studies'. Schumpeter (1934) identified economic growth as the main incentive for innovation, suggesting that entrepreneurs seek out new opportunities via technological novelties. Yet he considered the opportunity itself, for instance a new technology, an exogenous factor to the *entrepreneurial process* (Schumpeter, 1946). He proposed that the act of utilizing a new opportunity is constantly repeated in a process of *creative destruction.* This destruction of the 'establishment' makes place for instant creation of a new structure, hence change sustains economic growth. In this repetitive Schumpeterian process structures exist around new innovations, replacing structures associated with earlier innovations. Following in the footsteps of Marx (Marx and Engels, 1848), Schumpeter argued that the introduction of an entrepreneurial innovation disrupts the established form of capitalism to such an extent that it destroys existing frameworks of value and power that were derived from earlier forms of technologic, economic, organisational, and regulatory paradigms. Innovations meet institutions and *"… two social forces collide, one for stability, the other for change"* (Hargadon and Douglas, 2001, p.476). Building further on such ideas of disruption, the notion of 'disruptive innovation' was then coined by Bower and Christensen (1995; Christensen and Raynor, 2013). Expounding upon processes by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves up market, eventually

displacing established competitors. Christensen (2003; Johnson, Christensen, and Kagermann, 2008) argued that few technologies are intrinsically disruptive or sustaining in character and that it is in combination with the business model that science and technology are enabled to create disruptive impact.

Pisano (2006, p2.) looks at the dynamics of structures that integrate science and business, and posits that the 'science-based business' is used to: *"…connote a commercial enterprise or collection of enterprises that attempts to both create science and to capture value from it. That is, the science-based business actively participates in the process of advancing and creating science"*. He states that in the biotechnology industry the science *is* the business. Experimentation and innovation in business models, structures, and arrangements are as important to the health of these sectors as the experimentation and innovation in the science. Yet, as he observes, there exists a natural tension between science and business. Science-based businesses seek to mitigate a natural tension between science and business in order to reconcile conflicting norms of science (publish, disseminate) and of business (keep secret, appropriate). One may become the dominant factor, allowing for a distinction to be made between *"in business to do science"* and *"in science to do business"*, the former being subject to the dominant influence of academia and the latter by that of commercial concerns (Powell and Sandholtz, 2012a, p.104 and p.107). A balance is not necessarily struck naturally (Durand, Bruyaka, and Mangematin, 2008), and a combination of technology and social structure as established and 'closed' may not allow for the further exploration of existing tensions.

2.4.1.2 Contributions and shortcomings

The structurational perspective on technology has benefited from the absence of any explicit treatment of technology by Giddens' (1984) theory of structuration. Technology's properties become significant through the process of structuration. Structures of technology use are constituted through established regular and recursive human interactions with certain properties of a technology and thus shape the set of rules and resources that serve to structure their interaction. Both organisation and technology *'embody'* structures that (re)present various social rules and political interests. In line with this tendency, organisational scholars started to use notions such as 'innovation', 'learning', and 'improvisation' to account for the dynamic and emerging patterns of organising they observed in the relation between technology and organisation (Barrett et al., 2012; Brown and Eisenhardt, 1997; Brown and Duguid, 1991). However, this perspective does not account for the structures to be contested.

2.4.2 Institutional complexity: Emergent organisation / Stable technology

Institutional complexity emerges when an organisation is confronted by multiple institutional prescriptions stemming from incompatible demands (Schildt and Perkmann, 2017; Greenwood, Raynard, Kodeih, et al., 2017). New social structures may emerge as a result of mitigating tensions in new or changing institutional environments, for instance linked to change that occurs following newly introduced patterns of technology use. Failing to create synthesis between competing demands may turn tensions into clashes that threaten, demise, fragment, or paralyse the

organisation (Greenwood et al., 2011). Closely attending to institutions and the social dynamics of work relations, detailed accounts of affordances, constraints, and technologies-in-use tend to fade into the background. The fundamental concepts discussed are institutional logics, hybrid organisations, and amphibious entrepreneurs.

2.4.2.1 Key theoretical concepts

Institutional logics

The conceptual notion of logics transgresses the micro with the macro, for instance as is shown in the following definitions of logics. Between institutional theory and practice theory a natural conceptual connector can be found in 'institutional logics' (Smets et al., 2017; Smets et al. 2012). Friedland and Alford's (1991) initially defined institutional logics as: *"symbolic systems, ways of ordering reality, and thereby rendering experience of time and space meaningful"* (p.243). Schatzki (2005) concurs with this definition, stating that *"symbolic elements [...] are vital to organizations"* (p.482). Thornton and Ocasio (1999) define logics as: a *"…socially constructed, historical pattern of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality"* (p.804). Thus, logics are part of every practice, organisation, and institutional context. They provide distinct forms of rationality that inform the behaviour of different kinds of practices within or by actors, organisations, fields, or contexts, and facilitate variation in how organisations respond to the growing allure of a particular kind of practice. At the same time different logics can compete with one another, facilitating practice variation (e.g.

Lounsbury, 2008). In many ways, logics are the thread that weaves the fabrics of institutional theory practice theory together. It is a fabric that connects the 'practice' and the 'institution'.

A substantial amount of work studied shifts in logics over time (Lounsbury 2002; Scott et al., 2000; Haveman and Rao, 1997; Thornton and Ocasio, 1999). Institutional shifts are often treated as period effects segregating one relatively stable period of activities and beliefs from another, reinforcing notions of stability and institutionalisation that harkens back to the early neo-institutional formulations (Reay and Hinings, 2005). The notion of stability in institutionalism contrasts with the notion of a continuous process of co-creation, and thus change, that underlies practices. Meyer and Rowan already signalled a more pluralistic approach to institutional rationality (1977) that requires an approach to logics which conceptualises institutional environments as more fragmented and contested (e.g. Lounsbury, 2008; Schneiberg, 2007; Schneiberg and Soule, 2005; Townley, 2002; Washington, 2004). Systemic change in practice is unlikely to be a clean-cut transition. It is rather a messy negotiation as it is likely to contest and divide existing frameworks. Hence, institutional theory experienced a significant change when the theoretical focus shifted from institutions to logics (Ocasio et al., 2017; Smets et al., 2017). It allowed for adopting a way for being receptive to endogenous institutional change (in addition to exogenous influences), provoked through 'contradictions' or 'ruptures' between institutional prescriptions (Seo and Creed, 2002, p.233-234). Additionally, institutional scholars began to see the co-constitution of structure and agency, as well as

increased recognition of societal orders as a potential source of agency and variation, instead of just stability. The use of logics can further be understood as a multiplicity of broader cultural beliefs and rules structuring cognition that guides decision-making of actors in a field (Lounsbury, 2007). The capitalist market, the professions, the corporation, the bureaucratic state, the nuclear family, religions, and community can be conceptualised as logics that constitute the interests of actors and thereby shape cognition and action (Thornton, Ocasio, and Lounsbury, 2012; Thornton, 2004; Friedland and Alford, 1991). Thus logics resonate from the societal level, through field, organisation, and individual.

Hybrid organisations

Combining science and business within a single organisation may produce contradictory pressures and tensions between multiple logics at play. Science-based businesses are prone to finding themselves in pluralistic and complex institutional environments (Greenwood, Raynard, Kodeih, et al., 2017; Schildt and Perkmann, 2017), as it lies in the very nature of the organisation to be subjective to the prescriptions from multiple institutional logics. Such an organisation may find itself caught up between institutional logics that are not always compatible (Greenwood et al., 2011) as they may represent competing demands (Pache and Santos, 2013): *"The biggest problem with hybrid companies is that they are inherently confused organizations, buffeted by all sorts of contradictory pressures. This means that their internal operations can be hard to understand and their behaviour may be hard to predict"* (Economist, 2009). Hybrid organisations are defined as organisations that are

exposed to, and incorporate elements from, complex contexts with different institutional logics (Battilana and Dorado, 2010). For instance, Pache and Santos (2013) describe the conflicting combination of social welfare and market logic; Jay (2013) refers to public-private partnerships incorporating elements of state, market, and civil society logics; Dunn and Jones (2010) write about medical schools incorporating health care and academic logics. It is suggested that there is a growing pervasiveness of hybrid organisations, which can be explained through an increasing prevalence of pluralistic institutional environments (Greenwood et al., 2011; Pache and Santos, 2010; Seo and Creed, 2002). Using the science-based businesses as example, these companies have incorporated both 'science' and 'market' logics (Powell and Sandholtz, 2012a). Organisations with two logics may be confronted with conflicting priorities: The logic of academia aims to create and share knowledge, whereas the logic of the market instils the norm of being secretive about knowledge and to capitalise on it (Perkmann, McKelvey, and Phillips, 2019). However, adopting the demands and elements as prescribed by one logic often entails defying those of another logic, potentially jeopardising legitimacy vis-à-vis important institutional referents (D'aunno, Sutton, and Price, 1991). Consequently, a dilemma is faced, and there is a need to find ways of dealing with multiple demands (York, Hargrave, and Pacheco, 2016). These demands prescribe appropriate goals and legitimate means of achieving these goals (Thornton and Ocasio, 2008; Lounsbury, 2007). If the degree of incompatibility between logics increases the challenges faced by hybrid organisations are also heightened (Besharov and Smith, 2012; Pache and Santos, 2013). Hybrids may try to address these challenges either by keeping the logics that they face

separate or they may attempt to reconcile them internally (Besharov and Smith, 2012; Greenwood et al., 2011; Murray, 2010; Simsek, 2009). Having a hybrid nature can be advantageous in that it allows the organisation to combine institutional logics in unprecedented ways (Gumusay et al., 2020).

Closely related to the theme of commercialising academic research, D'Este and Perkmann (2011) and Perkmann and Walsh (2007; 2009) studied the 'university-industry relationship' (Perkmann, 2015) within engineering. The established structures of academia and industry engage in cross-fertilisation, in order to drive technological and economic development for mutual benefit in both industry applications and academic research (Perkmann, McKelvey, and Phillips, 2019). They address policy implications and emphasise the notion of a recursive nature of the university-industry relationship where academics' access to industrial technology generates learning in universities which in turn can lead to innovation shaping technology, calling for further exploration of practice-relevant research on this topic from a management studies perspective (Perkmann, Fini, Ross et al. 2015). In similar fashion Kaplan and Murray (2010) suggested that technology and field interact, allowing for multiple interpretations as clashes occur between different dominant perspectives. These contests take shape around value and may change both field and technology, especially when embedded within complex environments.

The hybrid organisation is likely to emerge and do well when situated in complex environments as it incorporates elements prescribed by various logics and hence

projects at least partial suitability in relation to the interaction with a wider set of institutional referents and their relative power of local epistemic (Greenwood, et al. 2011; McGivern and Dopson, 2010; Kraatz and Block, 2008; for an overview see also: Battilana, Besharov, and Mitzinneck, 2017; Battilana and Lee, 2014; Schildt and Perkmann, 2017). The organisation can aim to maintain its hybrid nature in the absence of a 'ready-to-wear' model for handling diverse logics that are at tension within and with the organisation (Battilana and Dorado, 2010). Pache and Santos (2013) observed that when lacking legitimacy in a given field, hybrids may manipulate the templates provided by the multiple logics in which they are embedded. Such organisations do this in an attempt to gain acceptance in accordance with the faced logic(s). Powell and Sandholtz (2012a) refer to the actors navigating such ambivalent activity as *'amphibious entrepreneurs'* as they cobble together different practices and templates to assemble an organisation that can navigate the forces of unprecedented logics. When challenged with hybridisation, different aspects of a certain logic might prevail, be more dominant, or more emphasised at different stages within the lifespan of an organisation. It also opens up the possibility to address shifting tensions between logics throughout the emergence of an organisation in an adaptive and elastic manner (Gumusay et al., 2020).

2.4.2.2 Contributions and shortcomings

Conceptualisation occurs through blended *logics* (Thornton, Ocasio, and Lounsbury, 2012) that give shape to *hybrid* organisations (Battilana and Dorado, 2010) and *amphibious* entrepreneurs (Powell and Sandholtz, 2012a). Hybrid organisation may be challenged to engage dynamically with competing institutional demands to

structurally fix a balance or synthesis in an elastic manner between a continuously shifting equilibrium of logics (Gumusay et al., 2020). Hybrid organisations pose conceptual questions for institutional theory, as they challenge the premise that organisations are entities reproducing a single coherent institutional template in order to gain legitimacy and secure support from external institutional referents (Smets et al., 2017). Traditionally neo-institutionalism suggests that organisations become similar, even if they evolved in different ways; as through isomorphism (Di Maggio and Powell, 2000; 1983). In reality it appears to be the case that institutions are complex, settings pluralistic, and organisations likely to turn out diverse. The social structures of hybrid organisations are bound to be contested as they sit at the intersection of different forces negotiating between micro and macro, the individual and the field, endogenous and exogenous, but also between institution and practice. However, what is missing is a clearer picture of which elements of logics are enacted by individuals within organisations as they navigate competing demands, and the factors that drive these behaviours (Pache and Santos, 2013). Those actors and their practices are the focus of scholarship discussed in the next section.

2.4.3 Social construction: Stable organisation / Emergent technology

Scholarship that scrutinizes established social structures, such as the organisation, focuses on how people's technology usage is dictated by the social structures of the organisations within which they act. Through such activity social structures are imprinted on technologies, considering technology as emergent and unsettled. The

fundamental concepts addressed here are social construction, practice, and technology-in-practice.

2.4.3.1 Key theoretical concepts

Social construction

In contrast to perspectives of determinism social construction considers the development of technology as non-linear, highly complex, not isolated, but created by the development of the common context (e.g. Bijker, Hughes, and Pinch, 2012; Bijker, 1997; 1987; Fleck, 1935). This social constructivist approach holds that technology is manmade. The ways in which a technology emerges and is used cannot be understood without first perceiving how that technology is embedded in its social context. In order to understand the drivers underlying emergence, contestation, and acceptance, sensitivity to the variety of actors involved (human and nonhuman) and their actual use of the technology is required. In particular, it is imperative to ask who defines the technical criteria that success is measured by, why the technical criteria are defined this way, and who is included or excluded from this process. This understanding is still rare in studies of organisational institutionalism and technology. Failure to take into account the actual content of technological innovations still results in the widespread use of simple linear models to describe the process of innovation. Bijker et al. (2012, p.15) argue that most common are studies carried out by economists that look at conditions for success in innovation: *"In the economic analysis of technological innovation everything is included that might be expected to influence innovation, except by discussion of the technology itself".* They refer to a

passage by Layton, who notes: *"What is needed is an understanding of technology from inside, both as a body of knowledge and as a social system. Instead, technology is often treated as a 'black box' whose contexts and behaviour may be assumed to be common knowledge"* (1977, p.198). The metaphor of the black box was cemented. Latour (1987) described the development of science and technology – what he coined 'technoscience' – as a black box that is only closed once the controversies evolving from, and surrounding, a new invention are settled. Respectively, Latour identified two statuses: (1) '*science in the making*', refering to an open black box of controversies in which context and content are still merged; and, (2) '*ready-made science'*, describing the black box in a closed state, when the development process of new science and/or technology is settled and no longer challenged by the social context.

Latour (1987) argues that science and technology can only be properly understood through their practice, and their technical content and social context. Social construction emerges during the course of people's encounters with a technology as they use it in the conduct of their everyday work. It takes shape through pragmatic action and situated improvisations (Orlikowksi, 2000). Orlikowski (1992) documented how tools can reinforce an organisation's structure. As opposed to the top right that treats structures as though they are relatively fixed and embodied in technological artefacts, work categorised in this quadrant treats structures as patterned streams of action and interaction. As such, structures are not given but rather emerge over time as forms of use and social relations sediment into place. The imagery is one of

situated ‘improvisation’ (Orlikowski, 2000) or ‘improvised learning’ (Boudreau and Robey, 2005). Structures shift as people go about solving the problems they confront and as they adapt an emerging technology into their everyday practice.

Practice

Practice theory allows to “… (i) foreground the collective performance of institutions through situated, emergent and generative *practices*, (ii) acknowledge the institutional significance of *praxis*, the everyday work performed by and in organisations, and (iii) draw attention to the role of frontline *practitioners*, ordinary people doing ordinary work in the constitution of institutional orders” (Smets et al., 2017, p.3, emphasis in original). This theoretical perspective adopts the notion that an entity is defined not by what it is, but by the practices and system through which it is enacted (Feldman 2004). The material characteristics and capabilities of a technology become relevant only in relation to specific situated and enacted practices (cf. Scott and Orlikowski, 2009; Nicolini et al., 2020). By focusing on dynamics, relations, and enactment, it is particularly well positioned to offer powerful analytical tools to help understand the organisation in all its complex facets (Feldman and Orlikowski, 2011). In practice theory, individual behaviour is always embedded within a web of social practices and relationships: praxis relies on practices, and practices are enacted in praxis (Whittington, 2019; 2006). The practice perspective thus confronts one of the central issues in social studies: how social structures and human agency link together in the explanation of action (Whittington, 2019; Vaara and Whittington, 2012; Whittington, 2006). Practice theory strives to understand how actions produce

outcomes. Thus, when viewing routines or the use of technology, the specific outcomes – being that of stability or change – are seen as consequential only in the context of the performances and dynamic relations through which such (provisional) stability and change are achieved in particular instances of practice (Feldman 2004).

Technology-in-Practice

"Technology-in-practice" (Orlikowski, 2000, p.404) helps to inform the understanding of how practice is important (in particular in relation to technology), and is defined as: "… a practice lens to examine how people, as they interact with a technology in their ongoing practices, enact structures which shape their emergent and situated use of that technology. Viewing the process of enactment enables a deeper understanding of the constitutive role of social practices in the ongoing use and change of technologies in the workplace". Orlikowski (2000) argues that technology is developed through a socio-political process that results in structures (rules and resources), which are embedded within the technology. She does this by building on Giddens (1979; 1984), who argued that 'structure' (or structural properties of social systems) is a set of enacted rules and resources that mediate social action. Actors do not enact structures in a vacuum, but draw on their (tacit and explicit) knowledge gained from prior actions, the situation at hand, the facilities available to them (e.g., land, buildings, technology), as well as norms and values which inform their ongoing practices. In this manner actors apply knowledge, facilities, and habits to 'structure' their current action, and in doing so they recursively instantiate and thus build the rules and resources that structure their social action. Technology-in-practice focuses

on studying knowledgeable human action and how its recurrent engagement with a given technology constitutes and reconstitutes particular emergent structures of technology usage (Orlikowski, 2000, p.421). In this manner, it provides an anchor in practice theory for practice driven institutionalism and helps to unlock new phenomena of social practices in the on-going use and change of a technology.

2.4.3.2 Contributions and shortcomings

In essence, technology-in-practice is a tool which can aid in developing a deeper understanding of those everyday practices that develop a technology and shape specific properties of organisations like that of the science-based business. However, one aspect that remains unaddressed is how the social structures that dictate practices came to be. Next, organisation and technology relate to each other if they were to emerge at the same time through co-constitution: emergent organisation structuring emergent technology, and vice versa.

2.4.4 Practice Driven Institutionalism: Emergent organisation / Emergent technology

To date, in organisational institutionalism, technology has been considered exogenous, determining, or subjective. However, as opposed to considering technology as an outside entity, a structuring force, or being subject to imprinting by individuals inhabiting and enacting existing structures, the co-evolvement of technology and social structure has largely been overlooked. This section addresses how shared understanding of technology is emerging but not yet established; how social structure is emerging in symbiosis; and, how both are co-constituted simultaneously. In the outset, much is contested and negotiated, including practice

(activity and logic combined), technology, the social structure of the organisation, as well as field structures. Scholarship that examines how individuals craft structures of technology and organisation through practices formulates the basis for this angle. Hence, the concept of 'practice driven institutionalism' (Smets et al., 2012) is considered central to this theoretical perspective.

2.4.4.1 Key theoretical concepts

Practice-driven institutionalism

A recent addition under the umbrella of neo-institutionalism is 'practice-driven institutionalism'. Practice driven institutionalism brings together *institutional* and *practice* scholarship. By combining the "best of both worlds" it allows for unlocking new phenomena that previously eluded investigation with either of the two conceptual toolkits alone (Smets, Greenwood, and Lounsbury, 2015b, p.283; Smets et al., 2017). With practice driven institutionalism institutional scholars are following the 'practice turn' that has been evolving in organisation theory over the past two decades (Whittington, 2019; Smets et al., 2017; Smets et al., 2012; Barrett, Oborn, Orlikowski, and Yates, 2012; Sandberg and Tsoukas, 2011; Whittington, 2006; Knorr-Cetina, Schatzki and Savigny, 2005). Institutional theorists building especially on process and practice driven ontologies inspired this turn: For instance, scholars addressing ontologies on strategy-as-practice (e.g., Suddaby, Seidl, and Lê, 2013; Whittington, 2006), routines (e.g., Feldman, 2016; Feldman and Pentland, 2003), and technology-in-practice (e.g., Orlikowski, 2000; 1996) have been influential in this turn in the organisational literature. As part of the practice turn institutionalists seek to enhance understanding of the role that institutions play throughout the actual

everyday life on the work floor. As Smets et al. (2017) point out, the aspects that practice driven institutionalism specifically advances are how institutional logics are theorised (e.g., Ocasio, Thornton and Lounsbury, 2017) and the complexities that occur when incommensurable logics clash (e.g., Greenwood et al., 2011). In this sense, practice driven institutionalism informs important conversations of current institutionalist theorising.

Smets et al. (2017; Smets et al., 2012) build practice driven institutionalism on Schatzki's (2001, p.2) definition of practice as *"…embodied, materially mediated arrays of human activity centrally organised around shared practical understanding".* Following this definition Smets et al. (2017, p.4) state that "…*any given practice comprises multiple interrelated and interdependent activities. To be relevant to a given practice, these activities should be intelligible for participants in a specific situation or spatio-temporal context, be collectively meaningful and accomplishable, and also be recurrently performed and recognized by multiple people"* (see also Schatzki, 2012; Feldman and Orlikowski, 2011). Basically, practices can be seen as *"shared routines of behaviour, including traditions, norms and procedures for thinking, acting and using 'things', this last in the broadest sense"* (Whittington, 2006, p. 619). With this understanding practice driven institutionalism introduces the notion of practice into the framework of institutionalism.

Smets et al. (2017) point out that *both* institutional *and* practice scholars appear to have lost sight of organisations. Institutionalists seem to have focussed much of their

recent empirical work on fields rather than on (intra)-organisational dynamics. Practice scholars looked in the opposite direction, focussing on the micro tendencies inside the organisation (e.g. Whittington, 2006; Vaara and Whittington, 2012). Smets et al. (2017) observe that: *"despite the recent coming-together of these two perspectives, few scholars appear to be looking at the box; or more precisely, at organizations and their specific properties"* (p.36). These are exactly what may be explored with practice driven institutionalism. The theoretical lens reasserts the focus on the organisations and their specific properties, whilst paying attention to underlying practices deep inside the organisation as well as the external institutional demands. This can contribute to an understanding on how organisations emerge, are maintained, change, and the role of institutional logics and practices in that process.

2.4.4.2 Contributions and shortcomings

The literature does not yet sufficiently address some of the underlying dynamics witnessed; in particular, (1) the creation of new organisations as a conduit for development and dissemination of technology; And, (2) the emergence and shaping of technology and practice throughout the intra- and inter-organisational settings – moving from practice, to organisation, to field. The consideration of these characteristics (e.g. Thornton, Ocasio, and Lounsbury, 2012; Battilana and Dorado, 2010; Lounsbury, 2001, 2002, 2007; Pache and Santos, 2013) allows for looking at organisations as structures designated to develop and disseminate new technology. However, what is still missing is a lens that allows for looking directly within the formation of the technology, and how the technology shapes the organisation by the

activity of the people within it. Technology as a complement to practice driven institutionalism would allow further integration of technology into the framework of institutional theory. A start in acknowledging technology was made developed in the work of Garud and Karnoe (2001; Garud and Ahlstrom, 1997), Orlikowski and Yates (1992; Orlikowski, 1992), and Lawrence and Suddaby (2006); as part of a broader turn to taking 'materiality' more seriously (Bijker, Hughes, and Pinch, 2012).

In terms of the sociology of organisations and technology Orlikowski's (e.g. 2000) work proves especially relevant as it explores the interactions between technology and intra-organisational practices, such as everyday interactions taking place on the work floor. Practice driven institutionalism (Smets et al., 2017) provides a way to link Orlikowski's everyday 'technology-in-practice' within the organisation with higher-level institutional dynamics. The approach enables to examination of tensions observed from intra- and inter-organisational dynamics related to the introduction and development of a new technology. However, Orlikowski's (2000, p.406) framework focuses on human actions associated with embedding structures within a technology through "improvisation", and enactment of the social structures in the technology use. Although she refers to "development" of technology, this is in terms of adjustments made to established technology such as existing software, and not in terms of technological development from scratch. Studying the emergence and co-constitution of new practice in relation to technology and organisation can contribute to a richer understanding of the workings and content of a technology – and its materiality – and the relevant practices, related social structures, and the aggregate

conditions (psychological, social, political, and cultural, rather than just economic and technical) in which radical technological innovations and co-evolving organisations emerge and take shape.

2.5 Conclusion

The power of a more comprehensive and inclusive approach to organisations through 'practice driven institutionalism' *cum* 'technology' becomes evident when considering the question of where new technology comes from, how it emerges through and with the organisation, and how both technology and organisation become established within a field through practice. Although a start has been made in exploring such a question in terms of inductive study looking at new practice creation (cf. Lounsbury and Crumley, 2007), this hinges on the roles of legitimacy and diffusion, and redirects attention toward the multiplicity of actors that interactively produce institutional change. To understand how new practices and technologies emerge and become established requires paying greater attention not only to the broader cultural frameworks that are created and changed by field-level actors, but as well to the lower-level activities within and by organisations and their associated actors. It is here that an understanding of co-constitution of technology and organisation can be insightful.

Orlikowski and Barley (2001, p.148) observed that the problem with theories attempting *''to reduce technology to an abstract material cause in the name of generalizability",* is not just understanding materiality but also *"the desire to quickly leap to broad, law-like claims*". Following the juxtaposition of materialism and

determinism in contingency theory, social constructionists have a tendency to discard both instantaneously. The effect is that those who might claim that the material properties of a technology can influence the organisation risk being branded as 'determinists'. 'Determinism' is a term that has become somewhat of a slur in academia (for instance see Winner, 2001; or Bijker et al., 2012). Perhaps because 'materialism' has acquired the stigma of 'determinism' scholars studying technology and organising are generally paying little analytic attention to a technology's (material) constraints and affordances. Instead, the focus is most often on showing how people organise themselves around the technologies that they use. As a result, attention is brought to the social structures in which technology becomes embedded. This entails social dynamics such as interactions, interpretations, and behaviours that formulate the basis for social structures (e.g. Barley, 1986; Orlikowski, 1992, 2000; Leonardi and Barley, 2008). Even the most influential studies of technologies and organisations – often those on 'information systems' – direct their attention predominantly towards social dynamics like the interactions between people that find themselves around technology. This happens instead of *"…providing evidence of what specific material features people use, why they use them, and how and why their patterns of use shift over time"* (Leonardi and Barley, 2008, p.163). It is as if those scholars that have moved away from a deterministic understanding now may have overshot to arrive at a purely social structuring one – ignoring the material aspects of technology. Leonardi and Barley (2008, p.160) observed that: *"Although theorists may argue that social and material factors are equally important, most papers on the*

creation, perpetuation or change of technologies and organizations eventually favor one or the other."

The emergence of a new technology coincides with the emergence of practice (Orlikowski, 2000). The interplay between technology, practice, organisation, and institutions is complex. The bottom-up approach of practice driven institutionalism can contribute to a richer understanding of the complexity that springs from 'technology'. Further integration of technology into institutional theory is also likely to change our perception of social dynamics and materiality within organisational settings. A more profound notion of technology-related practices offers a window into how technology-engaged practices emerge through technology-based organisations and interact with institutions that are being maintained and transformed through everyday activities. More can be done to understand where new practices come from and how they relate to the institutional setting. The challenge is to explore the different kinds of logics – also the less obvious ones –, and in turn how these affect the creation and development of technology as well as the organisation. In this manner a contribution can be made to an integrative approach towards the emergence of new technology. Such an approach should account not only for practice but for institutional processes as well (Smets et al., 2017).

The lens of practice driven institutionalism offers a powerful conceptual toolkit to trace the emergence of such new practice from everyday work, throughout the organisation, and ultimately the organisation's field. It helps to understand those

settings in which conflicting prescriptions collide in everyday operations of the organisation, and institutional complexity must be managed continuously. These concepts only acquire their proper meaning when considered as a dynamic interplay rather than simply in 'isolation' (Smets et al., 2017). In this respect the opportunity can be identified to contribute to institutional scholars addressing calls for studies that *"delve deeper into the dynamic patterns of [institutional] complexity"* (Greenwood et al., 2011, p.334). Tapping into an empirical case study to explore the emergence of new technology and related practice can help to build further on practice-theoretical notions of 'emergence', 'becoming', and that of 'continuous change'. It is an opportunity to attend to *"the earliest moments of new practices emerging and gradually taking shape"* (Smets et al, 2017, p.19), thereby constituting the emergence of both organisation and technology.

Most constructivists in Organisation Studies that study the design and commissioning of new technologies have focused on adoption and use, rather then contestation and constitution. As discussed above, the first three perspectives begin research after adoption, thereby divorcing implementation and use from preceding decisions and events. When studies begin with little insight into why technologies were designed as they were, why one technology was chosen over another, or how the technology was deployed, they essentially censor the construction process. This tendency makes it impossible to determine whether patterns of use are shaped in important ways by dynamics of power, control, status, and conflict that set the context of use. On the other hand, sociologists of technology who have studied such development ended

their examination of technological change at the point where a technology has been designed and is ready to be adopted. In other words, they have not necessarily looked at the dynamics of use once a technology is considered closed and stable (Bijker et al., 2012; Latour, 1987). Both approaches have been successful and powerful in their own right, but for a comprehensive understanding constructivists could connect both agendas and undertake studies that cover the entire range from development through organisational emergence (or significant change).

As a new technology emerges the practices of structuring technology and organisation converge as both of them arise simultaneously. Work practices (occasioned by a technology) can vary (Lounsbury, 2007) or may lead to changes in the institutional structures of social order, as understood through practice driven institutionalism (Smets et al., 2012). Studying how the formations of structures take shape following the emergence of new practices throughout organisations, and particularly those around new technologies between micro (the individual) as well as macro (the field) levels of analysis, brings closer the goal of explaining how emergent and inherently indeterminate social phenomena are transformed into the seemingly objective and immutable facticities of organised life. It allows for highlighting the important role that technology may play in the dynamics of organising, thereby encouraging organisational theorists to recognise that technologies are more than tools or physical artefacts. How technology is developed, adopted, implemented, and used shapes how organisations emerge, replicate, and change. This entails moving beyond the perception of a technology-in-practice, and to consider it rather as a

technology-as-practice whilst technology and organisation co-evolve, constitute, and materialise through practice. This observation is further elaborated upon in the discussion chapters.

This literature review discusses how various authors have tried to systematise their thinking regarding organisation as a social structure, technology as a social structure, as well as the relationship between the two. By identifying key scholarship through which the field of institutional theory arrived at its intellectual status quo, the purpose of this review was to set the stage for contribution to the continuation of these efforts. It provides a basis to extend this structurational perspective through continued systematised thinking about the relationship between organisation and technology.

On a final note, the theoretical concepts discussed in this chapter emerged as relevant or innovative from this study. The inductive interpretive research approach that has been adopted grounds the previously discussed concepts and the theoretical framework emerging from the data analysis of this thesis in empirical findings (Strauss and Corbin, 1990; Glaser and Strauss, 1967). Thus, the framework was not derived from a prior theory and did not guide the data collection. The following chapter, the methodology, discusses how the study was set up and how empirical data was collected. This is followed by the analysis chapters, which pick apart empirical data using the lens of practice driven institutionalism cum technology as discussed in this literature review.

3. METHODOLOGY

3.1 Introduction

This research is an inductive theory building exercise based on qualitative research with a comparative multi-case study design. The description is linear for the sake of clarity, but the research journey through which this doctoral thesis came to be is a product of thoughtful and deliberate iteration between data and theory. The following detailed description of the conducted research process allows the reader to assess the adequacy of used methods and the soundness of the subsequent findings (Eisenhardt and Graebner, 2007; Bono and McNamara, 2011).

The outline of this chapter is as follows: first, the ontological and empirical stance of the thesis is clarified, followed by a discussion of the research design, the data collection process, and the data analysis. The chapter is concluded with a synthesis on how the comparative research approach allows inducing and generalising findings for theory building (Eisenhardt, 1989) in the following chapters.

3.2 Ontological and epistemological stance

The research problem this thesis addresses is '*how'* new technology and organisations are co-constituted through practices of commercialisation. The research problem implies an 'interpretive' ontology as it refers to the social construction of both technology and organisation as is visualised in figure 1 with the help of the Burrell and Morgan quadrant (1979) that summarises and maps different ontological assumptions. According to this perspective, the key variables of interest are internal and subjective. Human beings do not passively react to an external reality but rather

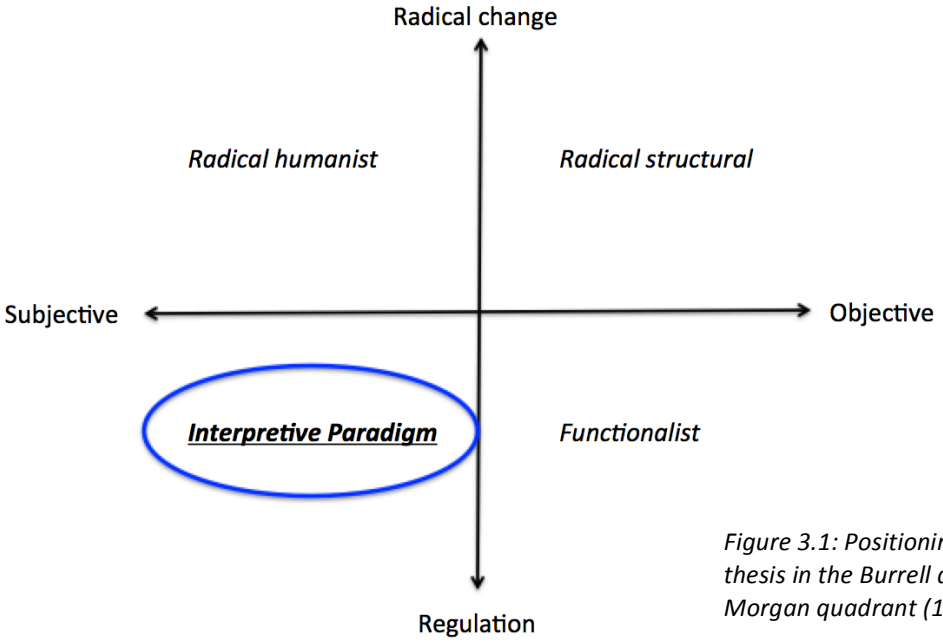


Figure 3.1: Positioning of the thesis in the Burrell and Morgan quadrant (1979)

impose their internal perceptions and ideals on the external world and through this actively create their realities (Morgan and Smircich, 1980). This understanding of the world has a perspective of stability and gradual 'regulated' change (Durkheim, 1893) rather than 'radical' Marxist change through revolution – as visualised on the vertical-axe. Social reality is considered an emergent social process constructed through a network of negotiation between inter-subjective meanings and assumptions. Knowledge is provisional and may change through individual and/or collective interaction (Glaser and Strauss, 1967; Suddaby, 2006). The focus is on understanding these interactions and how they shape or are shaped.

When applying these understandings on the empirical phenomenon central to this thesis, the emergence of a new technology and related uses is truly part of a complex and networked reality, embedded in interactive practices, organisations, actors, objects, rules, structures, and institutional influences. The research strategy aims to

elicit fresh an understanding about how practices actively construct our reality (c.f. Smets et al., 2012; Whittington, 2006; Glaser and Strauss, 1967) by letting the empirical data speak to the constructs and eventually let theory evolve, instead of vice-versa, when theory dictates the research approach (Mintzberg's, 1979). This is done, for instance, through participant experience and in-depth interviews to draw on subjective experiences of individuals. Hence, the researcher is not an objective tool and the personality, experience, and character, of the researcher ought to become important components of the research process and should therefore be accounted for as part of the analysis (see also Strauss and Corbin, 1998). However, to see the empirical data for what it is, ideological preconceptions and theoretical commitments should be dampened. The following sections further detail the 'research design', 'data collection', and 'data analysis' methods on how data is translated into theory as conducted in the research process.

3.3 Research Design

3.3.1 Case study approach

This study starts with the phenomenon. It was researched in real-time how and why new technology and organisations are co-constituted through practices of commercialisation. With a new, understudied, highly complex, and messy empirical context of an on-going contemporary social phenomenon within a real life context over which no control can be exercised by the investigator, a case study approach was used to allow for inductive theorising based on qualitative data (Bansal, Smith, and Vaara, 2018; Nadkarni et al., 2018; Yin, 2009). This is in line with Yin (2009) who states that exploratory research questions that start from '*how'* are particularly suited

for case study based research, as such empirical inquiry allows for replication, comparing, contrasting, and extensions to the emerging theory with lateral shifts in knowledge (Bansal et al., 2018).

3.3.2 Comparative multiple case study

This research uses a comparative multiple case study design with a total sample size of thirteen CRISPR companies. The sole purpose and the sole right of existence for these organisations is to commercialise a specific CRISPR application in the field of human therapeutics. Sampling was initiated with the first four CRISPR companies that emerged around the same time in 2013 – wave 1 – when key CRISPR scientists spun their innovations out of their universities to establish privately funded *new* organisations with the *sole* goal of further developing CRISPR applications for the market as public funding alone was not sufficient to fund development. The subsequent nine companies are 'follower' CRISPR companies – wave 2 – shortly established after. Inspired by a 'theoretical sampling' approach (Glaser and Strauss, 1967) the sampling criteria can be divided in 'constants' and 'variables', and were as follows:

Constant:

1. **The organisation must be based in the local setting in which it spun out or originated.** *This helps to trace the genealogy of the organisation. Furthermore, geographically it will be close to the origin of where the practice was locally developed.*
2. **The founding scientist(s) needs to still be involved in some capacity within the organisation.** *This contributes to the idea that the organisation still has close connections to its source, the research institution from which it spun out.*
3. **The organisation's right of existence must be fully dependent on the success of the practice that it develops.** *This is to ensure that samples have co-constitution of technology and organisation.*
4. **The organisation must be based of academically developed knowledge.** *This is to ensure a process of commercialisation takes place.*
5. **This knowledge must be related to the practice of CRISPR for human therapeutics.** *The focus of this research is on CRISPR organisations.*
6. **The organisation must grapple with a form of intellectual property.** *This functioned as indicator for insights into locally embedded tensions as IP is firstly negotiated locally.*
7. **The organisation should be accessible in order to collect data through interviews.** *Interview data provides valuable insights into the organisations and their practices.*

Variable:

1. **There is variation in institutional contexts between the different cases:** *The Netherlands, the UK's golden triangle Oxford – London – Cambridge, the US Boston area.*
2. **There is variation between cases in the use, application, and development of CRISPR for human therapeutics.** *This provides insight into the development dynamics of different CRISPR applications.*
3. **There is variation in stage of the life cycle the cases.** *This allows to look at different phases of co-constitution of organisation and technology.*

These criteria led to the following sample for data collection and analysis (see table 3.1 for the sample, and Appendix 1 for a more detailed background on each of the companies).

1st Wave

Company Code		CRISPR application	Year founded	Type of management	Institutions / Patent holders	Funding*	Employees	HQ
1	Editas Medicine	Human therapeutic	2013	Professional management	Broad Institute, Duke University, Massachusetts General Hospital	IPO	50 - 100	US
2	Caribou Biosciences	Human therapeutic	2013	Professional management	UC Berkeley, University of Vienna	Series +	50 - 100	US
3	Intellia Therapeutics	Human therapeutic	2011	Professional management	Caribou Biosciences	IPO	50 - 100	US
4	CRISPR Therapeutics	Human therapeutic	2014	Professional management	Emmanuelle Charpentier	IPO	50 - 100	CH/US

2nd Wave

Company Code	CRISPR application	Year founded	Employees	Funding	Location next round	Type of management	IP	HQ
A1	Intracellular delivery system	2015	< 10	€250k (NL subsidy) €1.5mln (EU grant)	NL/EU/US	Inventor / CSO	Licensed	NL
A2	Drug discovery system	2017	< 10	€5mln < (Series A)	NL/US	Inventor / CSO	Licensed	NL
A3	Therapeutics	2012*	100 <	$100mln < (IPO)	US	Professional management	Fully owned	NL
B1	AI powered CRISPR library	2012*	< 10	$5mln <	UK/US	Inventor / CSO	Fully owned	UK
B2	Software tool	2011*	20 - 50	$20mln (Series A)	UK/US	Inventor / Professional management	Fully owned	UK
B3	AI tool for genomic data analysis	2011*	50 -100	$50mln < (Series D)	UK/EU/US	Professional management	Fully owned	UK
C1	Sequencing of microbiome	2016	< 10	Seed	US	Inventor / CSO	Licenced	US
C2	Gene editing based xenotransplantation	2014	< 10	$40mln < (Series A)	US	Inventor / Professional management	Licenced	US
C3	Human emulation system	2013	50 - 100	$100mln (Series C)	US	Inventor / Professional management	Licenced	US

*Some companies have an earlier start date than 2013 because they worked on other genome editing technologies before shifting to CRISPR

The CRISPR field was in its infancy between 2013 and 2015 and introductions were crucial, especially regarding second-wave CRISPR companies, as it took specific insider knowledge to know about companies before or during their process of spinning out of a university and development of CRISPR applications. Academics working on the technology made the initial introductions to the organisations.

Each organisation worked towards (different) CRISPR applications, divided between three contexts, and was at various development stages. By sampling similar cases in terms of organisation and general technology, yet with systematised variation, the aim was to collect an optimal sample for comparative inquiry allowing for representativeness of concepts and not of persons or individual cases (Yin, 2009). Here, the purpose of comparison between case-based empirical evidence was to create theoretical constructs and/or midrange theory (Eisenhardt and Graebner, 2007; Eisenhardt, 1989; Yin, 2009; Gehman et al., 2018).

3.3.3 Institutional Context

The first movers all have a link to the US and are predominantly based in the US East Coast area around Boston. From here on followers are spread more widely with concentrations in the UK, Northern Europe, and China. In 2015, at the outset of this research project most (reported) research activity into CRISPR occurred within the US and Europe (figure 4). In order to understand how CRISPR is commercialised the most active epicentres to focus on were located in the Boston area in the US, the golden triangle of Oxford – London – Cambridge in the UK, and the Netherlands. This display

of institutional differences was interesting for cross-case comparison. Each of these settings were active and decisive in the development of CRISPR and contained different sets of institutional structures and influences, adding diversity to the comparison between cases and providing different cultural understandings of what CRISPR was supposed to be. Using a form of theoretical sampling these different institutional settings allowed for three different institutional dimensions: The US and the UK fairly similar and progressive in terms of innovation stimulating policy and culture, yet holding capitalistic attitudes reflecting differences regarding established channels for commercialisation, access to capital, regulation, ethics, and risk appetite; whereas the Netherlands is also a Western context, but one more akin to continental European structures and concerns. In terms of convenience, the author is based out of the UK and a Dutch native.

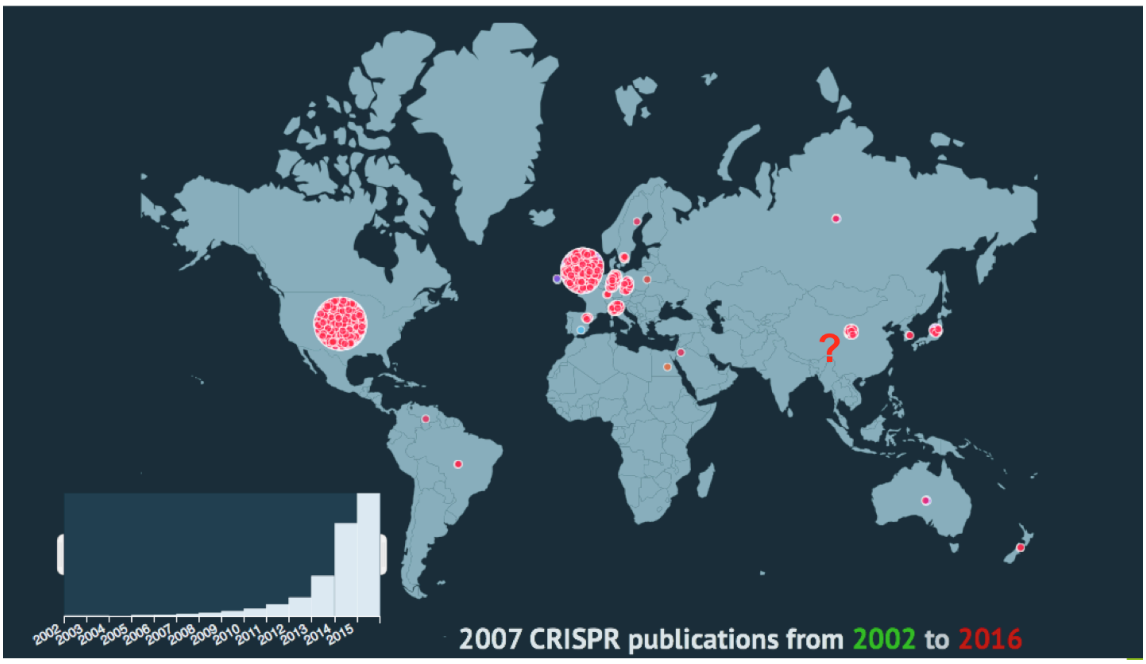


Figure 3.2: The density of CRISPR research activity as reported in 2016 (Bronshtein, 2016)

3.3.4 Time

Between 2013 and 2015 the author researched the international commercial roll out of genetically modified mosquitoes (Campos, Hartley, and de Koning et al., 2017), which included a technology referred to as 'gene drives'. This CRISPR-based technology made it possible to rapidly disseminate combinations of man-inserted genes throughout the population of any reproducing species (e.g., Esvelt et al., 2014). Hence, the author was "in the field" from 2013 onwards and therefore deeply familiar with its players from the outset of this thesis research. The development of such biotechnology raised questions of all sorts: technical, social, commercial, ethical, and regulatory, making it a rich setting to explore the co-constitution of technology and organisations; in the case of this thesis in the context of CRISPR applications for human therapeutics.

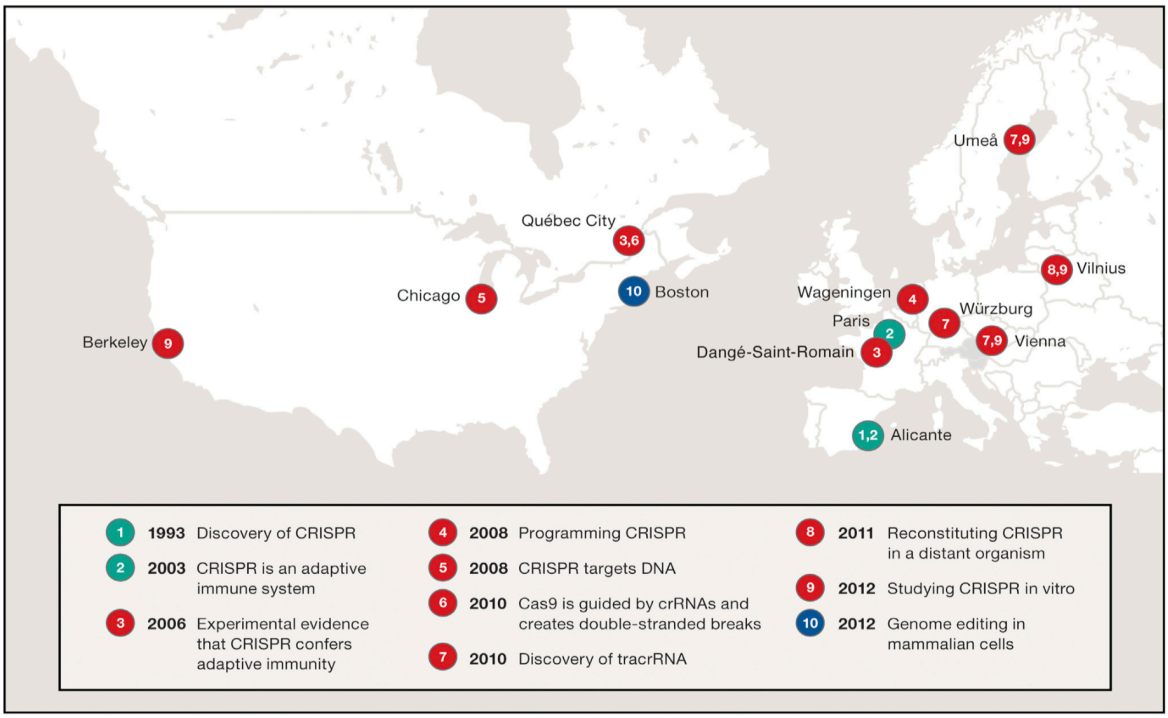


Figure 3.3: The major events in the scientific development of CRISPR that led up to the commercialisation of the technology in 2013 (Lander, 2016)

In the research design the relevance of time is twofold: First, the cases are positioned within the first five years of CRISPR's commercial developments, 2013 – 2018. The procedures of Van de Ven and Poole (1990) to establish 'a chronology of the major events' enabled diving deeper into the emergence of the actual practices around CRISPR and the commercial establishment of CRISPR technology. A series of preceding key events helped to identify the year 2013 as the pivotal point for the occurrence of the first commercial practices concerning CRISPR (figure 3) when the establishment and development of the first CRISPR-centred organisations occurred.

Second, there is the variable of what stage of the life cycle each organisation is in, largely distinguishing the difference between the first and second wave CRISPR organisations. The author named the first-generation CRISPR companies '*first wave'* and those companies closely following in their slipstream *'second wave'*. All 'first-wave' organisations in the sample were established in 2013, when key CRISPR scientists spun CRISPR technology out of their university laboratories to start developing applications for human therapeutics through spinouts: Jennifer Doudna with *Intellia Therapeutics Inc.*, Emmanuelle Charpentier with *CRISPR therapeutics AG*, and Feng Zhang with *Editas Medicine Inc*. The 'second wave' companies followed in the slipstream of the 'first wave' companies, further expending the type of CRISPR applications they would develop. They were in the early days of their development during this study.

3.4 Data collection

As is characteristic of case studies, this research draws on various kinds of data from various sources to enrich the account and enable triangulation. This minimises (retrospective) bias and increases validity (Yin, 2009; Eisenhardt in Gehman et al. 2018). Specifically, I draw on interviews, documents, and observations, which collectively allow me to theorize dynamics at the level of the field, organisation and practice, as well as their multi-level interactions (figure 3.4). Documents and observations were particularly helpful in examining the organisation and the field, as where interviews helped with insights into the organisations and practices.

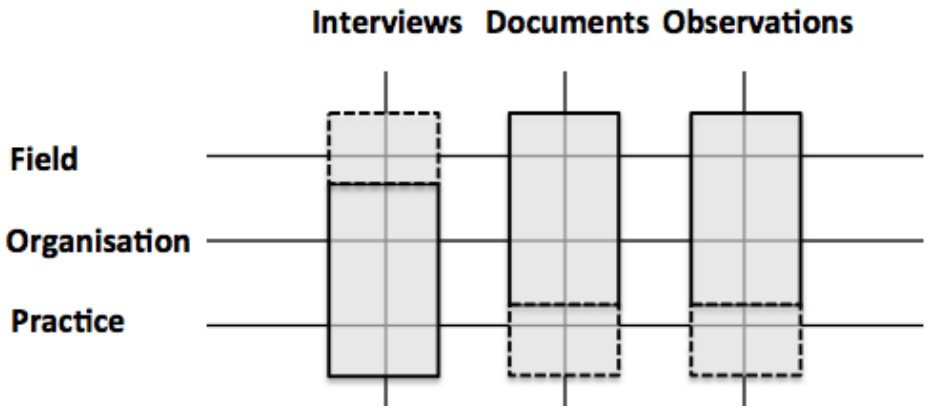


Figure 3.4: The schematic relation between triangulated data sources (interviews, documents, and observations) and the research design structure (field, organisation, and practice) form the input for the data analysis. Emphasis is added in terms of importance of the sources for each of the different comparative levels.

Data collection took place in four phases over the period of October 2016 until December 2018: Phase 1 'exploration', phase 2 'first wave', phase 3 'second wave', and phase 4 'verification' (table 3.2):

Table 3.2: The four phases of data collection	
Phase 1: 'Exploration'	*October 2016 – December 2016*
The purpose of this exploratory phase was to become acquainted with the field, institutions, organisations, and key informants related to CRISPR. When entering the field, the author did this as both researcher and research instrument. For the author to be well equipped for conducting in-depth qualitative research on these science-based companies and to be able to understand interviewees and organisational dynamics, it was necessary to gain a basic understanding of the field in which the sample operates and to be familiarised with the used (scientific) language. In anticipation of this, exploratory interviews with scientists in the field were held, and many technical papers were read that underlie the development of the relevant technologies and applications studied in this thesis.	
Phase 2: 'First wave'	*January 2017 – June 2017*
In this phase the data collection consisted of a more direct approach and the four first-mover CRISPR companies were directly contacted. In-person contact was made with the founding scientists or CEOs of these organisations at conferences, lectures, workshops, or privately hosted events. In some instances interviewees encountered in the first phase of 'exploration' made further introductions. Each company invited the researcher to visit their organisation and agreed to interviews.	
Phase 3: 'Second wave'	*July 2017 – July 2018*
In this phase the data collection approach had to be pivoted towards 'second wave' companies as access changed due to practices of secrecy. Data collection was focussed on getting a rich and more structured understanding of the second wave companies.	
Phase 4: 'Verification'	*July 2018 – December 2018*
This phase served to verify and triangulate theoretical constructs produced by this study. Follow-up interviews were conducted to test whether findings were recognisable and to see if theoretical ideas made sense to those within the field. Throughout this exercise several stakeholders proactively sought to learn about the findings. In particular, this brought forward special interest in best practices for the early stages of translating academic scientific research into viable commercialisations.	

The next three sections address the different data sources of interviews, documents, and observations used throughout the data collection.

3.4.1 Interviews

Interviews constitute the primary data source because they provided unique insights inaccessible via documents or observations, such as sensitive understandings about the inner works of organisation and technology development, allowing to gain in-depth insight when linked to different findings from observed dynamics and written sources. Interviewees are 'knowledgeable agents' who *"know what they are trying to*

do and [that they] can explain to us quite knowledgeably what their thoughts, emotions, intentions, and actions are" (Gioia in Gehman et al., 2018, p.291).

Interviews were conducted with internal (I) and external (II) informants (see table 3.3 for an overview and Appendix 2 for a full detailed and anonymised list). (I) Internal informants included (co-) founders, board members, executive directors, and technical experts; Given the small scale of spin-out companies, this included all members of the leadership or even of the entire organization on some occasions. (II) External informants were funders, partners, licensers, advisors, policy makers, lobbyists, representatives of industry, and many other stakeholders in the direct environment of the companies. Throughout this thesis interviewees are cited with various specificity between chapters with the purpose of providing as much information and insight as possible without infringing on their anonymity.

Table 3.3: Relevant interviewees per case

Overview of interviewed informants *N=88*		*Wave 1* *CRISPR organisations*				*Wave 2* *CRISPR organisations*								
		1	2	3	4	A1	A2	A3	B1	B2	B3	C1	C2	C3
12	Scientists turned scientist-entrepreneurs	x	x	x	x	x	x	x	x	x		x	x	
10	Technology researchers (scientists/practitioners)	x	x	x	x	x	x	x	x	x	x	x	x	x
12	Non-scientist C-level executives	x	x	x	x			x		x	x		x	x
10	Business development support (university staff/not-for-profit trusts/science park)	x	x	x	x	x	x	x	x	x		x	x	x
10	Investors	x		x	x	x	x		x	x	x			
13	Field and industry experts	x	x	x	x	x	x	x	x	x	x	x	x	x
8	Policy experts (professors/civil servants/lobbyists)	x	x	x	x	x	x	x	x	x	x	x	x	x
5	Ethics experts (in residence within laboratory/professors/civil servants)	x			x	x	x	x	x	x	x	x	x	X
3	Science park directors						x	x		x	x			
5	Others	x	x	x	x	x	x	x	x	x	x	x	x	x

Total interviews = 110

The content of the interview (interview guide) was organised around the following themes: company founding and growth, development of CRISPR applications, organisational structure and governance, human resources, commercial strategy, financial strategy, performance, stakeholders, and field dynamics (partly inspired by Pache and Santos, 2013). Questions were targeted at what hurdles the companies encountered, how they were overcome or are to be overcome, as well as how and why companies are operating in certain ways.

The process by which the interview subjects were identified, selected, and contacted was as follows: Initial points of access were created in the first round of data collection through exploratory open interviews with knowledgeable stakeholders in the ecosystem. These stakeholders were selected based on their publications and early involvement with the development of CRISPR. This was a select group – or inner circle. Interviewees were selected because of their relation with the few CRISPR companies at that time, or they were suggested and introduced by previous interviewees through a process similar to snowballing. Subjects were then contacted directly for an interview. Almost all these interviews were conducted in person and at location. In subsequent data collection rounds interviews were semi-structured and lasted between 45 min and 2 hours each. Twenty interviews were conducted in each of the three setting when information was being repeated, a sign of saturation for the line of inquiry (Strauss and Corbin, 1998; Suddaby, 2006).

If possible and permitted, interviews were recorded with a recording device. On many occasions this proved problematic due to the nature of interviews, for instance when discussing sensitive topics such as related to pre-IP ideas and post IPO strategies. Recording was more readily accepted during the follow-up interviews and the data collection 'verification' phase when meetings were used to discuss less sensitive material to verify theoretical ideas of this study. When recording was not permitted or if it would mean that an informant could not speak freely, detailed notes were taken and typed up shortly afterwards. Additional data was collected through follow-up conversations over the phone and via email to confirm or complement findings to ensure that efforts to build theory would encompass the observed reality. All recordings, transcripts, and notes were stored securely and in compliance with the CUREC of this study.

*In terms of processing t*he interview language depended on the setting. Most interviews were conducted in English, but several interviews in the Netherlands were conducted in Dutch. In some settings, such as in the Netherlands, it felt more natural for interviewees to communicate in Dutch. English terms were used during Dutch interviews in instances that technical or specific description was necessary. Transcripts and notes were made in the language in which the interviews were conducted. Dutch interviews were first transcribed in Dutch and then translated into English. Translating some concepts proved particularly difficult due to the language barrier. In order to stay as close as possible to the original expressions, extensive use

was made of the companies' websites, which all had a Dutch to English translation setting. This helped to achieve and verify the translation of key terminology.

Data derived from the interviews helped to gain insights into everyday practice, the co-evolvement of organisation and CRISPR application, and field dynamics. The insights drawn from the interviews were particularly powerful when examining the levels of 'practice' and 'organisation'.

3.4.2 Documents

The author collected archival data that enabled interpretation and contextualisation of the other data, that of interviews and observations. For instance, leading CRISPR scientists noted in their interviews the significant challenges in the development of their respective CRISPR applications as they had no set pathways or templates to rely on and, on top of that, had to deal with a heated patent dispute centred around who had right to the underlying intellectual property (IP). Dynamics became especially heated when applications were being developed for humans (Nuffield Council, 2018; 2016), sparking debate on norms, values, regulations, good conduct, control, implications, scientific demarcations, and new business models. Documents gave context and insight into these developments that added further complexity to the already incredibly difficult process of building a successful science-based business (i.e. Powell, 1998; Pisano, 2006).

The content of collected data can be divided in the two categories of 'internal' and 'external' to the organisations: (i) *Internal* data gave insights into the technological

development process through for instance (technical) research articles, magazine and journal articles, and about the organisations via analyst reports, company websites, and investor pitches. (ii) *External* data gave insights into the institutional contexts through law texts, professional documents, white/policy papers, and books.

For the collection process 'Google alerts' were used for a real-time data feed allowing to keep track of the most recent developments in relation to the sample. The used search terms were the names of the organisations, 'CRISPR', 'gene-editing', and 'human genome editing'. Every day since January 2017 this report was received, to date totalling over 1000< daily reports on the organisations of interest and CRISPR. Similar search terms were used to find relevant documents through search engines. Interviewees recommended additional sources. Examples of used documents are listed in table 3.4.

Table 3.4: Examples of used documents

Documents used for archival analysis	**Pages**	**P**	**O**	**F**
1000< RSS feed notifications	3000+	x	x	x
CRISPR related scientific articles and books	2000+	x		
IPO documents, analyst reports, announcements, and annually published shareholder updates	1000+	x	x	
News reports in press and other outlets	1000+		x	x
Conference and meeting information books and handbooks	1000+	x		x
Field overview data reports produced by data outlets (such as TechNation, Crunchbase, CBInsights), accelerators, and others	1000+		x	x
Notes and reports by Parliaments and Senate	500+			x
Statements on human genome editing by National Academies	500+	x		x
Reports by human genome editing national policy advisories, such as the UK Nuffield Council on Bioethics on, the Dutch RIVM, and DC government advisories	500+	x		x
Company websites	500+		x	
Investor pitches and product & service presentations	200+	x	x	
Reports by International Summits on Human Genome Editing	100+	x		x
European Commission policy documents and announcements	100+			x
Patents and IP documents	100+	x	x	

Note: Marked with 'x' are the type of documents relevant for P = practice level, O = Organisational level, or F = Field level.

In terms of processing, the documents (I) provided provisional reading to understand basic terms and common practices, such as technical terminology drawn from academic papers – hence an understanding necessary to conduct interviews; (II) helped to build an initial understanding and profile of the organisations in the sample, such as through analyst reports, company websites, and IPO documents – and hence helped to understand the emergence of CRISPR organisation and technology; (III) assisted in identifying tendencies in the institutional contexts, common practices, tendencies, and dynamics, such as through policy documents and legal texts – hence helped to get an appreciation for the logics at play; and, (IV) verify other collected data.

3.4.3 Observations

Observations complemented findings drawn from interview and document data. *In terms of collecting data,* almost every interview was conducted on location and being physically present as researcher allowed for obtaining a sense of the operational settings of the organisations, as well as the prevailing practices and culture. For instance, interviews were often followed by a tour of the company, the laboratories, the workspaces, and included introductions to employees, administrators, founders, and other stakeholders. Although the observations did not follow a strict ethnographic protocol they allowed for a glimpse into everyday activity reflecting the significantly contributing to the understanding of common practices, organisations, and the context of the academic and industry settings in which CRISPR-based organisations operate.

In terms of content, on a few occasions it was allowed to take pictures of some of the settings, to have a copy of product/service presentations, or investor pitches. But in most instances the nature of the activities done by the organisations was highly sensitive, not allowing for direct onsite recording of observations through means of audio recording devices, photos, or video, as it would entail sensitive work not yet secured under IP, activities taking place in laboratories with high biosafety levels – and therefore not accessible without special training and clearance –, or academic as well as commercial competitor sensitive information.

Additionally, I attended relevant field events such as conferences, (private) events, lectures, and gatherings alike, where knowledgeable actors from industry, policy, academia, and sample companies were present and shared information (table 3.5).

Table 3.5: Examples of relevant field events attended

Event	Location	P	O	F
Company visits	US / UK / NL	x	x	
Cambridge Genomics Centre conference on the commercialisation of Biotechnology	Cambridge , UK (3 days)	x		x
The Wellcome trust Sanger Institute AstraZeneca CRISPR conference	Cambridge, UK (3 days)	x	x	x
Lecture by Professor Jennifer Doudna (CRISPR pioneer) one of the developers of CRISPR	Oxford, UK	x		x
Meeting hosted by the Dutch government on the use, development, and regulation of Genomics	Rotterdam, NL (2 days)			x
Lorentz workshop on 'Challenges for the regulation of Gene Drives'	Leiden, NL	x		
The Nuffield Council on Bioethics, event on 'Genome editing in human reproduction'	London, UK	x	x	x
The Nuffield Council on Bioethics, event on Genomic editing	London, UK	x	x	x
Evening on Genomic company investments at large investment fund	London, UK		x	x
Harvard event on genomics related policy	Cambridge, US			x
Talk by Professor George Church (CRISPR pioneer) on the potential and use of CRISPR	Cambridge, US	x		x
Dinner with Alex Gorsky, CEO Johnson & Johnson, world largest pharmaceutical company	Oxford, UK			x
Dinner with Mr Pirimal, CEO/owner of Pirimal Group, large pharmaceutical company	Oxford, UK			x
Global Young Scientist Summit	Singapore (1 week)	x		x
Lectures series on Medicine Discovery and Computer Science, Singapore Management University	Singapore			x
Evening with Prof. David Gann, Imperial College London, on "The Business of Science and the Science of Business"	Oxford, UK		x	x
More than 10 start-up competitions for early stage biotechnology and STEM companies organised by e.g. the NHS, university incubators, and private for-profit and not-for-profit accelerator programmes	Oxford/London, UK Wageningen, NL (14+ days)		x	
Several events on the regulation of genomic technologies in Europe hosted by the European Commission	Ispra , Italy (6+ days)			x
Several events on the regulation of genomic technologies in the UK by the House of Lords Select Committee on Science and Technology	London, UK (3+ days)			x

Note: Marked with 'x' are the type of events relevant for observations on P = practice level, O = Organisational level, or F = Field level.

Consequently, *in terms of processing,* the observations also include notes on a multitude of informal conversations (150 <, between 2015 – 2020) with laboratory directors and technicians; science-entrepreneurs; CRISPR company employees; C-level executives in big pharma; investors; leading scientists and academics; policy makers

from several governments, not-for-profits, and EU-directorates; researchers, young and old, ranging from PhDs to full professors; lobbyists; representatives of big pharma; IP lawyers; activists; biohackers; and many more. The observations helped to bring together the data collected through interviews and documents, as it was possible to see the findings drawn from those sources in action.

3.5 Data analysis

"No analysis strategy will produce theory without an uncodifiable creative leap, however small" (Langley, 1999, p.691). It relies on mutual dependence between methods, data, and theory, to make sense of data in terms of the capacity to generate accurate theory. How the data of this study was translated into theory is described here. First the data insights are discussed followed by the approach to data analysis and the data-to-theory.

3.5.1 Data insights

'What issues can the data (uniquely) illuminate?'. This question was guiding in the data analysis. Dynamics of technology-based organisations came to foreground, bringing forward an understanding related to the structuring aspects of technology, and to the structuring aspects of the organisation:

On the technology: (1) A technology like CRISPR can be (developed into) a business. (2) All ventures start with science that is identical at the bench; and differentiation occurs in the uses of CRISPR through different practices. (3) Hence, CRISPR is a multi-

purpose technology, yet out of all possible outcomes only very few materialise. The data offers clues on why this is the case; what helps and/or hinders the process of commercialisation; and what leads to diversification between development processes.

On the organisations: (4) There are insights to be gained into contemporary motivations for spinning out and scaling research on CRISPR. (5) Between settings the process of spinning out / starting up occurs in different ways, and the data provides some further insights into 'why' this happens (e.g. Eisenhardt, 1989). (6) Firstly, this is due to the different actors involved, and the data can provide insights into what actors are involved in the direct context of these ventures, and how they relate to each other. (7) Secondly, different institutional context may lead to different practices, as the data shows that companies develop strategies to deal with this because settings may be (less) favourable with (policy) resistance to new technologies, be host to various societal debates surrounding the evolvement of a new technical practice and disruptive biotech ventures, as well as facilitate or hinder the movement of knowledge and IP between organisations, institutions, and geographical loci.

Overall, (9) the data suggests that characteristics of CRISPR businesses might find resonance in other technology-based companies of this era. Corely and Gioia (2011) emphasise that concepts and relationships developed from inductive theorising should reflect principles that are portable or transferable to other domains and

settings. Within the scope of this research the focus is on CRISPR, but it generates ample of ingredients for a follow up study to understand to what degree the concepts and dynamics of this research are transferable to other technologies and fields. This could for instance be the case for science-based businesses that work with those technologies mentioned under the denominator of the fourth industrial revolution (Schwab, 2016) causing "Grand Challenges" (George et al., 2016, p.1880).

3.5.2 Analytical approach

The analysis took shape in the following manner: I used the process of constant comparison as outlined by Strauss and Corbin (1994). Going back and forth between data collection and analysis allowed for making adjustments to the protocols whenever new concepts emerged. Data collection and analysis are interrelated processes; early analysis directed the next round of data collection. Like Strauss and Corbin (1990, p.9), the aim is ultimately *"to build a theoretical explanation by specifying phenomena in terms of conditions that give rise to them, how they are expressed through action/interaction, the consequences that result from them, and variations of these qualifiers*". The aim was to understand the processes by which actors construct meaning out of 'intersubjective' experience (Suddaby, 2006, p.634). This is similar to Gioia's approach of trying to understand the phenomenon from the experience of those that are living the phenomenon. The intention was to gather as many varied perspectives on the phenomenon as possible. The objective was to capture the variability and try to understand why that variability in the analysed

practices exists (Gioia et al., 2013; Gioia in Gehman et al., 2018); and, explain the differences (Eisenhardt in Gehman et al., 2018).

Concepts are core to the analysis: Incidents are taken as potential indicators of phenomena, which are given a conceptual label. 'Categories' were developed and related by grouping codes into increasingly abstract concepts. Starting with a similar approach for structuring data in my analysis as Gioia et al. (2013) and Canato, Ravasi, and Phillips (2013), two levels of analysis were adopted. The *first order analysis* is derived from informant-centric terms or codes. The *second order analysis* is a form of axial coding and derived from researcher-centric concepts, themes and dimensions (see Gioia in Gehman et al., 2018). This brought forward deeper structures and processes that helped to understand and formulate dynamics at a more abstract (second-order) theoretical level. Having adopted a process of *constant comparison* (Strauss and Corbin, 1967), going back and forth between data collection and analysis, allowed for making adjustments to the protocols whenever new concepts emerged. The objective was to build theoretical explanation by specifying the phenomenon in terms of the conditions that gave rise to it, how it was expressed through observed action/interaction, the consequences that resulted from them, and variations between those (Corbin and Strauss, 1990). From the experience of those that are living the phenomenon I tried to understand how practitioners understand the phenomenon and construct meaning (Gioia et al., 2013; Gioia in Gehman et al., 2018). This is illustrated with examples such as power quotes and the evolution of conceptual categories (Suddaby, 2006). Themes and theoretical dimensions are

summarised and presented by (a) verbatim quotes; (b) verbatim extracts from observations field notes; and (c) verbatim extracts from documents. Data extracts are marked “Int.” (for interview), “Obs.” (for fieldnotes on observations), and “Doc.” (for document). This is then further aggregated and abstracted into a theoretical framework, formulating the data-to-theory connections and visualised in the format of a data structure.

3.5.3 Data-to-theory approach

Practice driven institutionalism specifically advances how institutional logics are theorised (e.g., Smets et al., 2017; Ocasio, Thornton and Lounsbury, 2017), unpicking the complexities that occur when logics are at tension in a complex environment (e.g., Greenwood et al., 2011). This perspective foregrounds the performance of institutions through situated, emergent and generative practices and acknowledges the institutional significance of the everyday work (Smets et al., 2017). However in the studied phenomenon of CRISPR, technology and organisation are entirely inter-dependent. The organisation’s right to existence relies entirely on the development of the technology, and the materialisation of the technology on the development of the uses formulated through the practices exercised in the organisation. To understand the studied phenomenon, it is therefore paramount to include the dimension of ‘technology’. Practice driven institutionalism has not yet been applied to such a technology dependent context. The inclusion of the notion of ‘technology’ extents the theoretical framework so that it can account for the dynamics observed in technology dependent settings, enabling a better understanding of the evolution of a new

academic science/technology and their associated practices; how these practices shape the technology, the organisation, as well as the institutions they are subject to. Adding the notion of 'technology' to practice driven institutionalism can inform important conversations of current institutionalist theorising. The combination of the four core concepts – technology, institution, organisation, and practice – allows for the examination of how people interact with a technology in their ongoing situated practices. These theoretical links form the core of this thesis and are visualized in 'Figure 3.5'.

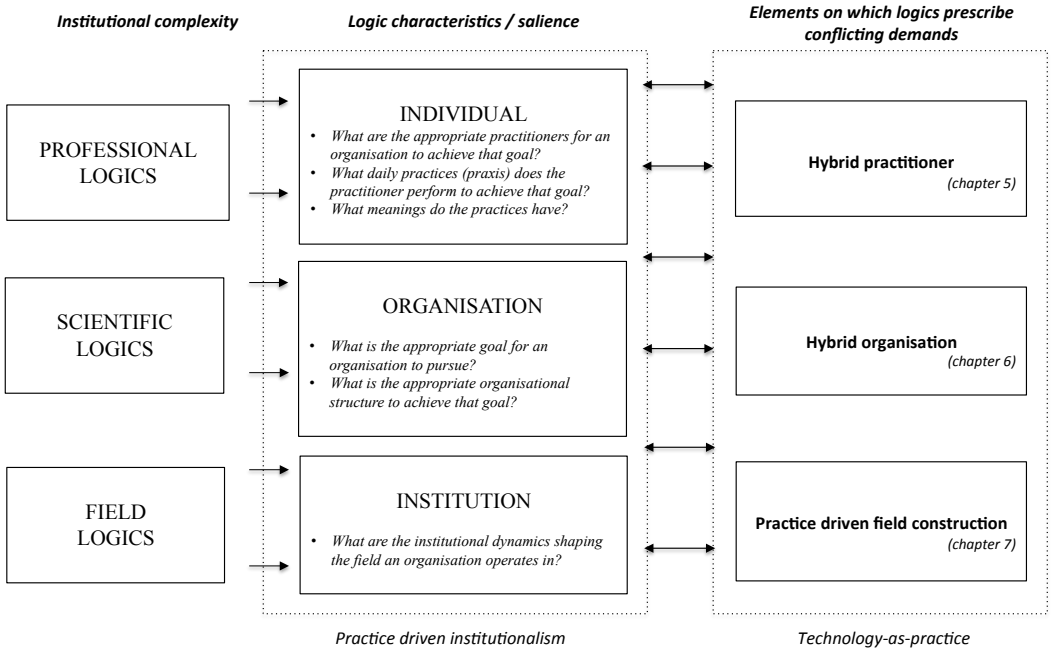


Figure 3.5: Data-to-theory structure of the main theoretical contributions

As discussed in the literature review, such a practice and technology lens enables a deeper understanding of the constitutive role of social practices in the ongoing use and change of technologies in the workplace. This was described by Orlikowski (2000) as 'technology-in-practice'. 'Technology-in-practice' serves essentially as a "behavioural and interpretive template" (Barley 1988, p. 49) for people's situated use

of the technology. Continued habitual use of a technology will tend to re-enact the same technology-in-practice, to further reinforcing it over time, so that it becomes taken for granted. The adoption of a technology-in-practice coincides with the structures that emerge as people interact recurrently with whatever properties of the technology are at hand, whether these were built in, added on, modified, or invented on the fly. Yet, Orlikowski (2000) reminds us that the structures of technology use are not fixed or given, but constituted and reconstituted through the everyday, situated practices of particular users using particular technologies in particular circumstances. By attending to such an on-going (re)constitution, it entails the examination of emergence, improvisation, and change over time as people reconfigure their technologies, alter their habits of use, and thereby enact different technologies-in-practice; as they do with CRISPR. With the notion of technology-in-practice Orlikowksi provides a useful approach to understanding that there is so much more to a technology than just the actual artefact.

With the CRISPR organisations, the survival of the organisation depends on how well the development of the technology thrives. Relevant to technology driven organisations, institutional scholars have recently begun to acknowledge the need to focus on material practices as they unfold in (the everyday life of) organisations (Thornton et al. 2012, Smets et al. 2012; Friedland, 2012). As Friedland noted: “Practices not only mark, they make objects [and technologies]. But… the fact is that we have no institutional logical account of the ‘dynamics of the material’ “ (2015, p.590). The development of technology, as the material, forms a part of practice.

Highlighting a more prominent role for technology, and related 'dynamics', through studying the emergence of technology related practices a broadening of the scope of 'practice driven institutionalism' is suggested (Smets et al., 2017). Further integration of technology into institutional theory renews the understanding of material dynamics within social and organisational settings, acknowledging the structuring capacity of technology within practices and organisation. This understanding of structuring goes beyond Orlikowski's technology-in-practice, as not only technology is structured by the organisation but the relationship between technology and organisation is understood as one of mutually structuring, diverging from technology-in-practice's one directional understanding of the organisation structuring technology. This observation of co-constitution between technology and organisation is conceptualised by me, the author, as 'technology-*as*-practice'. 'Technology-*as*-practice' formulates the aggregate elements on which logics prescribe conflicting demands: The hybrid practitioner, the hybrid organisation, and field construction through practice. These themes are further elaborated and discussed in the upcoming chapters.

In addition to the dialectic relationship between technology and organisations, Pinch (2008) pointed out that the absence of materiality from institutionalism represents a shortcoming that should be addressed. As proposed by Jones, Boxenbaum, and Anthony (2013), multiple avenues exist for institutional logics research to engage with objects and the material world. Drawing inspiration from constructivism provides additional sensitivity to the historical, political, and cultural contexts throughout

which technological innovations emerge. It helps to acknowledge the messiness of the constant negotiations between actors, social groups, and different contexts that give technology a fluid nature. It allows taking into account geographical and historical situations of individual and collective behaviour that could enable, or shape inertia and rigidities that possibly challenging and stifling innovation. Because rather than just the economic factor, innovative behaviour needs to explain the formation or change of companies' practices, routines, objectives, and behaviours in the specific social, cultural, and historical context in which they operate. To uncover richness in how differences in such (non-linear) mechanisms affect the processes by which 'technology-as-practice'-driven (institutional) dynamics unfold, shape the organisation, and move to the level of the field; or are prevented from doing so.

More can be done to understand where logics and new practices come from and how they relate to each other. The challenge is to explore the different kinds of logics – also the less obvious ones –, and in turn how these affect the creation and development of technology as well as the organisation. After setting the research context *(chapter 4)* each of the discussion chapters highlights one set of logics in particular: *academic and commercial logics (chapter 5), scientific discipline logics (chapter 6),* and *geographical field logics (chapter 7).* In this manner a contribution can be made to an integrative approach towards the emergence of new technology. Such an approach should account for practice but as well for institutional processes (Smets et al., 2017). Institutions matter in fundamental ways and the institutional approach could assist in understanding questions related to the dynamics of

(technologies-as-) practice. In particular a focus on institutional rationality in the form of multiple competing logics that create the hybrid organisation and the individuals negotiating the tensions within as they construct field through practice, can be useful.

3.6 Synthesis

The purpose of this thesis is to understand the dynamics of the different ways in which the technology of CRISPR materialises (or doesn't) through practices in the processes of commercialisation. CRISPR is a multi-purpose technology that can fulfil many purposes and take many forms in different sectors of human life. Yet. Out of all these possible outcomes, only very few materialise. Herein, the focus lies on uses of CRISPR in applications of human therapeutics. By focussing on one particular technology of the fourth industrial revolution, CRISPR, this thesis may offer insights that can help to understand the development of contemporary science-based businesses at a broader scale. Hence, hopefully helping others to scrutinise, use, and further the findings of this study.

This thesis is an inductive qualitative study using a multi-case study design, to help identify dynamics and concepts that lead up to theory building. The qualitative data are helpful for understanding the dynamics underpinning observed dynamics (Eisenhardt, 1989). Zooming in on newly emerging practices with the CRISPR technology this study closely followed several organisations developed around CRISPR uses.

Dynamics triggered by different sets of competing logics were observed on three levels: First, that of the *individual* – proactively engaged with the dynamics of materialising the uses of a new technology from academic research institutes into the science-based business through practices of commercialisation; as discussed in Chapter 5 *'The commercialisation process of CRISPR: Balancing logics at the level of the practitioner'*. Second, that of the *organisation* – with close observations of this process unearthing evolving tensions in the interactions with and between the structures of different scientific disciplines that the CRISPR technology is composed of; as discussed in Chapter 6 *'The co-constitution of organisation and technology'*. Third, that of the *field* – observing that due to the complex nature of the technology, it takes an ecosystem to support the translation of it into different uses. Strong interactions were observed between the CRISPR organisations and the fields in which they thrive; as discussed in Chapter 7 *'Comparing local field logics: A multi-level model of the materialisation of CRISPR '*.

4. THE RESEARCH CONTEXT: COMMERCIALISATION AS HYBRIDISATION

4.1 Introduction

This chapter identifies the research context of this thesis, namely the commercialisation process of CRISPR. Through this process the CRISPR technology is moved from the academic setting of the university towards the commercial setting of the organisation. Through commercialisation a commercial logic is introduced alongside the academic logic, thereby giving rise to a situation where the logics' competing belief systems are brought together. The process of commercialisation therefore takes shape as a process of hybridisation. The understanding of 'commercialisation as hybridisation' formulates the basis for the following three discussion chapters. The outline of this chapter is as follows: first a brief introduction on the CRISPR technology, this followed by an identification of different phases in the process of commercialisation, and a discussion of why the process of commercialisation can be understood as a hybrid process, closing the chapter with a conclusion.

4.2 CRISPR

CRISPR is a relatively easy-to-use precision genome editing technique that allows for proactive modification and sequencing of DNA. A bacterial defence system to fight viruses, the technology was discovered in nature before it evolved over several decades into a biotechnological tool to be first commercialised in 2013. CRISPR is an acronym that stands for '**C**lustered **R**egularly **I**nterspaced **S**hort **P**alindromic **R**epeats',

referring to its characteristics as found in nature as well as its treats for DNA modification by genetic engineering. Broadly speaking the term '*genetic engineering*' defines any technology that allows for the alteration of DNA sequences. DNA stores all the biological information that makes up organisms. Alterations in the DNA make it possible to change the physical as well as social characteristics of organisms. CRISPR can be used for genetic engineering on anything that contains DNA such as insects, plants, bacteria, viruses, or animals (and thus also humans).

The way that CRISPR can be used for genetic engineering is as follows: In nature, when a virus invades bacteria, its unique DNA is integrated into a CRISPR sequence in the bacterial genome. This means that the next time the virus attacks, the bacteria will remember it and can locate and destroy the virus. In 2013 scientists reported to have successfully repurposed this adaptive immune system into a reliable technique for editing in living cells (Cong et al., 2013; Mali et al., 2013). CRISPR technology was soon adapted for a vast range of applications and is now being used in thousands of laboratories worldwide. CRISPR pioneers pushed the scientific frontiers, and a quest was instigated for further improving and extending the CRISPR system to a vast range of biological problems. Within a year researchers had reported the use of CRISPR-based genome editing in a multitude of organisms including yeasts, nematodes, fruit flies, zebra fishes, mice, and even monkeys (Lander, 2016). CRISPR applications are now mainly used for creating complex animal models of human-inherited diseases and cancers; performing genome-wide screens in human cells to pinpoint the genes of underlying biological processes; turning specific genes on or off; or, for genetically

modifying plants. For decades only crude techniques were available to do this. For many applications (like in humans) they were often not considered precise enough for safe usage. The scientific breakthrough led to the formation of an actual scientific CRISPR field (for more detailed accounts the reader is referred to recent reviews: Barrangou and Marraffini, 2014; Hsu et al., 2014; van der Oost et al., 2014; Sander and Joung, 2014; Jiang and Marraffini, 2015; Sternberg and Doudna, 2015; Wright et al., 2016; Lander, 2016; and Kozubek, 2018) and the 2020 Nobel Prize in chemistry being awarded to the CRISPR pioneers Emmanuelle Charpentier and Jennifer Doudna, for their contributions to the development of the technology (Ledford and Callaway, 2020). As the gene-editing system is considered to be relatively easy to make and use, researchers from a wide range of scientific disciplines are able to adopt and apply the technology to genetically engineer any organisms of their choice. CRISPR is widely applicable and has the potential to contribute to how we tackle some of the world's most prominent problems, like cancer, food shortages, organ transplant needs, or as an efficient disease diagnostics tool. High impact industries likely to benefit are medicine, food, agriculture, and the industrial biotechnology space – and the intersection between those industries – as there is serious interest and activity to translate CRISPR from progressive research laboratories into applications directly applicable in society at large (CB Insights, 2019a).

While scientific and commercial interest is warming up towards the potential of CRISPR, ethical concerns are mounting with possible applications further extended into more provocative proposals such as using CRISPR techniques to revive woolly

mammoths and Neanderthals (e.g. George Church, personal communication, 2017; Lander, 2016), or the prospect of creating 'designer babies' through human embryo modification (Normile, 2018). Many of the CRISPR applications come with a deep uncertainty linked to technical feasibility and ethical conduct: How to avoid unintended consequences from off-target cuttings that may produce unwanted changes in the characteristics of organisms? How to overcome limits in genome target selection allowing for wider applicability? But also possible implications of interactions with still un-identified and understood parts of the DNA, also referred to as the dark matter of the genome (de Koning, Gu, Castoe, et al., 2011). The story of CRISPR knows a multitude of interests, concerns, and controversies, which consistently lead to heated debates taking place in academic laboratories, corporate boardrooms, and parliamentary corridors. CRISPR technologies are subject to different understandings, perceptions, hopes, and applications. As a technology, it has implications reaching far beyond the material procedures as conducted by the laboratories it was first discovered. There are many potential applications that are now being shaped by many different practices, through many different actors, and in many different settings.

CRISPR is like a Swiss army knife with different functions depending on how the practitioner wants to use it (Doudna and Sternberg, 2017). Out of the many different applications for CRISPR the focus of this thesis is on those that are being developed for human therapeutics and pharmaceuticals such as patient treatment of disease, the development of beneficial properties of drugs, and their clinical uses. The future

of medicine is affected by the developments around CRISPR as those help for instance to shorten the research timeline of traditional drug discovery processes or allow for the development of personalised and customised therapies. Different organisations are created with the purpose to further develop specific CRISPR applications – such as those in the sample of this study.

It is the combination of all the above aspects that make the story of CRISPR an inherently complex and unique setting. CRISPR-companies grapple with all kinds of technical, ethical, societal, and business challenges. Challenges like these go hand in hand with profound and persistent uncertainty as the effects of a business' R&D process can have far reaching implications. These implications are much more far-reaching and uncertain than commonly seen in other kinds of organisations (Pisano, 2006); not only because the commercialisation process of the technology becomes crucial for the development of specific applications, but also because the implications the developed applications may have on society. It is therefore important to better understand how technology and organisation emerge through commercialisation.

4.3 Three phases of commercialisation

The empirical case of CRISPR provides a rich opportunity to examine the challenges of starting, building, and running an organisation with the purpose of further developing a new technology. The organisation draws from *both* academic science *and* commerce, seeking to deliver *both* technological advancement *and* value creation. Academia and commerce are entangled as academic science forms the basis for the company, and the commercial organisation allows for value creation enabling further

development of both technology and organisation. Throughout the process of commercialisation the organisations adjust to, and bring together, academic and commercial characteristics by alternating practitioners, their practices, and the meanings attached to those. Three phases were identified in the commercialisation process: That of the (1) '*University*' (academic scientific demands are dominant), (2) the '*spinout*' (interstitial between the belief systems of academia and commerce, allowing for hybridity/ambidexterity), and (3) the '*accomplished company*' (the commercial demands are dominant) – figure 4.1.

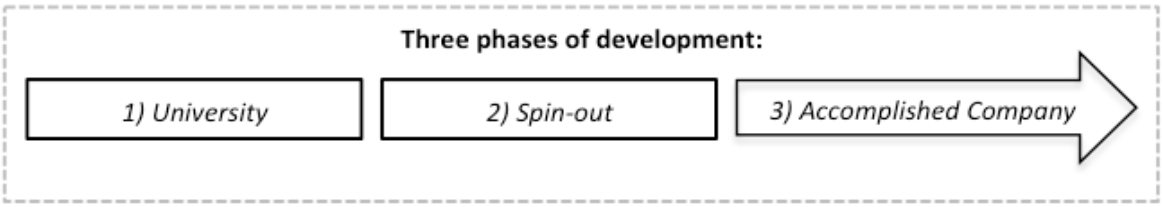


Figure 4.1: Three phases in the commercialisation process

(1) The *University* is the first phase. There is minimal tension. The practices of this phase show the characteristics of a dominant academic science logic. This setting encompasses characteristics, like being curiosity driven, seeking the 'discovery' of new knowledge, and fact building (Latour and Woolgar, 1979). Scientists work on ideas for the sake of the advancement of science and academia, sharing thoughts and findings with the help of publications in academic journals: "my academic colleagues focus on exploring… the scientists follow their own interests" (Int.). Research is funded through grants, and legitimacy gained through peer review and approval. Although operating through locally based laboratories at universities and research

institutions, knowledge sharing takes place on an international level via collaborations and conferences; as scientists have "a global outreach … connected with all sorts of institutes around the world, mainly through scientific collaborations – these scientists in turn are influential in their own countries" (Int.).

(2) The *spinout* is the second phase and takes place when academic research is spun-out (e.g. Klepper, 2016) of the academic setting and a science-based business is established. The link with the university or the institution out of which the organisation is created is often still very strong: e.g. "…the first steps for the R&D and development of a new medicine are often paid for by university hospitals. Industry becomes involved at a later stage" (Int.). For example, in many instances the organisation still uses the university's laboratory space at the early stages of its establishment or uses university IP: "In the US IP often stays with the university, so that if the company goes bankrupt the technology will not go down with it" (Int.). The scientist turns scientist-entrepreneur, a hybrid practitioner that needs to divide itself between academic obligations and that of the newly founded science-based business. The necessities to form such a science-based organisation need to be established; such as intellectual property, initial funding or investment, a space to operate from, and the establishment of a commercial legal entity:

> "To start your own biotech company you need a technology and a patent. The challenge lies in how you translate science into a product. You need to make a switch from academic thinking towards a business-like perspective. What do you need in order to bring an idea to market? Well, you need a good and fashionable technology, specialist knowledge, IP, you have to put together a team, and then there is the need for funding" (Int.)

Moving into this interstitial space between academia and commerce, the first tensions become vividly visible as priorities between the different phases may not always align and new practices are introduced:

> "Some scientists consider patents dirty, and wish to make all their knowledge openly available. But I am not sure it is actually smart to do so. If you decide to do so, there is no added value for companies, and hence no insurance to invest on. This may lead to mutual mistrust and incomprehension between academia and industry" (Int.)

(3) The *accomplished company* is the third phase. The organisation is established and rapidly scaling. Scientific research that lies at the core of the organisation no longer emphasises discovery, but seeks to standardise the gained knowledge and practices: "The company is refining the tech, really simplifying things… development of user interface and standardisation" (Int.). As the prerequisites for the establishment of the science-based business are being met, focus is on the development of the product and/or service. This is in order to make the organisation ultimately financially sustainable:

> "We operate in an extremely capitalistic manner, we do not do it based on subsidies. There is 1/3 of our own money in the company as financing. We are tough capitalists and want to keep 20% returns. We do not have a new vision as a company, but we do have a new potential market of $500 billion; Many do not realise that. But you need 50-100 million to produce a MPV [minimal viable product]" (Int.)

Although science still lies at the core of the organisation, financial aspects become more important as these formulate a more dominant part of the requirements for survival of the organisation, at least in the long run. As the company matures from spinout into an accomplished company it becomes subject to stronger market forces, and less so to those of academia, as it moved away from its initial roots at the university:

> "You need a team that is not always full of scientists; you need also people that are willing to take a risk. People with diverse backgrounds, and some that will also bring previous experience on board" (Int.)

As the territories come together, the practitioners, practices, and attached meanings change; advisors, stakeholders, funders and investors, intrinsic drives, and legitimacy. The initial scientist-entrepreneur(s) tend to make place for a professional management board by taking on an advisory role that focuses on the science, and less so on the day-to-day managerial aspects of the organisation: "The board picks the investors, the investors choose the management team. The scientists tend to step back and become advisors" (Int.). Often such a move is well coordinated as it is a prerequisite for larger investors to come on board. Sometimes such a push for managerial professionalism can cause tensions as it may give the initial founders the sensation of losing control over their company:

> "When VCs fund projects, the first thing they do is to throw out the CSO [Chief Scientific Officer, who often is the initial scientists that turned entrepreneur]. We did not want that." (Int.)

Each phase raises a different range of questions that need to be tackled. Assessing the changes whilst an organisation moves along the spectrum raises the questions of: What activity is done (praxis) in one setting that is not done in the other? (e.g. IP litigation and secrecy); what activity is done in various settings (practice) but has different meanings (logics) assigned to it? (e.g. academic science for genuine discovery vs. signalling of value-added); who does the activities and do new practitioners enter the picture? What value systems do they represent, as in what meaning do they attach to a practice? (i.e. the arrival of VCs, professional managers, and professional board members).

Shifting from one phase to the next, tensions emerge between the different profiles of the phases, transition stages. Such transitions can introduce friction and tension between the old and new establishment, producing a gestalt change in the organisation. These transitions between phases are not hard fault lines, but mark tension-filled transitions that have direct impact on the daily life of the practitioners: The gestalt change creates a shifting balance between competing belief systems. The different phases show that when an organisation spins out of the university it becomes less academic, and more commercially oriented. This process integrates aspects from both academia and commerce alongside each other. Each phase can be identified by the practitioners, practices, and meaning that make up the characteristics of the organisation at that time. Analysing the sample of companies, the everyday practices – praxis – on the work floor (Whittington, 2006) show different profiles as the organisations take shape in different manners at different stages of their development; breathing different priorities, norms, values, beliefs, drives, but also characteristics, and structures. In their ongoing use and development of technology people engage in different practices as their 'shared practical understanding' (Schatzki, 2001) that gives meaning to these practices changes throughout the process of commercialisation.

4.4 Commercialisation as a process of hybridisation

Throughout the process of commercialisation science and commerce are brought together, each associated with different practitioners, practices, and meanings. The empirical observations map onto broader institutional categories. A method developed by Thornton and colleagues (2004; 2005; 2012; see also Smets et al., 2015) was used in table 4.1 to summarise the observations of behavioural characteristics that map onto the competing demands of the logics of academia and science, as they are instantiated through practice. The following root metaphors are listed in the table: Sources of legitimacy, sources of authority, sources of identity, basis of norms, basis of attention, basis of strategy, informal control mechanisms, formal control mechanisms, forms of ownership, and the economic system. They helped to identify tensions and hybridity as observed between the logics of academia and commerce. The aspects on the left are linked to the academic logic, and the aspects on the right are linked to the commercial logic. The quotes in the middle bring together both logics, with those on the left closest linked to the academic logic, those on the right closest linked to the commercial logic, and those in middle showing clear tension between both:

Table 4.1
Representative Indicators of the Competing Belief Systems of the ideal types of Academic Science and Commercial Logics

Root metaphor	**Academic science logic** *(relational network)*	---------- >	**Tensions / Hybridity**	< ----------	**Commercial logic** *(transaction)*
Sources of legitimacy	**Personal expertise**	"See the scientist as a hedgehog, you need to be very good to stay ahead of the rest, but protective of what you do." (Int.)	The [academic] Nature Medicine reports wiped $664 million from Editas Medicine, Intellia Therapeutics and CRISPR Therapeutics on the day of publication. Although stock had bounced back 70% by the time of the Bradley study, within 20 minutes of online publication they again lost $300 million collectively…as many CRISPR companies publicly floated very early in their technology cycle, the wild ride for CRISPR stocks looks set to continue –particularly in an age where Wall Street algorithms comb hundreds of millions of daily tweets on Twitter, social media posts and news outlets to derive data for trading decisions. In a research setting in which preprints now enter feeds as easily as peer-reviewed papers – and a dwindling number of media outlets have science-literate journalists – CRISPR stock volatility looks here to stay. (Doc.)	"Yes, the stock exchange is a measure for everything you do….we now have to create value… we put a lot of pressure on ourselves, but obviously there is also pressure coming from the financers." (Int.)	**Market position of firm & share price**
Sources of authority	**Professional association**	"It was a tiny research community then—in 2012 only 126 papers were published on CRISPR, compared with 2155 last year[2016] —and this simple vision seemed healthy for the field: practical and intellectually turbocharged. We thought in the beginning it would be very important to bring everyone together." (Doc.)	"[This professor] has also got a bit of Santa in him, bringing the gift of his imagination — and his name — to so many private companies (as advisor, cofounder, or consultant) that his conflict-of-interest slide is notorious." (Doc.)	"The biggest single purchase by an insider was by the Executive VP & COO who bought US$118k worth of shares at a price of US$16.00 per share. That implies that an insider found the current price of US$16.85 per share to be enticing. While their view may have changed since the purchase was made, this does at least suggest they have had confidence in the company's future." (Doc.)	**Shareholder activism**

Sources of identity	**Association with quality of craft**	"I'd just as well not hang myself out to dry with someone I barely know, but I feel an obligation to be balanced about it. I'm sitting in the middle and everyone else is so extreme that it makes me look like his buddy. He's just an acquaintance. But it seems like a bullying situation to me. The most serious thing I've heard is that he didn't do the paperwork right. He wouldn't be the first person who got the paperwork wrong. It's just that the stakes are higher." (Doc.)	"…a leading genome editing company, today announced it has exclusively licensed intellectual property related to new CRISPR technologies for human therapeutics that will enhance and broaden the range of medicines the Company can develop. These global licensing agreements include intellectual property owned by the Broad Institute of MIT and Harvard (Broad Institute), Harvard University, Massachusetts Institute of Technology (MIT), Wageningen University, the University of Iowa, and the University of Tokyo." (Doc.)	"CRISPR is mainly just a laboratory automation that we already do, it is just a bit quicker. Basically, it is like PCR but this time with IP – only it's not clear who owns the IP." (Int.)	**Faceless**
Basis of norms	**Membership of academic community**	"Many scientists do not have any interest in the commercial aspects of science. Only until recently you were frowned upon if you would go commercial as an academic. It was as if you had gone over to the dark-side. You pursue your passion instead of the idea to make money, because if not so you would have done something else… it is still seen a bit … like… selling your soul." (Int.)	"It follows that with the first setback scientists often go back into the university where they get more security, for example, a permanent contract. Hence there is not enough commitment to build actual spin-outs. Because if you happen to go bankrupt.. well then that is something to be ashamed of." (Int.)	"We had to fight hard to establish the company. The very fact of registering it was already very difficult in relation to the university. All levels [in the university] worked against it. I ended giving up my [professor] chair to be able to pursue the company." (Int.)	**Self-interest**
Basis of attention	**Status position in network**	"There is currently an assumption that if you are strong in public communication you must superficial as a scientist. It is difficult to mix the social, the scientific, and the commercial. This is very quickly seen as a conflict of interest. This is very sensitive and probably has to do with cultural visions. Once something goes commercial, is it still in line with your career as a scientist?" (Int.)	"Well.., the importance of role models: It is necessary to have that driving stimulation from leaders and role models in the field to which people can look up. We do have something of a start-up scene, but the conversion-rate of spinning out science really needs to be much higher." (Int.)	"Then there are the analyst reports: These are incredibly diverse. One values you very low, the other estimates you very high. And then there is everything in between." (Int.)	**Status in the market**
Basis of strategy	**Increase knowledge**	"Fundamental research happens in the universities and is then further developed privately, standardised." (Int.)	"We outsource our research to an academic institution, and maybe in the future a CRO (contract research organisation). The director of the academic institution is also a board member with us. Whatever they develop or find in this research, we automatically gain a sub-licence. We maintain ownership over the IP, but the academics have a right to publish the research." (Int.)	"The company is refining the tech, Really simplifying things. Development of user interface and standardization." (Int.)	**Increase efficiency / profit**

Informal control mechanisms	**Social control through network**	"Pre-registration is needed: 1) Pre-registration of research and experiments, 2) no use and development of self-sustaining drive system outside, 3) newly generated IP - possibly based on earlier included IP - should add to the [patent] pool and help to grow it, and keep it up to date. Through IP the option can be forced. We are creating a patent pool. And, focus on specific individuals as perpetrators, not at the system as a whole - as the government is the major contractor in the US -, but there is a legal basis to target specific individuals and make them outcasts." (Int.)	"The editors of Time have put the creator of the first gene-edited children on its list of '100 Most Influential People' in the world for 2019. But in a twist, the magazine tapped CRISPR co-inventor Jennifer Doudna to write the profile—and, safe to say, she is no fan." (Doc.)	"There is self-regulation amongst commercial developers, but there is also awareness in policies needed – e.g. on gene drives and sterile products as used for instance with seeds in agriculture, or when used for tobacco. We try to avoid supplying these kinds of developments for such applications. How we enforce this approach? – If people or institutes breach with our set framework, they will lose their license for use." (Int.)	**Industry analysts / organisation culture**
Formal control mechanisms	**Peer review & grants**	"Publication makes the development process significantly slow down. Sometimes it takes up to 3 years to publish something, but the concept did not change in all this time." (Int.)	"Often the early-stage funding, also referred to as seed funding, consisted of government subsidies. For instance, as company A is looking to scale up, it aims for EU grants that will help the company to further develop their proof of concept. This proof of concept should open the door for additional funding; the first round of venture capital funding also referred to as Series A." (Int.)	"The board picks the investors, the investors choose the management team. The scientists tend to step back and become advisors. This will also help them to stay in academia and avoids conflict of interests. In the end, only few scientists actually quit academia to join their company." (Int.)	**Board and management authority**
Forms of (IP) ownership	**Public**	"The licences that are being given out [by the university], as well as the parties to which they are given out should fit with the public interest… In the US, IP often stays with the university, so that if the company goes bankrupt the technology will not go down with it."(Int.)	Tensions exist between establishing intellectual ownership through scientific publication, aimed at collective sharing, and filing for a patent, aimed at secrecy. The processes involved are significantly different: The former is inspired by openness and the latter by secrecy. (Obs.)	"Our ability to generate revenue from product sales and become profitable depends significantly on our success in … maintaining, protecting and expanding our portfolio of intellectual property rights, including patents, trade secrets and know-how." (Doc.)	**Private**
Economic system	**Capital committed to research**	"Some tech needs to be capitalism driven. Why? Because there are no philanthropic funds available." (Int.)	"The difference between industry and science is money and time. And you should not confuse this. One can buy the other." (Int.)	"To start your own biotech company you need a technology and a patent. The challenge lies in how you translate science into a product. You need to make a switch from academic thinking towards a business-like perspective." (Int.)	**Market capitalism**

Table based on Thornton et al. (2012; 2004). The chief basis of these summaries is derived from data from this study. Data extracts are marked "Int." (for interview), "Obs." (for fieldnotes), and "Doc." (for document).

These insights were induced from practitioners negotiating the tensions between both logics and help our understanding of what bringing together academic and commercial activities, meanings, and practitioners entails. What is deemed appropriate behaviour to the academic community may conflict with how to position oneself in a commercial setting, the latter often associated with more emphasis on 'self interest' instead of openness and sharing. What the above observations show is that process of commercialisation entails the introduction of new practices focussed on commerce, besides that of academic science. This is accompanied with a change in the institutional demands faced. CRISPR companies embody elements from different institutional logics at the same time, making them hybrid organisations (Battilana and Dorado, 2010; Pache and Santos, 2013). As hybrid organisations the CRISPR organisations are arenas of contradiction as they are challenged by competing and often paradoxical demands of academic logic and commercial logic. The demands by the institutional logics of academic science and that of commerce are combined as a hybrid organisation takes shape – figure 4.2:

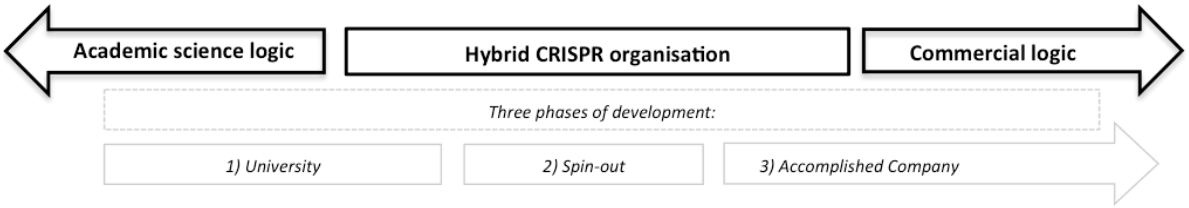


Figure 4.2: Within the CRISPR organisation tensions have to be negotiated between commercial and academic scientific logics, provoking organisational challenges. The hybridity is as if a spectrum between the two logics, shaping the organisation according to the dominance of the logics at play (see also Pisano, 2006, p.14)

Tensions within the behavioural characteristics highlight a persistence of conflicting belief systems in the day-to-day behaviour of those working in the science-based organisations dealing with CRISPR. Without exception these tensions existed throughout the whole sample of CRISPR organisations in this study. Each and every company in the sample was negotiating the tension between those two logics, trying to strike a balance between ever 'shifting' logics (Gumusay et al., 2020). By looking at the nexus of different institutional logics, such as that of the logics of academia and commerce, it becomes possible to see how actions that are situated within multiple logics draw from both. We may understand this as a form of hybridity through people's practical coping with institutional complexity; for instance through the adoption of 'hybrid practices' (Smets et al., 2012, p.889) that blend practices and logics from both sides of the spectrum, whilst being subject to both institutional demands. Hybridisation occurs as a commercial logic is introduced alongside the academic logic. Research on hybridity – mixing core organisational elements that do not conventionally go together – offers insights into managing the competing goals pursued by each of the distinct logics (Battilana et al., 2017).

4.5 Conclusion

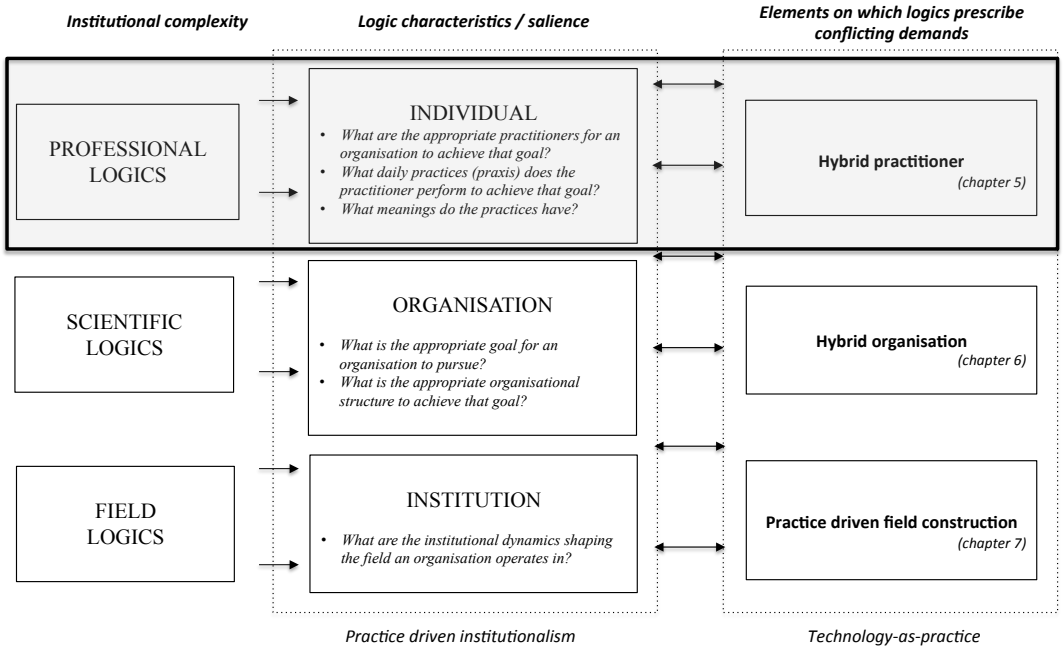
The research context of this thesis is the process of commercialisation that occurs through hybridisation. The tables in this chapter bring to the foreground tensions between academic and commercial logics, each with their own distinctive characteristics for the organisations' internal structure. The practices, practitioners, and meanings within the organisation can change in form and shape throughout the process of commercialisation. CRISPR companies are challenged to engage

dynamically with institutional demands as the equilibrium of logics continuously shifts. Being a 'contested organisation' is the nature of being a CRISPR organisation as both academic and commercial logics are central to the organisations. However, low compatibility between those logics can lead actors to "confront and grapple with divergent goals, values, and identities, as well as different strategies and practices for achieving these goals … as a result the core of the organisation is continually disputed" (Besharov and Smith, 2014, p.371; see also Battilana and Dorado, 2010). Tensions emerge as an organisation attempts to combine both logics as it shifts from one phase to the next. This transition is not clear-cut. Different sets of characteristics are adopted and the organisation's characteristics develop into different forms and shapes. The following chapters further deepen the understanding of those tensions that emerge as hybridisation occurs through commercialisation: Chapter five focuses on the tensions as enacted and experience by the practitioners, chapter six focuses on how the co-constitution of organisation and technology is anchored in different logics, and chapter seven compares focuses on how tensions of hybridisation/commercialisation are navigated between different geographical field settings.

5. BALANCING LOGICS AT THE LEVEL OF THE PRACTITIONER

This chapter is developed as a stand-alone article for submission to a management journal. The chapter addresses how practitioners construct hybrid organisations to materialise uses of the CRISPR technology – and pre-empt conflict normally associated with contested hybrids. The focus is on the 'earliest moments' of structuration that happens in 'the spinout phase' (as described in chapter four). The organisational structures and technological applications are yet to be brought into existence (see also 'practice driven institutionalism' in table 2.1 of the literature section). The settings of academia and commerce merge and give rise to competing demands and expectations at the level of the practitioner – figure 5.1.

Figure 5.1: Positioning of chapter 5 in the thesis



Article Title

COMMERCIALISING CRISPR: HOW PRACTITIONERS PRE-EMPT CONFLICT BETWEEN INCOMPATIBLE INSTITUTIONAL LOGICS IN THE CO-CONSTITUTION OF TECHNOLOGY AND ORGANISATION

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Abstract

Drawing on an inductive empirical comparative multiple case study of thirteen companies commercialising the genomic technology CRISPR, this paper makes three contributions to current discussions on hybridity and institutional complexity. First, we zoom in on the 'earliest moments' of the co-constitution of technology and organisation – that is when structures are yet to be brought into existence. We identify how practitioners alternate and reinvent combinations of practitioners, practices, and meanings in the process of creating hybrid organisational structures. Second, we note that the literature has focussed either on structural organisational solutions *or* on the practices of individuals but not yet on the interplay between both. Third, we observe how the interplay between these mechanisms allows practitioners' to align competing demands of academic and commercial logics thereby pre-empting conflict that is normally associated with contested hybrids.

Keywords

Hybrid organisations, co-constitution, technology, technology-as-practice, practitioners, commercialisation, CRISPR, institutional complexity, institutional logics, practice driven institutionalism

5.1 Introduction

More often tackling society's most intractable problems requires the work of "hybrid" organisations that are consciously straddling and merging competing expectations and "logics" (Greenwood, Raynard, kodeih, Micellota, and Lounsbury, 2011). A growing number of organisations take shape as religious banks, social enterprises, public–private partnerships, and health-care organisations (Gumusay, Smets, and Morris, 2020; Perkmann, McKelvey, and Phillips, 2019; Schildt and Perkmann, 2016; Almandoz, 2012; Battilana and Lee, 2014; Jay, 2013; Reay and Hinings, 2009). These hybrids attempt to deliver "the best of both worlds" by seeking to incorporate paradoxical elements in a complementary manner at their core, thereby embrace tensions that other organisations would normally seek to minimise or avoid (cf. Perkmann et al., 2019; Lewis, 2000).

Prior literature suggests that hybridity can bring challenges of tension and conflict (Pache and Santos, 2013), but that if successfully managed practitioners may build in "structural" solutions to find a fruitful balance for these challenges (Greenwood et al., 2011; Perkmann et al., 2019). It is known that organisational structure helps to manage institutional complexity (cf. Greenwood et al., 2017; 2011), obtaining insights predominantly from cases with existing organisational structures that experience change following internal incentives (cf. Orlikowski, 2000) or institutional incentives (cf. Lounsbury, 2008; Seo and Creed, 2002). Particularly relevant examples are studies that bring together academic science and commerce (Powell and Sandholtz, 2012; D'Este and Perkmann, 2011), as we look in this paper at

organisations that are being brought into existence to develop technology that can tackle diseases; such as hybrid organisations working on CRISPR, a genome editing technology that can be used for the development of new therapeutic treatments. The organisation becomes part of an empirical puzzle on why certain select applications of a new technology eventually materialise even though a far greater number would theoretically be conceivable. Hybridity that emerges from interactions around existing technologies has not been subject of rigorous research (cf. Garud and Karnoe, 2001; Leonardi and Barley, 2008), and even less so that in relation to emerging technologies. Furthermore, the hybrids discussed in this paper are not established organisational forms (cf. Smets et al., 2015; Pache and Santos, 2013), nor were they founded as hybrids from the onset (cf. Gumusay et al., 2020; Battilana and Dorado, 2010). We examine hybrids at their earliest moments when they emerge as spinouts from existing organisations into a new hybrid organisational form. We do not only look at the competing logics that are brought together in one organisation, but also at how people transition between logics, how new people join the organisation, and how new practices and meanings are introduced. This raised the following research question: how do early stage hybrids pre-empt conflict in the co-constitution of technology and organisation?

This question was triggered by a multiple-case study on the Nobel Prize winning multi-purpose biotechnology CRISPR. CRISPR can be used for developing an unlimited amount of life-saving applications, yet developing novel applications from laboratory bench to patient's bedside is extremely challenging and only a limited number actually materialise. The emergence of thirteen organisations developing

CRISPR applications was compared over a five-year period (2013-2018) between the three geographical settings of the US East Coast Boston area, the UK's Golden Triangle (Oxford – London – Cambridge), and the Netherlands. This represents relevant and comparable contexts for developing conceptual insights in why certain technologies materialise and others do not. As practitioners form organisations for the development of CRISPR applications, their organisational structures will have to be able to balance competing demands in the long run. This entails discovering what these structures should look like and how to construct them. A lens of practice-driven institutionalism (Smets et al., 2012; 2017) is adopted to scrutinize how people, as they interact with a technology in their ongoing practices, constitute hybrid structures that shape their emergent and situated use of that technology. Drawing on these instructive cases, our study makes three contributions to the literature.

First, we derive how technology can facilitate the formation of preliminary structure. We attend to the development of hybrid organisations and *"the earliest moments of new practices emerging and gradually taking shape"* (Smets et al, 2017, p.19). At the first moments of the spinout organisations, when practitioners come together to develop new applications for CRISPR technology, there are no structures. There is a nascent understanding how individuals balance institutional complexity (Smets et al., 2015; Nicolini, 2011) and how individuals' practices emerge in relation to evolving structures of emerging organisations (Gümüsay et al., 2020; Almandoz and Marquis, 2017; Smets et al., 2015), but this is often in absence of technology. We study occasions where the development of novel technology is a central ingredient to the

emergence of organisations. Prior studies predominantly focus on knowledge work and intangibles rather than on technology as a coordinating feature, and the materiality of (early) practices remains under explored. Practice structures behaviour, and for technology and organisation to develop practices are required. So far the focus has been on what people do but less so on the technology they do it with. This study found that when people interact with a new technology in their ongoing practices, this very interaction constitutes the development of both organisational structure and technology. As organisation and technology evolve practices are instilled with different meanings, serving different purposes of the development. A practice lens (Smets et al., 2017) helps to understand not only what people do, but what they do together. Technology can be a central reason for people to come together and interact with each other. Technology, therefore, implicitly coordinates their activities and is thus constitutive of – and constituted through – people's practice.

Second, there is significant knowledge about how hybrids manage conflicting demands *either* through structural organisational solutions (cf. Besharov and Smith, 2014; Pache and Santos, 2013; Greenwood et al., 2011) *or* through the practices of individuals (cf. Whittington, 2019; Furnari, 2014, Schatzki, 2006). We extend this understanding by our observations on the importance of the interplay between the both the former, *"organisational differentiation",* and the latter, *"personal integration"*. An integral part of this interplay is attracting new people (and then organising them) to aid in constituting the organisation and subsequently materialising a new technology. As technology and organisation develop, new kinds

of expertise and professional activities are drawn in, each with their own role and expectations. This requires the development of structural solutions to prevent conflict between competing understandings. Balancing between demands not only depends on balancing competing logics, but also depends on balancing (competing) mechanisms of integration and differentiation – and doing so across the different levels of organisation and individual. The practice lens (Smets et al., 2012; 2017) allowed us to see that hybridisation not only appears at an organisational level but is linked to integration of the different logics within practitioners, their activities, and attached meanings.

Third, we derived how through the interplay of the mechanisms of "organisational differentiation" and "personal integration" conflict in contested hybrids can be *"pre-empted"*, allowing for a more aligned form of hybridity. Practitioners preempt conflict by creating better compatibility from the outset and not by managing it once people are inside the organisation. We looked at organisations where there is a high risk of "*contested"* hybridity (Besharov and Smith, 2014): both the logics of science and commerce are core to the organisational function. There is substantial knowledge about how existing hybrids manage conflict through existing organisational structures (cf. Perkmann et al., 2019; Smets et al., 2015; Pache and Santos, 2013), or how new practices and logics are introduced into hybrids alongside new people (Battilana and Dorade, 2010); yet little is known about the process in which new practitioners representing a contested logic can be invited without causing extensive conflict. We found that hybrid practitioners use two dynamics to pre-empt conflict. First, through personal integration practitioners are able to

reassign and re-allocate the meaning of their own practices thereby enhancing compatibility and "*alignment".* This dynamic is extended into organisational differentiation as they exercise agency in selecting and inviting those representatives of another logic into their organisation whose enactment of this contested logic is more compatible with their own practices and meanings. Second, at the same time, instrumental non-hybrid practitioners (purists) are kept at the periphery of the organisation and drawn on in an auxiliary manner. Surprisingly there is less conflict once the hybrid organisation exists – because it has been more carefully designed to "pre-empt" conflict.

These three contributions jointly illustrate the value of incorporating technology as practice into discussions of institutionalism, thereby joining others in management research in a more general turn to adopting the 'practice' driven label (Whittington, 2019): for instance, Strategy-as-Practice (Whittington, 2006), Entrepreneurship-as-Practice (Thompson et al., 2020), Leadership-as-Practice (Raelin, 2016), Marketing-as-Practice (Skålén and Hackley, 2011), Accounting-as-Practice (Ahrens and Chapman, 2007), and now also "Technology-as-Practice".

In the next section we outline the theoretical context of our arguments. We then describe our research methods and the findings of the CRISPR case studies. In our discussion section, we develop the aforementioned contributions and present our final conclusion.

5.2 Theory: The co-constitution of technology and organisation through practice

5.2.1 Four perspectives on the development of organisation and technology

There is consensus that technology and organisation both arise at the intersection of social and material phenomena (Leonardi and Barley, 2008). Technology is simultaneously a social as well as a physical artefact (Orlikowski and Barley, 2001). Hence, neither a strictly materialist nor a constructivist stance is adequate for studying technology and organisation. Orlikowski and Barley (2001, p.148) observed that the problem with theories attempting *''to reduce technology to an abstract material cause in the name of generalisability".* Following the juxtaposition of materialism and determinism in contingency theory, social constructionists have a tendency to discard both instantaneously. The effect is that those who might claim that the material properties of a technology can influence the organisation of work risk being branded as 'determinists'. 'Determinism' is a term that has become somewhat of a slur in academia (for instance see Winner, 2001; or Bijker et al., 2012). Scholars studying technology and organising are generally paying little analytic attention to a technology's (material) constraints and affordances. Instead, the focus is on showing how people organise themselves around the technologies that they use. As a result, attention is brought to the social structures in which technology becomes embedded (Barley, 1986; Orlikowski, 1992, 2000; Leonardi and Barley, 2008; Powell and Sandholtz, 2012). Even the most influential studies of technologies and organisations – often those on 'information systems' or 'digital innovation' (Hinings et al., 2018; Jones and Karsten, 2008; Poole and DeSanctis, 2004; Orlikowski and Iacono, 2001) – direct their attention predominantly towards social dynamics, instead of *"…providing evidence of what specific material features*

people use, why they use them, and how and why their patterns of use shift over time" (Leonardi and Barley, 2008, p.163). Those scholars that moved away from a deterministic understanding now may have overshot the mark by arriving at a purely social structuring understanding – thereby ignoring the material aspects of technology. Leonardi and Barley (2008, p.160) observed that: *"Although theorists may argue that social and material factors are equally important, most papers on the creation, perpetuation or change of technologies and organizations eventually favor one or the other."*

Different strands of literature have addressed the emergence of either organisation or technology. Social structures in 'use' can be perceived as stable, whereas social structures that are constituted 'from scratch' are emergent. To be more precise, a structure is *stable* when it entails a legitimate and socially recognised pattern of social action that it is repeatedly reinforced by a community (Feldman and Orlikowski, 2011; Levina and Orlikowski, 2009; Greenwood et al., 2008; Heugens and Landers, 2009), at which point the patterns become treated as predetermined prescriptions for social action and as such may impede change. A structure is *emergent* when the community has not yet reached consensus and processes are still being negotiated (Bijker et al., 2012; Klein and Kleinman 2002; Latour, 1987; Woolgar and Grint, 1991; Orlikowski, 2000; Callon, 2007; 1984). Four semi-coherent perspectives are differentiated that dominate institutional scholarship on this topic. Table 5.1 summarises these perspectives, their take on the structuring of organisation and technology, and the key underlying theoretical concepts. Each institutional perspective on organisation and technology is characterised by the

emphasis institutional theorists put on the direction of structuring capacities of either organisation, technology, or both.

Table 5.1		**Organisation**	
		Stable	*Emergent*
Technology	*Stable*	**Technological determinism** (1) *Stable organisation / stable technology* Shared understanding of technology established; shared understanding of organisation established. *What is negotiated/contested:* - internal structures*:* Relationships / structures (conflicted interests, values, & power) *What is established:* - organisation - technology - field structures *Tech as opportunity for social structuring; Innovation studies; determinism*	**Institutional complexity** (2) *Emergent organisation / stable technology* Shared understanding of technology established; no shared understanding of organisation established. *What is negotiated/contested:* - organisational design - field structures (following blending logics) *What is established:* - technology - logics are fixed (how does that work if the field is emerging?) *(blended) institutional logics, hybrids, amphibious entrepreneurs*
	Emergent	**Social construction** (3) *Stable organisation / emergent technology* No shared understanding of technology established; consensus on meaning of organisation established. *What is negotiated/contested:* - Technology + activity (praxis) *What is established:* - field structures - organisation - (institutional context / logics are fixed) *social construction, practice, technology-in-practice*	**Practice driven institutionalism** (4) *emergent organisation / emergent technology* No shared understanding of technology established; no shared understanding of organisation established. *What is negotiated/contested:* - *practice (activity + logic together)* - technology - organisation - field structures *What is established:* - logics *Practice-driven-institutionalism; 'Technology-as-practice'*

5.2.2 Determinism: Stable organisation / Stable technology

Scholarship focussed on 'stable organisations' combined with 'stable technology' produces theory and research that pertains how existing social structures interact with established technology and its material properties. Focusing on social structures such as the organisation (Barley, 1986; Scott, Reuf, Mendel, and Caronna, 2000), the field (DiMaggio and Powell, 1983; Owen-Smith and Powell, 2008), but also the individuals within them (Owen-Smith, 2005), technology is often considered as

exogenous to the social processes being studied; differentiating between 'institutional environments' and ' technical environments' (Meyer and Scott, 1981), as a traditional distinction between administration and industry (Czarniawska, 2008). The anchor points are drawn from 'Technology as opportunity for social structuring' (Barley, 1986; Barley, 1990, Leonardi and Barley, 2008) and foundational innovation studies literature (Schumpeter, 1934; Barrett et al., 2012; Brown and Eisenhardt, 1997; Brown and Duguid, 1991; Christensen and Raynor, 2013; Christensen, 2003; Johnson et al., 2008). The structurational perspective on technology has benefited from the absence of any explicit treatment of technology by Giddens' (1984) theory of structuration. Technology's properties become significant through the process of structuration. Structures of technology use are constituted through established regular and recursive human interactions with certain properties of a technology and thus shape the set of rules and resources that serve to structure their interaction. Both organisation and technology *'embody'* structures that (re)present various social rules and political interests. However, this perspective does not account for structures to be contested.

5.2.3 Institutional complexity: Emergent organisation / Stable technology

Institutional complexity emerges when an organisation is confronted by multiple institutional prescriptions stemming from incompatible demands (Schildt and Perkmann, 2017; Greenwood, Raynard, Kodeih, et al., 2017). New social structures may emerge as a result of mitigating tensions in new or changing institutional environments, for instance linked to change that occurs following newly introduced patterns of technology use. Failing to create synthesis between competing demands

may turn tensions into clashes that threaten, demise, fragment, or paralyse the organisation (Greenwood et al., 2011). Closely attending to institutions and the social dynamics of work relations, detailed accounts of affordances, constraints, and technologies-in-use tend to fade into the background. Anchor concepts are institutional logics (Friedland and Alford, 1991; Schatzki, 2005; Thornton and Ocasio, 1999), hybrid organisations (Pache and Santos, 2013; Greenwood, Raynard, Kodeih, et al., 2017; Schildt and Perkmann, 2017; Battilana and Dorado, 2010), and amphibious entrepreneurs (Powell and Sandholtz,2012a).

5.2.4 Social construction: Stable organisation / Emergent technology

Scholarship that scrutinizes established social structures, such as the organisation, focuses on how people's technology usage is dictated by the social structures of the organisations within which they act. Through such activity social structures are imprinted on technologies, considering technology as emergent and unsettled. The anchor concepts here are practice (Schatzki, 2005; Whittington, 2019), social construction, and technology-in-practice (Orlikowski, 2000).

"Technology-in-practice" (Orlikowski, 2000, p.404) informs understanding of how practice is important (in particular in relation to technology), and is defined as:

> "… a practice lens to examine how people, as they interact with a technology in their ongoing practices, enact structures which shape their emergent and situated use of that technology. Viewing the process of enactment enables a deeper understanding of the constitutive role of social practices in the ongoing use and change of technologies in the workplace".

Orlikowski (2000) argues that technology is developed through a socio-political process that results in structures (rules and resources), which are embedded within

the technology. This builds further on Giddens (1979; 1984) who argued that 'structure' (or structural properties of social systems) is a set of enacted rules and resources that mediate social action. Actors do not enact structures in a vacuum, but draw on their (tacit and explicit) knowledge gained from prior actions, the situation at hand, the facilities available to them (e.g., land, buildings, technology), as well as norms and values which inform their ongoing practices. In this manner actors apply knowledge, facilities, and habits to 'structure' their current action, and in doing so they recursively instantiate and thus build the rules and resources that structure their social action. Technology-in-practice focuses on studying knowledgeable human action and how its recurrent engagement with a given technology constitutes and reconstitutes particular emergent structures of technology usage (Orlikowski, 2000, p.421). However, an aspect that remains unaddressed is how the social structures that dictate practices came to be.

5.2.5 Practice Driven Institutionalism: Emergent organisation / Emergent technology

To date, organisational institutionalism has considered technology as exogenous, determining, or subjective (Oliver et al., 2008). Instead of considering technology as an outside entity, a structuring force, or being subject to 'imprinting' (Perkmann and Spicer, 2014) by individuals inhabiting and enacting existing structures, the co-evolvement of technology and social structure has largely been overlooked. How do everyday practices develop a technology and shape specific properties of organisations? In the outset, much is contested and negotiated, including practice (activity and logic combined), technology, the social structure of the organisation, as well as field structures.

A start in acknowledging technology was made in the work of Garud and Karnoe (2001; Garud and Ahlstrom, 1997), Orlikowski and Yates (1992; Orlikowski, 1992), and Lawrence and Suddaby (2006); as part of a broader turn to taking 'materiality' more seriously (Bijker, Hughes, and Pinch, 2012). Extending Orlikowski's (e.g. 2000) work on the interactions between technology and intra-organisational practices, such as everyday interactions taking place on the work floor, practice driven institutionalism (Smets et al., 2017) provides a way to link Orlikowski's everyday 'technology-in-practice' within the organisation with higher-level institutional dynamics. Smets et al. (2017) point out that practice driven institutionalism specifically advances how institutional logics are theorised (e.g., Ocasio, Thornton and Lounsbury, 2017) as well as those complexities that occur when incommensurable logics clash (e.g., Greenwood et al., 2011). In this sense, practice driven institutionalism informs important conversations of current institutionalist theorising. The approach enables the examination of tensions observed throughout the earliest stages of emergence of institutional complexity in science-based organisations as they spinout and are working to develop technological CRISPR applications.

As people organise themselves to further develop applications with the genome editing technology of CRISPR, technology becomes a central reason and a common ground for people to come together and interact with each other on the basis of everyday work. It is their collective performance of practices that constitute the CRISPR organisations (Schatzki, 2001), their structures (cf. Giddens, 1984), and

ultimately the institutional field in which they operate (Smets et al., 2012). Human activity relies on practices, supported by (institutional) rules and resources that are structural by token of their enduring and pervasive nature. In empirically focussing on technology related practices that constitute the structures of newly emerging CRISPR organisations, this study joins others in management research in a more general turn to adopting the 'practice' label: for instance, Strategy-as-Practice (Whittington, 2006), Entrepreneurship-as-Practice (Thompson et al., 2020), Leadership-as-Practice (Raelin, 2016), Marketing-as-Practice (Skålén and Hackley, 2011), Accounting-as-Practice (Ahrens and Chapman, 2007), and now also "Technology-as-Practice": The co-constitution of technology and organisation through practice.

5.3 Data and Methodology

5.3.1 Research context

The addressed empirical case is the commercialisation of the emerging precision genome-editing technology 'CRISPR' as applied in the development of human therapeutics. CRISPR is an easy-to-use precision genome editing technique that allows for proactive modification and sequencing of DNA: "Genetic scissors, [that are] a tool for rewriting the code of life" (The Nobel Prize committee for chemistry, 2020). A bacterial defence system to fight viruses, the technology was discovered in nature before it evolved over several decades into a biotechnological tool to be first commercialised in 2013. In 2020 two CRISPR pioneers, Emmanuelle Charpentier and Jennifer Doudna, were awarded the Nobel Prize in chemistry for their contributions to the development of the technology (Ledford and Callaway, 2020). CRISPR is a

multi-purpose biotechnology that has potentially an unlimited amount of applications such as a treatment to sickle-cell anaemia, cancers, and blindness. It is acknowledged for its significant potential to change our society and identified as one of the technologies driving the fourth industrial revolution (George et al., 2016). With CRISPR comes the capability for rewriting the genetic code of cells and organisms (Jinek et al., 2012). The technology is more accessible than preceding genomic technologies as one only needs a standard level of skills in molecular biology to be able to use it. This significantly lowers the economic cost of genome-editing as expensively trained specialists are no longer a requirement, whilst increasing the pool of potential users (cf. Kozubek, 2018). Users of the technology already include non-specialists and even amateur enthusiasts such as biohackers (Nascimento, Pereira, and Ghezzi, 2014). While the CRISPR system is undergoing continuous refinement, the implications of being able to alter the code of life are far-reaching and also trigger questions of ethics.

5.3.2 Case study design

This research uses a comparative multiple case study design with a total sample size of thirteen CRISPR companies. The sole purpose and the sole right of existence for these organisations is to develop and commercialise a specific CRISPR application in the field of human therapeutics. Advancement of science is costly and many CRISPR applications for human health become a material reality following commercialisation. CRISPR companies grapple with all kinds of technical, ethical, societal, business, and institutional challenges (table 5.2).

Table 5.2. Hybridity: Academic vs. Commercial logics in CRISPR spin-out organisations

Dimension	Academic logic	Commercial logic
Economic system	Publicly funded/Not-for-profit	For profit
Basis	Fundamental research: pursue scientific novelty and contribute to scientific debates	Applied science: the purpose is to use knowledge to solve problems and develop products
Output	Sharing and open publishing	Secrecy and IP monetisation
Status	Scientific reputation	Organisational recognition

Table partially based on Thornton et al. (2012; 2004) and Perkmann et al. (2019, p.302)

Such challenges are accompanied with profound and persistent uncertainty as the effects of a business' R&D process can have far reaching implications. These implications are highly uncertain and much greater than commonly seen in other kinds of organisations (Pisano, 2006). Sampling was initiated with the first four CRISPR companies that emerged around the same time in 2013 – wave 1 – when key CRISPR scientists spun their innovations out of their universities to establish privately funded *new* organisations with the *sole* goal of further developing CRISPR applications for the market as public funding alone was not sufficient to fund development. The subsequent nine companies are 'follower' CRISPR companies – wave 2 – shortly established after. Inspired by a 'theoretical sampling' approach (Glaser and Strauss, 1967) the sampling criteria can be divided in 'constants' and 'variables', and were as follows:

(1) The organisation must be based in the local setting in which it spun out or originated. This helps to trace the genealogy of the organisation. Furthermore, geographically it will be close to the origin of where the practice was locally developed. (2) The founding scientist(s) needs to still be involved in some capacity within the organisation. This contributes to the idea that the organisation still has close connections to its source, the research institution from which it spun out. (3)

The organisation's right of existence must be fully dependent on the success of the practice that it develops. This is to ensure that samples have co-constitution of technology and organisation. (4) The organisation must be based of academically developed knowledge. This is to ensure a process of commercialisation takes place. (5) This knowledge must be related to the practice of CRISPR for human therapeutics. The focus of this research is on CRISPR organisations. (6) The organisation must grapple with a form of intellectual property. This functioned as indicator for insights into locally embedded tensions as IP is firstly negotiated locally. (7) The organisation should be accessible in order to collect data through interviews. Interview data provides valuable insights into the organisations and their practices.

Variables. (1) There is variation in institutional contexts between the different cases: The Netherlands, the UK's golden triangle Oxford – London – Cambridge, the US Boston area. (2) There is variation between cases in the use, application, and development of CRISPR for human therapeutics. This provides insight into the development dynamics of different CRISPR applications. (3) There is variation in stage of the life cycle the cases. This allows to look at different phases of co-constitution of organisation and technology. These criteria led to the following sample for data collection and analysis; see table 5.3 for the sample.

Table: 5.3							
1st wave							
Company Code	**CRISPR application**	**Year founded***	**Type of management**	**IP holders**	**Funding**	**Employees**	**HQ**
1	Human therapeutic	2013	Professional management	Licensed	IPO	50 - 100	US
2	Human therapeutic	2013	Professional management	Licensed	Series +	50 - 100	US
3	Human therapeutic	2011	Professional management	Fully owned	IPO	50 - 100	US
4	Human therapeutic	2014	Professional management	Fully owned	IPO	50 - 100	CH/ US
2nd wave							
Company Code	**CRISPR application**	**Year founded***	**Type of management**	**IP holders**	**Funding**	**Employees**	**HQ**
A1	Intracellular delivery system	2015	Inventor / CSO	Licensed	€250k subsidy) €1.5mln (EU grant)	< 10	NL
A2	Drug discovery system	2017	Inventor / CSO	Licensed	€5mln< (Series A)	< 10	NL
A3	Therapeutics	2012*	Professional management	Fully owned	$100mln< (IPO)	100 <	NL
B1	AI powered CRISPR library	2012*	Inventor / CSO	Fully owned	$5mln <	< 10	UK
B2	Software tool	2011*	Inventor / Professional management	Fully owned	$20mln (Series A)	20 - 50	UK
B3	AI tool for genomic data analysis	2011*	Professional management	Fully owned	$50mln< (Series D)	50 -100	UK
C1	Sequencing of microbiome	2016	Inventor / CSO	Licenced	Seed	< 10	US
C2	Gene editing based xenotransplantation	2014	Inventor / Professional management	Licenced	$40mln< (Series A)	< 10	US
C3	Human emulation system	2013	Inventor / Professional management	Licenced	$100mln (Series C)	50 - 100	US

*Some companies have an earlier start date than 2013 because they tried other genome editing technologies before entirely shifting to CRISPR

5.3.3 Data collection

Interviews. Data collection occurred through 110 qualitative interviews with 88 interviewees, archival/documentary data, and observations (table 5.4). The sample of interviewees consisted of different individuals, occupying various roles such as scientist, entrepreneur, investor, policy maker, or professional manager – each and everyone shaped by their education and career history that mediated understanding, motivations, and, consequently, behaviours. These interviews constituted the primary data source as it allowed for collecting sensitive information

about the inner workings of the organisations, their technology development, and the institutions in which they are embedded, providing an in-depth insight when linked to different findings from observed dynamics and written sources.

Table 5.4 Overview of interviewed informants N=88	
10 CRISPR academics (postdocs/PIs/technicians)	12 non-academic C-level executives
12 academics turned scientist-entrepreneur	10 business development support (university staff/not-for-profit/trusts)
10 investors	8 policy experts (professors/civil servants/lobbyists)
13 field and industry experts	5 ethics experts (in residence within laboratory/professors/civil servants)
3 science park directors	5 others
	Number of interviews = 110 (several informants were interviewed twice)

Observations. Observations were made at field events, company tours, and laboratory visits, and helped to capture impressions that contributed to an understanding of common practices, organisations, and the context of the academic and industry settings in which CRISPR-based organisations operate.

Documents. Documentary evidence helped with triangulating findings across data sources and connected practitioners' behaviour and organisational structures to wider institutional contexts. This multi-method approach allowed for theorising dynamics at the level of the practice, organisation, and field, as well as their multi-level interactions.

5.4 Data analysis and Findings

In line with our research question our unit of analysis was the CRISPR organisation. The data analysis is a synthesis of the comparative research approach allowing for inducting findings from empirical observations for mid-range theory building

(Eisenhardt and Graebner, 2007; Eisenhardt, 1989). Through constant comparison between sample data and emerging analysis a process of gradual abstraction made analytical generalisation possible (Suddaby, 2006; Strauss and Corbin, 1990). Zooming in on the dynamics that consist of the praxis of individuals within the organisations, before zooming out again to show how organisational–individual interplay shifts practice, meaning, and practitioner. First, tensions in the hybridisation process at the micro-foundation are discussed and, secondly, these are summarised in the workings of the aggregate mechanisms of "organisational differentiation" and "personal integration".

5.4.1 Understanding tensions in micro-foundations in the hybridisation process of commercialising CRISPR

The findings show a shift from academic activities to commercial activities, and a change in the meaning attached to those activities. The data-to-theory connections are visualised in a data structure – figure 5.2. The data was analysed in four steps: First, we compiled a list of chronological key events on how CRISPR was turned commercial. Second, we created narrative accounts of how the organisations developed. Third, we used open coding with specific focus on themes that related to challenges and tensions in spinning out, developing technology, and building a new organisation. The 1st order codes started emerging as tension and challenges become visible between the academia and commerce. This allowed to observe and identify the tensions that are negotiated in the spinout phase (2n order codes). Our last, fourth, step was about identifying what dynamics anchored the tensions and challenges.

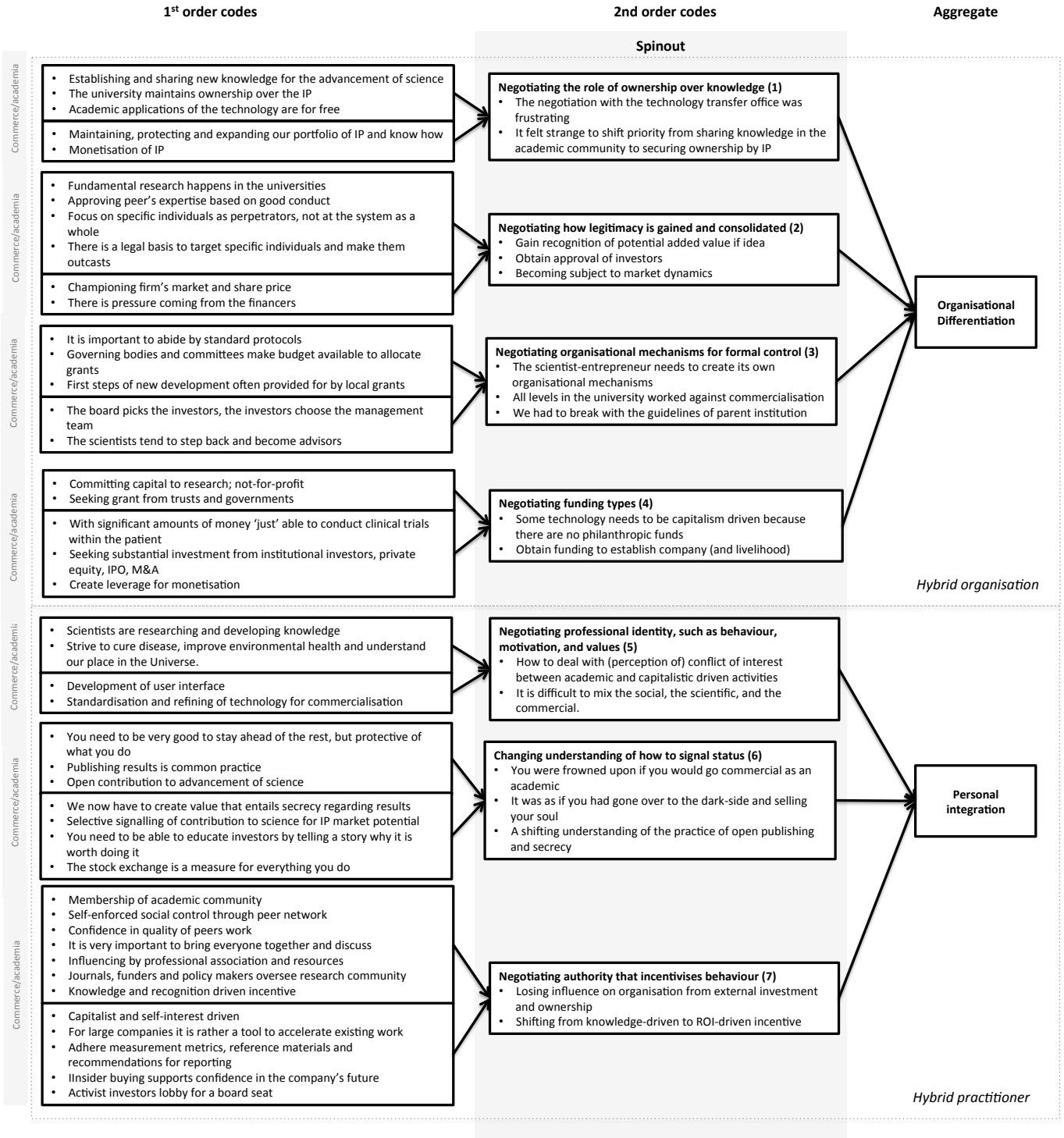


Figure 5.2: Data structure

Seven dimensions of change were identified as second order themes that capture the tensions and challenges observed in the spinout phase: (1) ownership, (2) legitimacy, (3) formal control mechanism, and (4) funding, (5) professional identity (6) signalling of status, (7) authority. An overview illustrating the coding structure with examples of power quotes is provided in table 5.5:

Table 5.5 **Data table: Summary of Core Concepts, Empirical Observations *(first order)*, and Illustrative Data**

#	1st order: (a) Academic / (b) Commercial	2nd order: Spinout tensions	Agg.
(1) Ownership	**(1a) Intellectual ownership through sharing and publication** "Harvard maintains the ownership over the IP. The institute helps until the point of licensing and to make generated data publicly available. Academic applications of the technology are for free." (Interviewee #8, University business development specialist) **(1b) Private ownership by legislation and secrecy** "Our ability to generate revenue from product sales and become profitable depends significantly on our success in … maintaining, protecting and expanding our portfolio of intellectual property rights, including patents, trade secrets and know-how." (Doc.)	**Negotiating the role of ownership over knowledge** Tensions exist between establishing intellectual ownership through scientific publication, aimed at collective sharing, and filing for a patent, aimed at secrecy. The processes involved are significantly different: The former is inspired by openness and the latter by secrecy. (Interviewee #2, co-founder)	**Organisational differentiation**
(2) Legitimacy	**(2a) Highlighting personal expertise and craft for legitimacy** "I'd just as well not hang myself out to dry with someone I barely know, but I feel an obligation to be balanced about it. I'm sitting in the middle and everyone else is so extreme that it makes me look like his buddy. He's just an acquaintance. But it seems like a bullying situation to me. The most serious thing I've heard is that he didn't do the paperwork right. He wouldn't be the first person who got the paperwork wrong. It's just that the stakes are higher." (Doc.) **(2b) Championing the firms market position and share price for legitimacy** "We now have to create value… we put a lot of pressure on ourselves, but obviously there is also pressure coming from the financers." (Interviewee #36, CEO & Founder CRISPR company, Professor in Pharmacogenetics)	**Negotiating how legitimacy is gained and consolidated** "We can show that we create value in non-monetary ways, for instance the development of know-how, chemical IP, and such. It is sort of a proof of concept package we are creating." (Interviewee #36, CEO & Founder CRISPR company, Professor)	
(3) Organisational Control Mechanism	**(3a) Institutional control through peer review and grants allocation** "There are special 'compassionate use' programmes; hospitals make a budget available for these programmes. So the first academic steps for the R&D and development of a new medicine are often paid for by grant allocations provided by hospitals." (Interview #27, industry representative / lobbyist) **(3b) Control exercised by management board** "The board picks the investors, the investors choose the management team. The scientists tend to step back and become advisors." (Interviewee #3, Chief Business Officer)	**Negotiating organisational mechanisms for formal control** "There is self-regulation amongst commercial developers… there is awareness what policies are needed" (Interviewee #4, Co-founder)	
(4) Funding	**(4a) Committing capital to research** "In science you learn from failure. Also with funding, you get so many NOs. But you learn why you get those. The next time you've a successful [grant] application." (Interviewee #2, CEO & Founder spinout) **(4b) Market capitalism is guiding** "… much money is needed to bring it [a new therapeutic] to market and risk is inevitably attached to trying to do this... with €25mln you might 'just' be able to conduct clinical trials within the patient." (Interviewee #36, CEO & Founder CRISPR company, Professor)	**Negotiating control over capital, a shift in funding type** "Academic funding works on grants and when spinning-out often the early-stage funding consisted of government subsidies. For instance, [company A] is looking to scale up and it aims for EU grants that will help the company to further develop their proof of concept." (Interviewee #39, Head of government funding initiative for development of STEM companies)	

(5) Professional Identity	**(5a) Aiming to increase knowledge** "A fundamental goal of the scientific endeavour is to advance society through knowledge and innovation. As scientists, we strive to cure disease, improve environmental health and understand our place in the Universe." (Doc.) **(5b) Aiming to increase efficiency and profit** "The company is refining the tech, really simplifying things. Development of user interface and standardisation." (Interviewee #4, Co-founder spinout)	**Negotiating professional identity such as behaviour, motivation, and values** "A very vivid challenge is 'conflict of interest' – e.g. for the PIs… I am still not sure how to navigate this." (Interviewee #4, Co-founder spinout)	**Personal integration**
(6) Signalling Status	**(6a) Signalling status position in the professional network** "See the scientist as a hedgehog: you need to be very good to stay ahead of the rest, but protective of what you do – make sure you publish to do so." (Interviewee #18, World leading CRISPR expert) **(6b) Signalling organisational status in the market** "Get the branding right. You need to be able to educate investors by telling a story why it is worth doing it… be strategic what you share" (Interviewee #2, CEO & Founder spinout company)	**Negotiating understanding of how to signal status** "Following the first [academic] publication of Zhang [for therapeutics] mainly agricultural companies showed interest." (Interviewee #3, Chief Business Officer)	
(7) Authority	**(7a) Influencing by professional association in the research community** "Incentives come from: journals, policy makers, funders. Need for a collective action model." (Interviewee #18, World leading CRISPR expert) **(7b) Using shareholder activism to exercise influence** "…the activist investing fund is nearly doubling its stake in […] a British gene editing company by buying shares from [...]. The stake will help the US activist in its efforts to lobby for a board seat." (Doc.)	**Negotiating authority that incentivises behaviour** "…in the absence of a global oversight body anyone could reach out to their deans, the US National Institutes of Health or relevant scientific societies, such as the Association for Responsible Research and Innovation in Genome Editing.. " (Doc.)	

Commercialisation is a process of hybridisation. As CRISPR is commercialised a differentiation can be made between 'academic activities' and 'commercial activities', as well as the attachment of different meanings to practices as a shift occurs from 'academic meanings' to 'commercial meanings' of practices. As the hybridisation unfolds actors (practitioners), activities (praxis), and meaning (practice) are merged or changed. The seven dimensions of change in table 5.5 can be mapped onto changes in actors (practitioners), activities (praxis), meaning (practice). Transitions are market by 'fault lines' that are fluid and merely an indication of emerging tensions and change. Such an overview, based on data table 5.5, is provided in table 5.6:

Table 5.6: **The dimensions of change**
(*Developed by author)*

'Old' academic research logic is dominant **|** **---------- Direction of commercialisation processes of CRISPR ---------->** **|** ***'New' commercial logic is dominant***

Identified tensions on practitioners throughout the commercialisation process of CRISPR ⬇		**Phase** ➔ / **Characteristics** ⬇	**Phase/site 1** **University** Within the original research institute **- a -**	**Fault lines of tension field** ***Spinning out*** *Establishment of science-based business*	**Phase/site 2** **Spin-out** The early-stage science-based business	**Fault lines of tension field** ***Scaling up*** *Standardisation*	**Phase/site 3** **Accomplished company** Within the advanced science-based business **- b -**	
1. Ownership Change in the role that ownership over knowledge plays, for instance a shift from sharing knowledge in the academic community to protection by IP	**1a**	**Actor** *(practitioners)*	Scientist	Universities & Technology Transfer Offices	Company		Company	**1b**
		Activities *(praxis)*	Establishing and sharing new knowledge	Establishing ownership of knowledge			Protecting ownership of intangible asset (IP litigation)	
		Meaning *(practice)*	Contribution to advancement of science	Securing ownership over intangible asset			Monetisation of IP	
2. Legitimacy Change in how legitimacy is gained and consolidated amongst the practitioners	**2a**	**Actor** *(practitioners)*	Peers	Investors	Investors and end users		Stock market, analysts, shareholders, end users	**2b**
		Activities *(praxis)*	Approving peer's expertise	Approval by investors	Adoption by market		Championing firm's market and share price	
		Meaning *(practice)*	(good) conduct-based	Recognition of added value	Adoption of added value		Value-based	
3. Organisational control mechanism Change in organisational mechanisms through which formal control is exercised over practitioners	**3a**	**Actor** *(practitioners)*	Institutional councils (e.g. editors, ethics committees, governing bodies)	Scientist-entrepreneur			Professional CEO	**3b**
		Activities *(praxis)*	External experts provide verdict	External experts provide verdict	Internal team expertise		Internal team expertise	
		Meaning *(practice)*	Abide by standard protocols	Abide by standard protocols	Create own protocols and standards		Create own protocols and standards	
4. Funding Tensions regarding control over organisational practices, for instance indicated by a shifting notion of funding	**4a**	**Actor** *(practitioners)*	Scientist / Principal investigator (PI)	Scientist-Entrepreneur			Professional management team	**4b**
		Activities *(praxis)*	Seeking grant from trusts and governments	Seeking funding from friends, family, angels investors	Seeking funding VCs, funds, high net worth individuals		Seeking substantial investment from institutional investors, private equity, IPO, M&A	
		Meaning *(practice)*	Get funding (Committing capital to research; not-for-profit)	Get funding (to establish company)			Get funding (to create leverage for monetisation; for-profit)	

5. Professional identity Change in the kind of behaviour, motivation, and values are deemed appropriate and internalised by the practitioners	**5a**	**Actor** *(practitioners)*	Scientist	Scientist-Entrepreneur		Entrepreneur	**5b**
		Activities *(praxis)*	Researching and developing knowledge	Researching and developing knowledge	Capitalist and self-interest driven	Capitalist and self-interest driven	
		Meaning *(practice)*	Knowledge creation, discovery	Conflict-of-interest		Value creation, standardisation	
6. Signalling status Signalling (scientific) excellence is done differently depending on the activity and the role of the actor, resulting in a shifting understanding of the practice of publishing	**6a**	**Actor** *(practitioners)*	Academic scientist	Scientist entrepreneur		Scientist advisor	**6b**
		Activities *(praxis)*	Publishing of results	Publishing of results	Secrecy regarding results	Secrecy regarding results	
		Meaning *(practice)*	Open contribution to advancement of science	Contribution to science	Selective signalling of contribution to science for IP market potential	Selective signalling of contribution to science for IP market potential	
7. Authority Change in the authorities that provide incentives for certain behaviour by practitioners	**7a**	**Actor** *(practitioners)*	Journals, funders, policy makers	Investors	Shareholders	Shareholders	**7b**
		Activities *(praxis)*	Influencing by professional association and resources	Influencing through investment	Exercising rights as (partial) owners	Exercising rights as partial owners	
		Meaning *(practice)*	Knowledge and recognition driven incentive	Return on investment driven incentive	Return on investment driven incentive	Shareholder activism	

5.4.1 Unpacking the seven dimensions of change

The hybridisation that gives rise to these seven dimensions of change follows from practitioners integrating competing logics. Tensions are balanced between 'a – academic' activity and 'b – commercial activity', as marked in the data structure (figure 5.2), table 5.5, and table 5.6. In the interstitial 'spinout' phase cross over tensions arise between actors, activities, and their meaning. Each dimension of change is now further elaborated, with focus on the tensions as observed in the interstitial 'spin-out' phase.

Negotiating organisational differentiation

(1) Ownership: Tensions were observed over the change in the meaning of 'ownership'. *Differentiation* entailed intellectual ownership and sharing of knowledge in the academic community developed into private ownership protected by legislation and secrecy. *Integration* occurred through change in activities, meanings, and the actors themselves. Intellectual ownership moved between actors from the scientists, to the universities technology transfer offices, to the companies; as activities changed from establishing and sharing new knowledge to establishing ownership of knowledge to the protection of ownership over intangible assets; the attached meanings developed from contribution to advancement of science to securing ownership over intangible assets to the monetisation of the IP over those assets. This could be observed as follows.

In the university collaboration between academics is common practice. Publications are prioritised over patents thereby facilitating the sharing of knowledge, know-how, and ideas: "…academics have a right to publish their research" (Interviewee #34, scientist). Findings are published and research is presented at conferences. Shifting from academia towards incorporation entails a change in priority, alliances, and power as new activities and meanings are introduced:

> "…Once you publish it is difficult to get IP [intellectual property]. Therefore you have to make sure you get the IP going before you publish. This process is quite complex due to the different timings; it is easy to miss your window of opportunity. [If you] wait too long with the publication you cannot really use the IP, if [the] IP comes too late everybody already has the knowledge." (Interviewee #4, Co-founder)

Intellectual property and associated rights are critical for organisations in science-based business (see also Teece, 1998; Pisano, 2006). For instance, the *academic* collaboration between the scientists Doudna, Church, Joung, Zhang, and David Lui was the basis for the development of CRISPR. This led to the incorporation of the first wave CRISPR company Editas Medicine Inc. Although they were academic collaborators, internal rifts within the *commercial* setting led to Doudna's departure and her involvement in setting up the competitors Intellia Therapeutics Inc and Caribou Biosciences Inc. As commercial organisations were formed around CRISPR the involved stakes and stakeholders changed: Each first wave organisation started various partnerships with big pharmaceuticals, venture capitalists, and fellow disruptive biotechnology start-ups, in a complex series of exclusive licensing deals, joint ventures, and strategic collaborations (Obs.). For instance, "Intellia [therapeutics inc.] agreed to give Regeneron exclusive rights to develop CRISPR-based therapies targeted at any of 10 different genes in the liver" (Doc.). As

substantial funding was raised professional C-level executives formed the board instead of scientists (Obs). Patent lawyers were contracted, backed by the academic institutions from which the organisations hail, to seek claim to the intellectual property over the CRISPR system for each of the commercial parties. This instigated a fierce patent fight over who had the claim to CRISPR-Cas9:

> "Risks related to our intellectual property: Third party claims of intellectual property infringement against us, our licensors or our collaborators may prevent or delay our product discovery and development efforts… third parties may assert that we infringe their patents or that we are otherwise employing their proprietary technology without authorization, and may sue us" (Intellia Therapeutics, Annual report, 2016, p.62)

Academic collaborations broke down and alliances were reshuffled. Protection of owned intellectual property became crucial for the survival of the organisations:

> "We have never generated any revenue from product sales and our ability to generate revenue from product sales and become profitable depends significantly on our success in a number of factors: …. Maintaining, protecting and expanding our portfolio of intellectual property rights, including patents, trade secrets and know-how…" (Intellia Therapeutics, Annual report, 2016, p.45)

Besides the pioneering CRISPR scientists that developed the underlying process or technology, other practitioners became involved that introduced new activities or attached new meaning to existing activities regarding ownership over scientific findings. These different stakeholders held radically diverse worldviews; as tensions turned into clash, even between former colleagues, new identities were created as hybrid practitioners bridged between academia and commerce.

(2) Legitimacy: "Legitimacy emphasizes the social acceptance resulting from adherence to social norms and expectations" (Carter, 2005, p.329), hence it is granted externally. It as observed that organisational differentiation created

tensions in how and through whom practitioners obtain legitimacy for their day-to-day practices. With different logics merged by hybridisation the meaning attached to 'legitimacy', the respected activities, and those actors involved, changed. The verdict of academic peers was replaced by that of investors, end users, and the forces of the market.

In academia peers approve or disapprove other peer's expertise, highly valuing both rigorous and ethical conduct. For instance, this professor discussing his peer following the backlash caused by the experiment that produced the first genetically modified humans assesses:

> "I'd just as well not hang myself out to dry with someone I barely know, but I feel an obligation to be balanced about it. I'm sitting in the middle and everyone else is so extreme that it makes me look like his buddy. He's just an acquaintance. But it seems like a bullying situation to me. The most serious thing I've heard is that he didn't do the paperwork right. He wouldn't be the first person who got the paperwork wrong. It's just that the stakes are higher." (Doc.)

As the development of the organisation advances investors come on board: "raising investment is crucial for the survival of the company" (Interview #7, founder). The investors' approval is based on them recognising enough added value created by both technology and the organisation:

> "We now have to create value… we put a lot of pressure on ourselves, but obviously there is also pressure coming from the financers… we *also* create value in non-monetary ways, for instance: the development of know-how, chemical IP, and such. It is a proof of concept package we are creating." (Interviewee #36, CEO & Founder CRISPR company, Professor in Pharmacogenetics).

Once a product or service is developed legitimacy is bound by the impression end users have how willing they are to adopt it: "to partner with end customers … is the

aim… own the customer relationship" (Interview #7, founder). Once the organisation becomes established legitimacy becomes value-based as shareholders champion a firm's market and share price: "when you trade publicly the share price determines everything – even if you want to set up a partnership" (Interviewee #38, Chief Development Officer). As the nature of the organisation changes so do the practitioners that grant legitimacy: "This industry can only exist by the continuous increase of shareholder values" (Interviewee #39, Head of government initiative for development of regional STEM companies). Investors, market sentiment, the stock market, analysts and shareholders decide on legitimacy as good conduct now goes hand in hand with the generation of added value and is no longer (only) assessed by peer networks.

(3) Organisational control: Following commercialisation tensions were observed as the organisational control mechanisms to exercise formal control by practitioners over practitioners changed. Formal frameworks changed, the introduction of new responsible actors, their activities, and attached meanings alternated – this arose as follows. In the academic setting actors consist of institutional councils such as editors, ethics committees, and appointed governing bodies. They head formal structures with standard protocols for conduct. New CRISPR applications challenge standard protocols and the way "things are done" as a way to squeeze diverse innovative work into a framework that can be overseen by those institutional councils warrantying good conduct:

> "When we publish things now, we are often asked to compare our data with animal models. It's a challenge that reviewers ask for that, because it misses the point. We have to remind them about why we developed the technology.

> Organs on chips versus animal models. E.g. mice don't develop asthma, yet they are used for testing asthma medicine. Idea is to develop different organs and interlink them like an electronic system board." (Interviewee #4, Co-founder)

Formal control mechanisms often set the stage for a lock-in of dominant structures that define common practice. This can sometimes be challenging for innovative practitioners to work with: "A challenge is [that] other labs might have the incentive not to adopt this tech instead of their common practice. You could say there is a lock-in of knowledge, willingness, and people" (Interviewee #4, Co-founder). As a new organisation is spun-out the scientist-entrepreneur forms new internal structures for formal control. With a team in place new protocols and standards are created that work for the organisation, a transformation often led by a hired professional CEO (Obs). As practitioners move towards a more commercial structure, expertise over what is considered good conduct can start to be formulated within the organisation. This allows for more flexibility and agility as the scientist-entrepreneur can start making the rules themselves (a form of personal integration). However, once the organisation matures new bureaucratic frameworks are likely to be put in place as structures for standardised practices are likely to emerge, thereby locking in practitioners.

(4) Funding: Tensions were observed in relation to the practice of raising financial means. The actual practice (and meaning) of fund raising is consistent whilst the activities evolve and are subsequently linked to different actors. In the academic setting funding is raised via grants from trust and governments but as an organisation is spun out and grows, larger sums and diverse investor expertise is

drawn. This entails moving from smaller investors such as friends, family, and angel investors to venture capitalist, private equity, and IPO. This can be understood in the following way.

When a science-based businesses spins out of the university's 'academic' setting funding is needed to finance further development of the technology and the organisation. Although funding is crucial the prerequisites that often come with it are not always appreciated: "We encountered young companies that are afraid to involve outsiders into their business… this enhances the chances of misinterpretations between young companies and VCs" (Interviewee #28, Chairman science park). Not all scientist-entrepreneurs are eager to bring in any funding they can obtain. Others may perceive funding as a necessity, but one that brings along outsider influence from other practitioners: "When VCs [Venture Capitalists] fund projects, the first thing they do is to throw out the CSO [the Chief Scientific Officer, who often is the initial scientists that turned entrepreneur]" (Interviewee #38, Chief Corporate Development Officer). The instalment of a professional board may feel to some founders as giving away control over their company. Some companies actively develop strategies to avoid such situations: "We did not want to give control to a VC. That has been a reason why we have done an IPO so quickly, to raise capital in other ways and to keep control over our company" (Interviewee #38). But significant investments are often needed for further development of a technology – and these are not easily obtained. Running an organisation and developing research is expensive. This may cause a high burn-rate:

> "You can calculate a company's cash runway by dividing the amount of cash it has by the rate at which it is spending that cash. In June 2019, CRISPR Therapeutics had US$428m in cash, and was debt-free. In the last year, its cash burn was US$133m. That means it had a cash runway of about 3.2 years as of June 2019." (Yahoo Finance, 2019)

Few scientist founders have the skillset for successfully (and often do not even aspire) running the growth of an organisation: "…only few scientists actually quit academia to join their company" (Interviewee #3, Chief Business Officer). Because of the stakes involved, most investors have as a prerequisite for their investment that a professional board is established to manage the company; thereby introducing a new set of practitioners: "the investors choose the management team" (Interviewee #3, Chief Business Officer). But as we have seen, as new actors are introduced, tensions may arise between the practitioners of new and old management, between founders and professional management boards, and between investor and investee.

Negotiating personal integration

(5) Professional identity: Tensions were observed as different professional identities were are adopted by individuals: The scientist turns scientist-entrepreneur and might eventually become entirely entrepreneurially driven as it changes perspective from being discovery oriented to focussing on standardisation and value creation driven by capitalist incentives. The actor internalising different perspectives (that of academia and commerce) may lead to the scientist turning into hybrid practitioner, or scientist-entrepreneur.

Hybridity of the individual may be problematized: "A very vivid challenge is 'conflict of interest' – e.g. for the PIs (principal investigators). I am still not sure how to

navigate this" (Interviewee #4, Co-founder). Fourteen of the interviewees said they felt challenged by this, yet the interpretation of 'conflict of interest' varied and was understood differently by informants. Overall it was referred to as biases in practitioners' conduct. Especially scientists conducting entrepreneurial activities raised this issue: "Many scientists do not have any interest in the commercial aspects of science. Only until recently you were frowned upon if you would go commercial as an academic" (interviewee #27). Research with commercial association – e.g. through a company or by corporate sponsorship – was perceived likely to be biased: "It was as if you had gone over to the dark-side. You pursue your passion instead of the idea to make money, because if not so you would have done something else… it is still seen a bit … like… selling your soul" (Interviewee #36, CEO & Founder CRISPR company, Professor). Work in the interest of the sponsor was deemed harmful to research independency, quality, and conduct. Academic-industry collaboration can therefore seem less appealing as any suspicion of bias can be very damaging to the career of an academic. Other informants that referred to such biases were investors, policymakers, and industry representatives. As logics come together in the practitioner tensions may result in scientists deciding not to pursue commercialisation due to entrenched cultural biases barring personal integration of the logics:

> "It is difficult to mix the social, the scientific, and the commercial. This is very quickly seen as a conflict of interest. This is very sensitive and probably has to do with cultural visions. Once something goes commercial, is it still in line with your career as a scientist?" (Interviewee #26, Professor and Senator)

What context a practitioner is set in may determine how a 'conflict-of-interest' should be understood and what kind of clash can emerge from inter- and intra-

personal tensions as ‘personal integration’ takes place through ‘practitioner reinvention’. The notion of ‘conflict of interest’ is an example of how ‘organisational differentiation’ triggers tensions between ‘old’ academic logic and ‘new’ commercial logics as ‘practitioner reinvention’ mitigates these tensions under the mechanism of ‘personal integration’.

(6) Signalling status: Signalling scientific excellence is done differently depending on the activity and the actor, resulting in a shifting understanding of the practice of publishing. Practitioners introduced commercial practices alongside academic practices, accepting different interpretations of how new knowledge should, if it all, be communicated. It was observed that the main actor, the scientist, faced competing practices as activities changed and its role was being redefined.

As practitioner, the scientist shifts from being an ‘academic scientist’ to ‘scientist entrepreneur’ to ‘scientist advisor’. As “fundamental research happens in the universities and is then further developed privately” (Obs) introducing a corporate approach can be challenging as it gives a different meaning to the very same activity of signalling scientific excellence: “The processes involved are significantly different, the former is inspired by openness and the latter by secrecy” (Interviewee #2, Founder). To publish and disseminate findings for the advancement of science is deemed to be the core practice in the academic setting: “In 2012 it was a tiny research community… only 126 papers were published on CRISPR, compared with 2155 last year [2016]… We thought it would be very important to bring everyone together to share our knowledge” (Doc). In an academic setting the priority of

practitioners is to advance science. The motivation to commercialise may be in the interest of science: “Some tech needs to be capitalism driven. Why? Because there are no philanthropic funds available” (Interviewee #18, Chief Corporate Development Officer). But this transition is not always seamless: “You were frowned upon if you would go commercial as an academic” (Interviewee #36, CEO & Founder CRISPR company, Professor). Nonetheless, the commercially inspired practitioner needs to aim for signalling market potential and added value: “Be the very closest to the data that is being generated to own up to the value proposition” (Interviewee #7, founder). Shifting to a ‘new’ mind-set also introduces new practice such as secrecy. The purpose of outward communication is no longer to share knowledge, but to signal the market potential of obtained knowledge owned by the organisation to the market: “This will give a clear signal to the outside world about how solid the company [is]” (Interviewee #6, CEO & Co-Founder). Scientists continue to fulfil their original role although with a different purpose: “We [the business] maintain ownership over the IP, but the academics have a right to publish the research” (Interviewee #34, CEO & Founder). Organisations move from being open in sharing of knowledge to closed structures that stimulate secrecy: “Tensions exist between establishing intellectual ownership through scientific publication, aimed at collective sharing, and filing for a patent, aimed at secrecy (Interviewee #2, Founder). Although many actual activities remain the same, both the role of the scientist becomes different as “the scientists tend to step back and become advisors” (Interviewee #3, Chief Business Officer), as well as the meaning of its activities in the organisation: “you need to be able to communicate the science to investors… be strategic about what you share” (Interviewee #4, Co-founder). As the role of the actor adjusts, the

activity of signalling scientific excellence is done in a selective manner as it gains new meaning with science being communicated for investment rather than knowledge, ultimately leading to a dominant practice of secrecy in the organisation.

(7) Authority: Tensions were observed as change occurred in the authorities and how they provided incentives for certain behavioural changed As consequence, the practice by which authority is exercised was reinvented; instilling different meanings to how 'authority' was perceived, integrating new practices and attached meanings by the persons subject to the authority.

It was observed that change in authority provides for change in the very incentives for certain behaviour. In academia actors have a drive for knowledge and are incentivised by professional association through publication, academic funders, and policy makers: "Incentives come from journals, policy makers, funders" (Interviewee #18, World leading CRISPR expert):

> "It is very difficult to address accountability in science when it is done in small groups, amongst specialists, or behind closed doors. There is basically no accountability, unless self-enforced." (Interviewee #18, World leading CRISPR expert)

As technology spins-out the nature of the organisation changes incentives. The role investors play becomes more prominent, effectuating a more controlling voice for shareholders as they might exercise their rights as partial owners over the development process of both organisation and technology:

> "Make sure you bring on board an investor – possibly even for less cash – that understands what you are trying to do. This way it may not only help you in the process, but you may also avoid them trying any unsolicited and

> counter-productive activity as they try to exercise control over their rights at a later stage … like trying to cash out for a quick return on their investment" (Interviewee #30, CEO).
>
> "These investors do not interfere with the actual operationally, but rather look at the team of people that the company has – Can this team actually pull it off? The challenge is to have confidence without overselling." (Interviewee #38, co-founder).

The importance of the shareholder increases as their influence increases: "Once you file for the IPO you have to play the game: The unyielding integration, you can actually arrange everything except the laboratory data, if there is a delay you have to let them know (Interviewee #38). Eventually this might result in investors or shareholders aiming to take full control over an organisation. Such shareholder activism can have further implications and complications in terms of incentives and authority – as well for the end users:

> "Pharma currently buys the almost successful companies, which are of course expensive, as a result of which the market value becomes inflated (too high). As the assets are mainly intangible, there is only book profit and no actual products. Shareholders do not accept that, the price of drugs rises merciless, and patients no longer accept that." (Interviewee #34, CEO & Founder)

As incentives and authority change, practitioners change or adjust – through personal integration – providing new meaning to the activity that takes place, the role of the practitioner and the manner in which technology and organisation are structured.

5.5 Discussion

Drawing on a five-year multiple case study of thirteen companies commercialising the genomic technology CRISPR, we have explained how these hybrid organisations come into being in their earliest moments as spinouts that aim to materialise new

technological applications. In this section, we develop three contributions that jointly explain how *"contested"* hybrids can *pre-empt* conflict arising from incompatible logics to accomplish what scholars of hybrids call "*alignment"* of logics (Besharov and Smith, 2014). First, we theorise the hybridisation of individuals and their professional role in the earliest moments when there are no structures, driven by the nature of the technology and the materialisation of its applications – and based on "personal integration" by the dynamics of *"reinventing practitioners"* and *"reinventing practices".* Second, these dynamics enable the development of organisational structures, drawing attention to interplay between the mechanisms at the individual level, *"personal integration",* and that of the organisational structure through *"organisational differentiation".* Third, we derive how through this interplay it becomes possible to pre-empt conflict in contested hybrids by establishing alignment of competing logics through hybrid practitioners and practices at the core of the organisation. We argue that the interplay extends the framework of Besharov and Smith (2014) by allowing the organisation to become less "contested" and more "aligned" at its core.

The data shows interactions and recombinations between the meanings and activities related to (a) academic and (b) commercial logics. Theorising the deeper structures and interplay gave rise to a matrix that lay bare the underlying mechanisms of the spinout phase – table 5.7. This resulted in a further specification of "organisational differentiation" and "personal integration" into a framework of four categories based of different combinations of activities, meanings, and practitioners: (i) 'purely academic', (ii) 'purely commercial', (iii) 'reinventing

practice', and (iv) 'reinventing practitioner'. The first contribution provides context for all four categories and then focus on the dynamics in (iii) and (iv), the second contribution discusses the interplay between (iii) and (iv) and those of (i) and (ii), and the third contribution is about the strategic use and balancing of all four quadrants to pre-empt conflict at the core of the hybrid CRISPR organisation.

Table 5.7

	ACADEMIC ACTIVITIES	**COMMERCIAL ACTIVITIES**
ACADEMIC MEANINGS	"PURELY' ACADEMIC (i) ***Organisational differentiation*** *Example:* The academic scientist conducting laboratory work with the aim of producing academic publications.	REINVENTING PRACTITIONER (iii) ***Personal integration*** *Example:* The scientist turning into a science-entrepreneur, as academic activities are complimented by commercial ones.
COMMERCIAL MEANINGS	REINVENTING PRACTICE (iv) ***Personal integration*** *Example:* Scientists may continue to publish but have adopted a commercial mindset as IP, market signaling, and trade secrecy are prioritized over academic contribution.	"PURELY' COMMERCIAL (ii) ***Organisational differentiation*** *Example:* The management board performing the duties associated with a mature commercial organisation.

5.5.1 Hybridisation of the individual at the earliest moments through reinventing practice and practitioner

So far, in the literature discussed earlier, the focus has been on what people do but less so on the technology they do it with (and for). The data shows that people come together to form an organisation with the intention to develop new CRISPR applications such as a new therapeutic, an AI powered CRISPR library for genomic data analysis, or a new drug delivery system. The technology is the central reason for the emergence of the organisation. At the earliest moments in the formation of

these spinouts, before there is any organisational structure, technology can facilitate preliminary structure as it interacts with existing assumptions about practitioners' roles. It provides indication of required activities (e.g. conducting science, obtaining funding, protecting knowledge, administration) and it is an anchor for the roles that are needed (e.g. scientists, investors, lawyers, administrators). This interaction constitutes the development of both organisation and technology through role specific practices, and the establishment of new roles due to deviation from existing ones: the scientist becoming a scientist-entrepreneur as it takes on commercial activities that are normally not associated with the role of being a scientists (e.g. making pitch decks, signalling market potential, setting up a business account). The repetition of those scientific and commercial practices and the interactions of groups involved structures behaviour and creates formal organisational structures that facilitate and consolidate those activities. As structure evolves these practices are instilled with different meanings and the role of those practitioners central to the organisation might change; for instance scientists that alongside their laboratory work pitch their academic scientific findings to investment professionals that have purely a commercial incentive. These dynamics become visible through the use of a practice lens that helps to look beyond what people do and to observe the role and negotiation of interdependences as practitioners shape structures together. It becomes visible that technology, therefore, implicitly plays a role in coordinating their early activities and is thus constitutive of – and constituted through – people's practice.

Introducing the commercial logic alongside the academic logic comes with changes in practices, practitioners, and meaning. Throughout the process of commercialisation the combination of stakeholders can change, as investors, regulators, end users, and IP holders – *"purely" commercial* practitioners – join scientists and researchers – *"purely" academic* practitioners:

i) *'Purely academic'* (academic activities x academic meanings) is for instance the academic scientist conducting laboratory work with the aim of producing academic publications. The main incentive is the production of new knowledge. Everything is tailored towards academic success. This is the starting point from where the commercialisation process departs.

ii) '*Purely commercial*' (commercial activities x commercial meanings) is for instance the management board performing the duties associated with a mature commercial organisation. The practitioners are operating with a full focus on financial aspects. The main incentive is creating commercial value. In some circumstances an over emphasis on the business aspects can overshoot the mark as it overlooks the scientific core of an organisation.

It is the conflict between the logics of these "purist" practitioners that is commonly referred to in literature on structural hybrids (cf. Thornton et al. 2012; 2004; Perkmann et al., 2019). The dynamics between 'academic' and 'commercial' make for a mechanism of *"organisational differentiation"* as an aggregate dimension. This mechanism gives rise to a hybrid organisation as both logics are joined. In essence this mechanism produces an organisation that is exposed to, and incorporates elements from, complex contexts with different institutional logics (Battilana and

Dorado, 2010) as it shifts equilibrium between the academic logic and the newly introduced commercial logic in an elastic manner (Gümüsay et al., 2020).

Central to the 'balancing of logics' in these hybrid organisations are the individual practitioners and their practices. There is a limited understanding about how individuals balance institutional complexity (Smets et al., 2015; Nicolini, 2011), and even less about how individuals' practices emerge in relation to evolving structures of emerging organisations (Gümüsay et al., 2020; Almandoz and Marquis, 2017; Smets et al., 2015). This research extends these understandings as it found coping mechanisms at the level of the practitioner to balance the different logics of academia and commerce as they sit at the core of the CRISPR organisation. We noted that individual practitioners attempt to find a balance between 'commercial' and 'academic' logics by changing their own behaviours, their interactions towards one another, the technology, and their direct environment. As the 'academic' and 'commercial' logics were merging into the core of the spinout, practice and practitioner were being reinvented. The mechanism of *"personal integration"* was theorised as consisting of two dynamics, namely *"reinventing practice"* and *"reinventing practitioners"*:

iii) *'Reinventing practice'* (academic activities x commercial meanings) is for instance the scientist that continues to publish as the setting moves from purely academic to commercial. The practice of publishing remains the same but the scientists has adopted a somewhat more commercial mindset as the publications are to support market signalling and IP or trade secrecy are

prioritised over academic contribution. This recombination aligned academic conduct with commercial incentives.

iv) *'Reinventing practitioner'* (commercial activities x academic meanings) is for instance the scientist turning science-entrepreneur, as academic activities are complimented by commercial ones. This may be that laboratory work is still at the core of the work that needs to be done, but this is complemented with commercial activities such as pitching to raise funding, balance sheets, and team hiring.

Logics become dis- and re-associated when practices become infused with new meanings (e.g. academic activities but with a commercial meaning), "reinventing practice"; or, that when new practices emerge these are sometimes still connected to the meanings of an old logic (e.g. commercial activities but with an academic meaning), "reinventing practitioners". Practices become the loci of organising structuring (Nicolini, 2011), and practitioners become organising actors where different logics are brought together and integrated (McGivern et al., 2015). Each dynamic is discussed in further detail:

Practices reinvented. The emergence of organisation and technology are instantiated in practice as they arise through the day-to-day actions of individuals at work (Powell and Colyvas, 2008; McGivern et al., 2015; Sandberg and Tsoukas, 2011). Everyday (material) practices have been neglected in institutional research. Looking at the actions of individuals at the nexus of different institutional logics such as that of academia and commerce, it becomes possible to see how actions that are situated within multiple logics draw from both and, hence, construct ambidexterity

(Jarzabkowski et al., 2009; Jarzabkowski et al. 2013). We may understand institutional ambidexterity related to the materialisation of technology at the collective practice level through people's practical handling of institutional complexity; for instance through the adoption of "hybrid practices" (Smets et al., 2012, p.889) that blend practices and logics from both sides. The recombination of existing practices may occur when the networks that constitute different social domains — that is in this case those of academic and commerce— interact with each other (Padgett and Powell, 2012). Working to different prescriptions, while difficult, has the potential to benefit organisations (cf. Perkmann et al., 2019; Besharov and Smith, 2014). For instance, the data shows that scientists may continue to publish but have adopted a commercial mind-set as IP, market signalling, and trade secrecy are becoming a priority alongside academic contribution to increase knowledge – organisational incentives permitted. The activity of publishing remains the same but becomes multipurpose as additional meanings are added. For the scientist publication is no longer only a practice to signal academic contribution but also to signal market potential. This integration of activity and meaning by the (same) practitioner bridges the counterbalances of academia and commerce. This dynamic allows for both hybridisation and the sustainability of hybridity. The hybrid CRISPR organisation relies on a system of mechanisms in which individuals continuously enact both the conflict and the interdependence of coexisting logics. For instance, purely depending on secrecy prohibits signalling market potential, as where direct publication of findings makes it impossible to claim IP rights. Hence, arguments suggesting hybrids can be sustained by the removal of tension are incomplete (e.g. Battilana and Dorado, 2010; Dunn and Jones, 2010). As practitioners iteratively

separate and integrate logics in their practices they not only balance competing logics but also blend them. Being mindful of personal integration during organisation differentiation allows seeing dynamics being negotiated at the level of the practitioner that are "conflicting yet complementary" (Smets et al., 2015, p.962).

Our observation of integration makes it possible to move beyond the understanding of logics being just conflicting or compatible (Goodrick and Reay, 2011; Greenwood et al., 2011; Besharov and Smith, 2014). The reinvention of practices is not a form of transitory hybridisation marked by the spinout phase. It is an exercise in finding balance in hybridity by the individual – and to maintain that hybrid status. For instance, scientific research akin to that in academia may remain at the core of an organisation, such as the use of CRISPR to find new targets for cancer treatments. However, instead of academic incentives that focus on exploring novel knowledge at the fringes of the known, research may now be purposed to serve commercial priorities such as the optimisation of these newly found processes (e.g. the sequencing of the microbiome) to increase efficacy or to help with standardisation, thereby preparing a treatment or application for introduction to a large market. The activity remains the same but the status becomes hybrid. The academic and market logics represent separate institutions, and institutions themselves (and their logics) cannot be ambidextrous; rather, *people do* institutional ambidexterity in their everyday actions and interactions as they work within and enact multiple logics by introducing new meaning to existing activity, or by adding new activity to an existing practice – thereby reinventing the practice itself. We can observe the same activity

but with a different purpose and audience, as practices are reinvented to embody meanings and understandings that reflect the different logics at play.

Practitioners reinvented. Working on novel CRISPR applications, we observed practitioners cobbling together different practices into a bundle to assemble an organisation (Schatzki, 2009). While science and commerce are complimentary in certain aspects – e.g. additional funding, standardisation, scalability, and dissemination of research – in some instances this may lead to shock and rebellion; maladjustment and misalignment may arise from a "fundamental conflict in the goals and values of scientists and businesspersons" (Shapin, 2008, p.114). While science aims to uncover *truth*, business aims to unearth *profits* – reconciling these two *raisons d'eˆtre* that are a conundrum occurs at the individual level. The scientist changes personal conviction and professional identity as it merges academia and commercial influences. In line with observations in other research, it was found that relatively few academics turn commercial for the sake of financial profit while many are motivated by the purpose of furthering their academic research agendas (D'Este and Perkmann 2011; Perkmann et al., 2019). The pressures and monetary rewards of industry tarnish the contemplative and humble virtues of academic research whilst giving rise to organisation and technology. The challenge lies within having to align practices and structures with behavioural templates and logics that are incompatible. When pressure emanates from various sources and pulls in different directions (Pache and Santos, 2013) disruption occurs from the introduction of new practices, competing logics, or the influence of new or changing settings, or through the introduction of new technology. This resonates to some extent with prior

theorising about change driven by “individuals at the front line” (Reay et al., 2006), “amphibious entrepreneurs” (Powell and Sandholtz, 2012a), or “hybrid professionals” (McGivern et al., 2015). We use the label of “hybrid practitioners” to describe best those actors that have one foot in academia, one foot in commerce.

Once a scientist decides to turn scientist-entrepreneur (hybrid practitioner), it starts drawing on the practices of various new communities and associations. This entails ignoring previously established practices with the risk of diminished support. In any particular situation “practical understanding” (Schatzki, 2006, p.1864; 2002; see also Giddens, 1984) allows a practitioner to select and competently exercise specific activities which it considers pertinent to that particular situation, based on its personal tacit know-how – even in complex situations when different logics and demands are presented. The data shows that as one changes practices the practitioner is forced into the demanding and risky process of both the making of new rules and the assembly of new resources - “Rules tell us how; resources let us do” (Whittington, 2019): the scientist trying to figure out the rules of the game in how to be an entrepreneur. When scientists move from the academic ‘Ivory Tower’ into a commercial environment scientific virtues need to be reconfigured. Changes in activity implicate that meanings and understandings that stabilise established practices are understood to change together in the process of hybridisation. The scientist changes personal conviction and professional identity as it merges academia and commercial influences; for instance, when the academic scientist figures out how to make a balance sheet or to calculate its burn-rate until IPO whilst accounting for commercial expenses and production costs. Practitioners are formed

by practices, but they are also at the same time the creators of practices through their praxis (Whittington, 2019). The data shows an example of the development of user-friendly and refined protocols for a commercial and scalable version of an academically developed organ-on-chip, a device to mimic organ functions. A postdoc who used to work in the academic laboratory that developed the initial technology turned scientist-entrepreneur to build a commercial organisation that was capable of standardising and refining the technology. The academic laboratory became the first customer.

Practitioners respond to situations at hand as these evolve within a specific context (cf. Niccolini, 2011; Sandberg and Pinnington, 2009; Gherardi, 2000). When practitioners working within the organisation integrate multiple "conflicting-yet-complementary" logics (Smets et al., 2015) central to the purpose of the organisation (Perkmann, McKelvey, and Phillips, 2019; Denis, Langley, and Rouleau, 2007), we noted that this eventually entails reinvention of the practitioner itself or having it replacement by a suitable actor. For instance, the scientist (academic practitioner) turns entrepreneur (hybrid practitioner) *or* the scientist takes on an advisory role (and remains an academic actor) while substituted by professional management that attends to running the organisation (commercial practitioner). Practitioners are reinvented as scientists turn scientist-entrepreneur by changing the meaning of their practices, the start of new practices, or through welcoming new practitioners into the organisation. The most common examples in the data refers to the scientist taking on commercial activities such as raising commercial capital, establishing IP, or taking on management tasks. In other instances these tasks are

taken over by commercial practitioners such as technology transfer offices, IP lawyers, or a professional board. Eventually, as with 'practices reinvented', it comes down to finding a balance between counterbalances as the CRISPR organisation cannot exist neither without good science nor without proper corporate expertise. Overemphasis on one will deny the other with the risk of slippage as the detrimental creative friction at the basis for the organisations fades, changing organisational identity, strategy, and practice (e.g. Jay, 2013; Smets et al., 2015; Plowman, Baker, Beck, et al., 2007).

5.5.2 Organisational structures emerge from the interplay between personal integration and organisational differentiation

Second, we noted that there is significant knowledge about *either* structural organisational solutions – *organisational differentiation* – (cf. Besharov and Smith, 2014; Pache and Santos, 2013; Greenwood et al., 2011) *or* the practices of individuals – *personal integration* – (cf. Whittington, 2019; Furnari, 2014, Schatzki, 2006; Creed, DeJordy, and Lok, 2010; McGivern, Currie, Ferlie et al., 2015), but not yet about the interplay between both. By drawing attention to this interplay we extend nascent conversations on institutional analysis that state more focus is needed on practices at the level of the practitioner – the 'micro-foundation' – in order to better understand the dynamics at the macro-level (Smets et al., 2017; Nicolini, 2011). Practitioners' behaviour is always embedded within a web of social practices and interdependent relationships (Smets et al., 2017): praxis relies on practices, and practices are enacted in praxis (Vaara and Whittington, 2012). The

practice perspective thus confronts a central issue: How are social structures and human agency linked together in the explanation of action?

Balancing between competing demands not only depends on balancing competing logics, but also depends on balancing mechanisms of integration and differentiation – and doing so across the different levels of organisation and individual. Closely examining the emergent structures in interaction with the CRISPR technology gives an understanding of the practice drivers that entail emergence, improvisation, and change over time (Schatzki, 2013; Shove et al., 2012) as practitioners alter their habits of use and the role they play themselves, thereby enacting different technology related practices. Successful behaviour is repeated, establishing and reinforcing its legitimacy. However, this is not straightforward and often a process of trial and error. People improvise; they make mistakes; change intentions; try new twists; or sometimes, just might be lucky and find an incremental practice improvement. Practices and practitioners do, therefore, have the potential for endogenous organisational structuring. Practitioners constitute structures in their recurrent use of the technology as structuring occurs through practice (Orlikowski, 2000; Giddens, 1979, 1984; Bijker et al., 2012) thereby giving rise to organisational differentiation. Thus, hybridisation not only appears at an organisational level, but is linked to integration of the different logics within practitioners, their activities, and attached meanings.

Whilst the initial practitioners (the scientists) turn hybrid, new people are also invited to join and to further the development of the organisation – thereby

changing an organisation's characteristics. Attracting new people (and then organising them) is central to constituting the organisation and subsequently materialising a new technology. As technology and organisation develop, new kinds of expertise and professional activities are drawn in, each with their own role and expectations; for instance, capital is provided by investors to pay for more experiments and clinical trials conducted by scientists, lawyers establish the IP of new technological applications, and administrative staff is hired to deal with bureaucracy and regulatory compliance. The data shows that the organisation can be "multiple things to multiple people" (Kraatz and Block, 2008, p.244); for example, the scientist will look at the scientific aspects to which the organisation tailors, as where the financial analyst is mainly interested in market potential and stock valuation. This requires the development of structural solutions to prevent conflict between competing understandings.

We know that organisational structures help to manage institutional complexity (cf. Greenwood et al., 2017; 2011; Pache and Santos, 2013), and we have some insights as to how individuals balance institutional complexity within existing organisations (Raey and Hinings, 2009; Noordegraaf, 2011; Giacomelli, 2020), but there is little exploration of how individual practices emerge in relation to emerging organisational structures in the face of (shifting) institutional complexity (Gümüsay et al., 2020; Niccolini, 2011). Past research identified differentiation (Battilana et al., 2012; Battilana et al., 2015; Battilana et al., 2017) and integration (Battilana and Dorado, 2010; Ebrahim, Battilana, and Mair, 2014; Mair et al., 2015; and Pache and Santos, 2013) as two approaches to deal with the tensions that may emerge from

hybridisation. *Differentiation* entails structurally separating conflicting practice elements while *integration* entails bringing the conflicting elements together (cf. Klein and Amis, 2020). The separation of both mechanisms gives "a simplified view of change" (Delbridge and Edwards, 2008, p.304). Recent work started to explore the combination of both (Smets et al., 2012; 2015; Smith and Besharov, 2019; Klein and Amis, 2020), but even when combining both exigencies everyday work has not been included as part of one of them (Gümüsay et al., 2020). We argue that by linking both the mechanisms of differentiation and integration across the levels of the individual and the organisation, whilst focusing on the practitioner and its everyday activity, offers more nuanced understanding of the dynamics. From the data we know that both practitioners and organisations can capitalise on interdependencies between logics "academic practice x commercial meaning" *or* "academic practitioner x commercial practice", and not just remedy conflicts arising from their tensions. Thornton and Ocasio (2008, p.120) already argued "work on institutional logics is inherently cross-level". Nonetheless, the majority of related empirical studies tend to focus on one level or another, such as on the individual (e.g. Creed, DeJordy, and Lok, 2010; Lok, 2010) *or* on the organisation (e.g. Perkmann et al., 2019; Battilana and Dorado, 2010; Jarzabkowski, Matthiesen, and van de Ven, 2009; Jarzabkowski et al., 2009) – with exception of Smets et al.'s (2012) study of German and English professional logics colliding in a law-firm merger. In line with Besharov and Smith's observation (2014, p.376) that "there is a paucity of theoretical work conceptualising how factors at multiple levels of analysis affect the manifestations of logics in organisations" we furnish insights through our practice lens into practical actions in situations of novel institutional complexity. We highlighted the importance of

acknowledging the micro-level and the link between the mechanisms of personal integration at the practitioner-level and that of structural organisational differentiation at the organisational-level.

5.5.3 Pre-empting contested conflict

Third, we derived how through the interplay of the mechanisms of "organisational differentiation" and "personal integration" conflict in contested hybrids can be "*pre-empted"*, allowing for a more aligned form of hybridity. Practitioners pre-empt conflict by creating better compatibility from the outset instead of managing it once people are inside the organisation. We saw that the CRISPR organisations have a high risk of "*contested"* hybridity (Besharov and Smith, 2014): both the competing logics of science and commerce are highly central to the organisational function. There is substantial knowledge about how existing hybrids manage conflict through existing organisational structures (cf. Perkmann et al., 2019; Smets et al., 2015; Pache and Santos, 2013), or how new practices and logics are introduced into hybrids alongside new people (Battilana and Dorade, 2010); yet little is known about the process in which new practitioners representing a contested logic can be invited without causing extensive conflict. Surprisingly there is less conflict in the hybrid CRISPR organisation once it exists than one would expect. This is because it has been more carefully designed in accordance with what is needed to develop the technology; the main reason why the organisation was developed in the first place.

According to Besharov and Smith's (2014) framework for hybrids CRISPR organisations should "contested hybrids". Not succeeding to create synthesis

between competing demands may turn tensions into clashes that threaten, demise, fragment, or paralyse the organisation (Greenwood et al., 2011). These are particularly relevant risks in the early years of an organisation as at this stage the central goal of the spinout is becoming viable and to "make it to the start line". Although fears for these tension were expressed by informants, such as concerns about conflict of interest as 'going commercial' was considered 'going over to the dark-side' by colleagues, these conflicts were actually minimally visible in the spinout organisations. We observed that challenges of conflict associated with being a *"contested"* hybrid were *pre-empted.* This occurred through two dynamics, both are visualised in figure 5.3.

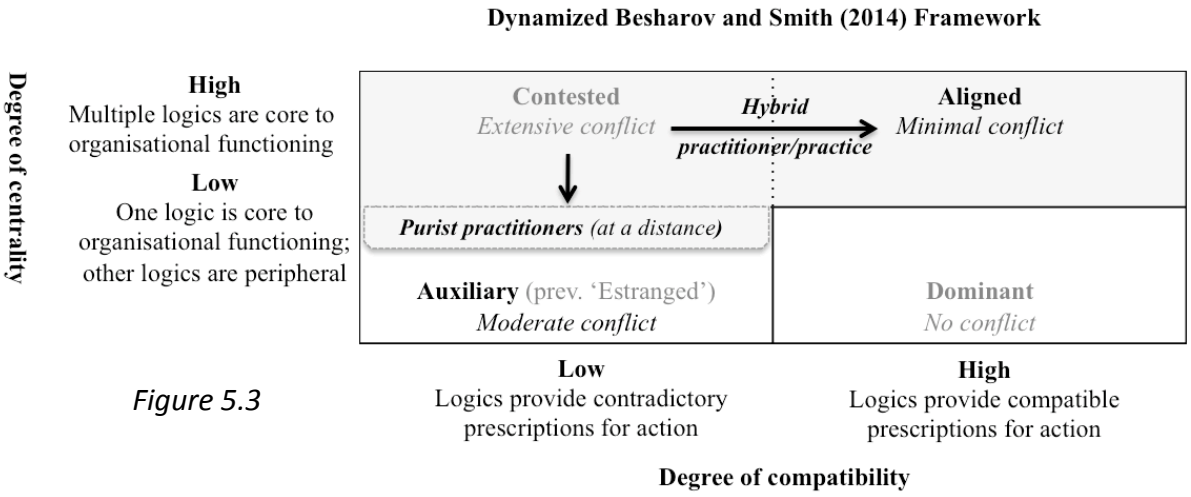


Figure 5.3

First, practitioners are able to reassign and re-allocate the meaning of their own practices, as discussed in the first contribution. They thereby enhance compatibility through reinventing practice and reinventing practitioner (giving rise to hybrid practitioners and hybrid practices), and thus create *"alignment"* between contested logics through "personal integration". For instance, the academics in the organisation reshape themselves as science-entrepreneurs to be more receptive to the corporate logic. Something similar occurs in terms of "organisational

differentiation": We found that hybrid practitioners are exercising agency in choosing how to become more commercial. They do this by selecting and inviting those representatives of another logic into their organisation that enact the contested logic in such a way that there is more compatibility with their own practices, expectations, and belief system so that integration becomes much easier. The data shows that when activity occurs that departs from the parameters of a prevailing logic, practitioners (re-)negotiate institutional complexity by foregrounding and giving voice to particular audiences, while silencing or subordinating others. The practitioners establish 'who matters' and, by implication, whose logic should apply – opening up the possibility of giving existing activity a new meaning: for instance, a professional management board raising funding for scientific research. Consequently, the core of the hybrid organisation becomes populated with hybrid professionals that integrate with each other. Reflecting on Besharov and Smith's framework (2014) there is a high centrality of contradictory logics, but build-in in such a way through hybrid professionals that there is surprisingly high compatibility (alignment) and minimal conflict.

Second, it may be instrumental for organisations to draw on non-hybrid practitioners. On each side of the spectrum has 'purists': practitioners with an entirely academic focus, or those with an entirely commercial focus. They may poses relevant expertise like an academic professor that can advice on the scientific core process; or, their activities may have direct implications for the organisation such as the financial analyst making calls on what stock to champion for what share price thereby driving an organisation's valuation, market potential, or legitimacy. There is

low compatibility between the 'purists'. It was observed that these practitioners are kept in peripheral areas of the firm. However, instead of being "*estranged"* (low compatibility and peripheral) the purists on each side of the spectrum can be essential to the organisation. The hybrid professionals at the core of the organisation draw on these purists in an *"auxiliary"* manner. This way conflict is pre-empted as the purist professionals do not get together and maintain a lower degree of centrality. For instance, the academic professor can be part of a scientific advisory board and the investment professional is part of an external team hired on a consultancy basis. In this manner the hybrid professionals maintain the core of the organisation whilst allowing for non-conflicted linkages with "purist" professionals. This observation shows that practitioners can be both low in compatibility, peripheral, yet not "estranged".

Thus, practitioners "pre-empting" conflict through proactive "alignment" or by drawing on purists in an "auxiliary" manner. This way conflict between competing logics is minimalised where there would otherwise have been a risk of a highly contested core of the hybrid organisation. That is why, much to everyone's surprise, there is actually less conflict in the CRISPR organisations once the organisation exists – because it has been more carefully designed by creating better compatibility from the outset and not by managing it once people are inside the organisation.

These three contributions *jointly* illustrate the value of incorporating technology as practice into discussions of institutionalism, thereby joining others in management research in a more general turn to adopting the 'practice' driven label (Whittington,

2019) through “Technology-as-Practice”: People come together as technology related practice can be a central ingredient to the emergence of organisations.

5.6 Generalizability, scope, and further research

To what extent are our findings generalizable? Practitioners, as scientists turn entrepreneur, find themselves torn between the competing belief systems of that of the academic and that of the commercial logics. We observed how practitioners pre-empt conflict and establish organisational structure to mitigate such conflict at the earliest moments. If and how the practitioners resolve these tensions can be crucial for the survival and success of an organisation, especially at the spinout stage. Not being able to pre-empt or manage the tensions may stall the development of the organisation as well as that of the technology it aims to materialise. Drawing attention to the interplay between personal integration and organisational differentiation can help institutional analysis and may facilitate further insight into how practitioners build organisational structures that enable the materialisation of new technological applications throughout the process of commercialisation.

Institutional theory stands to benefit from such a micro-foundational practice-driven insight into hybrids (cf. Gumusay et al., 2020; Smith and Besharov, 2019; Furnaci, 2014), because it can help institutionalists in developing a more accurate and granular understanding of those logics instantiated in everyday praxis of the organisation (Whittington, 2019; Smets et al., 2017), its practitioners (McGivern et al., 2015; Reay and Hinings, 2009), and surrounding network (Perkmann, 2016) – especially in relation to technology (Nicolini et al., 2020; Jones et al., 2013). To date,

most research on institutional theory has been focussing on the inter-organisational field level for analysis, mainly paying attention to the development and diffusion of rules, norms, and cognitive-cultural practices that span the boundaries of organisations, social networks, industries, and countries (Scott, 2008b). Organisational and individual behaviour are largely taken for granted as they are stylised in customs, social norms, and laws (Van de Ven and Lifschitz, 2012). By zooming in on the dynamics of reinventing practice and practitioner, this paper replied to the call for "…a clearer picture of which elements of the logics actors in organisations enact as they navigate competing demands, as well as what factors drive these behaviours" (Pache and Santos, 2013, p.973); and, the need for "…a richer understanding of how individuals locate themselves in social relations and interpret their context,.. how organisational participants maintain or transform the institutional forces that guide daily practice,… (Powell and Colyvas, 2009, p.2). In our response to these questions we join a growing interest in identifying the micro-foundations of institutional theory and how they affect the macro-level (Whittington, 2019; Nicolini, 2011; Gumusay et al., 2020; Smets et al., 2015; Powell and Colyvas, 2009).

Our findings are subject to a likely scope condition, as the sample used in this study was not exhaustive. The focus was on CRISPR applied for human health innovations as this was the field for which CRISPR applications were originally intended for, and where the technology's development gained most traction at the earliest moments of commercialisation. Geographically the focus was on the West because this was here that the initial developments took place. Soon activity also moved to China –

and only later to other places. China proved difficult to gain access to due to secrecy and language barriers, and this option was soon dropped nonetheless, for future research it would be interesting to see what tendencies of co-constitution and commercialisation can be observed between culturally more different institutional fields – like between Asia and the West – as different norms, values, and practices might prevail. Furthermore, the studied timeframe is between the years of 2013 and 2018. This period covers the first five years that CRISPR was commercialised and was highly formative for the development of the first applications. This window presents a time bound consideration of a dynamic process. Future research into maturing and contrasting first and second wave organisations could produce fascinating longitudinal insights into how a promising yet controversial technology like CRISPR is further absorbed into our society.

In addition, this research focused on the emergence of technology-as-practice and the phenomenon of the commercialisation of CRISPR, studied as it unfolded. We can recommend to future institutionalists researching the emergence of technology to study the phenomenon in real-time, as this significantly informed my thinking and theorising. We observed first-hand how different practices came to matter as an organisation commercialises academic technology. Real-time experience later became an important observation regarding the development of the organisations, its change in priorities, and how different practices came to matter in the process of technology commercialisation. The result was a pivot of the study towards second wave CRISPR companies. This experience limited access and partly derailed the

research temporarily. At the same time it informed our theorising as it lay bare the very process that we were studying.

Finally, parallels can be drawn between CRISPR and other emergent multi-purpose technologies. With the arrival of the Fourth Industrial Revolution (4IR), technologies fuse, blurring the lines between the physical, digital, and biological spheres (e.g. Church, Gao, and Kosuri, 2012; Church and Regis, 2012 Kang, Coates, and Strawderman, 2020). Advances in artificial intelligence, robotics, quantum computing, nanotechnology, and biotechnology have the potential to disrupt society in a profound and similar way (Schwab, 2016).

5.7 Conclusion

To date, institutional theory has not looked at the dynamics of use when both technology and organisation are emergent. Our study on the commercialisation of CRISPR illustrates that when people come together to interact over a new technology, this very interaction constitutes in their on-going practices the development of both novel organisations and technological applications. The focus of this research was on the earliest moments when organisational structures and technology are being conceived – and both still need to be developed. How to study structures that do not yet exist? By examining the activities that create the structures. Human activity relies on practices, supported by (institutional) rules and resources that are structural by token of their enduring and pervasive nature. As people organise themselves to further develop applications with the genome editing technology of CRISPR, technology becomes a central reason and a common ground for people to come together and interact with each other on the basis of everyday

work. It is their collective performance of practices that constitute the organisation and new CRISPR applications. This way, practitioners materialise uses of CRISPR technology as they construct both organisation and technological applications through their practices. How organisations emerge, replicate, and change, shapes how technology is developed, adopted, implemented, and used – and vice versa. We showed that in the earliest moment, when technology spins out of the university and an organisation is formed, both technology and organisation take shape through negotiations of multiple logics at the level of the practitioner. To better understand this process and this negotiation over contestation and constitution for development, adoption, and use; we developed an integrated model of organisational differentiation and personal integration that emphasises the role of practitioners, meaning, and activity in shaping both technology and organisation. The model describes how through reinventing practice and practitioner seemingly inevitable conflict between logics can in-fact be pre-empted. The aligned of these competed logics can be integrated into a structural solution through technology-as-practice.

6. THE CO-CONSTITUTION OF ORGANISATION AND TECHNOLOGY

6.1 Introduction

The focus of this chapter is on the earliest moments that technology and organisation co-constitute each other through 'technology-as-practice'. The emergence of organisation and CRISPR technology depends on navigating logic borne tensions following from pluralistic interpretations of the technology - figure 6.1. Overall, this chapter makes two novel contributions to the literature.

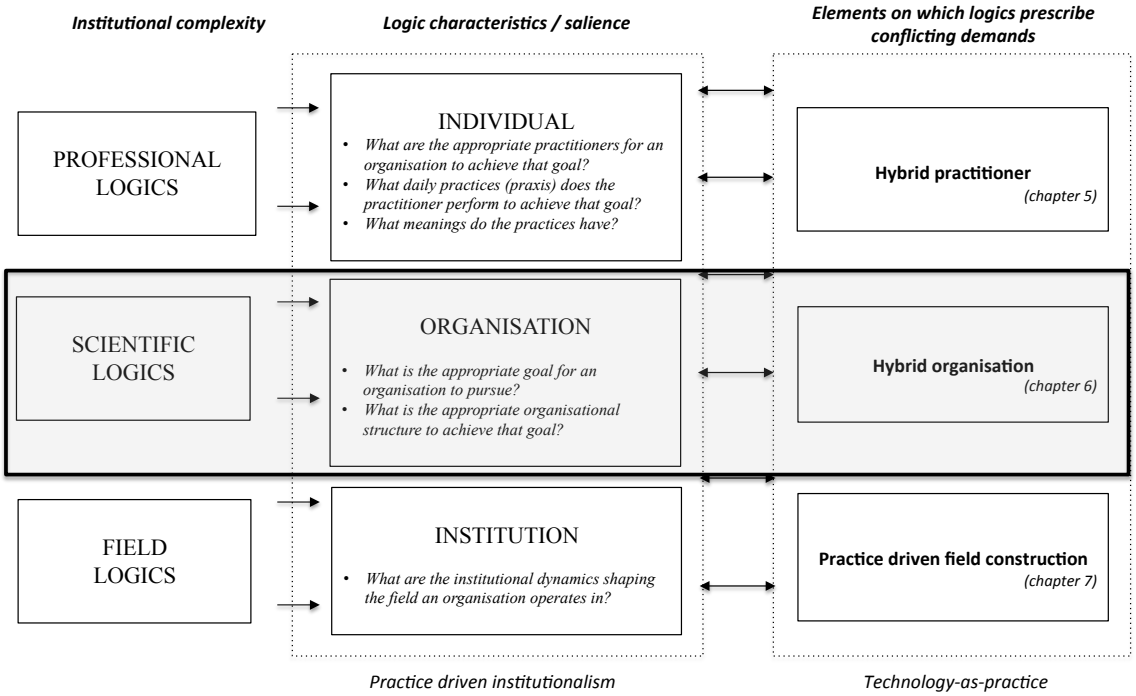


Figure 6.1: the positioning of this chapter in the thesis

Firstly, the literature understands 'structuring' as the 're-structuring' of existing structures; the focus is on how existing structures experience organisational change following internal incentives (cf. Orlikowski, 2000), institutional incentives (cf. Lounsbury, 2008; Seo and Creed, 2002) and – but to a far lesser extend – in interaction with existing technologies (cf. Garud and Karnoe, 2001; Leonardi and Barley, 2008) – see also the literature review, chapter two. This chapter responds to calls for research on how structuring / organising starts at the "earliest moments" (Smets et al., 2012, p.877; see also Smets et al. 2015; Gümüsay et al., 2020), why specific organisational elements emerge (Pache and Santos, 2013), and how this occurs in co-constitution with newly emerging technology (e.g., Murray et al., 2020; von Krogh, 2018; Smets et al., 2017; Leonardi and Barley, 2008). By looking at the earliest moments of structuring – this entails the emergence of structure and thus not 'restructuring' – it was observed that the process is anchored by three different determinants. Depending on which one preponderates during these first moments of engagement shapes the focus in the co-constitution process of technology and organisation. The different determinants are identified as approaches: *'technology led approach'*, *'organisation led approach'*, and *'institution led approach'*. Each approach is associated with a different set of practices that prioritise different organisational elements on which logics prescribe conflicting demands, such as an emphasis on technological development, organisational structuring, and institutional pressures.

Secondly, it was found that the practices associated with the three approaches are equally relevant for the survival of the organisation – although they may be

prioritised differently – as each presents a part of the process of co-constitution with its own demands and tensions. Unpacking the "black box" of the organisation, we find *inside the box* those practices that define the appropriate organisational objectives and structures. "An organisation, like any social phenomenon, is a bundle of practices" (Schatzki, 2006, p.1863) – it is the nexus of different practices as it brings together the three approaches in an integrated and practice driven manner. Institutions form the context *around the box.* The chapter responds to the observation of Smets and colleagues (2017, p.36; see also Whittington, 2006) that despite the recent coming-together of practice and institutional perspectives "few scholars appear to be looking *at the box*; or more precisely, at organisations and their specific properties". By (re-)establishes the focus on how organisational parameters moderate the interactions of practice and institutions, practice driven institutionalism (Smets et al., 2012) is extended with the observation that CRISPR technology and organisation co-evolve in an integrated multi-level fashion. The next sections consist of a presentation of the findings, followed by a discussion, and conclusion.

6.2 Findings

This section presents the findings and is structured as follows: (1) the data-to-theory connections of the three approaches that drive the co-constitution of technology and organisation, (2) an elaboration of the technology centred practices, (3) an elaboration of the organisation centred practices, and (4) an elaboration of the institution centred practices.

6.2.1 Data-to-theory connections

The data-to-theory connections of this chapter are summarised and visualised into a theoretical framework presented in the format of a data structure (figure 6.2). The development of new applications and the formation of the organisation that provides for these developments is not a straightforward process. CRISPR, the practitioners, the practices, and the organisations, configure various development trajectories in which technology and organisation are co-constituted. Building on different expertise, understandings, people, and networks, organisation and technology are subject to diverse pressures of competing demands.

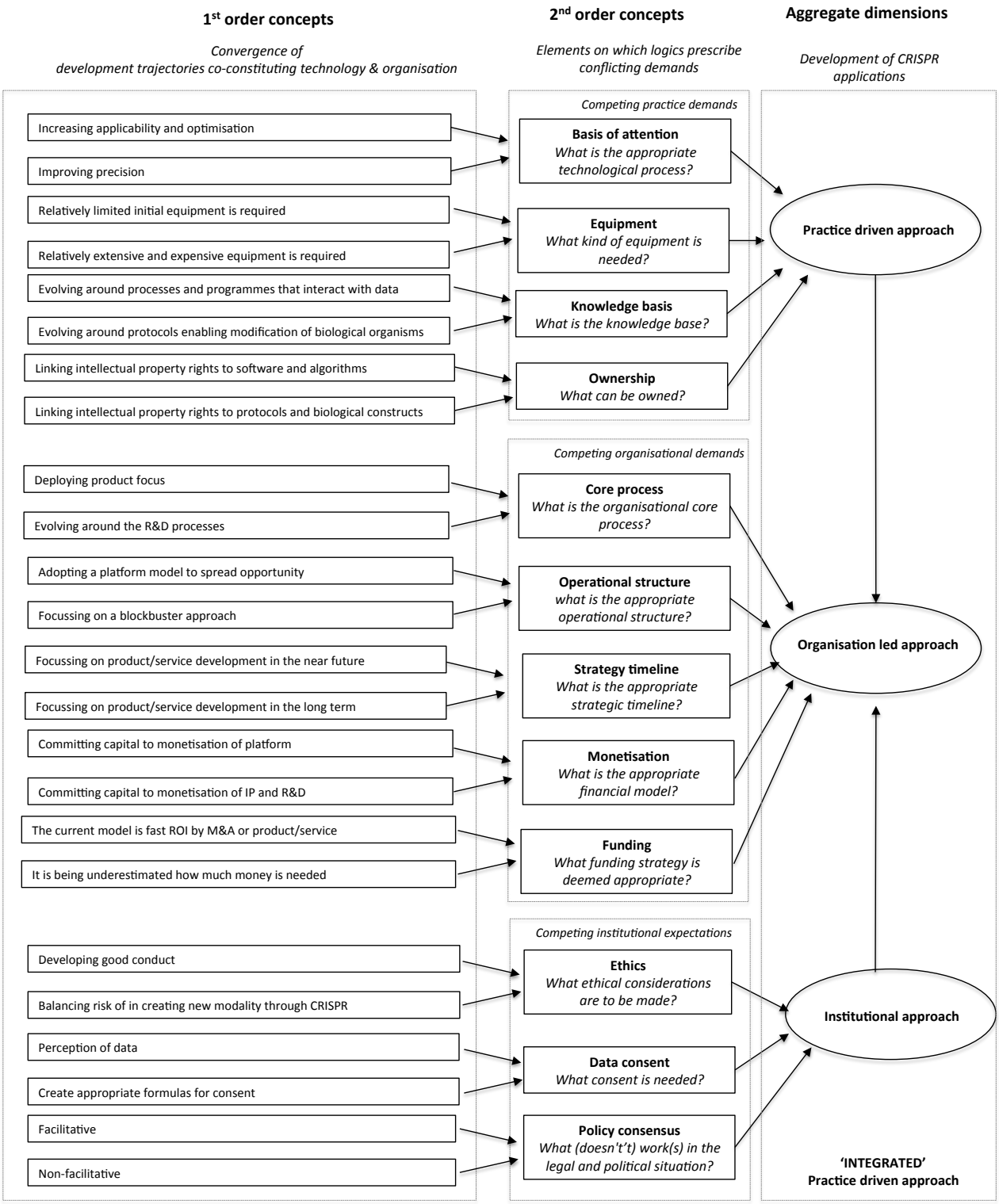


Figure 6.2:Data structure

Analysis brought forward deeper structures and processes that helped to understand and formulate dynamics at a more abstract aggregate theoretical level. The data-to-theory connections are further illustrated with examples of power quotes (Suddaby, 2006) in data table 6.1.

Table 6.1
Summary of Core Concepts, Empirical Observations, and Illustrative Data

Aggregate dimension	**Second order** *(Practitioners)*	**First order** *(empirical Observations)* **& Illustrative Data**
TECHNOLOGY LED APPROACH	TECHNOLOGICAL FOCUS	**Allowing for standardisation and scaling**
		"Thank god for the company otherwise they [the scientists] would have to do all of this… now my academic colleagues can maintain focus on exploring. The company provides focus while the scientists can continue to follow their own interests… … It is really simplifying things for us [academic researchers]. At the same time [it is providing the] development of user interface and standardisation [of the technology]." *(Interviewee #4, Co-founder)*
		"…some ideas are less suited for an academic setting, for example if you want to scale up. There are few academic labs that are larger than 10-20 people. This is easier in a commercial setting…" *(Interviewee #36, CEO & Founder, Professor)*
		Optimising and improving precision
		"Focus just on the top 2 (Cas9, Cpf1; Human, Mouse) – rest is waste of time, money, energy: the question to ask is what goes into the clinic?" *(Interviewee #7, COO & Founder digital CRISPR company)*
		"There are 6000 genetically defined diseases; for 95% there is no therapy; so called orphan diseases. Editas's goal is to expand the range of reparation." *(Interviewee #5, CEO)*
	EQUIPMENT	**Relatively limited initial equipment is required**
		Relatively *limited initial equipment* is required, such as a computer and software. The entry barrier is relatively low regarding necessities for establishing science-based business. (Obs.)
		Relatively exclusive and expensive equipment is required
		Relatively *extensive initial equipment* is required, such as an entire 'wet' laboratory. The entry barrier is relatively high regarding necessities for establishing science-based business. (Obs.)
		Especially equipment is expensive. There are local options that provide opportunities to lease equipment, such as 'Innovatie Credit' and 'MIBITON', but this is costly. It raises questions about future funding milestones. *(Interviewee #6, CEO & co-founder)*
	KNOWLEDGE BASIS	**Requiring digital expertise around processes and programmes that interact with data**
		"Algorithms help discover the "gaps in the minds of practitioners" – a pattern or trend that they may not have spotted… prevention of human errors… or to assist in decision making." (Doc.)
		The knowledge basis is "the study of processes that interact with data and that can be represented as data in the form of programs. It enables the use of algorithms to manipulate, store, and communicate digital information." (Doc.)
		Evolving around synthetic biology enabling modification of organisms
		"The accuracy and reliability of the CRISPR technology are severely hampered by the off-target effects - unintended cleavage of DNA at sites whose sequences show mismatches with guide RNA. Therefore, reducing the off-target effect becomes a timely critical issue in CRISPR genome editing technology." (Doc.)
		"The knowledge basis is a set of concepts, approaches, and tools that enable the modification or creation of biological organisms, aimed at improving the process of genetic engineering." (Doc.)
	OWNERSHIP	**Linking intellectual property rights to software and algorithms**
		Practices evolve around the development and use of code and algorithm. Intellectual property rights are linked to (digital) software and algorithms. (Obs.)
		"The digital, powered by artificial intelligence, includes software for the design and simulation of biological system, as well as methods of collating, connecting and analysing experimental data." (Doc.).

		Linking intellectual property rights to protocols and biological constructs
		"So there is a third party inclusive product, companies get 2 years of exclusivity on a license. This was also how Editas was founded. It had to chose the genes it wanted to develop. There are about 20.000 genes, and it can't develop something for all of them at the same time. So they got exclusivity and a first shot at which genes they wish to develop. The rest of the genes is free for others to use" *(Interviewee #3, Chief Business Officer University Institute)*
		Practices evolve around the development of biological construct through the modification or creation of biological organisms, and protocols aimed at improving the process of genetic engineering. Intellectual property rights are linked to physical biological constructs. (Obs.)
ORGANISATION LED APPROACH	CORE PROCESS	**Deploying product focus**
		"There are 6000 genetically defined diseases; For 95% there is no therapy; so called orphan diseases. Our company's goal is to expand the range of reparation." *(Interviewee #5, CEO)*
		"The uses of CRISPR are widespread: reagents, manufacturing, etcetera million different applications." *(Interviewee #3, Chief Business Officer University Institute)*
		Evolving around the R&D processes
		"Although we develop an orphan drug, you have to see it as a locomotive behind which we can hang small wagons. It is an innovation that opens doors for other developments." *(Interviewee #38, Chief Corporate Development Officer, serial entrepreneyr)*
		"A medicine is 2.5x times more expensive after an M&A, because that is the revenue model. If you buy it you must also be able to recoup it. In 2016, $135 billion of drug development was spent, and only 24 compounds were put on the market. That is $7.5 billion per drug on average. The costs go up and the demand goes down." *(Interviewee #34, CEO & Founder)*
	OPERATIONAL STRUCTURE	**Adopting a platform model to spread opportunity**
		"Reason for a platform-company approach is a 'not all eggs in one basket'-approach with more shots at success." *(Interviewee #38, Chief Corporate Development Officer)*
		What we see now, is a huge boom in the upsurge of small platform companies that focus on providing service. Their plan is to build products of this platform." *(Interviewee #40, Partner EY, expert on biotechnology industry)*
		Focussing on a blockbuster approach
		"Editas is focussed on just 1 technology – so it will be difficult/impossible for them to defer or to drop the development." *(Interviewee #3, Chief Business Officer Broad Institute)*
		The pharmaceutical industry is dominated by the blockbuster business model, that has a peak annual sales exceeding $1bln and typical for use by general population or large subset. Firms build their operations around a few blockbuster drugs that produce the bulk of their revenue and determine their strategy. (Doc./Obs.)
	STRATEGIC TIMELINE	**Focussing on product/service development in the near future**
		A short term focus (within +/- 3 years) in time line for product/service development and time to market (Doc.)
		"Developing a product-focussed mentality is essential to an AI-centred operating model. The reams deploying AI-centred applications must embed a deep understanding of application settings they are designed to enable, as with any product-focussed effort. (Doc.)
		Focussing on product/service development in the long term
		Long term focus of +/- 12 years on average in time line for product/service development and time to market. (Doc.)
		Traditional drug discovery requires a long development cycle absorbing most capital. The organisation evolves around the R&D process. (Obs.)

	MONETISATION	**Monetisation of IP and R&D platform**
		"We have incurred net losses in each period since our inception, anticipate that we will continue to incur net losses in the future and may never achieve profitability: We are not profitable … our net loss was $31.6 million for the year ended December 31, 2016. As of December 31, 2016 we had an accumulated deficit of $53.6 million. We expect these losses to increase as we continue to incur significant research and development and other expenses related to our ongoing operations, seek regulatory approvals for our future product candidates, scale-up manufacturing capabilities, maintain, expand and protect our intellectual property portfolio and hire additional personnel to support the development of our product candidates and to enhance our operational, financial and information management systems." (Doc.)
		"The aims are to develop a new way to look for drug targets. The business case is to find such targets, and to generate added value based on these premises." (Int.)
		Monetisation of a product
		"When reimbursed, who pays for it? We need to check with the payer, and see if it works. Because every cell is unique, so we would need to filter patients, and save money by checking whether the treatment will actually work – like with personalized medicine." *(Interviewee #7, COO & Founder digital CRISPR company)*
		Higher burn rate and scale of development costs in Bln/product (Doc.) results in a relatively short time to IPO (+/- after 3 years) (Obs.)
	FUNDING	**The current model is fast ROI by M&A or product/service**
		"When reimbursed, who pays for it? We need to check with the payer, and see if it works. Because every cell is unique, so we would need to filter patients, and save money by checking whether the treatment will actually work – like with personalized medicine." *(Interviewee #7, COO & Founder digital CRISPR company)*
		"The thing is though, normally, investors don't get too enthusiastic about target identification and sequence mapping… they rather see your product in a mouse, or even better, a patient. It means a shorter timeline. We don't even have the targets yet, just the platform that will help us 'hopefully' find them." *(Interviewee #36, Scientist / CEO)*
		It is being underestimated how much money is needed, you need a long breath
		"We operate in an extremely capitalistic manner, we do not do it based on subsidies. There is 1/3 of our own money in the company as financing. We are tough capitalists and want to keep 20% returns. We do not have a new vision as a company, but we do have a new potential market of 500 billion; Many do not realise that. But you need 50-100 million to produce a MPV [minimal viable product]. What we want to avoid is "drip financing", that every time a little bit is financed and you actually do not have the chance to make big leaps." *(Interviewee #38, Chief Corporate Development)*
		"There are mechanisms, but you have to understand them. You have to look at the entire timeline; and have suitable investment mechanisms for each stage." *(Interviewee #30, Serial entrepreneur, CEO, Professor)*
INSTITUTION LED APPROACH	ETHICS	**Balancing curiosity with 'good' conduct**
		"There is still too much focus on technical review, not much looking at any further consequences." *(Interviewee #18, World leading CRISPR expert)*
		"Balance, but learn to live with risk. Should you restrict or not restrict certain developments? Give as much thought as you can; that should offer sufficient protection [against possible risks]. The lawyers that advice the Broad are completely risk averse, but this approach does not bring any progress… very cautious, too cautious. Be thoughtful." *(Interviewee #3, Chief Business Officer Research Institute)*
		Balancing risks in creating new (biological) modality through CRISPR
		"Only focus [in applying the technology] on the areas you understand very well**.** Especially since regulatory and policy support is lacking, and regulations are always lacking somewhat behind. For therapeutics, don't do germ-line edits, don't work on eggs. Look at what has been developed well

	or not so well. What are the Pros or Cons and make sure to consult the actual experts in the field. *(Interviewee #3, Chief Business Officer University Institute)*
	"This [CRISPR] is a new dimension of therapeutics. It is a new modality. No-one has done this before. The bioethics applicable is another than for other biotech companies. Ours is more challenging, because of the nature and the possibilities of the technique. We need a long-term vision. Ours is." *(Interviewee #5, CEO)*
DATA CONSENT	**The perception of data**
	"Patients give body material to scientists, who develop something with it; after which it must be commercialised in order to become relevant. So you go from nothing to something. But that 2nd step is not appreciated, and brings complications with it. Because patients who have given their body material are very positive about the first step, but the 2nd step they are often wary about and do not want it to happen – they are against commercialisation. From free, to something that has economic value – how can you set up something so that all parties think it's fair? The body has become very valuable. This is perception dependent; who is allowed to do research with the data of the patients, only academics or can this data also be used for the next step of commercial development?" *(Interviewee #26, Professor / Senator)*
	"The difference between biological data and digital data? Both are exactly the same". *(Interviewee #10, Bioethicist on CRISPR)*
	Create appropriate formula for consent
	"There is an urgent need for a new formula for gaining consent [in collecting data from human subjects]. You find that addressing this issue is incredibly sensitive. It is highly sensitive to challenge existing guidelines on norms and values. Even if they no longer match the reality." *(Interviewee #10, Bioethicist on CRISPR)*
	"Comprehensive data sets to establish informatics links among ten thousand to a million human genome sequences and extensive phenotype analyses are needed to effectively generate and test hypotheses, but they also enable the identification of the individuals whose DNA sequences they contain. This puts the validity of the existing consent protocols into question." (Doc)
POLICY CONCENSUS	**Facilitative**
	"Policy-makers are data driven agencies. The FDA gets how it works and has the necessary authorities to make the calls. Genome editing has been around for a while; so the technical concepts exist, and the current approach is to regulate products, not technologies. These rules are not appropriate anymore. Tech standards need to get better; this is contextual. Look at data and context where you want to do it. But this requires flexibility." *(Interviewee #5, CEO)*
	"So there is the new political US regime versus the old: coordination for a coordinated regulation and policy framework was underway under Obama, but all was abolished under Trump. New tech has to fit into the framework. Currently there is basically an impasse as no revisions have been made. It didn't help that the White House science & tech committee was abolished under Trump." *(Interviewee #10, Bioethicist on CRISPR)*
	Non-facilitative
	"Politicians sometimes publically state really awkward things, but in spite of that the intentions are of course good. But good intentions should not be at the expense of safety in humans. For instance, the government now wants to completely abandon animal testing by 2025. The industry wants to abandon animal testing as well, but the timeline needs to be feasible. With the current status of things, it is more likely that this policy will not be successful and that statements like this will only making it less attractive for companies to settle here." *(Interviewee #28, Chairman science park)*
	"This kind of [political] interference can be perceived as fairly careless and discourages investors. Investors wonder, will it be difficult to be reimbursed later?" *(Interviewee #34, CEO & Founder)*

It was observed that tensions cannot sufficiently be explained based on the conflicting belief systems of academic science and commerce, as addressed in chapter four and five. Friction continues to surface once CRISPR is translated from academia into science-based business. Table 6.1 shows that tensions and clashes can be observed as structures are enacted that are embedded within different scientific, organisational, or institutional perspectives. These tensions cut across all layers and tie in with decisions making regarding belief systems, related structures, and enacted practices. Technology gives an additional dimension of complexity to these tensions. A brief example of such tensions is listed in Table 6.2 using a method by Thornton and colleagues (2004; 2005; 2012). A new set of behavioural characteristics was observed giving shape to different underlying processes and associated practices. The scope of these logics is of a hands-on nature: two different scientific disciplines and their different approaches converged into a single CRISPR application – for instance, digital and biotechnological. Frameworks to support such converged, or hybrid, innovation emerge as the organisation aims to unite different disciplines around a shared purpose. Different considerations emerge in addition to those between academia and commerce, the data structure puts forward three different sets of competing demands for divergence in the development of CRISPR organisations: (a) demands observed directly related to decisions on the development of the technology; (b) demands observed directly related to decisions on the development of the organisation; and, (c) demands observed directly related to decisions linked to the influence of institutional settings. The practices related to each of these tensions (and related decisions) are now discussed.

Table 6.2
Representative Indicators of Tensions between Competing Belief Systems of the Ideal Types of Scientific Logics across different Organisational Properties

Key characteristics	**Digital logic**	**Biotechnology logic**
Sources of identity	**Engineering/AI**: The knowledge basis is "the study of processes that interact with data and that can be represented as data in the form of programs. It enables the use of algorithms to manipulate, store, and communicate digital information." (Doc.)	**Synthetic biology:** The knowledge basis is a **"**set of concepts, approaches, and tools that enable the modification or creation of biological organisms, aimed at improving the process of genetic engineering." (Doc.)
Sources of legitimacy	**Commitment to and expertise in coding for analysis**: "The digital, powered by artificial intelligence, includes software for the design and simulation of biological system, as well as methods of collating, connecting and analysing experimental data." (Doc.). Relatively *limited initial equipment* is required, such as a computer and software. The entry barrier is relatively low regarding necessities for establishing science-based business. (Obs.)	**Commitment to and expertise in genomics for drug discovery:** "The aims are to develop a new way to look for drug targets. The business case is to find such targets, and to generate added value based on these premises. Genomics is used to develop innovative therapies for patients affected by severe diseases and to initiate a pipeline of preclinical discovery programmes for rare genetic disorders." (Int.) Relatively *extensive initial equipment* is required, such as an entire 'wet' laboratory. The entry barrier is relatively high regarding necessities for establishing science-based business. (Obs.)
Basis of attention	**Status of increased applicability and optimisation:** "Algorithms help discover the "gaps in the minds of practitioners" – a pattern or trend that they may not have spotted… prevention of human errors… or to assist in decision making." (Int.)	**Status of improved precision:** The accuracy and reliability of the CRISPR technology are severely hampered by the off-target effects - unintended cleavage of DNA at sites whose sequences show mismatches with guide RNA. Therefore, reducing the off-target effect becomes a timely critical issue in CRISPR genome editing technology." (Doc.)
Basis of strategy	**Short term focus** (within +/- 3 years) in time line for product/service development and time to market (Doc.)	**Long term focus** (+/- 12 years on average) in time line for product/service development and time to market. (Doc.)
Organisation form	**Platform** model as *operational structure:* "Reason for platform-company approach is a 'not all eggs in one basket'-approach with more shots at success." (Int.) "What we see now, is a huge boom in the upsurge of small platform companies that focus on providing service. Their plan is to build products of this platform." (Int.)	**Blockbuster** model as operational structure: The pharmaceutical industry is dominated by the blockbuster business model, that has a peak annual sales exceeding $1bln and typical for use by general population or large subset. Firms build their operations around a few blockbuster drugs that produce the bulk of their revenue and determine their strategy. (Doc./Obs.)
Informal (quality) control mechanisms	**Product focus**: "Developing a product-focussed mentality is essential to an AI-centred operating model. The teams deploying AI-centred applications must embed a deep understanding of application settings they are designed to enable, as with any product-focussed effort. (Doc.)	**Process focus**: Traditional drug discovery requires a long development cycle absorbing most capital. The organisation evolves around the R&D process. (Obs.)
Economic system	**Capital committed to monetisation of platform**: Lower burn rate and scale of development costs in Mln/product (Doc.); time to IPO in the long term (!0.1 years) (Doc.)	**Capital committed to the monetisation of IP and R&D**: Higher burn rate and scale of development costs in Bln/product (Doc.); relatively short time to IPO (after 3 years) (Obs.)
Forms of ownership	**Digital**: Practices evolve around the development and use of code and algorithm. Intellectual property rights are linked to (digital) software and algorithms. (Obs.)	**Physical**: Practices evolve around the development of biological construct through the modification or creation of biological organisms, and protocols aimed at improving the process of genetic engineering. Intellectual property rights are linked to physical biological constructs. (Obs.)

Notes: Data extracts are marked "Int." (for interview), "Obs." (for fieldnotes), and "Doc." (for document); Categories derived from Thornton et al. (2012; 2004). The chief basis of these summaries are derived from data from this study.

6.2.2 Competing Technological Demands

Different competing demands were observed in terms of what practices were to be chosen regarding the development of CRISPR applications. These considerations spring from the type of technological application to be developed – e.g. therapeutic, digital, or otherwise – and have direct consequences for the form and shape of the CRISPR organisation – e.g. equipment cost, development time, or required R&D. Technological development and related practices sit at the core of the organisation and set the parameters for everyday practices. The findings produced the following second order concepts: *'technological focus'*, *'equipment'*, *'knowledge basis'*, and *'ownership'.* These findings followed from first order concepts constituting alternatives courses of action within each second order concept – each is addressed here.

Technological focus. For the consideration of the technological focus the central question is: What technological process is the appropriate basis (for the organisation)? Two general tendencies came forward from the first order concepts in the data. Firstly, a focus on *'standardising and scaling'*:

> "Thank god for the company, otherwise they [the scientists] would have to do all of this… now my academic colleagues can maintain focus on exploring. The company provides focus while the scientists can continue to follow their own interests… … It is really simplifying things for us [academic researchers]. At the same time [it is providing the] development of user interface and standardisation [of the technology]." (Interviewee #4, Postdoctoral research, Co-founder spinout)

The company thereby takes work away from the scientists, allowing them to focus on their academic research as the spun-out organisation further standardises the

technology. At the same time this gives an opportunity for scaling that would not have been possible in academia:

> "…some ideas are less suited for an academic setting, for example if you want to scale up. There are few academic labs that are larger than 10-20 people. This is easier in a commercial setting…" (Interviewee #36, CEO & Founder, professor)

Secondly, an alternative priority may be *'optimising and improving'* the application and precision of the technology at hand. This option arises if multiple courses of action potentially possible:

> "Focus just on the top 2 [the Cas9 or Cpf1 mechanisms; applied to human and mouse] – the rest is waste of time, money, energy: the question to ask is what goes into the clinic?" (Interviewee #7, COO & Founder)

In this case the technological applications are still uncertain and substantial R&D is required. How to apply, standardise, and scale is not yet clear and the primary goal is expansion of knowledge: "There are 6000 genetically defined diseases; for 95% there is no therapy; so called orphan diseases. Our goal is to expand the range of reparation" (Interviewee #5, CEO company). The 'technological focus' might shift over time or be adapted according to circumstances.

Equipment. Understanding what equipment is needed is crucial in synchronising technology and organisation as it helps to understand how organisation and technological development process take shape. '*Limited equipment'* may be needed, or for instance, *'Equipment can be expensive, highly specialised, or customised'*:

> "Especially equipment is expensive. There are local options that provide opportunities to lease equipment, such as [device A] and [device B], but this is costly. It raises questions about future funding milestones. (Interviewee #6, CEO & co-founder)

Having to buy, build, or lease equipment or laboratories can be determining in how the development processes takes shape as "…entry boundaries for commercialisation can be high in terms of the necessities that need to be accessed" (Interviewee #6, CEO & co-founder). If relatively generic equipment is needed different considerations are to be made. For instance company B1 does not need a laboratory and mainly works digital and virtual by using AI algorithms and software (Obs.). For them, any "heavy-duty off-the-shelve computer would do" (interviewee #7, COO & Founder digital CRISPR company).

Knowledge basis. What knowledge stands central in the development of the technology and organisation? This raises questions in terms of what expertise is needed. In the data sample two different tendencies were observed. First, that of requiring *'digital expertise'* to interact with data processes and programmes:

> "Algorithms help discover the 'gaps in the minds of practitioners' – a pattern or trend that they may not have spotted… prevention of human errors… or to assist in decision making." (interviewee #42, CEO)

The sample contains several examples of companies working this way. For instance Company B2 is a synthetic biology company that provides services by conducted experiments with automated robotic equipment. In 2017 they entirely shifted their focus to building a software platform for "…computer-aided biology that enables a high[er] throughput of experiments" (interviewee #78, Chief of translation medicine AI/genomics). The integration of experimental hardware with software allowed for the automation of biological complex experiments aided by multi-factorial machine learning.

Alternatively, the knowledge basis may evolve around *'synthetic biology'* enabling modification of organisms. For instance Company C1 was started in an academic laboratory at Harvard University and focuses on stimulating the human gut microbiome to enhance health, physical performance, and to counter diseases (Obs.). They incorporated "a new approach to probiotic nutritional supplements based of genomic insights" – using CRISPR techniques – that may enhance the performance of athletes (Interviewee #83, Chief scientific officer). Deciding on a particular knowledge basis formulates the foundation of an organisation. It determines many aspects for both technology and organisation (Interviewee #38, Chief Corporate Development Officer): for instance, "what expertise is needed within a team to be able to pull it of" – a laboratory technician or a software engineer? However, as the field is evolving the lines between digital and biological are slowly blurring, introducing hybrid experts such as the bioinformatician (Obs.).

Ownership. Intellectual property forms the basis for all the companies studied in the sample. However, ownership can be structured in various ways, for instance depending on whether it is *'digital'* or *'biological'*. Companies can work of (i) a nonexclusive license, (ii) an exclusive license, or actually (iii) own the intellectual property themselves (Obs.): "One of our founders holds the relevant patent as they developed it themselves" (Interviewee #38, Chief Development Officer)**.** If a company owns the full IP over a technology, the company or its founders likely developed it. However, ownership is not necessarily straightforward: In many cases when a scientist develops a technology the institution in which it was developed determines (partial) ownership: "In the US, IP often stays with the university, so that

if the company goes bankrupt the technology will not go down with it" (Interviewee #34, CEO & Founder; Obs.). Several research institutions reiterated this, for example:

> "Our IP policy? Revenue flows out, but Harvard maintains the ownership over the IP. The institute helps until the point of licensing. There is a Wyss chapter that guides on this: collaboration IP-wise with MIT, Harvard, Broad, Wyss, etcetera" (Interviewee #8, Business development specialist).

But arrangements can take sophisticated forms to stimulate commercial activity:

> "So there is a third party inclusive product: Companies get two years of exclusivity on a license. This was also how Editas was founded. It had to choose the genes it wanted to develop. There are about 20.000 genes, and it [the company] can't develop something for all of them at the same time. So they got exclusivity and a first shot at which genes they wish to develop. The rest of the genes are free for others to use" *(Interviewee #3, Chief Business Development Officer at renowned Institute)*

A division of labour might be build into the way licences are given out, as both academic and commercial parties may benefit from the establishment of such companies:

> "IP has been licensed to [Company C3]. The IP is owned by Harvard and the company wants to commercialise it. Specialisms are assigned. We have another company to make the stem cells. So the scientists in the [academic] Wyss Institute can maintain focus on things like [academic scientific] exploration." (Interviewee #4, Co-founder)

But this might also take shape differently and founders may have to negotiate over intellectual property with the research institution they are spinning out from:

> "Negotiation for IP rights with universities is always an absolute pain. We had to negotiate for to rights to our own IP [of an application we developed ourselves] in the US as well as in the Netherlands. It is always complicated." (Interviewee #36, CEO & Founder CRISPR company / Professor)

This university claims rights to the IP as it provided the scientists with the initial infrastructures and resources to be able to conduct their research from which new ideas sprout. They are reminded of contractual obligations attached to it. These

rights can also be structured in different ways with various options for IP valorisation:

> "There are a zillion different opinions on therapeutics and exclusivity - ranging from total openness to full exclusivity. How to funnel these opinions for safe and responsible development? We are talking about billions of [dollars of] investment here, but nonetheless we should try to avoid to tie IP and licenses up completely." *(Interviewee #3, Chief Business Officer Research Translation Institute)*

'Ownership' over technology and IP can take diverse forms: what can be owned, who owns it, how is it owned (trade secret, IP, licence, copyright), and for how long do they own it (patents may expire)? Different practices apply to digital, biological, product, process, or service (Obs.). Shape and form of ownership affects how, by who, and if a technology is further developed. It is paramount to understand underlying ownership structures to examine the development process of technology and organisation.

6.2.3 Competing Organisational Demands

The organisation makes up the nexus in the decision-making process of what practices enable development in technology and organisation, and how. At the organisational level dynamics follow from the 'core process', 'operational structure', 'strategic timeline', 'funding', and 'monetisation'.

Core process. What is the core process of the organisation? Many variations are possible as the organisation can be build around a *'production process'* or '*product / service'* – and the licensing of IP that may follow from that. the nature of those variations are linked to the technology. "Digital technologies and biology are

becoming more intertwined than ever" (Interviewee #7, Founder & CEO), the overlap is evident in the CRISPR field. All CRISPR companies in the sample use some form of digital tools to support and understand their technology development:

> "The digital, powered by artificial intelligence, includes software for the design and simulation of biological system, as well as methods of collating, connecting and analysing experimental data." (Doc.)

Some are even entirely focussed on the digital aspect and build AI and software systems for CRISPR (Obs.). It takes IT to understand and manipulate the world of biology. Although the fields of engineering and biology are complementary in their technical aspects and merge under the denominator of biotechnological research, friction can be observed within the day-to-day praxis within the organisations themselves (Obs.). Much alike, tensions could be observed with company C1 that experienced a combination of different scientific disciplines creating a complication between the logics that underlie the disciplines of nutrition and diagnostics:

> "Our future steps comprise of 'functional studies', fundraising $2-3 million, the recruitment of athletes, and to actually successfully spin-out of Harvard late fall this year. But of all these things, bringing communities together is most challenging. What I mean with that… VCs and their portfolios do not always understand what it is we try to do. It is because we are the intersect of [1] nutrition, and [2] diagnostics. They only know the one or the other. It is hard to find an investor that understands both. It seems to be necessary to educate investors. Maybe that way we can find a suitable lead-investor, a partner that wants to bring nutrients, science, and sports together. Currently lots of time goes into pitching the idea. We are receiving support in R&D, optimisation, and having a lab. One of our advisors is actually in venture capitalism. Our COO used to be in GoldmanSachs. But even for him it is difficult answering questions like, how much is it going to yield? What we do is completely new." *(Interviewee #2, CEO & Founder company C1)*

These kinds of tensions regarding the core process of the organisation may be a result of the novelty that comes with the introduction of new technology. Operating on the intersection between different disciplines can result in tension between the logics of those disciplines.

Operational structure. What is an appropriate operational structure for the organisation? Different approaches were observed between companies in the sample. Comparing structures the spectrum ranged from working on diverse products – *'platform model'* – to being very focussed and narrow in approach – *'blockbuster model'* –, and a mix of both:

For the *platform model* a diverse R&D portfolio is needed with a wide variety of potential products, like company A3: "The reason for [our] a platform-company approach is a 'not all eggs in one basket'-approach with more shots at success." (Interviewee #38, Chief Corporate Development Officer). The underlying thought is to create a diverse portfolio to spread risk and increase potential success of finding a suitable R&D pathway, target, IP, or application (Obs.).

The *blockbuster model* is focussed on developing a single application: "Editas is focused on just one technology – so it will be difficult or impossible for them to defer or to drop the development" (Interviewee #3, Chief Business Officer Research Translation Institute). This approach is the opposite of the first approach presented, and can be summarised as 'all eggs in one basket': If successful it will generate a large yield but in case of failure all is lost. In this example the IP holder, The Broad Institute that represents patents from MIT and Harvard University, acknowledges the risk: "Companies that take a licence have only one option; to move forward with the development of the specific technology on the licence, whatever it takes. That single licence forms the entire foundation under that company" (Interviewee #3). In

the event that the company is unsuccessful the IP is returned to the license holder, in this case the Broad Institute.

Strategic timeline. What is the appropriate strategic timeline? The time period needed to successfully developed a market ready product or service can be *'short term focused'* or *'long term focused'*: On average development time spent by therapeutics companies is 10-15 years, often with an IPO at an earlier stage (PhRMA, 2016). Traditional drug discovery requires a long development cycle absorbing most capital. The organisation evolves around the R&D process (Obs.). For software/AI companies the process appears almost inverse. Product-to-market time is between 24 and 36 months and time-to-IPO on average 10.1 years (CB Insights, 2019b). Decisions on the required strategic timeline have implications for burn rate, product-to-market timeline, and hence the amount of capital that needs to be raised in order to bridge the time that no income is generated (Obs.).

Monetisation. What approach is used for monetisation of the core process? The organisation led approach is influenced by the chosen practice approach, such as whether the organisation chooses to monetise *'IP, R&D, product, or process'*. For instance, developing a new therapeutic is an incredibly risky and costly process:

> "The aims are to develop a new way to look for drug targets. The business case is to find such targets, and to generate added value based on these premises" (Interviewee #36, founder & CEO).

Given the high economic burden of drug discovery up to the marketing point – or a patient's bedside – public research institutions and academic laboratories can rarely afford this process (Obs.). Given that they would be willing to carry this burden. At

the same time, “the infrastructure and organisational arrangements of universities are not adapted to the laborious course of such product development - even though sometimes they think they can cope” (interviewee #27, lobbyist for the biotechnology industry; see also Hörig et al. 2005). Academic laboratories are primary sites of science discovery and innovation and the science funding system relies on governmental, non-profit, and private resources (Obs.). It was observed that with public research institutions and academic laboratories not being able to afford the processes of further development and scaling of their research, it is especially the process of drawing in private resources and the scaling of the research that is important. Herein, the organisation is not just a passive user of science, but an active participant in the process of further advancing the technology. However, to manage such high costs investments need to create a return by bringing a product or service to market:

> “When reimbursed, who pays for it? We need to check with the payer, and see if it works. Because every cell is unique, so we would need to filter patients, and save money by checking whether the treatment will actually work – like with personalized medicine.” (Interviewee #7, COO & Founder)

But the journey until market can be long. Companies may decide to file for an IPO before having a ready to use product that can be put on the market to provide for the high burn rate needed to develop the product. This is illustrated in the following shareholders report:

> “We have incurred net losses in each period since our inception, anticipate that we will continue to incur net losses in the future and may never achieve profitability: We are not profitable … our net loss was $31.6 million for the year ended December 31, 2016. As of December 31, 2016 we had an accumulated deficit of $53.6 million. We expect these losses to increase as we continue to incur significant research and development and other expenses related to our ongoing operations, seek regulatory approvals for our future product candidates, scale-up manufacturing capabilities, maintain,

> expand and protect our intellectual property portfolio and hire additional personnel to support the development of our product candidates and to enhance our operational, financial and information management systems." (Annual Report Intellia Therapeutics, p.47, 2016)

The burn rate is the total amount of money a company loses per month before it starts generating its own income. For organisation developing a therapeutic, the monthly costs – the burn rate – can be high due to costly laboratory research. In order to bridge that gap until break-even funding is needed to keep the organisation afloat (Obs.).

Funding. What funding strategies are deemed appropriate; Is the government providing grants, is there an investor community, and how much is needed or acceptable for what kind of approach – how large should the sum be, should it yield a *'quick ROI'*, or can is it a *'long-term investment'*? In essence funding strategy is a cornerstone of commercialisation as it enables many of the required activities:

> "Some tech[nology] needs to be capitalism driven. Why? Because there are no philanthropic funds available [to sponsor further research]" (Interviewee #18, World leading CRISPR expert).

Certain science or technologies have more chance for further development as commercialisation might provide funding resources that would otherwise not have been available within the academic or publicly funded settings.

Different science disciplines are subject to different criteria for funding or investment. When disciplines are merged within a new technology raising funding to build an organisation may be accompanied by misunderstandings and tensions:

> "We are currently looking for series A funding, but we have difficulties selling the idea. Our pitch is good, but we need a lead investor…. Tech companies don't seem to understand the biological aspects on which the company

> builds; hard core biotech/science investors only go into real therapeutics – We already started to make a profit within 6 months of our launch, so we kept pushing back the series A funding. We have time… but life science investment companies tend to go for hard core therapeutics; Tech funds are good value, but don't understand [the science of] DNA [technologies]; So for instance for Digital Health? Not sure where to go to for this." *(Interviewee #7 COO & Founder)*

The company operates at the intersection of two different scientific disciplines. New biotechnologies like CRISPR build on a mix of practices from across different disciplines, combining for instance classic genetic engineering with AI or medtech (Obs). Investors like VCs tend to build on knowledge they already posses based on experiences with they are familiar with. This means that many investors often have a narrow focus fuelled by a high level of expertise and experience. Funders may only posses knowledge of one discipline in which the company operates, and lack understanding of the other discipline (Obs.). For funders it is highly unlikely to invest into something that is not understood. Companies in the sample that work at the intersection of, or combine, different science disciplines, industries, or fields, have experienced difficulty in raising funding rounds. There is a serious interest amongst VCs to move into biotechnology, but for many the understanding might be thin (e.g. interviewees # 25, 45, 46, 53 – who all represent large VC firms). The capital markets reflect that most expertise sits with digital technologies and engineering. The annual investments by VCs in software is much higher than that into biotechnology. In the US and Europe, for every $2 that is invested in the digital industry $1 goes into biotech investments (CB insights, 2018). This contrast becomes especially vivid, given that the development and investment costs for biotechnology per unit tends to be much higher. Although the material activities of CRISPR may have merged, competing belief systems may appear to be deeper embedded than appears at the

onset of the technological development; tension that emerge at a later stage need to be navigated by the organisation.

6.2.4 Competing Institutional Demands

Being embedded in an institutional setting ties in with a separate set of demands, defining which practices are deemed appropriate and which are not. This awareness may have direct consequences for the form or shape of both organisation and technology, as they are subjected to institutional influences on guidelines, acceptable practice, or the rejection of activities: what is deemed acceptable by the field and what is not? The main concerns brought forward by the data are that of appropriate *'ethical conduct'*, '*data consent standards'*, and overall *'policy consensus'*.

Ethics. What ethical considerations are to be made by the organisation in order to be endorsed by the institutional field? Is it acceptable to conduct in-vivo genome editing on humans, are any modifications traceable and reversible, and what may be potential downsides? The *'balancing of risks while creating a new modality'* and *'development of good conduct'* are crucial to the development, and even the survival, of organisation and technology:

> "This [CRISPR technology] is a new dimension of therapeutics. It is a new modality. No-one has done this before. The bioethics applicable is another than for other biotech companies. Ours is more challenging, because of the nature and the possibilities of the technique. We need a long-term vision. Ours is." (Interviewee #5, CEO first wave CRISPR company)

If an organisation is developing a pathway that no one has explored before, it is crucial to be aware of risks and to balance them. It is suggested to do this as follows*:*

> "Only focus [your applications of the technology] on the areas you understand very well. Especially since regulatory and policy support is lacking, and regulations are always lacking somewhat behind. For therapeutics, don't do germ-line edits, don't work on eggs. Look at what has been developed well or not so well. What are the Pros or Cons and make sure to consult the actual experts in the field. (Interviewee #3, Chief Business Officer Research Institute)

The novelty that comes with deploying CRISPR asks for a strong internal ethical compass: "Balance, but learn to live with risk. Should you restrict or not restrict certain developments? Give [it] as much thought as you can; that should offer sufficient protection [against possible risks]" (Interviewee #3, Chief Business Officer Research Institute).

Data consent. The *'perception of data'* and the *'modes of informed consent'* are the considerations central to this second order theme. New is the sheer quantity of data CRISPR experiments produce and how this strains traditional modes of analysis and understanding beyond the capacity of researchers (Obs.; see also Leenay, Aghazadeh, Hiatt et al., 2019; Keller, 2002). Many of the new experimental results can no longer be interpreted by simply 'eyeballing' the data, as the data has become too vast for that. In certain situations genomic data can be so rich that the large datasets produced can be considered a form of 'big data' (Obs.). This requires skills not only associated with conventional biology, but as well with that of data-science. There is an increasing difficulty of accommodating verbal formulations as was common in the past (Bud, 1994). Biologists recognise the need for new modes of analysis:

> "The digital, powered by artificial intelligence, includes software for the design and simulation of biological system, as well as methods of collating, connecting and analysing experimental data." (Doc.)

For instance, company B1 develops a digital CRISPR library that can aid in the development of experiment design (Obs.). Some are turning to mathematical models for assistance, such as the software tool developed by company B3 (Obs.). The computer is indispensable for most experimental biologists – not just for processing the vast quantities of data that are accumulating but for analysis as well. With new developments in biological computation, the boundary between organisms and computers is becoming ever more porous: "The difference between biological data and digital data? Both are exactly the same" (Interviewee #10, Bioethicist on CRISPR). These developments are also changing our criteria for explanation, in ways that progressively blur the boundary between the sciences of organisms and computers (e.g. Church and Regis, 2012). These blurred boundaries raise questions of who owns the collected data, what consent needs to be given, and what regulations should be abided by?

> "Patients give body material to scientists, who develop something with it; after which it must be commercialised in order to become relevant. So you go from nothing to something. But that 2nd step is not appreciated, and brings complications with it. Because patients who have given their body material are very positive about the first step, but the 2nd step they are often wary about and do not want it to happen – they are against commercialisation. From free, to something that has economic value – how can you set up something so that all parties think it's fair? The body has become very valuable. This is perception dependent; who is allowed to do research with the data of the patients, only academics or can this data also be used for the next step of commercial development?" *(Interviewee #26, Professor and Senator)*

Institutional frameworks may not yet provide solid answers:

> "Comprehensive data sets to establish informatics links among ten thousand to a million human genome sequences and extensive phenotype analyses are needed to effectively generate and test hypotheses, but they also enable the identification of the individuals whose DNA sequences they contain. This puts

the validity of the existing consent protocols into question" (Lunshof et al., 2008, p.2).

Understanding what is perceived as 'good conduct' by society is crucial to achieve field endorsement to further develop technology and organisation.

Policy consensus. The policy consensus can be *'facilitative'*, *'non-facilitative'* – and anything in-between. What does the policy landscape looks like, what is legally and politically acceptable, and what elements are actively countered or promoted at the field-level? Policy frameworks may be non-existent or not sufficient:

> "We are experiencing delays in our development partly due to regulations, or rather the lack of regulations. It is necessary to have appropriate and applicable regulations in place. The current situation gives a lot of uncertainty around our product development… … and we need the product development in order to keep our company afloat." (Interviewee #6, CEO & co-founder)

Or, policy frameworks alter over time being subject to political tendencies:

> **"**So there is the new political US regime versus the old: coordination for a coordinated regulation and policy framework was underway under Obama, but all was abolished under Trump. New technology has to fit into the framework. Currently there is basically an impasse as no revisions have been made. It didn't help that the White House science & tech committee was abolished under Trump." (Interviewee #10, Bioethicist)

Companies need to be aware of shifting tendencies and adapt as this may work to their advantage:

> "Policy-makers are data driven agencies. The FDA gets how it works and has the necessary authorities to make the calls. Genome editing has been around for a while; so the technical concepts exist, and the current approach is to regulate products, not technologies. These rules are not appropriate anymore. Tech standards need to get better; this is contextual. Look at data and context where you want to do it. But this requires flexibility." (Interviewee #5, CEO)

Circumstances may be that the field is supportive and facilitative, or stifle development by being non-facilitative. It is paramount to navigate policy and political tensions when encountered.

6.3 Discussion

By theorising this chapter contributes to the literatures on structuring, technology in organising, and practice driven institutionalism. It responds to calls for theory to address organisational properties and organising in relation to technology (e.g., Murray et al., 2020; von Krogh, 2018; Smets et al., 2017; Leonardi and Barley, 2008) by re-establishing the focus on the organisation (Smets et al., 2017) and zooming in on why specific organisational elements emerge at the "earliest moments" (Smets et al., 2012, p.877; Smets et al. 2015; Gümüsay et al., 2020) and what the "determinants of those configurations" are (Pache and Santos, 2013, p.996).

6.3.1 The different approaches to the co-constitution of organisation and technology

The aggregate dimensions are summarised into a multilevel understanding that shows how prioritising different approaches and related practices diverges the co-constitution trajectories of CRISPR technology and organisation. The approaches map onto table 2.1 of the literature review and are summarised in table 6.3: *'technology led'* is derived from 'technological determinism' (it is technology driven but not deterministic!), *'organisation led'* from 'social construction', and *'institution led'* from 'institutional complexity'. The data shows that all three approaches are relevant to the CRISPR organisation and, hence, interdependent and complementary – thereby "anchoring" the emergent organisation (see also Perkmann et al., 2019,

p.1; alike to combining 'institutional' logics in the original text, 'anchoring' refers in this case to the ability of combining different approaches, or non-institutional 'logics').

Table 6.3: The different approaches to the co-constitution of organisation & technology

Technology Led *(a) – Technology driven approach* **Emphasising technology as opportunity for social structuring**	**Institution Led** *(c) – Institutional driven approach* **Emphasising institutional embeddedness**
Technological focus: what is the appropriate technological process? (applicability & optimisation < – > precision) *Equipment:* what kind of equipment is needed? (limited initial equipment < – > extensive and expensive equipment) *Knowledge basis:* what is the knowledge base? (processes & programmes interacting with data < – > in lab protocols) *Ownership:* what can be owned? (IP over software & algorithms < – > protocols & biological constructs)	*Ethics:* what ethical considerations are to be made? (balancing curiosity & good conduct < – > creating a new modality) *Data consent:* what consent is needed? (approval < – > new informed consent development) *Policy consensus:* What (doesn't) work(s) in the legal and political situation? (facilitative < – > non facilitative)
Organisation Led *(b) – Social constructive driven approach* **Emphasising path-dependency**	**INTEGRATED** *Practice driven approach* Various emphases on (a) technology as an opportunity for social structuring, (b) path-dependency, and (c) institutional embeddedness, at the earliest moments of new practices emerging and gradually taking shape. Integrates all three technology / organisation / institution led approaches in 'technology-as-practice', recognising that different emphases in development trajectories may lead to different outcomes in the co-constitution of organisation and technology but that all are needed.
Core process: what is the organisational core process? (product/service < – > R&D process focus) *Operational structure:* what is the appropriate operational structure? (platform model < – > blockbuster approach) *Strategic timeline:* what is the appropriate strategic timeline? (near future < – > long term) *Monetisation:* What is the appropriate financial model? (monetisation of platform < – > IP / R&D) Funding: What funding strategy is deemed appropriate? (fast ROI < – > long breath)	

Bringing together the three approaches in an integrated manner, the organisation takes shape at the nexus as a "bundle of [their] practices" (Schatzki, 2006, p.1863). As the collective activity of the practitioners inside the organisations emphasise and prioritise various aspects of technology, organisation, or institutional context (Chia and Holt 2009; Jarzabkowski 2005). As each practice has an (institutional) understanding attached to it their chosen approach gives rise to diverse organisational forms and features such as organisational goals and design (Puranam, Alexy, and Reitzig, 2014; Hsu and Hannan, 2005). For instance, if in the "earliest

moments" (Smets et al., 2012; Smets et al., 2017) an organisation is mainly focussed on fulfilling necessities to develop the material properties of a new technology, its collective organisational activities will be focussed on establishing practices that constitute an organisation (or "bundle" / "box") with features that can match that approach in providing supportive opportunities or constraints on further organisational activity (Leonardi and barley, 2008; Schatzki, 2006; Orlikowski, 2000;). Likewise, organisational properties may be tailored towards approaches aimed at facilitating specific organisational needs or institutional pressures.

Starting with the organisation being the nexus where all practices are bundled together (Schatzki, 2009), this research suggests that an aggregation of the three approaches forms an integrated practice driven approach wherein different emphases can exist regarding what practices are leading the behaviour within the organisation – across all three levels (Thornton and Ocasio, 1999). The findings show that each level corresponds with a set of practices linked to one of the approaches (technology led, organisation led, and institution led). With all three approaches originating in interaction between organisation and technology, they anchor the development of technology and organisation. This observation corresponds with the definition for technology as used in this thesis that outlines a combination of three layers: one layer material and two of them social (MacKenzie and Wajcman, 1985; Bijker, Hughes, and Pinch, 2012, p.xli-xlii). The first level is centred on 'material practices and related artefacts' – technology led –, the second on the 'activities or processes' – organisation led –, and the third on institutionalised 'evaluation routines' – institution led. Each level focuses on a different dimension of "the box"

(Smets et al., 2017, p.36), or more specifically, at the interactions inside the organisation, at the organisation and its specific properties, or at the dynamics outside the organisation. An overview is provided in table 6.4. The different approaches are now discussed one by one.

Table 6.4
Overview Integrated Practice Driven Approach

Practices / Approach to structuring	Properties determinants technology & organisation	Anchoring in technology definition[1]	'Box' metaphor[2]
Technology led structuring	Technology focus, equipment, knowledge basis, ownership	Material practices (related to physical objects and artefacts)	Looking inside the box
Organisation led structuring	Core process, operational structure, strategic timeline, monetisation, funding	Activities and processes	Looking at the box itself
Institution led structuring	Ethics, data consent, policy consensus	Evaluation routines	Looking outside the box

[1]MacKenzie and Wajcman (1985), Bijker, Hughes, and Pinch (2012, p.xli-xlii)
[2]Smets, Aristidou, and Whittington (2017)

6.3.2 Technology Led Approach

The technology led approach looks *'inside the box'* or more precisely, within the organisation. Technology driven considerations impact the emergence of organisational properties (Murray, Rhymer, Sirmon, 2020). For instance, *company C3* spun out of the university to develop organs on chips, small platforms that recreate the natural physiology and mechanical forces experienced within the human body. The goal is to test human physiological responses using the chips. The chips, representing different organs, can then be interlinked like an electronic system board; as to model system biology. The current development of the technical aspects is twofold: the development of a novel protocol for deriving kidney cells

from stem cells (which involves the use of CRISPR) to use for the creation of the chips and the construction of the organs-on-chips. In the development of supportive organisational properties, technological aspects related to equipment, knowledge, IP, and protocols are prioritised. Organisational aspects such as type of employees, amount of funding (to pay for equipment), and strategic timeline had to be tailored towards the technological setup. There is clarity about the technology that needs to be developed but uncertainty still exists on how to relate this to an organisational structure and the institutional setting. The technological practices are leading in how the organisation (or box) should take shape.

The findings show that anchoring in the 'technology led approach' entails weighing four different competing demands that raise the following questions. '*Technological focus'*: what is the appropriate technological process to be the basis of attention for the organisation? Is the aim to develop something entirely new or to optimise, standardise, and scale existing knowledge. '*Equipment'*: What equipment is needed? Is expensive highly specialised and customised laboratory equipment needed or would any off-the-shelve computer do? '*Knowledge basis'*: What is the knowledge basis for technology and organisation to be build on – e.g. what expertise is needed? And, *'Ownership'*: What aspects of this knowledge basis can be owned, and how – e.g. are there algorithms, protocols, or biological constructs that can be used as trade secret, IP, licence, copyright, or in another form?

Previous work shows that both technology's and organisation's properties are constituted in regular and recursive interactions with human actors (Murray,

Rhymer, Sirmon, 2020). These technology led practices, also referred to as "material practices" (Thornton and Ocasio, 1999, p.804), emphasise technological properties as they give shape to emerging patterns of organising following interactions between technology and organisation. At the core of organisation studies Giddens' (1984) theory of structuration did not explicitly addressed a structurational perspective on technology, but focusing at the mediating role of the organisation that brings together different approaches with different emphases allows for certain demands prescribed by logics to weigh more certain elements than others and thereby influence the process of co-constitution between organisation and technology (Leonardi and Barley, 2008). Technology led practices emphasise technology as an opportunity for social structuring (Barley, 1986; 1990; Leonardi and Barley, 2008), allowing characteristics of the technology to be dominant in shaping the organisation. This is not to be confused with technological determinism, as the technological drive is merely an anchor. The contribution is the recognition that this is an opportunity for organising and structuring, rather than for 're-organising' existing structures as commonly addressed in the literature.

6.3.3 Organisation Led Approach

The 'organisation led approach' looks *'at the box'* and emphasises social construction and path-dependency; the organisational features define organisation and technology. In the organisation led approach, organisational process are leading and define the use, adoption, and development of technology (cf. Orlikowski, 2000). The technological application often still needs to be developed and the organisational aspects are therefore leading. For instance, *Company A2* developed a new way to

look for drug targets by using genomics to develop innovative therapies for patients affected by severe diseases. It has initiated a pipeline of preclinical discovery programmes for rare genetic disorders, like lysosomal storage diseases and immuno-oncology. However, their approach hinges on understanding the suppression of gene expression, which is a very complex phenomenon only recently discovered and little is know about it. The possibilities for developing applications are endless but only if the organisation manages to crack this mechanism. Achieving this objective is highly uncertain and depends on setting up an organisation that can sustain costly R&D over the long run. Organisational structure is therefore leading. There is clarity about what is possible in terms of organisational structure, but uncertainty still exists on how the technology will take shape. The social practices are leading in how the organisation (or box) should take shape.

The findings show that the approach weighs five different competing organisational demands on. '*Core process'*: What should be the core process of the organisation? Is it build around a production process, the licensing of IP, a product, or a service? *'Operational structure'*: What is an appropriate operational structure given all other demands – Is it a platform model, a blockbuster model, or a mix? '*Strategic timeline'*: What is the appropriate strategic timeline? Does it take a decade long R&D process to develop a therapy or can a product readily be produced in the near future. '*Monetisation'*: What approach is used for monetisation of the core process? And, '*funding'*: What funding strategies are deemed appropriate to bridge the time until an income can be generated? Is the government providing grants, is there an

investor community, and how much is needed or acceptable for what kind of approach.

In the organisation led approach the organisation defines agentic behaviour (e.g. Pache and Santos, 2013; Heugens and Lander, 2009; Giddens, 1979) and is the main source of structure and agency (Smets et al., 2017). Social construction is dominant over technological influences, as technology is embedded within the organisational setting (Seo and Creed, 2002) and technology is still largely undeveloped (Orlikowski, 2000). By looking 'at the box', the organisational properties (Smets et al.,2017), influence of the organisational structure exerts agency over how technology takes shape. Instead of looking at how existing social structures interact with properties of existing technology (e.g. Barley, 1986; 1988; 1990) the contribution is in this case the observation of how being anchored in a more 'closed' organisational structure is an opportunity for structuring (and thus not re-structuring!) of a still relatively 'open', unsettled, and emerging technology.

6.3.4 Institution Led Approach

The 'institution led approach' looks 'outside the box'. These practices emphasise the importance of the influences of the institutional environment and embeddedness within it. The institutional setting affects and shapes everyday practices (cf. Lounsbury, 2008). An organisation is anchored in an institution led approach is leading when the developed organisation and its technologic application(s) are tightly related to tendencies in their institutional setting. For instance, *Company B3* develops a new approach to data-driven medicine through the application of

artificial intelligence to DNA sequencing. It is developing an AI system for clinical genomics that should ultimately help healthcare professionals to improve patient diagnosis and treatment. Although the company sees rapid growth and international expansions, it still has to maintain strong links with the institutional setting of the UK due to collaborations with its healthcare system, key funding, and office location. For growth and further development it is dependant on the NHS, the UK's national health service which is state run. Therefore strict compliance with, and sensitivity towards, ethics, data use, public sentiments, and policy is a matter of survival for this organisation – and therefore leading in all its activities. There is clarity about what is or is not possible within the institutional setting, the structuring of organisation and technology subject to that. The institutional practices are leading in how the organisation (or box) should take shape.

The findings show that such organisations weigh, overall, different competing institutional expectations. *'Ethics'*: What is deemed appropriate activity regarding societal/industry/academic/institutional concerns and what ethical considerations do they produce? Is it acceptable to conduct in-vivo genome editing on humans, are any modifications traceable and reversible, what are potential downsides, and what uncertainties are faced? *'Data consent'*: Who owns the collected data, what consent needs to be given, and what regulations should be abided by in collecting and handling the data? And, '*Policy consensus'*: what does the policy landscape looks like, what is legally and politically acceptable, and are there certain elements that are actively countered or endorsed? These demands prescribe what goals are

appropriate and what means are legitimate to achieve these goals (Lounsbury, 2007; Thornton and Ocasio, 2008).

If the institutional setting is crucial for a hybrid organisation (Besharov and Smith, 2012; Pache and Santos, 2013) structuring is anchored in the institutional approach. The organisations may attempt to reconcile it internally (Besharov and Smith, 2012; Greenwood et al., 2011; Murray, 2010; Simsek, 2009). Failure to comply satisfactorily with those values, norms, and beliefs – the institutional prescriptions (Seo and Creed, 2002) – that are eminent in the social context can cause development to stall unless organisation and technology are fully settled with respect to all commercial, social, political, and cultural aspects. Such negotiations between different framings take place at the interface of the organisation. Whenever controversies arise, it is up to the organisation to settle any challenge. The contribution is that institutional anchoring defines how both organisational and technological structures are organised as they emerge.

6.3.5 Integrated Practice Driven Approach

The 'integrated practice driven approach' encompasses all three approaches. It is a perspective that connects the individual, organisational, and institutional levels of analysis (e.g., Smets et al., 2017; Jarzabowski et al., 2013; Smets et al., 2012; Barley, 2008; Lounsbury and Crumley, 2007; Whittington, 2006; Bourdieu, 1990). It shows that at the *"earliest moments"* new and emerging practices gradually take shape by: (I) anchoring in technological elements that provide an opportunity for social structuring, (II) anchoring in organisational elements that provide social construction

shaping path-dependency, and, (III) anchoring in the institutional setting that emphasize the institutional embeddedness of activity. The findings of this chapter show that all three dynamics occur at the same time as they form part of the process of co-constitution, being equally relevant – although differently prioritised by practitioners and in their collective practice (Schatzki, 2002; Whittington, 2006). These practices are bundled into an organisation (Schatzki, 2006; 2009) and determine its specific organisational properties – shaping the "box". Variation exists between organisations – boxes – depending on situated practices in which some aspects may be leading over others alternating emphasis between technological determinants, organisational determinants, or institutional determinants. The enactment or emphasis on diverse sets of practices leads to different decision-making processes, organisational objectives, and technological development trajectories. Consequently, different practices come to exist regarding the same technology whilst giving different directionalities to the organisations and the technology embedded within them.

Awareness of these approaches contributes to gaining better insight into why particular organisations respond in certain ways or why others respond differently (Smets et al., 2017; Santos and Pache, 2013). It is through different practices that organisation (cf. Garud and Karnoe, 2001) as well as technology (Orlikowski, 2000) are structured – 'co-constituted' – and to be understood. In the development trajectories of organisation and technology different emphases on elements of technology, organisation, or institution, may lead to different outcomes. This involves a political process in terms of decisions over what constitutes impacts and

for whom, which actors are empowered, and what form or shape organisation and technology take.

Developing a multi-purpose technology like CRISPR into different applications can raise several interpretations over what the technology constitutes, how it should be used, and into what kind of applications it should be developed. Technology and material practices can only be properly understood through localised practice (Orlikowski, 2000; Lounsbury, 2007; Bijker et al., 2012; Latour, 1987) as it is situated differently in each of the organisations and constructed in interaction with a different direct context. The organisation is the localised situation in which different practices shape CRISPR applications and organisations for different uses while gaining different meanings and purposes. The findings help to see each organisation as a bundle of practices with material arrangements and features (Schatzki, 2009) as it unites both (technological) practice and institutional aspects by tailoring the properties of the organisation for survival.

6.4 Conclusion

The purpose of this chapter is to contribute to a critical and extended understanding of the different practices and their underlying drivers that give rise to the development of both organisation and technology in various ways. It is a response to the observation that *"few scholars appear to be looking at the box; or more precisely, at organisations and their specific properties" (*Smets et al., 2017, p.36), and an attempt to better understand the determinants of organisational properties.

By looking at 'the box' as a bundle of practices (Schatzki, 2009), a practice driven understanding offers a comprehensive and inclusive approach to investigate where new technological applications come from, how they emerge through and with the organisation, and how both technology and organisation become established through practice. Although a start has been made in exploring such a question in terms of inductive studies looking at new practice creation (cf. Lounsbury and Crumley, 2007; Smets et al., 2015; Gümüsay et al., 2020), this hinges on the roles of legitimacy and diffusion, and redirects attention toward the multiplicity of actors that interactively produce institutional change. To understand how new organisations and CRISPR applications emerge and become established, this chapter showed that it requires paying further attention to the various kinds of (material) practices with different underlying technological, organisational, or institutional drivers. This opens up new opportunities for institutional analysis not only in terms of the determinants of organisational properties, but also concerning extending the structuring capacities of technology. Although scholars of institutional logics have included materials, objects, or technologies in their studies (Jones, boxenbaum, and Anthony, 2013; Friedland, 2012; Leonardi and Barley, 2008; Orlikowski, 2000), they have not fully examined the role technology might play in anchoring or catalysing (organisational) change. There appears to be a blind spot to whether any technologies mobilise shifts in practices and structures. The perspective of technology-as-practice helps to look closer at such changes and their effects as it allows looking at the dynamics of the co-constitution between technology and organisation.

The next chapter shows that it takes the support of an entire field to materialise CRISPR and organisation – sometimes even multiple fields. Organisations are positioned in a wider environment, introducing additional logics that are set within the contexts of the organisations. Chapter seven provides insights into how CRISPR-organisations approach the organisational challenges from operating in various geographical field settings.

7. STRATEGIC FIELD LOCATION: A MULTILEVEL MODEL OF THE MATERIALISATION OF CRISPR THROUGH COMMERCIALISATION ACROSS DIFFERENT FIELDS

7.1 Introduction

It takes a village to raise a child; or in this case, it takes a field to develop CRISPR technology. This chapter focuses on the multi-level interaction of praxis, organisation, and field. It is observed that different organisations emerge around the same technology as they are embedded in different geographical institutional field settings. This research thus responds to the call that "…a comparative analysis of practise is overdue [for] field-level institutional logics enacted and transformed in the mundane activities of individuals and in response to the localised demands of situated activity" (Smets et al., 2012, p.900 - figure 7.1). As CRISPR organisations

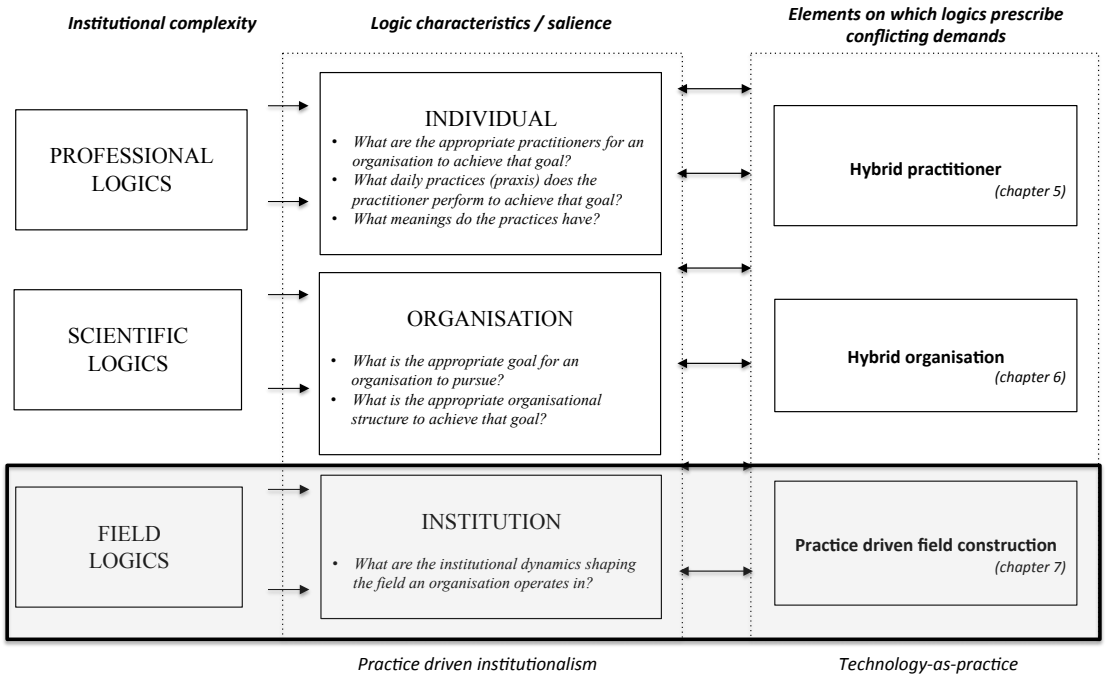


Figure 7.1: The positioning of this chapter in the thesis

develop novel technological applications they exploit, select, and construct different institutional, geographic field settings. The structures and practices within are enactments of, as well as responses to local logics that formulate rules, laws, conventions, and paradigms that constitute the local field setting (cf. Hinings, Logue, and Zietsma, 2017; Lounsbury, 2007). This chapter shows that institutional pressures are not merely enacted or escaped (i.e. Faulconbridge and Muzio, 2016) but, in fact, organisations have some managerial agency to choose their institutional environment. To make use of uneven dynamics between different institutional field locations organisations may (proactively) introduce strategic approaches for locating activities. The chapter contributes to recent work on institutional fields by identifying three such strategic practices. Firstly, *the institutional exploiter approach* shows that institutional fields are not just constraining structures to which organisations need to adapt (i.e. Cardinale, 2019; 2017; Scott, 2013; Thornton et al., 2012; Powell and DiMaggio, 2012; Heugens and Lander, 2009), but can be enabling and actively used. Secondly, with *the institutional orchestrator approach* organisations not only tap into the local institutional field, but also select, straddle, and align themselves with the practices of other more favourable institutional fields. Thirdly, *the institutional configurator approach* occurs when field and organisation are largely a mismatch and an infrastructure needs to be built bottom-up to suit the organisation's most urgent needs. These three contributions extend practice driven theorising (Smets et al., 2012) and are summarised in an integrated multi-level model for *practice driven field construction*. The model shows that as organisations navigate between institutional field settings this may lead to field-level change that

results from practice introduction and variation. The chapter is structured as follows: first the findings are discussed, followed by a discussion, and conclusion.

7.2 Findings

This section presents the findings. It identifies three different fields, their logics, and associated dynamics, namely: The Netherlands (setting A), the English Golden Triangle (Setting B), and the US East Coast Boston Area (Setting C). The structure of this section is as follows: first, a presentation of the data-to-theory connections summarised in three strategic approaches for navigating the fields, second an elaboration of the findings on the field dynamics in The Netherlands, third an elaboration of the findings on the field dynamics in the English Golden Triangle, and fourth an elaboration of the findings on the field dynamics in the US East Coast Boston Area.

7.1.1 Data-to-theory connections

The data-to-theory connections of this chapter are summarised into a theoretical framework presented in the format of a data structure – figure 7.2 – visualising links based on axial cross coding. Institutional logics were theorised from data collected on situated, emergent, and generative everyday activity practices in order to help unravel the complexities of the observed local field logics (e.g., Greenwood et al., 2011; Smets et al., 2017; Ocasio, Thornton and Lounsbury, 2017; Smets et al., 2012). The institutional dynamics of each local geographical logic is illustrated with examples of 'power quotes' (Suddaby, 2006) in data table 7.1.

Figure 7.2: The data structure

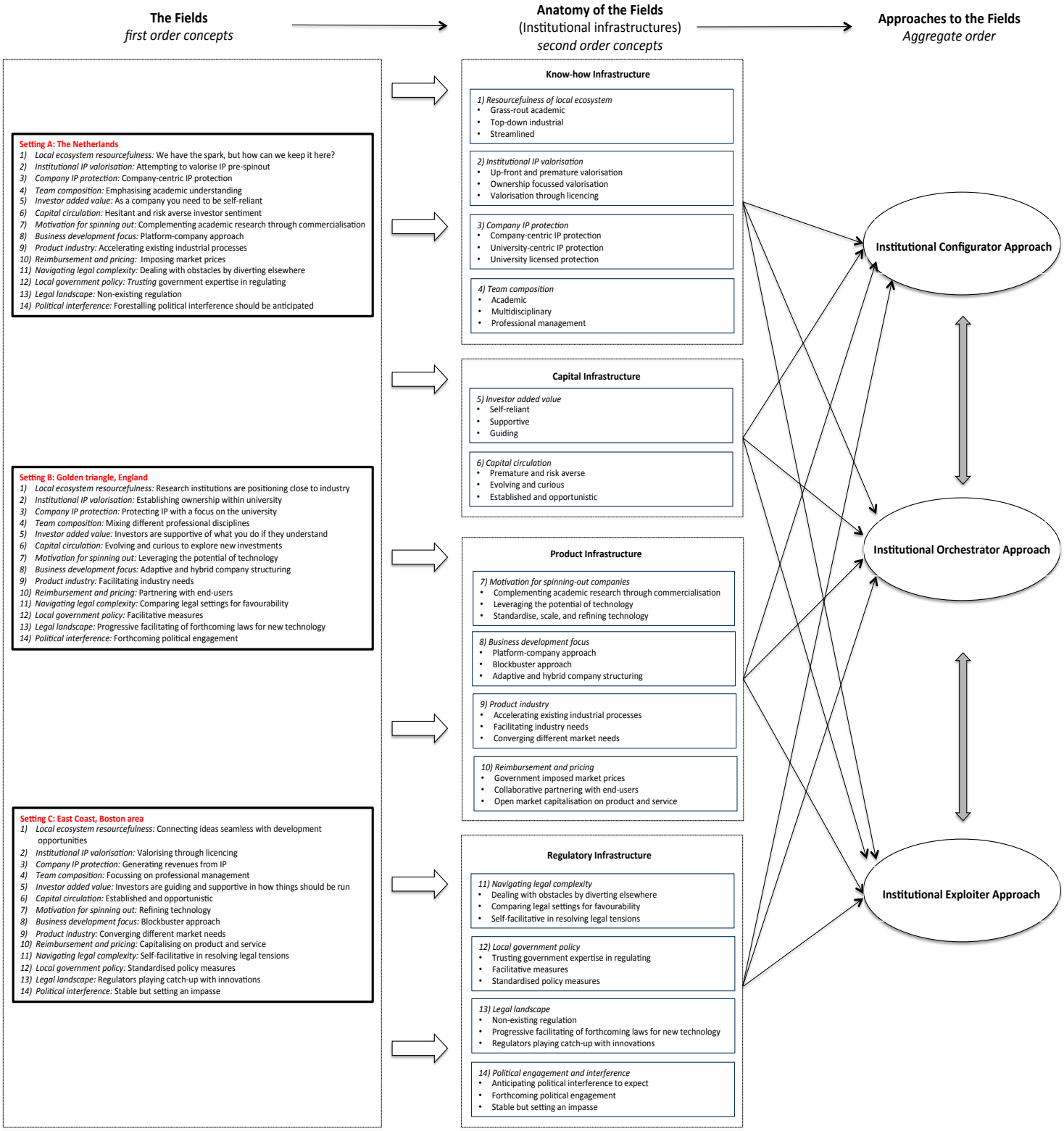


Table 7.1

A Comparative View of Geographical Field Logics and Their Enactment in Practice

Anatomy of the field *Second order* ↓	**Dominant Logic and Practice elements** *First order empirical observations* ↓	**Setting A** (Netherlands)	**Setting B** (England, Goldon triangle)	**Setting C** (East Coast, Boston area)
Know-how Infrastructure	**1) Resourcefulness of local ecosystem** "Geographical location helps that we can do face-to-face meetings on fairly short notice. It Helps with creation of industry feedback; as these are the potential customers in close proximity." (Int.) "A region's research strengths may influence or be influenced by the opportunities offered by geographical proximity of industry and academia." (Doc.)	*Grass-root academic* "We now have an infrastructure here in NL that leads to phase II, but after that everything is sold off. We have the spark, but how can we keep it here? Our [basic] knowledge is actually very profound and large: many phase I… and some …II ideas, but how further?" (Int.)	*Top-down industrial* "The academic sector in the UK's regions share numerous corporate collaborators. Almost every region collaborates with large pharmaceutical companies such as GlaxoSmithKline, Merck, Pfizer, and AstraZeneca, software giants like Microsoft, or diverse engineering companies like Rolls Royce, to one degree or another, which is why these companies appear in the centre of the chart….Universities and research institutions play a key role in generating innovation and defining future job growth in cities and regions – businesses position themselves close by in order to benefit from these outputs. For example, AstraZeneca decided to establish a new Global R&D Centre and corporate headquarters on the Cambridge Biomedical Campus in East England because of its proximity to world-leading scientific expertise and collaborative opportunities with academic research institutions, hospitals and biotech companies" (Doc.)	*Streamlined* "[Local] support is crucial. I receive support in R&D, optimization… basically having a lab or institute that can do that. And to have advisors. I have advisors in: venture capitalism - COO that used to be in GoldmanSachs, former coach from St John's is also a partner next to George Church, and 20-year-long basketball friend does the brand marketing." (Int.) "We always look for new ways to develop their technologies: We're not always sure what to do with them. People might want to create data packages, or modify fish, or strawberries. We help to pick the investors, and link the companies" (Int.)
	2) Institutional IP valorisation "..the universities hedge their bets on milestone, equity, and licensing fees – basically they apply all three forms." (Int.)	*Up-front and premature valorisation* "…with IP: we [university, state, and other research institutions] will simply sell the ideas to the highest bidder. The research that is being sold, well… that is sold to the highest bidder. Consequently, it often goes abroad. So we actually do research with public money for foreign companies!!! How do you justify that?!" (Int.) "In the US everyone wants to start something,	*Ownership focussed valorisation* "Russell Group universities excel in producing innovative new spin-out companies and licensing their IP and Technology Transfer Offices have been integral to these successes. The successful exploitation of IP is complex and it is vital universities should maintain autonomy to manage their own IP. Being able to vary approaches to IP and commercialisation depending on individual circumstances (e.g.	*Valorisation through licence* "In the US, IP often stays with the university, so that if the company goes bankrupt the technology will not go down with it." (Int.) "Here at the Broad we see commercialisation as needed to maximize benefit for public impact of technological development. This includes non-exclusive licensing, but in some cases, like with

	but here you see that less. TTOs in Europe are different: if you look at the US or Boston specifically. Suppose they have 100 patents, they give out 90 of them, 1 is perhaps successful of which they then can take 5% royalties. And that one keeps on giving returns. They do not haggle about a fee, just a percentage in royalties without a buy-out. Here, in the Netherlands, they want an up-front fee over the IP, so they can pay a few new PhDs. They [the TTOs] don't consider the bigger picture. But young biotech companies have to cough that up and then have no money left to actually start building something." (Int.)	on the nature of the research and company to be spun-out or technology to be licensed) and the market value provides the UK with a major competitive advantage. Russell Group universities have led the way in pioneering innovative new models for IP management, including Easy Access IP. A single, one-size-fits-all approach to technology transfer would not be fit for purpose…" (Doc.)	therapeutics that also means that the technologies are likely to be never developed. There is a need for natural monopolies to create incentive for investment. Therefore, market exclusivity needs to be allowed, for instance to permit big pharma to make 9 figure investments." (Int.)
3) Company IP protection "Make sure to have [IP] protection for your ideas." (Int.) "The disclosure of the most advanced and exciting gene editing technology involving CRISPR found its way into patent applications filed with the United states Patent and Trademark Office (USPTO) before being published in scientific journals." (Straus, 2017)	*Company-centric* "To start your own biotech company you need a technology and a patent. The challenge lies in how you translate science into a product. …What do you need in order to bring an idea to market? Well, you need a good and fashionable technology, specialist knowledge, [and] IP" (Int.) "We outsource our research to an academic institution, and maybe in the future a CRO (contract research organisation). The director of the academic institution is also a board member with us. Whatever they develop or find in this research, we automatically gain a sub-licence. We maintain ownership over the IP, but the academics have a right to publish the research." (Int.)	*University-centric* "With TTOs it is a funny dance you find yourself in, as they find themselves in a truly political game. In addition to that, Dutch TTOs are really too small. When compared, their American equivalents are much more professional. Or even when compared to Oxford there are a 100 people working for OUI [Oxford University Innovation, the TTO of the University of Oxford]." (Int.)	*University licenced* "We have never generated any revenue from product sales and our ability to generate revenue from product sales and become profitable depends significantly on our success in a number of factors: …. Maintaining, protecting and expanding our portfolio of intellectual property rights, including patents, trade secrets and know-how…" (Doc.) "So there is a third party inclusive product: Companies get two years of exclusivity on a license. This was also how Editas was founded. It had to choose the genes it wanted to develop. There are about 20.000 genes, and it [the company] can't develop something for all of them at the same time. So they got exclusivity and a first shot at which genes they wish to develop. The rest of the genes are free for others to use" (Int.)
4) Team composition "..You need a team that is not always full of scientists; you need also people that are willing to take a risk. People with diverse backgrounds, and some that will also bring previous	*Academic* Emphasis on scientific understanding (Obs.) "Another hurdle is that young Dutch companies are afraid to involve outsiders into their business… this enhances the chances of misinterpretations between young companies	*Multidisciplinary* Mixed between experienced entrepreneurs, scientists, and professional management (Obs.) "Here in Oxford we are lacking role models, or at least they are undercommunicated"	*Professional* Focus on professional management (Obs.) "…the investors choose the management team. The scientists tend to step back and become advisors." (Int.)

	experience on board" (Int.)	and VCs… appropriate mentorship could help to avoid this…" (Int.)	(Int.)	
Capital Infrastructure	**5) Investor added value** There is a strong variance of knowledge, network, and mentorship that can be offered by investors between geographical settings. (Obs.)	*Self-reliance* "There is a level of expertise amongst the investors in Boston that you will not find in the Netherlands. There is much more expertise in CRISPR. For instance, just the fact that the Broad Institute is based in the Boston area… there are already investors present that have an interest in investing into CRISPR applications. You don't have this in the Netherlands. The Dutch investors are incredibly hesitant to take the lead, and have a habit of 'drip-feed funding' [release funds just a little by a little, but not enough to make serious progress]. Yet they are likely to be interested in joining the investment round once an experienced investor from Boston takes the lead. At which moment we will have to ask ourselves whether we are still interested in having a Dutch investor on board." (Int.) "It is being underestimated how much money is needed to bring it [a new therapeutic] to market and the risk that is inevitably attached to trying to do this... with €25mln you might 'just' be able to conduct clinical trials within the patient." (Int.)	*Supportive* "The thing is though… normally, investors don't get too enthusiastic about target identification and sequence mapping… they rather see your product in a mouse, or even better, a patient. We don't even have the targets yet, just the platform that will help us 'hopefully' find them." (Int.) "If the leading academic capital fund has created no net value... the answer is either early-stage commercialisation can't create value, or academic capital as a model has failed financially. However, assuming good European science should be translated - the was to get it done is by creating decent opportunities to invest more capital in the best ventures - and for Europe to stop trying to build SME NewCos and focus on brutal winnowing of seeded NewCos." (Int.)	*Guiding* "This investment has been increasingly concentrated in large, established funds with a track record of investing in biotech. In addition, another interesting feature of these investments in the past year is that the funds have been deployed across fewer opportunities, reflective of new dynamics in the sector. Biotech has long been a "winner takes all" space, where a handful of successful exits provide the lion's share of returns to VCs, and it looks like investor sentiment appears to be shifting even more in this direction. Investors are writing bigger cheques while investing in fewer companies, a dynamic driven by the need to deploy larger and larger funds while maintaining discipline when evaluating opportunities and management teams. The result is that VCs are generally looking to take larger positions in fewer higher quality companies, suggesting greater confidence that they are able to pick the winners and that their concentrated backing of a few select biotechs will decrease their likelihood of failure." (Doc.)
	6) Capital circulation "The current investment model is that of a capital market; fast ROI by an IPO or M&A - not so much by developing." (Int.)	*Premature & Risk averse* "Often the early-stage funding, also referred to as seed funding, consisted of government subsidies. For instance, as company A is looking to scale up, it aims for EU grants that will help the company to further develop their proof of concept. This proof of concept should open the door for additional funding…. but with Dutch grants… the certainties that you have to give them [the Dutch funding institutions] … and all they might give you is €100k… if I would know the answer to all the things that they ask for, I would be able to easily raise €10mln. Once I have those	*Evolving & Curious* "On the one hand there are venture/pharma driven accelerators emerging designed to minimise risk and increase speed/quality vs. on the other you have academic-linked institutions trying to keep innovation inside (delaying IMPACT) to give access at later value inflection points. The latter would appear better than academic capital, as it involves the end customers (pharma), but I suspect it replicates the inherent problems (and decision making) we have seen in academic capital." (Int.)	*Established &Opportunistic* "Although it may be hard to access capital, this does not necessarily mean that capital is not present. Several internationally well-established funds from e.g. Silicon Valley and Boston, but also European VCs, are actively trying to connect with the European spinout and start-up scene in biotech. However, it turns out to be incredible difficult for these parties to gain a foothold in Europe and to break into the ecosystem of early stage biotechnology based companies. So there is actually capital present. Still there is the perception

		answers I am no longer interested in their €100k." (Int.) "The number of serious (super) angels are limited and often only focused on seed funding. So a possibility would be to go straight to VC funding, here or in the US." (Int.)	"Currently looking for series A funding, difficulties selling the idea. Pitch is good, but need for lead investor. Tech VC don't understand the biological aspects on which the company builds; hardcore biotech/science investors only go into real therapeutics." (Int.)	that there is no access to it." (Int.) "The ruling perception is truly 'conservative'. This is reflected in the IPOs. If you are a serious company … you go to the NASDAQ. There is no chance of raising a $100mln in Amsterdam. Not on the AMEX, not on the AEX." (Int.)
Product Infrastructure	**7) Motivations for spinning-out companies** "Most academics engage with industry to further their research rather than to commercialize their knowledge. However, there are differences in terms of the channels of engagement. Patenting and spin-off company formation are motivated exclusively by commercialization whilst joint research, contract research and consulting are strongly informed by research-related motives." (D'Este and Perkmann, 2010, p.1)	*Research complementary* "…some ideas are less suited for an academic setting, for example if you want to scale up. There are few academic labs that are larger than 10-20 people. This is easier in a commercial setting…" (Int.) To build out research and to bring in otherwise non-available funding (Obs.)	*Leveraging* "Initial idea was to make a machine that works as a better search engine for DNA, and to run it on a machine with DNA search algorithms: A machine that indexes DNA, but also something that scientist can assemble themselves. It was supposed to be DIY… something that fits with the current tradition of making devices yourself in the lab. The underlying motivation here is the idea to help research in the lab. Horizon was using the MIT index, but their system was always down, so we were looking for a solution. It started as an improved copy of the MIT tool." (Int.) To leverage the potential of technology (Obs.)	*Synergy, standardisation, and scaling* "Thank god for the company otherwise they [the scientists] would have to do all of this… now they can maintain focus on exploration, and my academic colleagues can maintain focus. The company provides focus while the scientists can continue to follow their own interests." (Int.) "The company is refining the tech, Really simplifying things. Development of user interface and standardization." (Int.) "Some tech needs to be capitalism driven. Why? Because there are no philanthropic funds available." (Int.) For the sake of standardisation and scaling (Obs.)
	8) Business development focus The organisational structures that are pursued or organically evolve (Obs.)	*Platform-company approach* "Reason for a platform-company approach is a 'not all eggs in one basket'-approach with more shots at success." (Int.)	*<---Hybrid / Mixed –-->* "Focus just on the top 2 (Cas9, Cpf1; Human, Mouse) – rest is waste of time, money, energy: the question to ask is what goes into the clinic?" (Int.)	*Block-buster* "Editas is focussed on just 1 technology – so it will be difficult/impossible for them to defer or to drop the development." (Int.)
	9) Product industry "...Over 100 years we will have other medicines: The development costs go down, But patient costs are rising (due to e.g. personalized medicine), maybe the pharma-industry is superfluous, game over, This	*Industry complementary* "For large companies … CRISPR is rather a tool to accelerate work that they already did, merely a tool to work quicker. Yet it is somewhat difficult to get the licences to use CRISPR. At this stage CRISPR cannot be distinguished from classical methods; the difference mainly lies within the R&D	*Industry facilitating* "Pharma currently buys the almost successful companies, which are of course expensive, as a result of which the market value becomes inflated (too high). As the assets are mainly intangible, there is only book profit and no actual products. Shareholders do not accept that, the price of	*Converging different market needs* "The increasing convergence of tech and healthcare will also provide fresh opportunities for the industry. We are already seeing the use of real world evidence to measure the actual performance of drugs post approval and drive future investment decisions.

	industry can only exist by the continuous increase of shareholder values. The idea of regenerative medicine … and personalized medicine, clinical trails become cheaper." (Int.)	processes to arrive at a certain strain. "one should see it as a lab automation for faster strain production, comparable with PCR but only now with IP. For PCR they have connected the IP to the purchase of such a machine (manufactured by Millipore in Europe), but for CRISPR it is not clear who has the rights." (Int.)	drugs rises merciless, and patients no longer accept that." (Int.)	Machine learning techniques are being employed not only to speed up drug discovery, but also drug development with the hope that data-driven approaches will help reduce R&D costs and industry failure rates." (Doc.)
	10) Reimbursement & pricing "A medicine is 2.5x times more expensive after an M&A, because that is the revenue model. If you buy it you must also be able to recoup it. In 2016, $135 billion of drug development was spent, and only 24 compounds were put on the market. That is $7.5 billion per drug on average. The costs go up and the demand goes down." (Int.) "When reimbursed, who pays for it? We need to check with the payer, and see if it works. Because every cell is unique, so we would need to filter patients, and save money by checking whether the treatment will actually work – like with personalized medicine." (Int.)	*Government imposed* "Health insurers are not automatically allowed to provide cover for any new medicine that comes onto the market. The Ministry of Health, Welfare and Sport and the Healthcare Institute of the Netherlands decide what drugs fall under the standard health insurance package. Registered medicines have to be assessed (in Dutch) before they can be included in the Medicines Reimbursement System (GVS). Medicines listed in the GVS are fully or partially reimbursed by health insurers. The Ministry of Health, Welfare and Sport exercises restraint in adding new medicines to the Medicines Reimbursement System. It wants to keep health care affordable. So the standard package offers a good, but not excessive, level of cover. The Ministry of Health, Welfare and Sport sets maximum allowable prices for medicines (in Dutch) in accordance with the Medicine Prices Act. When buying in drugs, pharmacists may not pay more than the maximum prices." (Doc.)	*Collaborative* "…drug formularies are developed locally by Primary Care Trusts (PTCs) and NHS Trusts. PCTs adapt these formularies to contain costs and remain in budget. In the UK there are few direct drug pricing controls, and the reimbursement mechanism is different to many other European countries. The branded drug price is set using the Pharmaceutical Price Regulation Scheme (PPRS) and the drug is then reimbursed by the NHS according to the manufacturer's list price. Government drug spending is affected by patient co-payment (in the form of prescription charges), a claw back system operated by the government for community pharmacies and discounting to hospital pharmacies." (Doc.) "Aim is to partner with end customers with a local focus, partner with the actual people who make the cells, such as research hospitals." (Int.)	*Open market* "Generally speaking, payers in the US (both CMS and private insurance companies) do not regulate the price of a pharmaceutical product, allowing the manufacturers to set prices freely. However, payers are allowed to set the reimbursement price/rate. The reimbursement process differs between the public sector (CMS) and the private sector." (Doc.)
Regulatory Infrastructure	**11) Navigating legal complexity** The tendency how legal complexity is approached (Obs.)	*Outwards directed* "Look for example at [Company A3], they start running their trials outside the Netherlands because it is made impossible for them to do them here." (Int.) "We are experiencing delays in our development partly due to regulations, or rather the lack of regulations. It is necessary to have appropriate and applicable regulations in place. The current situation gives a lot of	*Internationally oriented* "The role of regulation in all of this? – There is differences between locations; how are regulators responding to this, for instance the FDA, and how will CRISPR as a cell therapy develop?" (Int.) Often internationally and translative oriented (Obs.)	*Creative and self-facilitative* "The FDA is realizing the need, this helps for the development from a commercial perspective." (Int.) "There is a need to change incentives. Incentives come from: journals, policy makers, funders. There is need for a collective action model. Through IP the option can be forced: Create a patent pool. And, focus on specific individuals as

		uncertainty around our product development… … and we need the product development in order to keep our company afloat." (Int.) When the setting is not facilitative enough, opportunities are sought elsewhere if possible (Obs.)		perpetrators, not at the system as a whole (as the government is the major contractor in the US), but there is the legal basis to target specific individuals and make them outcasts. It is important to leverage different channels of power. Because the current developments in science led from physicality location/therapy to no oversight and decreased to no traceability." (Int.)
	12) Local Government policy "Strong government support for and understanding of start-ups to economic growth. Additionally, supportive policies should be in place covering economic development, tax and investment vehicles" (Feld, 2012, p. 186-187). Public accountability as the basis for trust (Jasanoff, 2005)	*Assumption of trust; role-based* "In Europe we tend to put the break on to quickly. Everything that is new is scary. To put it very black and white: Americans love new things, and Europeans find new things rather scary." (Int.) "A report by the National Institute for Public Health and the Environment (RIVM, May 2018) assessed whether the assessment methods for the current GM applications are adequate. It is reported that for half of the applications the current assessment method is possibly no longer fit, or there is insufficient knowledge or information to adequately assess the risks for people and the environment. This flags potentially significant bottlenecks regarding risk assessment." (Int.)	*Assumptions of trust; relational* "The UK has recently closed the gap with the US in terms of venture capital deal numbers across all sectors, but UK VC deal sizes continue to be smaller, so that UK companies are less capitalised than their US counterparts. The British Business Bank established British Patient Capital (BPC) in 2018 to increase the amount of long-term investment available for innovative UK companies wanting to scale up. BPC is already making a difference to the UK life science sector having committed £109m into four life science funds including the Dementia Discovery Fund. Other government initiatives, such as the commitment to unlock long-term capital held in the UK's pension funds to support science commercialisation is also yet to yield fruit and the BIA will remain an active participant in that work. Diversifying the domestic life sciences investor base is critical to the long-term resilience of our sector." (Doc.)	*Assumptions of distrust; legal* "Policy-makers are data driven agencies. The FDA gets how it works and has the necessary authorities to make the calls. Genome editing has been around for a while; so the technical concepts exist, and the current approach is to regulate products, not technologies. These rules are not appropriate anymore. Tech standards need to get better; this is contextual. Look at data and context where you want to do it. But this requires flexibility." (Int.) "The current approach is to "regulate products, not technologies. These rules are not appropriate anymore. Tech standards need to get better. Considerations should be contextual. Look at data & context where you want to do it [explain]. This needs flexibility." (Int.)
Regulatory Infrastructure (continued)	**13) Legal landscape** There is substantial uncertainty that needs to be coped with. The laws, regulations, and policies regarding CRISPR are still evolving in each of the geographical settings. (Obs.)	*Stymieing* "Regulations regarding this [CRISPR] technology are simply non-existent in the Netherlands." "It is not how you regulate it [CRISPR innovations] but how you deal with it [CRISPR innovations]. The developments will take place one way or another.	*Progressive* "In the UK, the law does not currently allow the use of genome editing techniques in human embryos or gametes (sperm or egg cells) for use in reproduction. This is prohibited under the Human Fertilisation and Embryology Act 1990, which defines the legal requirements for the use of gametes and embryos outside of the body, for	*Self-regulatory* "Regulators are sooo behind; Unable to jump in, policy makers have no real role in the development of this tech." (Int.) "Beyond consultation are voluntary self-regulation and nonbinding agreements. These are self-imposed rules that are seriously constraining with respect to

		Nonetheless, we still have a vivid discussion regarding genetic modification, at least in the Netherlands. And then, for example, if you are talking about new applications; if you will start tinkering with people, how far can you go? And then it really should not be about which tech you use, but what the outcome of its application will be…" (Int.)	research and in clinics. The use of embryos and gametes in research and in clinics is licensed and regulated in the UK by the Human Fertilisation and Embryology Authority (HFEA). The law may need to be further amended to address specific potential applications that might not fall within the scope of the current regulatory regime." (Doc.)	donation of tissues, recruitment of donors, and experimentation that raises concerns, such as the use of chimeras. Examples include the guidelines adopted by the International Society for Stem Cell Research, which have been amended to cover all forms of embryo research, from basic science to clinical trials with stem cells (ISSCR, 2016). Guidance also comes in the form of persuasive, albeit unenforceable, international instruments, such as those issued by the Council for International Organizations of Medical Sciences (CIOMS) for global standards for human subjects research." (Doc.)
	14) Political engagement and interference "This kind of [political] interference can be perceived as fairly careless and discourages investors. Investors wonder, will it be difficult to be reimbursed later?" (Int.) The visibility and transparency of expert bodies (Jasanoff, 2005)	*Nontransparent* "Politicians sometimes publically state really awkward things, but in spite of that the intentions are of course good. But good intentions should not be at the expense of safety in humans. For instance, the government now wants to completely abandon animal testing by 2025. The industry wants to abandon animal testing as well, but the timeline needs to be feasible. With the current status of things, it is more likely that this policy will not be successful and that statements like this will only making it less attractive for companies to settle here." (Int.)	*Variable* "The Human Fertilisation and Embryology Authority (HFEA) has approved a research application from the Francis Crick Institute to use new genome editing techniques on human embryos." (Doc.) "…the first government approval in the world to edit the genomes of human embryos for research purposes, opening a new front in genetics research." (Doc.)	*Transparent* **"**So there is the new political US regime versus the old: coordination for a coordinated regulation and policy framework was underway under Obama, but all was abolished under Trump. New tech has to fit into the framework. Currently there is basically an impasse as no revisions have been made. It didn't help that the White House science & tech committee was abolished under Trump." (Int.)

Notes: Data extracts are marked "Int." (for interview), "Obs." (for fieldnotes), and "Doc." (for document); Chief basis of these summaries is derived from data from this study. Structure for summaries inspired by Thornton et al. (2005), Smets, Morris, and Greenwood (2012), Jasanoff (2005, p.259).

Building on the sample's data tendencies are listed by local geographical context. Setting specific tendencies were induced from the data that allowed to identify first order concepts across the different settings: (1) local ecosystem resourcefulness, (2) institutional IP valorisation, (3) company IP protection, (4) team composition, (5) investor added value, (6) capital circulation, (7) motivation for spinning out, (8) business development focus, (9) product industry, (10) reimbursement and pricing, (11) navigating legal complexity, (12) local government policy, (13) legal landscape, and (14) political interference. Each of the fourteen observed tendencies is now discussed for each one of the thee geographical contexts.

7.1.2 The local field dynamics of the Netherlands (Setting A)

In setting A, the Netherlands, it was found that there is a strong academic scientific focus that is mainly aimed at the production of high quality research for publication in academic journals. The *resourcefulness of the ecosystem (1)* is not necessarily tailored towards venture building: "We now have an infrastructure here in the Netherlands that leads to phase II, but after that everything is sold off. We have the spark, but how can we keep it here? Our [basic] knowledge is actually very profound and large: many phase I and some phase II ideas, but how further?" (Int.). Consequently *institutional IP valorisation (2)* is less of a priority to the research institutions and often not tightly structured and valued. When interviewees expressed discontent over this situation comparisons were often made with the US as an ideal scenario:

> "In the US everyone wants to start something, but here you see that less. TTOs [technology transfer offices] in Europe are different: if you look at the US or Boston specifically. Suppose they have 100 patents, they give out 90 of

> them, 1 is perhaps successful of which they then can take 5% royalties. And that one keeps on giving returns. They do not haggle about a fee, just a percentage in royalties without a buy-out. Here, in the Netherlands, they want an up-front fee over the IP, so they can pay a few new PhDs. They [the TTOs] don't consider the bigger picture. But young biotech companies have to cough that up and then have no money left to actually start building something." (Int.)

Such situations may create difficulty for early stage science-based spinouts as IP is often central to their organisation *(3 - company IP protection)*: "To start your own biotech company you need a technology and a patent. The challenge lies in how you translate science into a product. …What do you need in order to bring an idea to market? Well, you need a good and fashionable technology, specialist knowledge, [and] IP" (Int.). As technology is spun-out and organisations are constructed academic understanding often tends to be overemphasised *(4 – team composition)*: "another hurdle is that young Dutch companies are afraid to involve outsiders into their business… this enhances the chances of misinterpretations between young companies and VCs… appropriate mentorship could help to avoid this…" (Int.). Especially since *added investor value (5)* through 'smart capital' is limited. This would entail that investors actively contribute to the organisations leveraging their network and expertise. Instead the companies need to be largely self-reliant – yet again the US is often emphasised as exemplary:

> "There is a level of expertise amongst the investors in Boston that you will not find in the Netherlands. There, there is much more expertise in CRISPR. For instance, just the fact that the Broad Institute is based in the Boston area… there are already investors present that have an interest in investing into CRISPR applications. You don't have this in the Netherlands. The Dutch investors are incredibly hesitant to take the lead, and have a habit of 'drip-feed funding' [release funds just a little by a little, but not enough to make serious progress]. Yet they are likely to be interested in joining the investment round once an experienced investor from Boston takes the lead. At which moment we will have to ask ourselves whether we are still interested in having a Dutch investor on board." (Int.)

This ties in with the experience of facing locally a premature investment community and a hesitant and risk averse investor sentiment *(6 – capital circulation)*: "The number of serious (super) angels are limited and often only focused on seed funding. So a possibility would be to go straight to VC funding, here or in the US." (Int.).

Organisational development often still has a strong academic connotation *(7 – motivation for spinning-out)* and focuses on complementing academic research with commercialisation: "…some ideas are less suited for an academic setting, for example if you want to scale up. There are few academic labs that are larger than 10-20 people. This is easier in a commercial setting…" (Int.). For instance, in order to scale research and to bring in otherwise non-available funding (Obs.). Hence, also the *business development focus (8)* tends to be somewhat risk mitigating by adopting sophisticated platform approaches: "Reason for a platform-company approach is a 'not all eggs in one basket'-approach with more shots at success" (Int.). The new ventures need to find their own way as local industry considers CRISPR applications mainly an add-on to existing industrial processes, making partnerships less appealing *(9 – product industry)*:

> "For large companies … CRISPR is rather a tool to accelerate work that they already did, merely a tool to work quicker. Yet it is somewhat difficult to get the licences to use CRISPR. At this stage CRISPR cannot be distinguished from classical methods; the difference mainly lies within the R&D processes to arrive at a certain strain. "one should see it as a lab automation for faster strain production, comparable with PCR but only now with IP. For PCR they have connected the IP to the purchase of such a machine (manufactured by Millipore in Europe), but for CRISPR it is not clear who has the rights." (Int.)

In terms of *reimbursement and pricing (10)* of possible end products and services local government takes a stance if it comes to health, imposing capped market prices that make the Dutch market less attractive – at least for new ventures:

> "Health insurers are not automatically allowed to provide cover for any new medicine that comes onto the market. The Ministry of Health, Welfare and Sport and the Healthcare Institute of the Netherlands decide what drugs fall under the standard health insurance package. Registered medicines have to be assessed (in Dutch) before they can be included in the Medicines Reimbursement System (GVS). Medicines listed in the GVS are fully or partially reimbursed by health insurers. The Ministry of Health, Welfare and Sport exercises restraint in adding new medicines to the Medicines Reimbursement System. It wants to keep health care affordable. So the standard package offers a good, but not excessive, level of cover. The Ministry of Health, Welfare and Sport sets maximum allowable prices for medicines (in Dutch) in accordance with the Medicine Prices Act. When buying in drugs, pharmacists may not pay more than the maximum prices." (Doc.)

The experience of a stymieing government attitude *(11 – navigating legal complexity)* ties in with *local government policy (12)* that grapples to find an appropriate framework to deal with the novelty of the emerging technology:

> "A report by the National Institute for Public Health and the Environment [RIVM, May 2018] ... reported that for half of the applications the current assessment method is possibly no longer fit, or there is insufficient knowledge or information to adequately assess the risks for people and the environment. This flags potentially significant bottlenecks regarding risk assessment." (Doc.)

As scientists and industry urge government to update the *legal landscape (13)* – "regulations regarding this [CRISPR] technology are simply non-existent in the Netherlands" (Int.) – as the consensus is that new applications should be tested on their purpose rather than their method *(14 – political interference)*:

> "It is not how you regulate it [CRISPR innovations] but how you deal with it [CRISPR innovations]. The developments will take place one way or another. Nonetheless, we still have a vivid discussion regarding genetic modification, at least in the Netherlands. And then, for example, if you are talking about new applications; if you will start tinkering with people, how far can you go?

> And then it really should not be about which tech you use, but what the outcome of its application will be…" (Int.)

For high quality academic research looking to spinout, this local setting is still grappling with finding facilitative balance. It was remarked that "…with the current status of things… it [is] less attractive for companies to settle here" (Int.).

7.1.3 The local field dynamics of England's Golden Triangle (Setting B)

In setting B, England's golden triangle Oxford-London-Cambridge, it was found that there is also a strong academic scientific focus like in setting A. Yet, there is more overall interest in scaling home grown research following the establishment of intellectual property. It was observed that setting B has a more supportive infrastructure in place. For instance in terms of *resourcefulness of the local ecosystem (1)* with research institutions positioning close to industry, and vice versa:

> "The academic sector in the UK's regions shares numerous corporate collaborators. Almost every region collaborates with large pharmaceutical companies such as GlaxoSmithKline, Merck, Pfizer, and AstraZeneca, software giants like Microsoft, or diverse engineering companies like Rolls Royce, to one degree or another, which is why these companies appear in the centre of the chart…. Universities and research institutions play a key role in generating innovation and defining future job growth in cities and regions – businesses position themselves close by in order to benefit from these outputs. For example, AstraZeneca decided to establish a new Global R&D Centre and corporate headquarters on the Cambridge Biomedical Campus in East England because of its proximity to world-leading scientific expertise and collaborative opportunities with academic research institutions, hospitals and biotech companies" (Doc.)

Institutional IP valorisation (2) is often establishing ownership within the universities, striking deals for spinning out or licencing with newly formed companies *(3 – company IP protection)*:

> "Russell Group universities excel in producing innovative new spin-out companies and licensing their IP and Technology Transfer Offices have been

> integral to these successes. The successful exploitation of IP is complex and it is vital universities should maintain autonomy to manage their own IP. Being able to vary approaches to IP and commercialisation depending on individual circumstances (e.g. on the nature of the research and company to be spun-out or technology to be licensed) and the market value provides the UK with a major competitive advantage. Russell Group universities have led the way in pioneering innovative new models for IP management, including Easy Access IP. A single, one-size-fits-all approach to technology transfer would not be fit for purpose…" (Doc.)

Capabilities are of mixed background with very specific role models in place, but the consensus is that 'success' can be communicated more *(4 – team composition)*: "Here in Oxford we are lacking role models, or at least they are under communicated" (Int.). There is some in*vestor added value (5)* but investment and support could be further improved: "…assuming good European science should be translated, the way to get it done is by creating decent opportunities to invest more capital in the best ventures, and to stop trying to build SME NewCos [new companies] and focus on brutal winnowing of seeded NewCos." (Int.). Yet investors are supportive but only if they understand the technology *(6 – capital circulation)*: "we are currently looking for series A funding, but face difficulties selling the idea. The pitch is good, but there is need for a lead investor. Tech VC don't understand the biological aspects on which the company builds [and the] hard core biotech/science investors only go into real therapeutics" (Int.). Nonetheless, significant capital is in circulation and frameworks to access it are emerging: "There are venture/pharma driven accelerators emerging designed to minimise risk and increase speed/quality" (Int.). These initiatives are designed to leverage the potential of academically developed knowledge and technologies, and are boosting *motivations to create spinouts (7).* Hence company structures tend to be adaptive depending on what format and focus is easiest picked up on and understood in their local field *(8 –*

business development focus), for instance, when there is opportunity to be merged with industry needs *(9 – product industry)*: "Pharma [large pharmaceutical companies] currently buys the almost successful companies, which are of course expensive" (Int.). *Reimbursement and pricing (10)* are made in partnership with the local authority, and is less one directional than in setting A as local government allows for discussing price:

> "…drug formularies are developed locally by Primary Care Trusts (PTCs) and NHS Trusts. PCTs adapt these formularies to contain costs and remain in budget. In the UK there are few direct drug pricing controls, and the reimbursement mechanism is different to many other European countries. The branded drug price is set using the Pharmaceutical Price Regulation Scheme (PPRS) and the drug is then reimbursed by the NHS according to the manufacturer's list price. Government drug spending is affected by patient co-payment (in the form of prescription charges), a claw back system operated by the government for community pharmacies and discounting to hospital pharmacies." (Doc.)

Hence, the legal system is also different from continental Europe *(11 – legal complexity)*: "The role of regulation in all of this? – There are differences between locations; how are regulators responding to this… how will CRISPR as a cell therapy develop?" (Int.). *Local government policy (12)* is often perceived as facilitative, internationally compatible, and technology-translation oriented, even when the existing *legal landscape (13)* needs to be adjusted:

> "In the UK, the law does not currently allow the use of genome editing techniques in human embryos or gametes (sperm or egg cells) for use in reproduction. This is prohibited under the Human Fertilisation and Embryology Act 1990, which defines the legal requirements for the use of gametes and embryos outside of the body, for research and in clinics. The use of embryos and gametes in research and in clinics is licensed and regulated in the UK by the Human Fertilisation and Embryology Authority (HFEA). The law may need to be further amended to address specific potential applications that might not fall within the scope of the current regulatory regime." (Int.)

Forthcoming *political interference (14)* helps to navigate this: "The Human Fertilisation and Embryology Authority (HFEA) has approved a research application from the Francis Crick Institute to use new genome editing techniques on human embryos…. [this is] the first government approval in the world to edit the genomes of human embryos for research purposes, opening a new front in genetics research" (Doc.).

7.1.4 The local field dynamics of the US Boston Area (Setting C)

In setting C, the US Boston area, scientific research is published in leading journals but not before IP is secured. Envisioned commercial applications are considered important for support of academic research. This is not because of potential monetisation, but because of the consideration for future scalability and societal relevance of research. Ideas need to have the potential to be pitched to possible future investors. For instance within the *(1) local ecosystem, resourceful* frameworks are in place to connect ideas with development opportunities:

> "We always look for new ways to develop their technologies: We're not always sure what to do with them. People might want to create data packages, or modify fish, or strawberries. We help to pick the investors, and link the companies" (Int.)

For the entrepreneur this might take shape like this:

> "[Local] support is crucial. I receive support in R&D, optimisation… basically having a lab or institute that can do that; And to have advisors. I have advisors in venture capitalism, like a COO that used to be in GoldmanSachs, but also a former coach from St John's that is also a partner next to Professor George Church that help with the product development, and a 20-year-long basketball friend does the brand marketing." (Int.)

The setting is strongly tailored towards pushing ideas out in order to make them beneficial to society. This is also reflected in how IP is valorised by the institutions *(2 – institutional IP valorisation)* and used within the companies:

> "Here at the Broad we see commercialisation as needed to maximize benefit for public impact of technological development. This includes non-exclusive licensing, but in some cases, like with therapeutics that also means that the technologies are likely to be never developed. There is a need for natural monopolies to create incentive for investment. Therefore, market exclusivity needs to be allowed, for instance to permit big pharma to make nine figure investments." (Int)

This approach can be reflected in how organisations are organised around IP *(3 - company IP protection*):

> "This was also how Editas was founded. It had to choose the genes it wanted to develop. There are about 20.000 genes, and it [the company] can't develop something for all of them at the same time. So they got exclusivity and a first shot at which genes they wish to develop. The rest of the genes are free for others to use" (int.)

The professionalism by which ideas are captured, supported, and developed also resonates in terms of how organisations take shape, for instance in their *team composition (4)*: "…the investors choose the management team. The scientists tend to step back and become advisors." (Int.). Investors are likely to play an important role early on as not only cash but also experience is added *(5 – investor added value)*: "This investment has been increasingly concentrated in large, established funds with a track record of investing in biotech" (Int.). Ample capital is present and investors are even taping into additional local fields to draw in further opportunity *(6 – capital circulation)*: "Several internationally well-established funds from e.g. Silicon Valley and Boston, but also European VCs, are actively trying to connect with the European spinout and start-up scene in biotech" (Int.). Within the industry it is

considered common knowledge that, eventually, "if you are a serious company … you go to the NASDAQ" (Int.).

The *motivation for spinning out (7)* can be many things, however, in the case of all sample companies in this setting C it was stated this occurred in a symbiosis between the academic laboratories and the commercial entities, for instance:

> "Thank god for the company otherwise they [the scientists] would have to do all of this… now they can maintain focus on exploration, and my academic colleagues can maintain focus. The company provides focus while the scientists can continue to follow their own interests." (Int.)

This symbiosis entails as well that "…the company is refining the technology, really simplifying things… [such as] development of user interface and standardisation" (Int.). Often this ties in with a blockbuster *business development focus (8):* "Editas is focussed on just one technology, so it will be difficult and near impossible for them to defer or to drop the development" (Int.). In terms of the *product industry (9)* the local field is ahead of the cure and recognises converging market needs:

> "The increasing convergence of tech and healthcare will also provide fresh opportunities for the industry. We are already seeing the use of real world evidence to measure the actual performance of drugs post approval and drive future investment decisions." (Int.)

Capitalisation on the technology through pricing as well as *product and service reimbursement (10)* are considered on an open market:

> "Generally speaking, payers in the US (both CMS and private insurance companies) do not regulate the price of a pharmaceutical product, allowing the manufacturers to set prices freely. However, payers are allowed to set the reimbursement price/rate. The reimbursement process differs between the public sector (CMS) and the private sector." (Doc.)

Local government policy (12) and the *legal landscape (13)* are standardised but try to keep up with innovation *(11 – navigating legal complexity)*:

> Policy-makers are data driven agencies. The FDA gets how it works and has the necessary authorities to make the calls. Genome editing has been around for a while; so the technical concepts exist, and the current approach is to regulate products, not technologies. These rules are not appropriate anymore. Tech standards need to get better; this is contextual. Look at data and context where you want to do it. But this requires flexibility." (Int)

Like in the other two settings it appears to be difficult for regulators and policy makers to keep up with innovation: "Regulators are sooo behind; unable to jump in, policy makers have no real role in the development of this tech" (Int.). The FDA is realising the need to adjust and "this helps for the development from a commercial perspective" (Int.), but the political landscape *(14 – political interference)* can cast uncertainty on what measures are to be taken, causing an impasse in terms of regulatory measures:

> "So there is the new political US regime versus the old: coordination for a coordinated regulation and policy framework was underway under Obama, but all was abolished under Trump. New tech has to fit into the framework. Currently there is basically an impasse as no revisions have been made. It didn't help that the White House science & tech committee was abolished under Trump" (Int.)

The effect is that local arrangements between practitioners emerge as temporary placeholders for the lack of sufficient policy and regulatory frameworks:

> "Beyond consultation are voluntary self-regulation and nonbinding agreements. These are self-imposed rules that are seriously constraining with respect to donation of tissues, recruitment of donors, and experimentation that raises concerns, such as the use of chimeras. Examples include the guidelines adopted by the International Society for Stem Cell Research, which have been amended to cover all forms of embryo research, from basic science to clinical trials with stem cells (ISSCR, 2016). Guidance also comes in the form of persuasive, albeit unenforceable, international instruments, such as those issued by the Council for International Organisations of Medical Sciences (CIOMS) for global standards for human subjects research." (Doc.)

Thus, with CRISPR and related practices emerging wide and bright, technology and organisation are interacting with different logics dominant in each of the three field

settings. The different logics are enacted through different professional practices and dynamics with variation between the different field settings. However, for some of the actors aspects and tendencies of one field setting can be perceived as more favourable than their own field settings.

7.3 Discussion

The data shows that when comparing different institutional settings, technology, organisation, and related practices, these cannot be understood as uniform and universally generalizable but rather as unique in their own situated activity (see also Lounsbury, 2007). As organisations move from one field to another this can be to escape institutional pressures (Faulconbridge and Muzio, 2016) or to optimise their chances of survival by straddling fields. Exploring this further the structure of the discussion is as follows: first the anatomy of the field is discussed, second three strategic approaches to navigate different field logics, and third a multi-level integrated model for practice driven field construction follows from the data as it is observed how field-level change occurs following the introduction or variation of practices.

7.3.1 The anatomy of the field

The data shows that for CRISPR organisations to flourish they need resources, IP protection, sufficient talent to staff teams, knowledgeable investors, capital, links with industry, facilitative legal frameworks, political support, end users, and a product market. Such a network of actors (DiMaggio and Powell, 1991) with a

collective context-bound shared understanding of the organisations' needs (Wooten and Hoffman, 2008; Scott, 1994) can be thought of as an institutional field (i.e. Zilber, 2014; Battilana and D'Aunno, 2009; DiMaggio and Powell, 1991). The dynamics observed in each of the geographical field settings can be summarised in four "features that bind a field together and govern field interactions" termed "institutional infrastructures" (Hinings, Logue, and Zietsma, 2017, p.171), namely *'know-how infrastructure'*, *'capital infrastructure'*, *'product infrastructure'*, and *'regulatory infrastructure'*. Bringing together the four dynamics of the institutional infrastructures an "anatomy of the field" (Pisano, 2006, p.81) is mapped out in figure 7.3 illustrating schematically the different actors, the institutional arrangements that connect these actors, as well as the rules that govern and affect how those arrangements work interact (Zietsman, Groenewegen, Logue, Hinings, 2016).

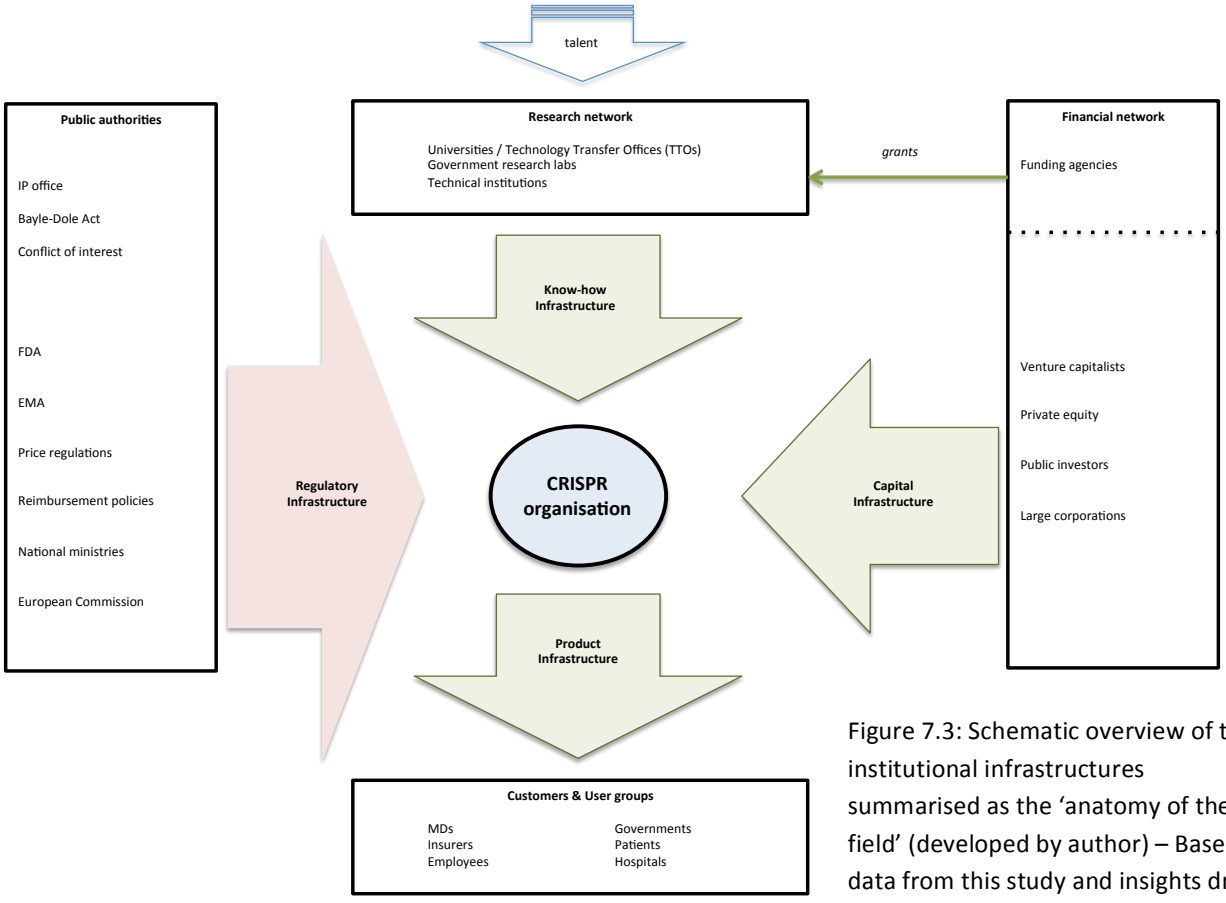


Figure 7.3: Schematic overview of the institutional infrastructures summarised as the 'anatomy of the field' (developed by author) – Based on data from this study and insights drawn from Pisano (2006) and Geels (2002).

Following on Lounsbury's (2007) seminal contribution recognising geographical variability between fields, this chapter extends a growing recognition that regarding the geography of fields differences in location and the capability to nurture emergence of new (CRISPR) organisations should be taken more seriously in institutional theory (e.g., Faulconbridge and Muzio, 2015; Greenwood et al., 2010; Lounsbury, 2007; Marquis et al., 2007). Faulconbridge and Muzio (2016, p. 91 / p.120) stated that "… institutional prescriptions are exercised in patchy and uneven ways within different field locations" and "in uneven and dynamic fields different locations are associated with varying degrees of complexity". Where they focussed on prescriptions within a single field this chapter takes a comparative approach across fields – as called for by Smets et al. (2012).

What characterises the field? For a technology (and organisation) to emerge in the way it does, we need to think of all the activities that have to be carried out for it to appear in the way it does (Schatzki, 2009). Structures are composed of understandings and agreements that have become part of the conventional way of doings things in that field (e.g. Becker, 2008; Jasanoff, 2005, Lounsbury, 2007). Activities like research ethics or raising funding occur in a particular way. If any of these activities does not get done, the work may occur in some other way. If there is no one who supports its doing, it will go unsupported – the material infrastructure exists in practical instantiation (Leonardi, 2010). Artefacts shape and are shaped by human agency (Orlikowski and Scott, 2008): If certain equipment is not available the

work cannot be done or will have to be done without it. Understandably, any of these aspects affects the practices that occur and the produced outcome will not be the same. Activities may be conducted in diverse ways with equal diverse results. All these things must be done for technology and organisation to occur as they actually do (Becker, 2008; Leonardi and Barley, 2008; Garud and Karnoe, 2001); some form of 'division of labour' is required. For each and everyone that contributes to the development and establishment of a technology and related practices there is a specific "bundle of practices" to fulfil (Schatzki, 2009). To denote the network of people whose cooperative activity, organised via their joint knowledge of conventional means of doing things, produces the field and the common practices that it is made of. Relevant is to understand who is acting together to produce the technology of CRISPR, and, what are the institutional dynamics at play? The relevant actors that make up the anatomy of the field were identified and grouped in general categories, each with different roles: 'research institutions', 'funders and funding agencies', 'public authorities', and the 'end users and customers'. Several actors fulfil multiple roles within the field and contribute to different underlying dynamics (table 7.2).

Table 7.2: ANATOMY OF THE FIELD (developed by author, builds further on table 7.1)

Institutional infrastructures	Variations between fields in logics and practices shaping the local institutional infrastructure	Illustrative findings
KNOW-HOW INFRASTRUCTURE The presence of a diverse and skilled group of workers, 'talent' for all levels of employees in all sectors and areas of expertise. Universities are an excellent resource for start-up talent and ideas and should be well connected to community. *Relevant actors:* Research institutions like universities, government research laboratories, technology transfer offices, technical institutions, large corporations	(1) Local ecosystem resourcefulness - Grassroots academic activity (NL) - Top-down industrial alignment (UK) - Streamlined interactions (US)	"A region's research strengths may influence or be influenced by the opportunities offered by geographical proximity of industry and academia" (Doc.)
	(2) Institutional IP valorisation - Up-front and premature valorisation (NL) - Ownership focussed valorisation (UK) - Valorisation through licencing (US)	"...the universities hedge their bets on milestone, equity, and licensing fees" (Int.)
	(3) Company IP protection - Company-centric IP protection (NL) - University-centric IP protection (UK) - University licensed protection (US)	"…make sure to have [IP] protection for your ideas" (Int.)
	(4) Team composition, - Academic practitioners (NL) - Multidisciplinary teams (UK) - Instalment of professional management (US)	"..you need a team that is not always full of scientists; you need also people that are willing to take a risk. People with diverse backgrounds, and some that will also bring previous experience on board" (Int.)
CAPITAL INFRASTRUCTURE Support by the community of venture capitalists, angels, seed investors and other forms of financing. This should be available, visible and accessible across sectors, demographics and geography. *Relevant actors:* Funders and investors like funding agencies, grants, trusts, venture capitalists, private equity, public investors, large corporations	(5) Investor added value - Receiving non-commercial funding to be self-reliant (NL) - Receiving support where the investors are able (UK) - Sturdy guidance from experienced investors with strong track records (US)	There is a strong variance in the standard of knowledge, network, and mentorship that can be offered by investors between geographical settings (Obs.)
	(6) Capital circulation - Investor networks are emergent, premature, and risk averse (NL) - Evolving and curious to engage with new opportunities (UK) - Established pipelines and affordance to make more opportunistic investments (US)	There are different degrees of access to investors and willingness to provide investment (Obs); "…it may be hard t access capital, but this does not necessarily mean that capital is not present" (Int.)
PRODUCT INFRASTRUCTURE The product is used by professional practitioners operating under shared traditions of problems and solutions. They define problems similarly and have a	(7) Motivation for spinning out - Complementing academic research through commercialisation (NL) - Leveraging the potential of technology (UK) - To standardise, scale, and refine technology (US)	Most academics engage with industry to further their researc rather than to commercialise their knowledge for monetisation (Obs.)

consensus on criteria for acceptable solutions; building on a history of previous attempts to solve those problems and novel problems generated by those attempts; and familiarity with the history of work like theirs their support personnel and end users can understand what has been attempted and how, and to what degree this works. *Relevant actors:* Customers and user groups like medical doctors, hospitals, government organisations, insurers, patients, incumbent companies, research institutions	(8) Business development focus - Platform-company approach (NL) - Blockbuster approach (UK) - A mix of both that is adaptive and hybrid in structuring (US) (9) Product industry - Add-ons and plugins to existing industry — (NL) - Facilitative towards industry (UK) - Ahead of the innovation curve and converging different influences into a market push (US) (10) Reimbursement and pricing - Government imposed pricing / reimbursement (NL) - Set in a collaborative manner by partnering with end-users (UK) - Floated onto an open market with no limits on prices associated with products and services (US)	"The reason for a platform-company approach is a 'not all eggs in one basket'-approach with more shots at success" (Int.) The way products are created for and matched with the industry is constantly evolving: "...Over 100 years we will have other medicines. The development costs go down, But patient costs are rising. This industry can only exist by the continuous increase of shareholder values" (Int.) Price setting occurs in different manners between settings (Obs); "When reimbursed, who pays for it? We need to chec with the payer, and see if it works." (Int.)
REGULATORY INFRASTRUCTURE The policies that are in place covering economic development, tax and investment vehicles. The state affects what can or can't be done by directly intervening in activities. Intervention takes different forms: open support, censorship, and suppression. The state acts in behalf of its own interests, taking actions designed to further those causes and activities its agents consider crucial or important for its and their survival and well-being. *Relevant actors:* Public authorities like IP offices, regulators, FDA, EMA, ministries, European Commission, reimbursement policies.	(11) Navigating legal complexity - Outwards directed and possibly deal with obstacles by diverting elsewhere to another setting (NL) - Internationally oriented by comparing and mixing legal settings in a favourable manner (UK) - By creating a self-facilitative community that pro-actively resolves legal tensions themselves (US) (12) Local government policy - Assumption of trust; role-based focus (NL) - Assumption of trust; relational focus (UK) - Assumptions of distrust in local authorities; legal focus (US) (13) Legal landscape - Stymieing (NL) - Progressive (UK) - Self-regulatory (US) (14) Political interference - Non-transparency and unpredictability in terms of political engagement and interference (NL) - Ambivalent and variable transparency encourages or discourages entrepreneurs and investors (UK) - Transparent (US)	"The role of regulation in all of this? – There is differences between locations; how are regulators responding to this, for instance the FDA or the EMA, and how will CRISPR as a cell therapy develop?" (Int.) Being open about government expertise in regulating, facilitative measures, standardised policy measures is the basis for trust (Doc.) Substantial uncertainty is faced with insufficient existing regulation in all three settings. Regulators are playing catch-up. Different degrees of progressive facilitation are witnesse for forthcoming laws on new technology (Obs). Political interference ties in with the visibility and transparency of expert bodies: "Investors wonder, will it be difficult to be reimbursed later?" (Int.). Different degrees of political interference were observed ranging from active engagement to causes for an impasse.

These institutional infrastructures correspond with, and are composed out of, each of the first order concepts of setting A (NL), B (UK), and C (US). Yet the characteristics of the infrastructures are taking shape differently in each field. Each 'institutional infrastructure' is now discussed.

Know-how infrastructure. An important element of an effective entrepreneurial field dynamic is the presence of a diverse and skilled group of workers, 'talent' (see e.g. Lee et al., 2004). Universities and research institutions are an excellent resource for knowledge, spinouts, and talent to be launched into the community (i.e. Perkmann et al., 2019; Ross, Perkmann, and Fini, 2013; Feld, 2012; Stam, 2015). They facilitate the creating and curating of new ideas, knowledge, and know-how as these are subject to the rationale according to which activities make sense pursuing. Different tendencies were observed for the know-how infrastructure between each of the three geographical settings. Relevant actors that fall under this category are: Research institutions like universities, government research laboratories, technology transfer offices, technical institutions, and large corporations from which new organisations spinout (see also Klepper, 2016).

Capital infrastructure. A "strong, dense and supportive community of venture capitalists, angels, seed investors and other forms of financing should be available, visible and accessible across sectors, demographics and geography" (Feld, 2012, p. 186-187). Relevant practitioners are field actors like funding agencies, grants, trusts, venture capitalists, private equity, ultra high net worth individuals, public investors,

and large corporations. Also the state can influence the development of technology and related practices by making funds available for some kinds and not for others. For instance when it considers a particular technology as an integral part of a nation's interest, development, or possibly even its identity and national culture. The state might provide financial support for activities that would otherwise have to come from elsewhere or would not be available at all.

Product infrastructure. For the product infrastructure the end user is crucial. The adoption of new (bio)technology often requires some training and skilled understanding. End users need to learn the relevant techniques to use the technology or product, and understand the characteristic of the kind of work they can do with it, whether it be the application of the product, the creation of ideas, execution, or some of the many support activities, or appreciation, response, and criticism. Relevant practitioners are customers and user group such as field actors like researchers, medical doctors, hospitals, government organisations, insurers, patients, incumbent companies, and research institutions. They are participants in the making of new technology and give shape to the creation process (Bijker et al., 2012). Professional practitioners operate as part of a shared tradition of problems and solutions (Kubler, 1962; Fleck, 1935). They define problems similarly and have a consensus on criteria for acceptable solutions (Wooten and Hoffman, 2008); building on a history of previous attempts to solve those problems and novel problems generated by those attempts (Scott, 1994); and familiarity with the history of work

like theirs their support personnel and end users can understand what has been attempted and how, and to what degree this works.

Regulatory infrastructure. The regulatory infrastructure consists of the public authorities and the governmental apparatus through which they operate within their borders, as they participate in the production and enforcement of policy and legislation. Legislatures and executives make laws, courts interpret them, and bureaucrats administer them. States have a monopoly over making laws within their own borders, and always tend to play some role in the making of technology. “The state acts on behalf of its own interests, taking actions designed to further those causes and activities that are thought to be crucial or important for its survival and well-being” (Becker, 2008, p.180). Being open about government expertise in regulating, facilitative measures, standardised policy measures is “as the basis for trust” within a field (Jasanoff, 2005). Although private persons or organisations may control access to distribution channels, the state may also intervene in the process by forbidding certain distribution, type of product, knowledge, or knowledge sharing. Other tasks lie within the creation of frameworks that support the legal protection of (intellectual) property and the establishment of mercantile law. Another part of a government’s role is providing support: “Strong government support for and understanding of start-ups to economic growth. Additionally, supportive policies should be in place covering economic development, tax and investment vehicles” (Feld, 2012, p. 186-187). For instance, this could be to stimulate development, national sophistication, or ethical understanding.

Thus by understanding the local anatomy of a field and the institutional infrastructures out of which it is composed, it can be comprehended to what extend the field provides opportunity for repaying investment of time, money, and materials – so that more time, materials, and cooperative activity can be made available with which more technology, knowledge, applications, and practices can be developed. Resources are needed to enable the move from invention to innovation with technology-as-practices giving rise to the organisations and the development of their technological applications. These resources are sourced from the field's infrastructures that make available materials and pool resources as a way of thinking of the processes of know-how (and talent), capital, product, and regulation; as well as the different actors in the field and how these actors interact with technology in their on-going practices and enactment of structures that shape their emergent and situated use of that technology within a particular situated setting. Technology and organisation bear the marks of the field through which they emerge. Institutional complexity (Greenwood et al., 2017; Lounsbury, 2007) and dissimilarity between local situations may give rise to variations in how that occurs.

7.3.1 Strategic approaches to the fields: The institutional exploiter, orchestrator, and configurator approach

The findings contribute by suggesting managerial agency in how people relate to the field within they are situated but also in how they choose to relate to other fields. By responding to a growing body of studies that calls for more theoretical and empirical

insights into the argentic use of institutions and logics (e.g., Smets et al., 2015; Smets et al., 2012; Greenwood et al., 2010; 2011) the chapter extends recent work that shows how organisations can handle complexity internally within their own structures and practices by highlighting the role of a field level strategy (e.g., Gumusay et al., 2020; Faulconbridge and Muzio, 2016; Smets and Jarzabkowski, 2013; Smets et al., 2012; Greenwood et al., 2011). The observations in the findings are a response to Marquis and Raynard's (2017, p.295) suggestion that little attention is paid to "how organisations strategically shape their institutional contexts to further their own individual ends" – in this case not only their own institutional field setting but also others. The findings show that different fields have different setups for institutional infrastructures. Consequently CRISPR organisations across the sample experience distinctively different forms of institutional complexity. The institutional infrastructures can enable or restrain the development of organisation and CRISPR technology. Hence, the success of an emerging organisation might hinge on the institutional context in which it is embedded (Vogus and Davis, 2005; Davis and McAdam, 2000).

This study extends our understanding of "how organisations navigate diverse institutional landscapes**"** (Marquis and Raynard, 2017, p.316) by zooming in on how those at the "earliest moments" of their emergence – as opposed to existing organisations – address institutional complexity (extending Smets et al., 2012; Gumusay et al., 2020) and what institutional strategies they deploy. Institutional strategies can be defined as "the comprehensive set of plans and actions directed at

leveraging and shaping socio-political and cultural institutions to maintain or improve an organisation's competitive position" (Marquis and Raynard, 2017, p.294). Organisations are not just a subject to a given institutional field, but they are capable of moving between different field settings or to combine them. Depending on the (mis)match between organisational properties and the institutional infrastructures of a field, organisations (and their practitioners) can decide to adopt: an (i) *institutional exploiter approach* in which organisation and field are aligned, an (ii) *institutional orchestrator approach* in which the organisation straddles between multiple fields, or an (iii) *institutional configurator approach* where the organisation attempts to configure the field in order to have it fulfil the most basic needs. The approaches take shape as follows:

i. **The institutional exploiter approach** occurs when organisations and their practitioners are *content with the single field* within they are based. Institutional fields are not just constraining structures to which organisations need to adapt (i.e. Cardinale, 2017; Scott, 2013; Thornton et al., 2012; Powell and DiMaggio, 2012; Heugens and Lander, 2009), but can actually be enabling and actively used. With this approach the organisation's needs and the field's institutional infrastructures are 'aligned' (or aligning) with field participants having mutually beneficial objectives and values (Patvardhan et al., 2015; Zietsma et al., 2017). "Actors exploit the available resources to solve the problems at hand" as the institutions are enabling "active use" (McPherson and Sauder, 2013, p.186). This field is a better facilitator compared to other fields and helps to enable the co-

constitution of organisation and technology: “I receive support in R&D, optimisation… basically having a laboratory or institute that can do that, and to have advisors” (Int.). The organisations therefore make full use of and derive benefit from the existing situation. This observation responds to the call that “more attention should be paid to how actors use available logics at sites where multiple institutions or organisations come together” (McPherson and Sauder, 2013, p.187).

ii. **The institutional orchestrator approach** allows organisations to not only tap into their local institutional field but to also select, straddle, and *align themselves with the practices of other more favourable* institutional fields. This approach is used by organisations and their practitioners that find themselves in a “home” field that is partially a mismatch with the organisation’s properties and needs. This (partial) mismatch may spark the need for organisations to *straddle* between multiple fields in order to obtain their essentials. The institutional infrastructures in place may be evolving and only offer some of the needed know-how, capital, product customers, or regulation: “We now have an infrastructure here that leads to phase II [clinical trials], but after that … how further?” (Int.). It was observed that CRISPR organisations – where possible – turn to other field settings in order to fulfil needs such as access to funding, end market, or facilitative regulatory frameworks. The unevenness and heterogeneity of fields (Wooten and Hoffman, 2017; Fligstein and McAdam, 2012; Lounsbury, 2007; Marquis, Glynn, and Davis, 2007) helps to explain proactive movement between

fields. Organisations need to undertake a greater variety of strategies to align their practices with different host contexts (Kostova and Roth, 2002; Lounsbury, 2007) as they (partially) "relocate" to start working across different field settings (Faulconbridge and Muzio, 2016) in order to escape institutional field pressures in their "home" field (Oliver, 1991). Planning or coordinating the elements of a situation to produce a desired effect can consist out of practitioners occupying positions or spaces between fields (Perkmann et al., 2019) with exposure to the distinctive institutions that characterise the geographically different institutional fields, thereby becoming better able to distance themselves from existing institutions and to "transpose," "translate," and "recombine" practices across those fields (Furnari, 2014; for review see Sahlin and Wedlin, 2008). Bridging multiple institutional field settings in order to facilitate for the emergence of new (material) practices (Smets et al., 2015; Souitaris, Zerbinati, and Liu, 2012) – and the organisations that bundle those practices (Schatzki, 2009) – provides a notion beyond that of the geographic field and shifts attention to the notion of a practice-based field. On these grounds this observation responds to calls for "… broader conceptualisation of the institutional environment—requiring a synthesis of ideas and insights from various research domains, as well as greater attention to the institutional underpinnings of firms' strategies" (Marquis and Raynard, 2017, p.318; see also Peng et al., 2009).

iii. **The institutional configurator approach** is adopted by organisations and their practitioners that find themselves *situated in a field that is largely a mismatch*

with the organisation's properties and needs. The institutional infrastructures in place are immature and do not offer the right kind of capital (e.g. informed investors), know-how (e.g. talent for hire), advanced regulatory infrastructures (e.g. possibility for clinical trials), and market for the end product (e.g. suitable reimbursement schemes). If an organisation has the means it is often keen to find a field that is a better fit – like in the institutional orchestrator approach. However "relocation" might (initially) not be an option due to, for instance, an organisation lacking the financial means, experience, or ethical grounds. The only option that then remains is for institutional infrastructures to be built bottom-up (Smets et al., 2012) in order to meet the most urgent needs. Consequently, this may drive field change and variation from within fields (Schneiberg, 2007). Oliver (1991) already argued that organisations do not passively submit to homogenising institutional pressures (see also Venkataraman et al., 2016; McPherson and Sauder, 2013) and field construction can take shape through organisations resisting institutional pressures (Marquis and Lounsbury, 2007). But, it might as well take shape as a collaborative effort – not to be confused with 'institutional entrepreneurship' (e.g. Micelotta et al., 2017). As change field level change occurs from within and 'from practice to field it induces practice-driven field change (Reay et al., 2013; Smets et al., 2012). This is a response to the statement that attention to how organisational actions could facilitate field-level institutional change has been limited (Smets et al., 2012; Lok, 2010; Lounsbury and Crumley, 2007) especially when it concerns how organisations

can “de-intensify the pressures … at the field level” (Greenwood, Raynard, Kodeih, Micelotta, and Lounsbury, 2017, p.357) .

CRISPR organisations are embedded in various geographical fields that offering diverse situations. Depending on the status of the field organisations and their entrepreneurs need to navigate inadequate or missing market and regulatory infrastructures and gain access to critical start-up capital and resources as a matter of survival (see also Hiatt and Sine, 2014). Institutional strategies may vary *between* different institutional settings (Marquis and Raynard, 2017) but also between the organisations within these settings. It is not so much about the collective rationality of a field (DiMaggio and Powell, 1983; Washington and Ventresca, 2004), but about the individual strategies of how organisations navigate the pressures of their institutional situation in order to bring various institutional infrastructures in line with their needs and interests (Seo and Creed, 2002). Until now the literature focused on repertoires of strategies and structures that organisations deploy to cope with various competing demands (Greenwood et al., 2011), but limited is known about how to actively and strategically utilise different institutional settings and pressures to the organisation’s benefit; and how different field settings affect responses to complexity that arises from institutional contradictions (Saka-Helmhout, 2020).

The characteristics of these three institutional approaches map onto to the profiles described in the first order settings. For instance, all non-US second wave companies (setting A & B) in the sample were planning, or already started drawing on useful aspects from other institutional fields settings like funding, market potential, and know-how. It was observed that the academic science is excellent in all three institutional fields settings, but in order to access a solid capital market, product market, or know-how market, organisations need to cast their web wide. In order to do that alignment with local practices under the logics from other institutional fields is a necessity. For instance as described in the example of setting A (the Netherlands), if a European company wants to IPO on the NASDAQ it will have to abide by US rules. The same counts for a US company if it wishes to move into the European market. It will have to abide by the rules and regulations of the European Medicine Agency (EMA); or vice versa, if a European company plans on moving onto the US market it needs to abide by the rules and regulations of the US Food and Drug Administration (FDA). Likely when companies grow, scale, and expand, they will be subject to other institutional fields that have their own distinctive local professional logics and related practices. Such exposure can happen early on in the development process, but also later. The observation of organisations actively shopping around for beneficial institutional infrastructures in other institutional fields that are better matches may lead to (partial) "field relocation" (Faulconbridge and Muzio, 2016) – yet it is important to note that this is not utterly driven by resistance to the situation of the institutional "home" field as is mainly suggested in existing work (i.e. Marquis and Lounsbury, 2007; Venkataraman et al., 2016; McPherson and Sauder, 2013).

Such a move can also be purely strategically motivated. The practice of (partial) field relocation is not only a strategic practice, but also a form of field construction as organisations and practitioners bring in different practices tailored towards other fields; for instance, a European company setting up for FDA regulations, a NASDAQ IPO, or clinical trials run by a foreign CRO. Hence, approaches can change once organisations shift setting. The motivation to adopt one of the three different approaches can be explained by a multi-level model.

7.3.2 A multi-level model of practice driven field construction

An additional contribution is made with an integrated multilevel model of practice driven field construction – summarised in figure 7.4 – that connects practice, organisation, and field. Local conventions, constituted by dominant local field logics, make collective activity simpler and less costly; yet unconventional activity less likely. By tracing how CRISPR materialises through commercialisation in a "concatenation" (see also Tilly, 2001, p.4) of institutional field dynamics, it was observed that practices of situated use of technology can transgress between field contexts, thereby consolidating practices across locations, giving enactment of local field logics a hybrid nature.

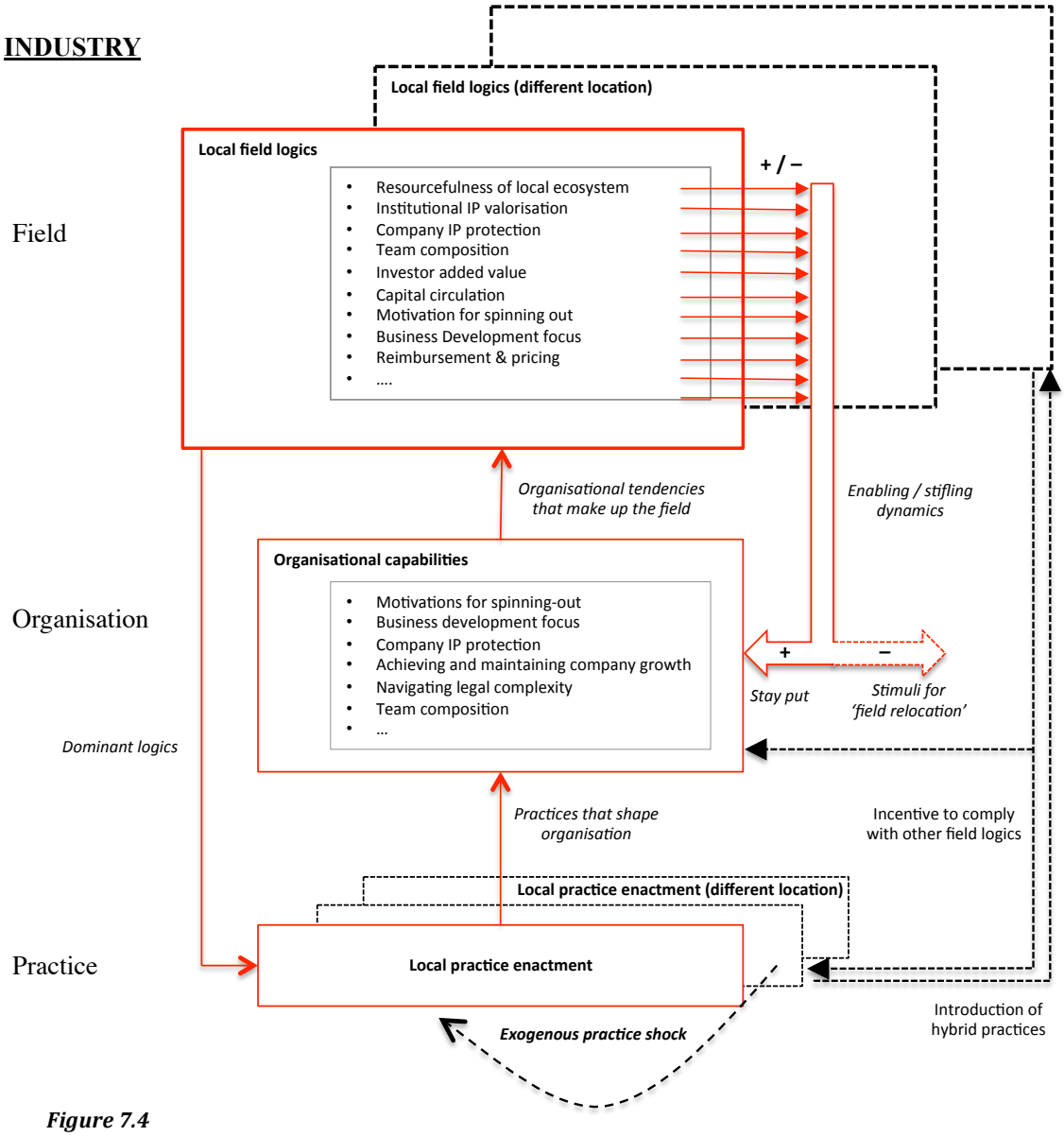


Figure 7.4

'*Local practices*' as part of each local geographic setting (e.g. A, B, or C) activate a chain of core dynamics that span individual, organisational, and field levels (cf. Lounsbury, 2007; Smets et al., 2012). Bundled together, practices define organisations (Schatzki, 2009) and shape their '*organisational capabilities*' (Pache and Santos, 2013) – see also chapter six. Each local geographic field setting is subject to dominant '*local institutional field logics*' and the associated anatomy of institutional infrastructures in that (local) field. In turn, these make up for the

tendencies that set the dynamics within the field. The characteristics of the field make for 'enabling' (+) or 'stifling' (-) interactions with the organisations. Depending on the local setup, organisations might decide resources are plenty locally and exploit those as part of an 'institutional exploiter approach'; or, the situation is such that the organisation might require greater resources and adopts the 'institutional orchestrator approach' in order to partially find required resources in a different field contexts through *'field relocation'*; or, if the field situation is such that the organisation cannot relocate to find the required resources in a different context it may try to adjust the field situation whilst reconceptualising its own practices so that the organisation does not require what is not available – understood as the 'institutional configurator approach'. As a consequence, the incentive of institutional configuration may arise to comply with institutional field logics that are dominant in an adjacent settings; thereby giving rise to hybrid practices as a consolidation for practice enactment adjusted to multiple field locations and influences. In the meanwhile external events may have implications for dynamics, sparking adjustment in local practices or the field level.

The findings address endogenous and inter-field practice induced field construction. In addition, it was observed that outside events, or "exogenous shocks" (Islam, Fremeth, Marcus, 2008, p.1) can also have a significant impact (cf. Micelotta, Lounsbury, and Greenwood, 2017; Seo and Creed, 2002; Clemens and Cook, 1999; Meyer, 1982). These exogenous shocks are described as large field events such as pandemics and illness (Arslan and Tarakci, 2019; Maguire et al., 2004), a terrorist

attack (Leagreid and Serigstad, 2006), economic downturn (Zilber, 2007), or a new technology (Benner and Ranganathan, 2013). Instead in the case of CRISPR, implications for local practice enactment were observed; described by the author as *"exogenous practice shocks".* In the case of exogenous practice shocks, the activities of a practitioner may rock the boat to such a degree that the event's ripples may be felt in other institutional field settings by fellow practitioners. For instance, a particular practice might acceptable in one institutional field context but not in another. This occurred in the case of CRISPR-edited human twins:

> "Years of research is needed to show that meddling with the genome of an embryo is not going to cause harm… Legislation and public discussion should also occur before genome editing is used in embryos destined for implantation. Today's report of genome editing human embryos for resistance to HIV is premature, dangerous and irresponsible" (Cyranoski, 2019a, p.607; see also 2019b; 2019c).

These CRISPR applications raised significant ethical concerns in the scientific community, making CRISPR scientist feel rather uncomfortable in the light of recent developments. What these observations show is that events occurring outside the contexts of the institutional field studied here, such as the editing of viable human embryos taking place in China and Russia (Cohen, 2019; 2018), primarily have implications at the practice level – and maybe secondarily at the field level – of other institutional fields. Without sufficient institutional regulatory field structures in place these practices raise responses amongst practitioners regarding ethics and ethical conduct, calls to arms for grass roots advocacy movements, or wider institutional response reflected in the instalment of policies promoting or prohibiting certain conduct:

> "Top scientists and ethicists from seven countries called last week for a global moratorium on gene editing of human eggs, sperm or embryos that would result in such genetically-altered babies saying this "could have permanent and possibly harmful effects on the species…". (Reuters, 2019 March 19)

This in turn affects practices and conduct by CRISPR researchers, CRISPR companies, as well as institutional fields and markets and their support for CRISPR related activities.

The integrated multi-level model presents a generative mechanism for practice driven institutional field construction and change. Attempts of situated improvisations to access and use resources are ways to cope practically with local fields and to accomplish specific tasks (Orlikowski, 1996; Tsoukas and Chia, 2002) – such as the materialisation of CRISPR practices. The *'institutional orchestrator approach'* may produce change in existing institutional arrangements; or following an *'institutional configurator approach'* local instructional field logics may be played out against each other through for instance *'field relocation*'. The three strategic approaches help to sustain the emergence of new material CRISPR practices and organisation, if necessary across multiple institutional field settings. New practices emerge when the multiple networks constituting the macro-level of different institutional fields interact with one and another (Padgett and Powell, 2012). New practices often emerge out of these inter-structural connections between fields, as a by-product of the recombination of existing practices that embody the distinctive institutions regulating those different fields (Furnari, 2014). Practice variation (Lounsbury, 2001, 2007), institutional complexity, and the coexistence of competing

logics within fields (Dunn and Jones, 2010; Greenwood et al., 2011; Quirke, 2013; Reay and Hinings, 2005, 2009) constitute an important pathway for field-level change (Micelotta, 2017; Zietsma et al., 2017) as the practices help to structure it (Smets et al., 2012). In turn practitioners'

> "…use of technology becomes structured by these experiences, knowledge, meanings, habits, power relations, norms, and the technological artifacts at hand. Such structuring enacts a specific set of rules and resources in practice that then serves to structure future use as people continue to interact with the technology in their recurrent practices" (Orlikowksi, 2000, p.410).

Over time, following repeated reinforcement by the community of practitioners (see also Whittington, 2006; Lounsbury, 2001; Scott et al. 2001; Orlikowksi, 2000), locally distinctive practices may emerge as predetermined and firm prescriptions for social action embedded in the context of local institutional fields. Practice driven institutionalism helps to formulate an extension to existing theories of situated change and evolving routines by highlighting those institutional changes that originate in mundane local praxis, but unfold effects beyond the organisation in which they started; moving 'from practice to field' (Reay et al., 2013; Smets et al., 2012). This process can be summarised as *"practice driven field construction"*.

7.4 Conclusion

This chapter further extended our understanding of institutional analysis (Smets, Morris, and Greenwood, 2012) through a comparative case study that answered to the call of Smets et al. (2010, p.900) that "…a comparative analysis of practise is overdue… [because] institutional change is bound to arise in response to breakdowns of institutionalised practices in real-life situations…". It was found that

that organisation and technology are not simply subject to or stuck in the structures of their local institutional field but may in fact draw from or navigate between different institutional fields. In doing so, new practices may be introduced into the institutional field and if consolidated the change that is brought about by these practices can take shape as 'practice driven field construction'. By adopting strategic approaches organisations give rise to a divergent (and not isomorphic) set of characteristics that develop a diverse set of CRISPR applications. Emerging organisations tapping into different geographical institutional field logics add to the institutional complexity (cf. Greenwood et al., 2017; 2011) faced by CRISPR organisations. Technology, organisation, and the practices within the organisation cannot be understood as uniform and universally generalisable, but rather as unique in their own local and situated activity of co-construction. This understanding enables institutional theorists to refine explanations of both practice driven endogenous as well as exogenous institutional field change, and use it as an aid in developing a much-needed multi-level understanding of human agency in highly institutionalised situations. The research in this chapter thereby opens up new possibilities for expanding the scope of institutional analysis by allowing for a new emphasis on organisational decision-making entailing a much more penetrating examination of practitioners and practices. These insights reflect on the adoption of more fine grained analyses to uncover substantive aspects of variation in how organisation and technology take shape, leading to more nuanced explanations of organisational behaviour that emphasises heterogeneous struggle between different institutional field settings that organisations may strategically navigate, draw on, and

construct. By conceptualising organisational environments such as the institutional field as multiple, changing, interlinked, and practice driven, institutionalists can generate new insights about divergent practice, technology, organisation, and field construction.

8. CONCLUSION

This study sprung from a personal interest in how new technologies emerge and become relevant to our society. With the introduction of CRISPR technology the prospect of engineering the actual building blocks of life arose. Mankind obtained the capability of modifying the genetic codes in our DNA with such detail and precision that unprecedented possibilities and responsibilities have been introduced. The potential applications of this technology are numerous and likely significant, marked by the award of a Nobel Prize in chemistry for the scientists pioneering CRISPR. The development of these applications from laboratory bench to patient's bedside is all but straightforward and closely ties in with the complex process of commercialisation. Problem-driven inductive research on the empirical case study of the multi-purpose technology CRISPR was used to develop further insights into how only a few select technologies materialise even though a far greater number of technologies would theoretically be conceivable.

This thesis addressed how new technology emerges through practices of commercialisation in emerging organisations. It was a response to the neglect within contemporary organisational literature of the structuring role of technology in its own constitution, as pertinent institutional theory addresses only instances where some structure is already in place. A significant blind spot in the institutionalists' perspective is the earliest moment of activity from which both organisational and technological structures emerge. There where structures do not yet exist, practices

do occur. Using a lens of practice driven institutionalism (Smets et al., 2012) allowed us to see the constitution of organisational and technological structures as it happens, thereby advancing existing bottom-up practice-driven theorising of institutional logics by integrating 'technology' as part of its theoretical framework. The lens was used to scrutinize how people, as they interact with a technology in their ongoing practices, constitute structures which shape their emergent and situated use of that technology. When people interact with a new technology in their ongoing practices this very interaction constitutes the emergent structures of both organisation and technology, and ultimately even institutions. For instance, CRISPR is like a Swiss army knife with different functions depending on how the practitioner wants to use it (Doudna and Sternberg, 2017). Different variances of CRISPR can materialise based on different practices, in turn shaping the organisation through which it is developed. This way, the empirical case of CRISPR provided a rich opportunity to examine the challenges of starting, building, and running an organisation with the purpose of developing a new technology.

8.1 Contributions

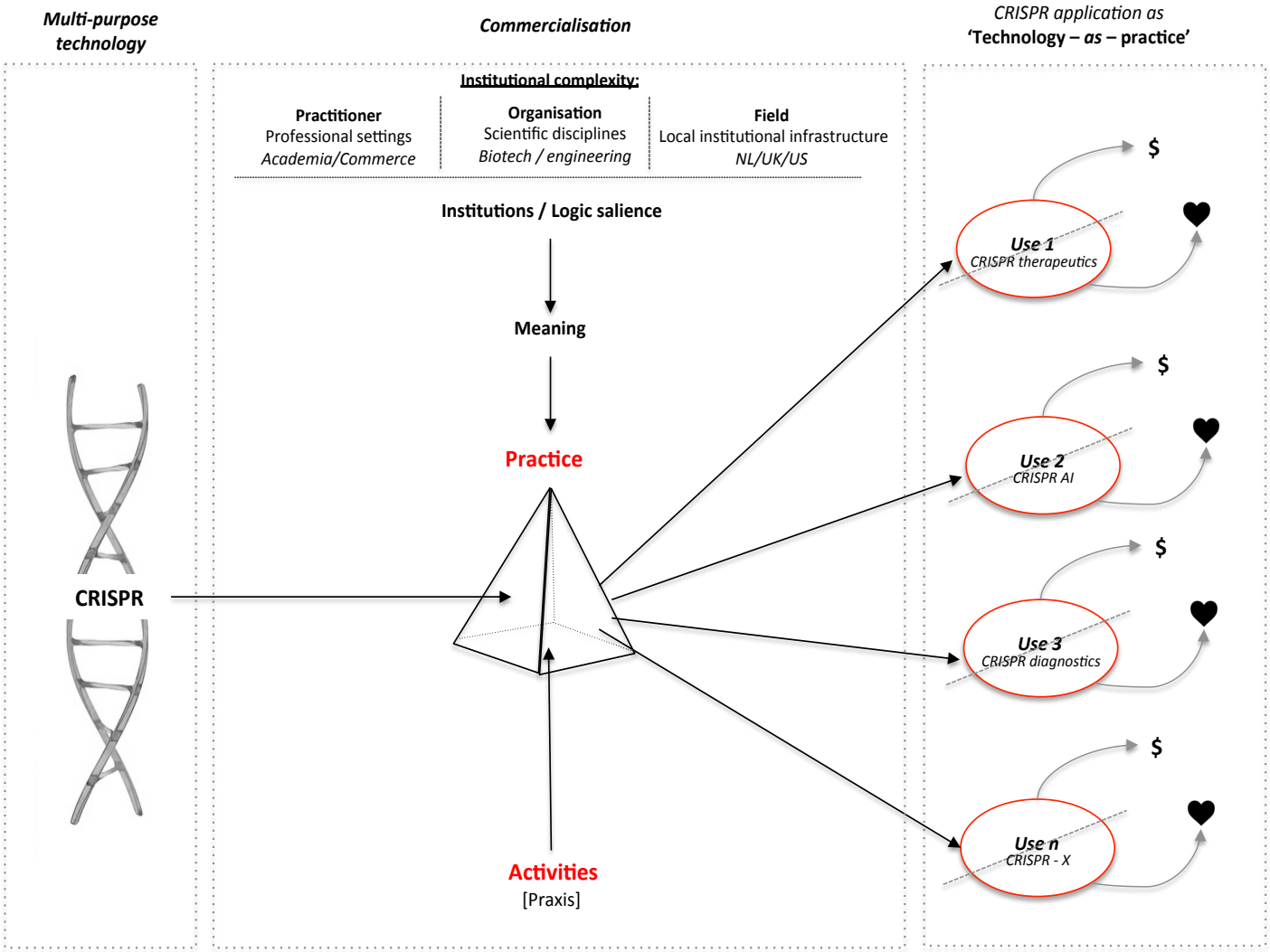
To date, if organisational institutional literature included technology it addressed instances where some structure was already in place (e.g. Leonardi and Barley, 2010; Orlikowski, 2000; Barley, 1986) and organisational or institutional arrangements are rarely studied as they are brought into existence. Exceptions are Smets et al. (2017) and Gümüsay et al. (2020), and their perspective was further extended throughout this thesis by addressing the "earliest moments" when organisational and

technological structures are mutually constitutive. The focus of this research was multi-level, establishing technology as nexus of praxis, organisation, and field.

As a new technology emerges the practices of social structuring technology and organisation converge into one as both emerge simultaneously: one-directional structuring by the organisation as explained through 'technology-*in*-practice' (Orlikowksi, 2000) becomes two-direction, coined 'technologies-*as*-practice' by the author of this thesis. This study joins others in management research in a more general turn to adopting the 'practice' label (Whittington, 2009). Technology-as-practice entails that technology and organisation are co-constituted through practice. A significant blind spot in the institutionalists' perspective is the earliest moment of activity from which both organisational and technological structures emerge. Through the lens of practice driven institutionalism (Smets et al., 2012) this research advanced existing bottom-up practice-driven theorising of institutional logics by integrating 'technology' into the theoretical framework. Examining occasions where the development of new technology is a central ingredient to the emergence of organisations, this study found that when people interact with a new technology in their ongoing practices, this very interaction constitutes the emergent structures of both organisation and technology. Different interactions result in variation between organisational structures and technological applications. Hence, practice driven institutionalism (Smets et al., 2017) is not just a lens to understand what people do, but what they do together. Technology is the central reason and a common ground for people to come together and interact with each other.

Technology, therefore, implicitly coordinates their activities and is thus constitutive of – and constituted through – people's practice.

The commercialisation process through which CRISPR evolves into different technology-as-practices with subsequently different 'uses' is schematically summarised in figure 8.1:



Against the background of the science-based business as a hybrid organisation, the lens of practice driven institutionalism connects technology to the dynamics of

institutional logics within and beyond the organisation. It establishes the hybrid organisation as an 'institutionally complex' play-field (Lounsbury, 2007) where different forces negotiate between micro and macro, institution and practice, endogenous and exogenous, the individual and the field level – guided through the rational and belief systems of different logics. Based on the above understanding three further contributions were made on the level of the practitioner, the organisation, and the field:

Practitioner level. First, on the level of the practitioner, it was observed that until now the literature had focused *either* on structural organisational solutions (cf. Besharov and Smith, 2014), *or* the practices of individuals (cf. Whittington, 2006; Creed, DeJordy, and Lok, 2010; McGivern, Currie, Ferlie et al., 2015) – but in fact, they are closely linked and interact. There is awareness of how organisational structure helps to manage institutional complexity (cf. Greenwood et al., 2017; 2011), yet little is known about how individuals balance institutional complexity (Smets et al., 2015; Nicolini, 2011), and even less about how individual practices emerge in relation to evolving organisational structures in the face of institutional complexity (Gümüsay et al., 2020). The commercialisation process of CRISPR gives rise to hybridity and tensions at the micro-level of the practitioner as it moves between the professional settings of academic science and commerce (D'Este and Perkmann, 2011). Both practitioner and practice can become hybridised in this process as tensions are negotiated between the different logics associated with each setting. To find a balance between demands not only depends on balancing

competing logics, but also depends on balancing (competing) mechanisms of '*organisational differentiation'* and *'personal integration'* – and doing so across the different levels of organisation and individual. Organisational differentiation occurs as commercial practices are introduced alongside the academic, thereby giving rise to hybrid organisations (cf. Pache and Santos, 2013; Battilana and Dorado, 2010); and, on the level of the practitioner, personal integration occurs as actors create and adjust to the new situation by introducing new activity or by providing new meaning to existing activities. Practitioners are formed by practices, but also create practices through their activities (Whittington, 2019). Because practitioners respond to situations at hand as these evolve within a specific context (cf. Niccolini, 2011; Sandberg and Pinnington, 2009; Gherardi, 2000), changes in activity implicate that meanings and understandings that stabilise established practices are understood to change together in the process of hybridisation (Smets et al., 2012). The mechanisms of 'organisational differentiation' and 'personal integration' can then be used to explain how hybrid organisations adjust to, and use shifting between, competing logics – like that of academia and commerce – by actively alternating and reinventing practitioners, practices, and the meanings attached to those.

Organisational level. Second, moving from the practitioner to the level of the organisation, it was observed that organisational institutional literature understands 'structuring' as the 're-structuring' of existing structures; mainly focusing on how existing structures experience organisational change following internal incentives (cf. Orlikowski, 2000), institutional incentives (cf. Lounsbury, 2008; Seo and Creed, 2002)

and to a far lesser extend in interaction with existing technologies (cf. Garud and Karnoe, 2001; Leonardi and Barley, 2008). Responding to calls for closer examination of how structuring occurs at the "earliest moments" (Smets et al., 2012, p.877; see also Smets et al. 2015; Gümüsay et al., 2020), why specific organisational elements emerge (Pache and Santos, 2013), and how this occurs in co-constitution with newly emerging technology (e.g., Murray et al., 2020; von Krogh, 2018; Smets et al., 2017; Leonardi and Barley, 2008); it was observed that the process is 'anchored' (Perkmann et al., 2019) in three different determinants that define the co-constitution process of technology and organisation: the *'technology led approach'*, the *'organisation led approach'*, and the *'institution led approach'*. The organisation, like any social phenomenon, "is a bundle of practices" (Schatzki, 2006, p.1863). Here it comprises the nexus of different practices as it brings together the three approaches in an integrated and practice driven manner. Each approach is associated with a different set of practices that prioritise different organisational elements and features on which logics prescribe conflicting demands (Puranam, Alexy, and Reitzig, 2014; Pache and Santos, 2013; Hsu and Hannan, 2005), such as an emphasis on technological development, organisational structuring, and institutional pressures – which in turn each may vary on an individual basis, depending on the (scientific) type of application that is being developed. The practices associated with the three approaches are equally relevant for the survival of the organisation but may be prioritised differently. By (re-)establishing the focus on how organisational parameters moderate the interactions of practice and institutions (Smets et al.,

2017), practice driven institutionalism is extended with the observation that CRISPR technology and organisation co-evolve in an integrated multi-level fashion.

Field level. Third, moving to the field level, it was observed that institutional pressures – as commonly addressed within instructional literature – are not merely constraining and therefore obediently enacted (Cardinale, 2019; 2017; Scott, 2013; Thornton et al., 2012; Powell and DiMaggio, 2012; Heugens and Lander, 2009) or fearfully escaped (i.e. Faulconbridge and Muzio, 2016). In fact, it was observed that organisations have some managerial agency in choosing their institutional environment. Different organisations emerge around the same technology as they are embedded in different geographical institutional field contexts. As CRISPR organisations develop novel technological applications they exploit, select, and construct different institutional, geographic field settings. To make use of uneven dynamics between different institutional field locations, organisations proactively introduced strategic approaches for locating their activities: *the institutional exploiter approach* 'actively uses' institutional fields in an enabling manner as the organisation's needs are 'aligned' with field infrastructures' offerings (McPherson and Sauder, 2013; Patvardhan et al., 2015; Zietsma et al., 2017). Secondly, with *the institutional orchestrator approach,* organisations not only tap into the local institutional field but use the unevenness and heterogeneity of fields (Wooten and Hoffman, 2017; Fligstein and McAdam, 2012; Lounsbury, 2007; Marquis, Glynn, and Davis, 2007) to select, straddle, and align themselves with the practices of other more favourable institutional field settings through (partial) "field relocation"

(Faulconbridge and Muzio, 2016). Planning or coordinating the elements of a situation to produce a desired effect can consist out of practitioners occupying positions or spaces between fields (Perkmann et al., 2019). Thirdly, *the institutional configurator approach* occurs when field and organisation are largely a mismatch and an infrastructure needs to be built bottom-up (Smets et al., 2012) to suit the organisation's most urgent needs. This may drive field change and variation from within fields (Schneiberg, 2007) in order to de-intensify pressures on the organisation at the field level (Greenwood, et al., 2017). These three contributions informed an integrated multi-level model for *practice driven field construction*.

8.2 Limitations and future research

The choices regarding research paradigm, strategy, and methodology were aimed at theory building and answering the research problem central to this thesis. The specific strengths of the chosen approach are at the same time the limitations of this research. Trade-offs had to be made in a conscious and informed decision-making process.

First, the sampling used in this study was not exhaustive. Thirteen CRISPR organisations in three geographical settings were examined (the Netherlands, United Kingdom, and the United States). This included first and second wave CRISPR organisations. The focus was on CRISPR applied for human health innovations as this was the field for which CRISPR applications were originally intended for, and where the technology's development gained most traction at the earliest moments of commercialisation. Geographically the focus was on the West because this was here

that the initial developments took place. Soon activity also moved to China – and only later to other places. China proved difficult to gain access to due to secrecy and language barriers, and this option was soon dropped. Nonetheless, for future research it would be interesting to see what tendencies of co-constitution and commercialisation can be observed between culturally more different institutional fields – like between Asia and the West – as different norms, values, and practices might prevail.

Second, the studied timeframe is between the years of 2013 and 2018. This period covers the first five years that CRISPR was commercialised and was highly formative for the development of the first applications. This window presents a time bound consideration of a dynamic process. Further activity took place at a later stage, introducing new companies that work with CRISPR. To explore these CRISPR related developments in an all-encompassing manner may be beyond the abilities of a single scholar, or in the wise words of Orlikowski and Barley (2001, p.159): “with respect to techno-social developments at the level of economies and societies, time frames may extend beyond the purview of single scholars, so that in the end historians must tell the story”. Nonetheless future research into maturing and contrasting first and second wave organisations could produce fascinating longitudinal insights into how a promising yet controversial technology like CRISPR is further absorbed into our society.

Third, this research focussed on the emergence of technology-as-practice and the phenomenon of the commercialisation of CRISPR, studied as it unfolded. I can recommend to future institutionalists researching the emergence of technology to study the phenomenon in real-time, as this significantly informed my thinking and theorising. I observed first-hand how different practices came to matter as an organisation commercialises academic technology. I was in Boston conducting company visits and interviews when the news broke that a first wave CRISPR company decided to initiate a public offering of their shares (IPO). This process reignited anew a patent dispute between first wave companies. Although initially the first wave companies welcomed collaboration on my research, the IPOs and the revival of the patent dispute significantly changed their position. New company guidelines inhibited any collaboration, making this line of inquiry too difficult to pursue. This real-time experience later became an important observation regarding the development of the organisations, its change in priorities, and how different practices came to matter in the process of technology commercialisation. The result was a pivot of the study towards second wave CRISPR companies. This experience limited access and partly derailed the research temporarily. At the same time it informed my theorising as it lay bare the very process that I was studying.

Fourth, I am mindful of my role as the research instrument in this study. Taking a pragmatic approach to social science research, empirical 'reality' is seen as "the ongoing interpretation of meaning produced by individuals engaged in a common project of observation" (Suddaby, 2006, p.633). The aim was to elicit fresh

understanding about how practices actively construct our reality by letting the empirical data speak to the constructs and eventually let theory evolve. The researcher is not an objective tool and ideological preconceptions and theoretical commitments should therefore be accounted for. The reader can be confident that I have the wherewithal to acknowledge my biases, and to trust that I did my best to ensure that the material spoke to me largely unobstructed by theoretical lenses. All I can hope is that researchers inspired by this work will take the theories developed here and apply them to other settings, where they can be validated or disproven.

Finally, parallels can be drawn between CRISPR and other emergent multi-purpose technologies. With the arrival of the Fourth Industrial Revolution (4IR), technologies fuse, blurring the lines between the physical, digital, and biological spheres (e.g. Church, Gao, and Kosuri, 2012; Church and Regis, 2012 Kang, Coates, and Strawderman, 2020). Advances in artificial intelligence, robotics, quantum computing, nanotechnology, and biotechnology have the potential to disrupt society in a profound way (Schwab, 2016). For instance, we are only years away from resurrecting extinct forms of life (Shapiro, 2020), creating life from inorganic components as we obtain the knowledge on how to write genetic code (Landau, 2020), or developing a vaccine for cancer (Mougel, Terme, and Tanchot, 2019; Mullard, 2020). As the intellectual spaces of cyber and biotechnology are merging many possibilities are still beyond our imagination. The breadth and depth of these changes are thought to transform entire systems of production, management, and governance. Many of these developments will emerge through processes of

commercialisation that fund research and development. New technologies and the organisations developing them will thrive if they successfully utilise (among others) the mechanism described in this thesis. Early-stage companies that exist owing to the development and commercialisation of fourth industrial revolution technologies are challenged to navigate a highly complex environment. Each organisation faces significant obstacles, as initially no set pathways exist for the development and scaling of these technologies. The technologies are spun out of (academic) research centres and privatised to acquire funds to scale (Klepper, 2016). Although this situation is not new, the types of technologies and the landscape in which they translate from research laboratories into commercial applications, and eventually scale up, is different from before. The emergence of these new technologies tests the existing frameworks of business (Johnson, Christensen, and Kagermann, 2008), namely that of practice, organisation, and fields. What challenges do these science-based businesses face, what are common hurdles or best practices, and, once identified, are these new and contemporary to the emergence of a specific technology? We may debate about what the future should look like (economically, technologically, socially, environmentally, ethically), however, the future is created today and technology-based organisations are likely to have wider implications for our society in numerous ways. It is therefore significant to better understand the practicalities of how they evolve and thrive whilst enabling the development of technology and science; and thereby, hopefully, a better society.

8.3 Practice and policy implications

This thesis provided insights that could be of wider relevance to, amongst others, scientists, entrepreneurs, university bureaucrats, policy makers, politicians, investors, accelerators, incubators, and other practitioners. Being positioned close to a real-life problem there is potential for narrowing the theory-practice gap within management and organisation studies. I address three themes for which the dynamics discussed in this thesis could be relevant: (I) the valorisation of academic science and technology through 'academic science entrepreneurship', (II) 'grand challenges', and (III) the 'fourth industrial revolution'.

Academic science entrepreneurship. This thesis presents a framework that helps scientist-entrepreneurs to conceptualise their work. Equally, this framework assists those in interaction with scientist-entrepreneurs to better comprehend their practices and underlying dynamics. Furthermore this research may help to better understand the practical implications of translating and scaling an emerging technology from academic research into science-based business. Specifically deeper insights are offered into the dynamics of organisation building, practitioner challenges, valorisation, knowledge translation, and early-stage commercialisation of science and technology through spinout. To the scientist-entrepreneurs I would like to say: There have been others before you from who you can learn, and there are different strategies to achieve your goals – even if the institutional infrastructures in which you are embedded are not forthcoming. On the other hand, those that may help in the process of developing organisation and technology, the insights of this

study may help to understand the impact of your activities and how you may help.

Grand challenges. I have the humble hope that this thesis can provide some contemporary insights that would allow for a wider understanding into the dynamics associated with the "Grand Challenges" that affect organisations and institutions as they face the challenges and opportunities of (human) genome editing through CRISPR (e.g. George et al., 2016, p.1880; Nobel Prize Committee, 2020). Grand challenges are global problems of a "wicked" nature that may plausibly be addressed and governed through coordinated and collaborative efforts (e.g. George et al., 2016; Dopson et al., 2013). These challenges are of a multilevel nature, impacting practitioners, organisations, and institutions – and in many instances likely related to technology. The multi-level dynamics discussed in this thesis provide insight into the processes that help or restrain the development of technology-based applications that can contribute towards possible collective solutions. CRISPR technology is of such general purpose that the technology has the potential to play an important role in addressing the challenges of health, hunger, clean water and sanitation, affordable and clean energy, or climate action (examples of the UN Sustainable Development Goals). In particular for CRISPR technology, health applications are not the only scientific applications where it can drive innovation. Other applications may, for instance, take shape in agriculture and the development of better yielding crops and pesticides (hunger) or in environmental sciences and the possibility of nitrogen fixation (clean water). With the right managerial and organisational support such applications may soon be reality; possibly the insights of this thesis can contribute to

a better understanding of how to support such developments as scientist, entrepreneur, investor, policymaker, and professional manager.

Fourth industrial revolution. The empirical case study of CRISPR concerns a biotechnology recognisable as part of the fourth industrial revolution and its associated complexities (WEF, 2020). Andreessen (2011) famously stated that "software is eating the world", as he referred to the upsurge and all-encompassing presence of software in our society. Today, the incorporation of software can almost be considered cliché. The writing on the wall is that "biotechnology is eating the world", an observation that triggered the writing of this thesis. The ability to engineer biology is reforming how we diagnose, treat, and manage disease – but as well how the technologies that enable this develop (cf. Kolchinsky, 2020). It is therefore vital to understand how technology becomes relevant to our society and in what ways; such as who is part of these processes, what role do they play, what are differences between settings, and the identification of potential bottlenecks. For several involved practitioners such as scientists, scientist-entrepreneurs, investors, professional managers, and policymakers, this thesis may provide new insights into where they fit in and how they may contribute to this revolution. Seminal works in sociology and management literature have discussed the societal implications of technological developments in previous industrial revolutions (most famously Marx, Durkheim, Weber, Foucault, and others) and prove that it is crucial to be aware of the workings and transformative power that lies with technologies – and, above all, people.

All in all, this research will hopefully help us in better explaining and possibly inspire organisational behaviour. The following quote offers, I believe, a proper end to this thesis:

> "When something like personal genomics or synthetic biology suddenly appears – it seems to suddenly appear – we might have been working on it for 30 years, but it seems to come out of nowhere. Then you need strategies for engaging *a lot of people* and thinking about where it will be going in the next few months or few years."
>
> – George M. Church, Professor of Genetics at Harvard Medical School, CRISPR pioneer

Technology is what brings people together and implicitly coordinates their activities. Technology is thus, constitutive of – and constituted through – people's practice. This thesis discussed the co-constitution of technologies, organisations, and institutions in the process of commercialisation – it is the collective process of people working together that constitutes it all. Concluding this thesis, the important thing is not to understanding what people do, but what they do together.

References

Abzug, R., & Mezias, S. J. (1993). The fragmented state and due process protections in organizations: The case of comparable worth. *Organization Science*, *4*(3), 433-453.

Ahrens, T. and C.S. Chapman. 2007. 'Management Accounting as Practice', *Accounting, Organizations and Society*, Vol. 32, No. 1–2, pp. 5–31.

Aiman-Smith, L., & Green, S. G. (2002). Implementing new manufacturing technology: The related effects of technology characteristics and user learning activities. *Academy of Management Journal*, *45*(2), 421-430.

Almandoz, J. (2012). Arriving at the starting line: The impact of community and financial logics on new banking ventures. *Academy of management Journal*, *55*(6), 1381-1406.

Almandoz, J. (2014). Founding teams as carriers of competing logics: When institutional forces predict banks' risk exposure. *Administrative Science Quarterly*, *59*(3), 442-473.

Almandoz, J., Lee, M., & Marquis, C. (2017). Different shades of green: Environment uncertainty and the strategies of hybrid organizations. In *Emergence*. Emerald Publishing Limited.

Andreessen, M. (2011). Why software is eating the world. *Wall Street Journal*, *20*(2011), C2.

Arslan, B., & Tarakci, M. (2019, July). Do Exogenous Shocks Help or Hurt Innovation Performance of Alliances? Evidence from Ebola Outbreak. In *Academy of Management Proceedings*(Vol. 2019, No. 1, p. 18075). Briarcliff Manor, NY 10510: Academy of Management.

Bansal, P., Smith, W. K., & Vaara, E. (2018). New ways of seeing through qualitative research.

Barley, S. R. (1986). Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments. *Administrative science quarterly*, 78-108.

Barley, S. R. (1988). On technology, time, and social order: Technically induced change in the temporal organization of radiological work. *Making time: Ethnographies of high-technology organizations*, 123-169.

Barley, S. R. (1990). The alignment of technology and structure through roles and networks. *Administrative science quarterly*, 61-103.

Barley, S. R. (2008). Coalface institutionalism. *The Sage handbook of organizational institutionalism*, 491-518.

Barley, S. R., & Tolbert, P. S. (1997). Institutionalization and structuration: Studying the links between action and institution. *Organization studies*, *18*(1), 93-117.

Barrangou, R., & Marraffini, L. A. (2014). CRISPR-Cas systems: prokaryotes upgrade to adaptive immunity. *Molecular cell*, *54*(2), 234-244.

Barrett, M., Oborn, E., Orlikowski, W. J., & Yates, J. (2012). Reconfiguring boundary relations: Robotic innovations in pharmacy work. *Organization Science*, *23*(5), 1448-1466.

Battilana, J. (2018). Cracking the organizational challenge of pursuing joint social and financial goals: Social enterprise as a laboratory to understand hybrid organizing. *M@n@ gement*, *21*(4), 1278-1305.

Battilana, J., & Casciaro, T. (2012). Change agents, networks, and institutions: A contingency theory of organizational change. *Academy of Management Journal*, *55*(2), 381-398.

Battilana, J., & Dorado, S. (2010). Building sustainable hybrid organizations: The case of commercial microfinance organizations. *Academy of management Journal*, *53*(6), 1419-1440.

Battilana, J., & Lee, M. (2014). Advancing research on hybrid organizing–Insights from the study of social enterprises. *Academy of Management Annals*, *8*(1), 397-441.

Battilana, J., Besharov, M., & Mitzinneck, B. (2017). On hybrids and hybrid organizing: A review and roadmap for future research. *The SAGE handbook of organizational institutionalism*, *2*, 133-169.

Battilana, J., Leca, B., & Boxenbaum, E. (2009). 2 how actors change institutions: towards a theory of institutional entrepreneurship. *Academy of Management annals*, *3*(1), 65-107.

Battilana, J., Sengul, M., Pache, A. C., & Model, J. (2015). Harnessing productive tensions in hybrid organizations: The case of work integration social enterprises. *Academy of Management journal*, *58*(6), 1658-1685.

Becker, H. S. (2008). *Art worlds: updated and expanded*. University of California Press.

Benner, M. J., & Ranganathan, R. (2012). Offsetting illegitimacy? How pressures from securities analysts influence incumbents in the face of new technologies. *Academy of Management Journal*, *55*(1), 213-233.

Berger, P. L., & Luckmann, T. (1967). The Social Construction of Reality: Everything that passes for knowledge in society. *London: Allen Lane*.

Besharov, M. L., & Smith, W. K. (2012). Multiple logics within organizations: An integrative framework and model of organizational hybridity. *Ithaca, NY: Cornell University working paper*.

Besharov, M. L., & Smith, W. K. (2014). Multiple institutional logics in organizations: Explaining their varied nature and implications. *Academy of management review*, *39*(3), 364-381.

Bijker, W. E. (1987). The social construction of Bakelite: Toward a theory of invention. *The social construction of technological systems: New directions in the sociology and history of technology*, 159-187.

Bijker, W. E., Hughes, T. P., & Pinch, T. (2012). The social construction of technological systems.

Bono, J. E., & McNamara, G. (2011). Publishing in AMJ—part 2: research design.

Boudreau, M. C., & Robey, D. (2005). Enacting integrated information technology: A human agency perspective. *Organization science*, *16*(1), 3-18.

Bourdieu, P. 1990. *The Logic of Practice*. Stanford: Stanford University Press.

Bower, J. L., & Christensen, C. M. (1995). Disruptive technologies: catching the wave.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation. *Organization science*, *2*(1), 40-57.

Brown, R. H. (1978). Bureaucracy as praxis: Toward a political phenomenology of formal organizations. *Administrative Science Quarterly*, 365-382.

Brown, S. L., & Eisenhardt, K. M. (1997). The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. *Administrative science quarterly*, 1-34.

Bud, R. (1994). *The uses of life: a history of biotechnology*. Cambridge University Press.

Burrell, G., & Morgan, G. (1979). *Sociological paradigms and organisational analysis: Elements of the sociology of corporate life*. Routledge.

Callon, M. (2007/1984). Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay. *The sociological review*, *32*(1_suppl), 196-233.

Campbell, J. L., & Pedersen, O. K. (2007). The varieties of capitalism and hybrid success: Denmark in the global economy. *Comparative Political Studies*, *40*(3), 307-332.

Campbell, J. L., & Pedersen, O. K. (Eds.). (1996). *Legacies of change: Transformations of postcommunist European economies*. Transaction Publishers.

Canato, A., Ravasi, D., & Phillips, N. (2013). Coerced practice implementation in cases of low cultural fit: Cultural change and practice adaptation during the implementation of Six Sigma at 3M. *Academy of Management Journal*, *56*(6), 1724-1753.

Cardinale, I. (2017). Beyond constraining and enabling: Toward new microfoundations for institutional theory. *Academy of Management Review*, *43*(1), 132-155.

Cardinale, I. (2019). Microfoundations of institutions and the theory of action. *Academy of Management Review*, *44*(2), 467-470.

CB Insights (2018). VC Report.

CB Insights (2019a). Report: What is CRISPR?. Retrieved March 2019 from: https://www.cbinsights.com/research/what-is-crispr/

CB Insights (2019b). Tech IPO pipeline report. Retrieved March 2019 from: https://www.cbinsights.com/research/tech-ipo-dead/

Chia, R. C., & Holt, R. (2009). *Strategy without design: The silent efficacy of indirect action*. Cambridge University Press.

Child J., Lu Y., Tsai T. 2007. Institutional entrepreneurship in building an environmental protection system for the People's Republic of China. *Organization Studies*, *28*: 1013–1034.

Christensen, C., & Raynor, M. (2013). *The innovator's solution: Creating and sustaining successful growth*. Harvard Business Review Press.

Christensen, C.M. (2003). The innovator's solution: creating and sustaining successful growth. Harvard Business Press.

Church, G. M., & Regis, E. (2012). *Regenesis: how synthetic biology will reinvent nature and ourselves*. Basic Books.

Church, G. M., Gao, Y., & Kosuri, S. (2012). Next-generation digital information storage in DNA. *Science*, *337*(6102), 1628-1628.

Clarke, A. E., & Fujimura, J. H. (1992). What tools? Which jobs? Why right. *The right tools for the job: At work in twentieth-century life sciences*, 3-44.

Clemens, E. S., & Cook, J. M. (1999). Politics and institutionalism: Explaining durability and change. *Annual review of sociology*, *25*(1), 441-466.

Cohen, J. (2018). What now for human genome editing?.

Cohen, J. (2019). Embattled Russian scientist sharpens plans to create gene-edited babies. *Science*.

Colyvas, J. A., & Powell, W. W. (2009). Measures, metrics, and myopia: The challenges and ramifications of sustaining academic entrepreneurship. *Advances in the study of entrepreneurship, innovation and economic growth*, *19*, 79-111.

Cong, L., Ran, F.A., Cox, D., Lin, S., Barretto, R., Habib, N., Hsu, P.D., Wu, X., Jiang, W., Marraffini, L.A., et al. (2013). Multiplex genome engineering using CRISPR/Cas systems. Science 339, 819–823.

Constant, E. W. (1987). The social locus of technological practice: Community, system, or organization. *The social construction of technological systems: New directions in the sociology and history of technology*, 223-242.

Constantinides, P., & Barrett, M. (2006). Negotiating ICT development and use: The case of a telemedicine system in the healthcare region of Crete. *Information and Organization*, *16*(1), 27-55.

Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative sociology*, *13*(1), 3-21.

Corley, K. G., & Gioia, D. A. (2011). Building theory about theory building: what constitutes a theoretical contribution?. *Academy of management review*, *36*(1), 12-32.

Creed, W. D., DeJordy, R., & Lok, J. (2010). Being the change: Resolving institutional contradiction through identity work. *Academy of management journal*, *53*(6), 1336-1364.

Cyranoski, D. (2019a). The CRISPR-baby scandal: what's next for human gene-editing. *Nature*, 440-442.

Cyranoski, D. (2019b). Russian biologist plans more CRISPR-edited babies. *Nature*, *570*(7760), 145.

Cyranoski, D. (2019c). Russian biologist plans more CRISPR-edited babies. *Nature*

Czarniawska, B. (2008). Organizing: how to study it and how to write about it. *Qualitative Research in Organizations and Management: An International Journal*.

D'Aunno, T., Sutton, R. I., & Price, R. H. (1991). Isomorphism and external support in conflicting institutional environments: A study of drug abuse treatment units. *Academy of management journal*, *34*(3), 636-661.

D'este, P., & Perkmann, M. (2011). Why do academics engage with industry? The entrepreneurial university and individual motivations. *The Journal of Technology Transfer*, *36*(3), 316-339.

Davis, G. F., & McAdam, D. (2000). Corporations, classes, and social movements after managerialism. *Research in organizational behavior*, *22*, 193-236.

De Campos, A. S., Hartley, S., de Koning, C., Lezaun, J., & Velho, L. (2017). Responsible Innovation and political accountability: genetically modified mosquitoes in Brazil. *Journal of Responsible Innovation*, *4*(1), 5-23.

de Koning AP, Gu W, Castoe TA, Batzer MA, Pollock DD (2011). "*Repetitive elements may comprise over two-thirds of the human genome*". PLoS Genetics. **7** (12).

Deephouse, D. L., & Suchman, M. (2008). Legitimacy in organizational institutionalism. *The Sage handbook of organizational institutionalism*, *49*, 77.

Delbridge, R., & Edwards, T. (2008). Challenging conventions: Roles and processes during non-isomorphic institutional change. *Human Relations*, *61*(3), 299-325.

Demers, C., & Gond, J. P. (2020). The moral microfoundations of institutional complexity: Sustainability implementation as compromise-making at an oil sands company. *Organization Studies*, *41*(4), 563-586.

Denis, J. L., Langley, A., & Rouleau, L. (2007). Strategizing in pluralistic contexts: Rethinking theoretical frames. *Human relations*, *60*(1), 179-215.

DeSanctis, G., & Poole, M. S. (1994). Capturing the complexity in advanced technology use: Adaptive structuration theory. *Organization science*, *5*(2), 121-147.

DiMaggio, P. (1991). Social structure, institutions, and cultural goods: The case of the US. In *Social theory for a changing society*. Westview Press.

DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American sociological review*, 147-160.

DiMaggio, P. J., & Powell, W. W. (2000). The iron cage revisited institutional isomorphism and collective rationality in organizational fields. *Economics meets sociology in strategic management*, *17*, 143-166.

Doudna, J. A., & Sternberg, S. H. (2017). *A crack in creation: Gene editing and the unthinkable power to control evolution*. Houghton Mifflin Harcourt.

Dunn, M. B., & Jones, C. (2010). Institutional logics and institutional pluralism: The contestation of care and science logics in medical education, 1967–2005. *Administrative science quarterly*, *55*(1), 114-149.

Durand, R., Bruyaka, O., & Mangematin, V. (2008). Do science and money go together? The case of the French biotech industry. *Strategic Management Journal*, *29*(12), 1281-1299.

Durkheim, E. (1912/1961). Moral Education, translated by Everett K. Wilson and Herman Schnurer.

Durkheim, E. (1972/1893). Selections from *The Division of Labor in Society*, in Giddens, A. (ed.), *Durkheim: Selected Writings*. New York: Cambridge University Press, pp.141-154.

Ebrahim, A., Battilana, J., & Mair, J. (2014). The governance of social enterprises: Mission drift and accountability challenges in hybrid organizations. *Research in Organizational Behavior*, *34*, 81-100.

Economist (2009). *The rise of the hybrid company*. Retrieved 10 June 2019, from: https://www.economist.com/business/2009/12/03/the-rise-of-the-hybrid-company

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of management review*, *14*(4), 532-550.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of management journal*, *50*(1), 25-32.

Esvelt, K. M., Smidler, A. L., Catteruccia, F., & Church, G. M. (2014). Emerging technology: concerning RNA-guided gene drives for the alteration of wild populations. *Elife*, *3*, e03401.

Faulconbridge, J., & Muzio, D. (2016). Global professional service firms and the challenge of institutional complexity:'Field relocation'as a response strategy. *Journal of Management Studies*, *53*(1), 89-124.

Feld, B. (2020). *Startup communities: Building an entrepreneurial ecosystem in your city*. John Wiley & Sons.

Feldman, M. S. (2004). Resources in emerging structures and processes of change. *Organization Science*, *15*(3), 295-309.

Feldman, M. S. (2016). Past, Present, and future. *Organizational Routines: How They Are Created, Maintained, and Changed; Oxford University Press: Oxford, UK*, 23-46.

Feldman, M. S., & Orlikowski, W. J. (2011). Theorizing practice and practicing theory. *Organization*

Feldman, M. S., & Pentland, B. T. (2003). Reconceptualizing organizational routines as a source of

Ferlie, E., Fitzgerald, L., McGivern, G., Dopson, S., & Bennett, C. (2013). *Making Wicked Problems Governable?: the case of managed networks in health care*. OUP Oxford.

Fleck, L. (1935; 2012). *Genesis and development of a scientific fact*. University of Chicago Press.

Fligstein, N., McAdam, D. (2012). A theory of fields, Oxford, UK: Oxford University Press.

Foucault, M. 1977. *Discipline and Punish: The Birth of The Prison*. New York: Pantheon Books.

Friedland, R. (2012). God, love and other good reasons for practice: Thinking through institutional logics. Paper presented at Organizing Institutions: Creating, Enacting and Reacting to Institutional Logics, ABC Network Conference. Banff Springs Hotel: Banff, AB, Canada.

Friedland, R., & Alford, R. R. (1991). Bringing society back in: Symbols, practices, and institutional contradictions. WW Powell, PJ DiMaggio, eds. The New Institutionalism in Organizational Analysis.

Friedland, R., Alford, R. R., Powell, W. W., & DiMaggio, P. J. (1991). The new institutionalism in organizational analysis. *The new institutionalism in organizational analysis*, 232-263.

Fujimura, J. H. (2006). Sex genes: A critical sociomaterial approach to the politics and molecular genetics of sex determination. *Signs: Journal of Women in Culture and Society*, *32*(1), 49-82.

Furnari, S. (2014). Interstitial spaces: Microinteraction settings and the genesis of new practices between institutional fields. *Academy of management review*, *39*(4), 439-462.

Garud, R., & Ahlstrom, D. (1997). Technology assessment: a socio-cognitive perspective. *Journal of Engineering and Technology Management*, *14*(1), 25-48.

Garud, R., & Karnoe, P. (Eds.). (2001). *Path dependence and creation*. Psychology Press.

Garud, R., & Rappa, M. A. (1994). A socio-cognitive model of technology evolution: The case of cochlear implants. *Organization science*, *5*(3), 344-362.

Gehman, J., Glaser, V. L., Eisenhardt, K. M., Gioia, D., Langley, A., & Corley, K. G. (2018). Finding theory–method fit: A comparison of three qualitative approaches to theory building. *Journal of Management Inquiry*, *27*(3), 284-300.

Gehman, J., Glaser, V. L., Eisenhardt, K. M., Gioia, D., Langley, A., & Corley, K. G. (2018). Finding theory–method fit: A comparison of three qualitative approaches to theory building. *Journal of Management Inquiry*, *27*(3), 284-300.

George, G. (2016). Management research in AMJ: Celebrating impact while striving for more.

George, G., Howard-Grenville, J., Joshi, A., & Tihanyi, L. (2016). Understanding and tackling societal grand challenges through management research. *Academy of Management Journal*, *59*(6), 1880-1895.

Gherardi, S. (2000). Practice-based theorizing on learning and knowing in organizations.

Giacomelli, G. (2020). The role of hybrid professionals in the public sector: a review and research synthesis. *Public Management Review*, *22*(11), 1624-1651.

Giddens, A. (1979). *Central problems in social theory: Action, structure, and contradiction in social analysis* (Vol. 241). Univ of California Press.

Giddens. (1984). *The constitution of society: Outline of the theory of structuration*. Univ of California Press.

Giddens, A. (1990). The consequences of modernity. Oxford: Polity.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organizational research methods*, *16*(1), 15-31.

Given, L. M. (Ed.). (2008). *The Sage encyclopedia of qualitative research methods*. Sage publications.

Glaser, B.G., Strauss, A.L., (1967). The discovery of grounded theory: strategies for qualitative research. Aldine Pub, Chicago.

Goodman, P. S., & Sproull, L. S. (1990). *Technology and organizations*. Jossey-Bass.

Goodrick, E., & Reay, T. (2011). Constellations of institutional logics: Changes in the professional work of pharmacists. *Work and Occupations*, *38*(3), 372-416.

Greenwood, R., & Meyer, R. E. (2008). Influencing ideas: A celebration of DiMaggio and Powell (1983). *Journal of management inquiry*, *17*(4), 258-264.

Greenwood, R., Oliver, C., Lawrence, T. B., & Meyer, R. E. (Eds.). (2017). *The Sage handbook of organizational institutionalism*. Sage.

Greenwood, R., Oliver, C., Sahlin, K., & Suddaby, R. (2008). The Sage handbook of Organizational Institutionalism, *327*, 352.

Greenwood, R., Raynard, M., Kodeih, F., Micelotta, E. R., & Lounsbury, M. (2011). Institutional complexity and organizational responses. *Academy of Management annals*, *5*(1), 317-371.

Gregory, R. W., Henfridsson, O., Kaganer, E., & Kyriakou, H. (2020). The Role of Artificial Intelligence and Data Network Effects for Creating User Value. *Academy of Management Review*, (ja).

Gümüsay, A. A., Smets, M., & Morris, T. (2020). "God at work": Engaging central and incompatible institutional logics through elastic hybridity. *Academy of Management Journal*, *63*(1), 124-154.

Hallett, T., & Ventresca, M. J. (2006). Inhabited institutions: Social interactions and organizational forms in Gouldner's Patterns of Industrial Bureaucracy. *Theory and society*, *35*(2), 213-236.

Hannan, M. T., & Freeman, J. (1977). The population ecology of organizations. *American journal of sociology*, *82*(5), 929-964.

Hargadon, A. B., & Douglas, Y. (2001). When Innovations Meet Institutions: Edison and the Design of

Haveman, H. A., & Rao, H. (1997). Structuring a theory of moral sentiments: Institutional and organizational coevolution in the early thrift industry. *American journal of sociology*, *102*(6), 1606-1651.

Heugens, P. P., & Lander, M. W. (2009). Structure! Agency!(and other quarrels): A meta-analysis of institutional theories of organization. *Academy of management journal*, *52*(1), 61-85.

Hiatt, S. R., & Sine, W. D. (2014). Clear and present danger: Planning and new venture survival amid political and civil violence. *Strategic Management Journal*, *35*(5), 773-785.

Hinings, C. R., Logue, D. M., & Zietsma, C. (2017). Fields, institutional infrastructure and governance. *The Sage handbook of organizational institutionalism*.

Hinings, B., Gegenhuber, T., & Greenwood, R. (2018). Digital innovation and transformation: An institutional perspective. *Information and Organization*, *28*(1), 52-61.

Hirsch, P. M., & Lounsbury, M. (1997). Ending the family quarrel: Toward a reconciliation of "old" and "new" institutionalisms. *American Behavioral Scientist*, *40*(4), 406-418.

Hoffman, A. J. (1999). Institutional evolution and change: Environmentalism and the US chemical industry. *Academy of management journal*, *42*(4), 351-371.

Hörig, H., Marincola, E., & Marincola, F. M. (2005). Obstacles and opportunities in translational research. *Nature Medicine, 11*(7), 705–708.

Hsu, G., & Hannan, M. T. (2005). Identities, genres, and organizational forms. *Organization science*, *16*(5), 474-490.

Hsu, P. D., Lander, E. S., & Zhang, F. (2014). Development and applications of CRISPR-Cas9 for genome engineering. *Cell*, *157*(6), 1262-1278.

Hutchby, I. (2001). Technologies, texts and affordances. *Sociology*, *35*(2), 441-456.

Hutchby, I. (2001). Technologies, texts and affordances. *Sociology*, *35*(2), 441-456.

Islam, M., Fremeth, A. Marcus, A. (2008). The impact of exogenous non-economic shocks on the global business environment: a cross-country analysis of the impact of September 11th Academy of Management Annual Best Paper Proceedings.

Jagtenberg, T. (1983). The social construction of science. In *The Social Construction of Science* (pp. 1-11). Springer, Dordrecht.

Jarzabkowski, P. (2005). *Strategy as practice: An activity based approach*. Sage.

Jarzabkowski, P., Matthiesen, J., & Van de Ven, A. H. (2009). 1 1 Doing which work? A practice approach to institutional pluralism. *Institutional work: Actors and agency in institutional studies of organizations*, *284*.

Jarzabkowski, P., Smets, M., Bednarek, R., Burke, G., & Spee, P. (2013). Institutional ambidexterity: Leveraging institutional complexity in practice. In *Institutional logics in action, part B* (pp. 37-61). Emerald Group Publishing Limited.

Jarzabkowski, P., Spee, A. P., & Smets, M. (2013). Material artifacts: Practices for doing strategy with 'stuff'. *European management journal*, *31*(1), 41-54.

Jasanoff, S. (2005). Designs on Nature: Science and Democracy in the US, UK and Germany.

Jay, J. (2013). Navigating paradox as a mechanism of change and innovation in hybrid organizations. *Academy of management journal*, *56*(1), 137-159.

Jensen, R., & Thursby, M. (2001). Proofs and prototypes for sale: The licensing of university inventions. *American Economic Review*, *91*(1), 240-259.

Jiang, W., & Marraffini, L. A. (2015). CRISPR-Cas: new tools for genetic manipulations from bacterial immunity systems. *Annual review of microbiology*, *69*, 209-228.

Jinek, M., Chylinski, K., Fonfara, I., Hauer, M., Doudna, J. A., & Charpentier, E. (2012). A programmable dual-RNA–guided DNA endonuclease in adaptive bacterial immunity. *science*, *337*(6096), 816-821.

Joerges, B., & Czamiawska, B. (1998). The question of technology, or how organizations inscribe the world. *Organization Studies*, *19*(3), 363-385.

Johnson, M. W., Christensen, C. M., & Kagermann, H. (2008). Reinventing your business model. *Harvard business review*, *86*(12), 57-68.

Jones, C., & Massa, F. G. (2013). From novel practice to consecrated exemplar: Unity Temple as a case of institutional evangelizing. *Organization Studies*, *34*(8), 1099-1136.

Jones, C., & Thornton, P. H. (2005). Transformation in Cultural Industries'. *Transformation in Cultural Industries (Research in the Sociology of Organizations, Volume 23). Emerald Group Publishing Limited, pp. xi-xxi Download as. RIS DOI https://doi. org/10.1016/S0733-558X (05)*, 23009-4.

Jones, C., Boxenbaum, E., & Anthony, C. (2013). The immateriality of material practices in institutional logics. In *Institutional logics in action, Part A*. Emerald Group Publishing Limited.

Jones, M. R., & Karsten, H. (2008). Giddens's structuration theory and information systems research. *MIS quarterly*, *32*(1), 127-157.

Kang, J., Coates, J. T., Strawderman, R. L., Rosenstein, B. S., & Kerns, S. L. (2020). Genomics models in radiotherapy: From mechanistic to machine learning. *Medical Physics*, *47*(5), e203-e217.

Kaplan, S., & Murray, F. (2010). Entrepreneurship and the construction of value in biotechnology. In *Technology and Organization: Essays in Honour of Joan Woodward* (pp. 107-147). Emerald Group Publishing Limited.

Keller, W. (2002). Geographic localization of international technology diffusion. *American Economic Review*, *92*(1), 120-142.

Klein, H. K., & Kleinman, D. L. (2002). The social construction of technology: Structural considerations. *Science, Technology, & Human Values*, *27*(1), 28-52.

Klein, J., & Amis, J. M. (2020). Changing Hybrid Organizations by Design. In *Academy of Management Proceedings* (Vol. 2020, No. 1, p. 18723). Briarcliff Manor, NY 10510: Academy of Management.

Klepper, S. (2016). *Experimental capitalism: The nanoeconomics of American high-tech industries*. Princeton University Press.

Knorr-Cetina, K. (1999). Epistemic cultures: The cultures of knowledge societies. *Cambridge, MA: Harvard*.

Knorr-Cetina, K. D., & Mulkay, M. (1983). *Introduction: Emerging principles in social studies of science* (pp. 1-17).

Knorr-Cetina, K., Schatzki, T. R., & Von Savigny, E. (Eds.). (2005). *The practice turn in contemporary theory*. Routledge.

Kolchinsky, P. (2020). The Great American Drug Deal. Boston: Massachusetts.

Kostova, T., & Roth, K. (2002). Adoption of an organizational practice by subsidiaries of multinational corporations: Institutional and relational effects. *Academy of management journal*, *45*(1), 215-233.

Kozubek, J. (2018). *Modern prometheus: Editing the human genome with crispr-cas9*. Cambridge University Press.

Kraatz, M. S., & Block, E. S. (2008). Organizational implications of institutional pluralism. *The Sage handbook of organizational institutionalism*, *840*, 243-275.

Kubler, G. (1962). *The shape of time: Remarks on the history of things* (Vol. 140). Yale University Press.

Kurzweil, R. (1999). *The coming merging of mind and machine*(p. 281). Scientific American, Incorporated.

Lægreid, P., & Serigstad, S. (2006). Framing the field of homeland security: The case of Norway. *Journal of management studies*, *43*(6), 1395-1413.

Landau, M. (2020). An Interview with George Church. *Clinical Chemistry*, *66*(1), 12-24.

Lander, E. S. (2016). The heroes of CRISPR. *Cell*, *164*(1-2), 18-28.

Langley, A. (1999). Strategies for theorizing from process data. *Academy of Management review*, *24*(4), 691-710.

Lanzara, G. F., & Patriotta, G. (2007). The institutionalization of knowledge in an automotive factory: Templates, inscriptions, and the problem of durability. *Organization Studies*, *28*(5), 635-660.

Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Harvard university press.

Latour, B., & Woolgar, S. (1979). Laboratory Life. Beverly Hills. *Calif.: Sage*.

Lawrence, T. B., & Suddaby, R. (2006). 1.6 institutions and institutional work. *The Sage handbook of organization studies*, 215-254.

Lawrence, T. B., Leca, B., & Zilber, T. B. (2013). Institutional work: Current research, new directions and overlooked issues. *Organization Studies*, *34*(8), 1023-1033.

Layton, E. (1977). Conditions of technological development. *Science, Technology, and Society. Sage: London*.

Ledford, H., & Callaway, E. (2020). Pioneers of revolutionary CRISPR gene editing win chemistry Nobel. *Nature*, *586*(7829), 346-347.

Lee, T. W., Mitchell, T. R., Sablynski, C. J., Burton, J. P., & Holtom, B. C. (2004). The effects of job embeddedness on organizational citizenship, job performance, volitional absences, and voluntary turnover. *Academy of management journal*, *47*(5), 711-722.

Leenay, R. T., Aghazadeh, A., Hiatt, J., Tse, D., Roth, T. L., Apathy, R., ... & Cirolia, G. (2019). Large dataset enables prediction of repair after CRISPR–Cas9 editing in primary T cells. *Nature biotechnology*, 1.

Leonardi, P. M., & Barley, S. R. (2008). Materiality and change: Challenges to building better theory about technology and organizing. *Information and organization*, *18*(3), 159-176.

Leonardi, P. M., & Barley, S. R. (2010). What's under construction here? Social action, materiality, and power in constructivist studies of technology and organizing. *Academy of Management Annals*, *4*(1), 1-51.

Levina, N., & Orlikowski, W. J. (2009). Understanding shifting power relations within and across organizations: A critical genre analysis. *Academy of Management Journal*, *52*(4), 672-703.

Lok, J. (2010). Institutional logics as identity projects. *Academy of management Journal*, *53*(6), 1305-1335.

Lounsbury, M. (2001). Institutional sources of practice variation: Staffing college and university recycling programs. *Administrative science quarterly*, *46*(1), 29-56.

Lounsbury, M. (2002). Institutional transformation and status mobility: The professionalization of the field of finance. *Academy of Management Journal*, *45*(1), 255-266.

Lounsbury, M. (2007). A tale of two cities: Competing logics and practice variation in the professionalizing of mutual funds. *Academy of management journal*, *50*(2), 289-307.

Lounsbury, M. (2008). Institutional rationality and practice variation: New directions in the institutional analysis of practice. *Accounting, organizations and society*, *33*(4-5), 349-361.

Lounsbury, M., & Crumley, E. T. (2007). New practice creation: An institutional perspective on innovation. *Organization studies*, *28*(7), 993-1012.

Lunshof, J. E., Chadwick, R., Vorhaus, D. B., & Church, G. M. (2008). From genetic privacy to open consent. *Nature Reviews Genetics*, *9*(5), 406-411.

MacKenzie, D., & Wajcman, J. (1999). *The social shaping of technology*. Open university press.

Maguire, S., Hardy, C., & Lawrence, T. B. (2004). Institutional entrepreneurship in emerging fields: HIV/AIDS treatment advocacy in Canada. *Academy of management journal*, *47*(5), 657-679.

Mair, J., Mayer, J., & Lutz, E. (2015). Navigating institutional plurality: Organizational governance in hybrid organizations. *Organization Studies*, *36*(6), 713-739.

Mali, P., Yang, L., Esvelt, K.M., Aach, J., Guell, M., DiCarlo, J.E., Norville, J.E., and Church, G.M. (2013). RNA-guided human genome engineering via Cas9. Science 339, 823–826.

March, J. G. (Ed.). (1965/2013). *Handbook of Organizations (RLE: Organizations)*. Routledge.

Markus, M. L., & Benjamin, R. I. (1996). Change agentry-the next IS frontier. *Mis Quarterly*, 385-407.

Marquis, C., & Raynard, M. (2017). Institutional strategies in emerging markets. *Academy of Management Annals*, *9*(1), 291-335.

Marquis, C., Glynn, M. A., & Davis, G. F. (2007). Community isomorphism and corporate social action. *Academy of management review*, *32*(3), 925-945.

Marx, K., and Engels, F. (1848/2004). The communist manifesto (1848). *Trans. AJP Taylor. London: Penguin*.

McGivern, G., & Dopson, S. (2010). Inter-epistemic power and transforming knowledge objects in a biomedical network. *Organization Studies*, *31*(12), 1667-1686.

McGivern, G., Currie, G., Ferlie, E., Fitzgerald, L., & Waring, J. (2015). Hybrid manager-professionals' identity work: The maintenance and hybridization of medical professionalism in managerial contexts. *Public Administration*, *93*(2), 412-432.

McPherson, C. M., & Sauder, M. (2013). Logics in action: Managing institutional complexity in a drug court. *Administrative science quarterly*, *58*(2), 165-196.

Meyer R. E. 2008. "New sociology of knowledge: Historical legacy and contributions to current debates in institutional research". In *The SAGE handbook of organizational institutionalism*, Edited by: , Greenwood R., Oliver C., Sahlin-Andersson K., Suddaby R. 519–538. Thousand Oaks, CA: Sage.

Meyer, A. D. (1982). Adapting to environmental jolts. *Administrative science quarterly*, 515-537.

Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American journal of sociology*, *83*(2), 340-363.

Meyer, J., Scott, W. R., & Strang, D. (1987). Centralization, fragmentation, and school district complexity. *Administrative science quarterly*, 186-201.

Micelotta, E., Lounsbury, M., & Greenwood, R. (2017). Pathways of institutional change: An integrative review and research agenda. *Journal of Management*, *43*(6), 1885-1910.

Mintzberg, H., (1979). An emerging strategy of "direct" research. Administrative Science Quarterly 24, 582–589.

Mohr, L. B. (1971). Organizational technology and organizational structure. *Administrative science quarterly*, 444-459.

Morgan, G., & Smircich, L. (1980). The case for qualitative research. *Academy of management review*, *5*(4), 491-500.

Mougel, A., Terme, M., & Tanchot, C. (2019). Therapeutic cancer vaccine and combinations with antiangiogenic therapies and immune checkpoint blockade. *Frontiers in immunology*, *10*, 467.

Mullard, A. (2020). Gene-editing pipeline takes off. *Nature reviews. Drug Discovery*.

Murray, A., Rhymer, J., & Sirmon, D. G. (2020). Humans and Technology: Forms of Conjoined Agency in Organizations. *Academy of Management Review*,

Murray, F. (2010). The oncomouse that roared: Hybrid exchange strategies as a source of distinction at the boundary of overlapping institutions. *American Journal of sociology*, *116*(2), 341-388.

Nadkarni, S., Gruber, M., DeCelles, K., Connelly, B., & Baer, M. (2018). New ways of seeing: Radical theorizing.

Nascimento, S., Pereira, A. G., & Ghezzi, A. (2014). From citizen science to do it yourself science. *Joint Research Centre, European Commission, Ispra, Italy*.

Neisser, U. (1980). On" Social Knowing". *Personality and Social Psychology Bulletin*, *6*(4), 601-605.

Nicolini, D. (2011). Practice as the site of knowing: Insights from the field of telemedicine. *Organization Science*, *22*(3), 602-620.

Nicolini, D., Reinecke, J. and Ismail, A. M. (2020) "You're grounded! Towards a theory of enactive legitimation, materiality and practice", *Research in the Sociology of Organizations* , 67

Noordegraaf, M. (2011). Risky business: How professionals and professional fields (must) deal with organizational issues. *Organization studies*, *32*(10), 1349-1371.

Normile, D. (2018). CRISPR bombshell: Chinese researcher claims to have created gene-edited twins. *Science*, *27*.

Nuffield Council on Bioethics (2016). *Genome Editing: an ethical review* (London: Nuffield Council on Bioethics).

Nuffield Council on Bioethics (2018). *Genome Editing and Human Reproduction: social and ethical issues* (London: Nuffield Council on Bioethics).

Ocasio, W., Thornton, P. H., & Lounsbury, M. (2017). Advances to the institutional logics perspective. *The Sage handbook of organizational institutionalism*, 509-531.

Oliver, C. (1991). Strategic responses to institutional processes. *Academy of management review*, *16*(1), 145-179.

Orlikowski, W. J. (1992). The duality of technology: Rethinking the concept of technology in organizations. *Organization science*, *3*(3), 398-427.

Orlikowski, W. J. (2000). Using technology and constituting structures: A practice lens for studying technology in organizations. *Organization science*, *11*(4), 404-428.

Orlikowski, W. J., & Barley, S. R. (2001). Technology and institutions: What can research on information technology and research on organizations learn from each other?. *MIS quarterly*, *25*(2), 145-165.

Orlikowski, W. J., & Iacono, C. S. (2001). Research commentary: Desperately seeking the "IT" in IT research—A call to theorizing the IT artifact. *Information systems research*, *12*(2), 121-134.

Orlikowski, W. J., & Robey, D. (1991). Information technology and the structuring of organizations. *Information systems research*, *2*(2), 143-169.

Owen-Smith, J. (2005). Dockets, deals, and sagas: commensuration and the rationalization of experience in university licensing. *Social Studies of Science*, *35*(1), 69-97.

Owen-Smith, J. (2005). Trends and transitions in the institutional environment for public and private science. *Higher Education*, *49*(1-2), 91-117.

Owen-Smith, J., & Powell, W. W. (2008). Networks and institutions. *The Sage handbook of organizational institutionalism*, 596-623.

Pache, A. C., & Santos, F. (2010). When worlds collide: The internal dynamics of organizational responses to conflicting institutional demands. *Academy of management review*, *35*(3), 455-476.

Pache, A. C., & Santos, F. (2013). Inside the hybrid organization: Selective coupling as a response to competing institutional logics. *Academy of management journal*, *56*(4), 972-1001.

Padgett, J. F., & Powell, W. W. (2012). *The emergence of organizations and markets*. Princeton University Press.

Patriotta, G., Gond, J. P., & Schultz, F. (2011). Maintaining legitimacy: Controversies, orders of worth, and public justifications. *Journal of Management Studies*, *48*(8), 1804-1836.

Patvardhan, S. D., Gioia, D. A., & Hamilton, A. L. (2015). Weathering a meta-level identity crisis: Forging a coherent collective identity for an emerging field. *Academy of Management Journal*, *58*(2), 405-435.

Peng, M. W., Sun, S. L., Pinkham, B., & Chen, H. (2009). The institution-based view as a third leg for a strategy tripod. *Academy of Management Perspectives*, *23*(3), 63-81.

Perkmann M. (2015). University–Industry Relations, Concise Guide to Entrepreneurship, Technology and Innovation, Editors: Audretsch, Hayter, Link, Cheltenham, Publisher: Edward Elgar, Pages: 227-233, ISBN: 9781783474189

Perkmann M. (2016). How Boundary Organizations Facilitate Collaboration Across Diverse Communities, Managing Knowledge Integration Across Boundaries, Editors: Tell, Berggren, Brusoni, Van de Ven, Publisher: Oxford University Press

Perkmann, M., & Walsh, K. (2007). University–industry relationships and open innovation: Towards a research agenda. *International Journal of Management Reviews*, *9*(4), 259-280.

Perkmann, M., & Walsh, K. (2009). The two faces of collaboration: impacts of university-industry relations on public research. *Industrial and Corporate Change*, *18*(6), 1033-1065.

Perkmann, M., Fini, R., Ross, J. M., Salter, A., Silvestri, C., & Tartari, V. (2015). Accounting for universities' impact: Using augmented data to measure academic engagement and commercialization by academic scientists. *Research Evaluation*, *24*(4), 380-391.

Perkmann, M., McKelvey, M., & Phillips, N. (2019). Protecting scientists from Gordon Gekko: How organizations use hybrid spaces to engage with multiple institutional logics. *Organization science*, *30*(2), 298-318.

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., ... & Krabel, S. (2013). Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research policy*, *42*(2), 423-442.

Perrow, C. (1967). A framework for the comparative analysis of organizations. *American sociological review*, 194-208.

Perrow, C. B. (1970). *Organizational analysis: A sociological view* (No. 04; HM131, P3.).

Pfeffer, J., & Gerald, R. (1978). Salancik. 1978. The external control of organizations: A resource dependence perspective.

PhRMA (2016). Tufts Center for the Study of Drug Development. Innovation in the pharmaceutical industry: new estimates of R&D costs. In: Briefing: Cost of Developing a New Drug. Retrieved May 2019 from https://chartpack.phrma.org/2016-perspective/chapter-2/the-lengthy-costly-and-uncertain-biopharmaceutical-research-and-development-process

Pickering, A. (1995). Cyborg history and the World War II regime. *Perspectives on Science*, *3*(1), 1-48.

Pickering, A. (2001). Practice and posthumanism: Social theory and a history of agency. *The practice turn in contemporary theory*, 163-74.

Pickering, M. (2001). *Stereotyping: the politics of representation*. Palgrave.

Pinch, T. (2008). Technology and institutions: Living in a material world. *Theory and society*, *37*(5), 461-483.

Pisano, G. P. (2006). *Science business: The promise, the reality, and the future of biotech*. Harvard Business Press.

Plowman, D. A., Baker, L. T., Beck, T. E., Kulkarni, M., Solansky, S. T., & Travis, D. V. (2007). Radical change accidentally: The emergence and amplification of small change. *Academy of Management Journal*, *50*(3), 515-543.

Poole, M. S., & DeSanctis, G. (1990). Group Decision Support Systems: The Theory of Adaptive Structuration. *Organizations and communication technology*, *173*.

Poole, M. S., & DeSanctis, G. (2004). Structuration theory in information systems research: Methods and controversies. In *The handbook of information systems research* (pp. 206-249). IGI Global.

Poole, M.S., & DeSanctis, G. (1992). Microlevel structuration in computer-supported group decision making. *Human communication research*, *19*(1), 5-49.

Powell, W. W. (1998). Learning from collaboration: Knowledge and networks in the biotechnology and pharmaceutical industries. *California management review*, *40*(3), 228-240.

Powell, W. W., & Colyvas, J. A. (2008). Microfoundations of institutional theory. *The Sage handbook of organizational institutionalism*, *276*, 298.

Powell, W. W., & DiMaggio, P. J. (Eds.). (2012). *The new institutionalism in organizational analysis*. University of Chicago press.

Powell, W. W., & Sandholtz, K. W. (2012b). Chance, necessité, et naïveté: Ingredients to create a new organizational form. The emergence of organizations and markets, 379-433.

Powell, W. W., & Sandholtz, K. W. (2012a). Amphibious entrepreneurs and the emergence of organizational forms. Strategic Entrepreneurship Journal, 6(2), 94-115.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative science quarterly*, 116-145.

Puranam, P., Alexy, O., & Reitzig, M. (2014). What's "new" about new forms of organizing?. *Academy of Management Review*, *39*(2), 162-180.

Quirke, L. (2013). Rogue resistance: Sidestepping isomorphic pressures in a patchy institutional field. *Organization Studies*, *34*(11), 1675-1699.

Raelin, J.A. 2016. *Leadership-as-Practice: Theory and Application*. Abingdon: Routledge.

Reay, T., & Hinings, C. R. (2005). The recomposition of an organizational field: Health care in Alberta. *Organization studies*, *26*(3), 351-384.

Reay, T., & Hinings, C. R. (2009). Managing the rivalry of competing institutional logics. *Organization studies*, *30*(6), 629-652.

Reay, T., Chreim, S., Golden-Biddle, K., Goodrick, E., Williams, B. E., Casebeer, A., ... & Hinings, C. R. (2013). Transforming new ideas into practice: An activity based perspective on the institutionalization of practices. *Journal of Management Studies*, *50*(6), 963-990.

Reay, T., Golden-Biddle, K., & Germann, K. (2006). Legitimizing a new role: Small wins and microprocesses of change. *Academy of Management Journal*, *49*(5), 977-998.

Reckwitz, A. 2002. 'Toward a Theory of Social Practices: A Development in Culturalist Theorizing', *European Journal of Social Theory*, Vol. 5, No. 2, pp. 243–63

Ross, J. M., Perkmann, M., & Fini, R. (2013, January). Translational research: When do public science projects result in real world impact?. In *Paper to be presented at the 35th DRUID Celebration Conference* (pp. 17-19).

Sahal, D. (1981a). Alternative conceptions of technology. *Research policy*, *10*(1), 2-24.

Sahal, D. (1981b). The determinants of best-practice technology. *R&D Management*, *11*(1), 25-32.

Sahlin, K., & Wedlin, L. (2008). Circulating ideas: Imitation, translation and editing. *The Sage handbook of organizational institutionalism*, *218*, 242.

Saka-Helmhout, A. (2020). Institutional agency by MNEs: A review and future research agenda. *Journal of International Management*, 100743.

Sandberg, J., & Pinnington, A. H. (2009). Professional competence as ways of being: An existential ontological perspective. *Journal of management studies*, *46*(7), 1138-1170.

Sandberg, J., & Tsoukas, H. (2011). Grasping the logic of practice: Theorizing through practical rationality. *Academy of management review*, *36*(2), 338-360.

Sander, J. D., & Joung, J. K. (2014). CRISPR-Cas systems for editing, regulating and targeting genomes. *Nature biotechnology*, *32*(4), 347-355.

Schatzki, T. (2009). Timespace and the organization of social life. *Time, consumption and everyday life: Practice, materiality and culture*, 35-48.

Schatzki, T. R. (2001). Introduction: Practice theory. In T. R. Schatzki, K. Knorr-Cetina, and E. v. Savigny (Eds.), The practice turn in contemporary theory: 1-14. London: Routledge.

Schatzki, T. R. (2002). *The site of the social: A philosophical account of the constitution of social life and change*. Penn State Press.

Schatzki, T. R. (2005). Peripheral vision: The sites of organizations. *Organization studies*, *26*(3), 465-484.

Schatzki, T. R. (2006). On organizations as they happen. *Organization studies*, *27*(12), 1863-1873.

Schatzki, T. R. (2012). A primer on practices: Theory and research. In J. Higgs, R. Barnett, S. Billett, M. Hiutchings, & F. Trede (Eds.), Practice-based education: Perspectives and strategies: 13-26. Rotterdam: Sense Publishers.

Schildt, H., & Perkmann, M. (2017). Organizational settlements: Theorizing how organizations respond to institutional complexity. *Journal of Management Inquiry*, *26*(2), 139-145.

Schneiberg, M. (2007). What's on the path? Path dependence, organizational diversity and the problem of institutional change in the US economy, 1900–1950. *socio-Economic review*, *5*(1), 47-80.

Schneiberg, M., & Soule, S. A. (2005). Institutionalization as a contested, multilevel process. *Social movements and organization theory*, *122*, 160.

Schumpeter, J.A. (1934) The Theory of Economic Development. Harvard University Press: Cambridge MA.

Schumpeter, J.A. (1946). “Process of creative destruction” Part II, Chapter VII in Capitalism, Socialism, and Democracy . New York, NY: Harper.

Schwab, K. (2016). *The fourth industrial revolution*. World Economic Forum.

Scott, S. V., & Orlikowski, W. J. (2009). 'Getting the truth': exploring the material grounds of institutional dynamics in social media.

Scott, W. R. (1994). Conceptualizing organizational fields: linking organizations and societal systems. In H-U. Derlien, U. Gerhardt, & F. W. Scharpf (Eds.), Systemrationalitat und partialinteresse. Baden-Baden Germany: Nomos Verlagsgesellschaft.

Scott, W. R. (1995). Institutions and organizations. Thousand Oaks, CA: Sage.

Scott, W. R. (1998). *Organizations: Rational, natural, and open systems*. Prentice hall.

Scott, W. R. (2001). *Institutions and organizations: Ideas and interests*. Sage.

Scott, W. R. (2005). Institutional theory: Contributing to a theoretical research program. *Great minds in management: The process of theory development*, *37*(2), 460-484.

Scott, W. R. (2008a). Lords of the dance: Professionals as institutional agents. *Organization studies*, *29*(2), 219-238.

Scott, W. R. (2008b). Approaching adulthood: the maturing of institutional theory. *Theory and society*, *37*(5), 427.

Scott, W. R. (2013). *Institutions and organizations: Ideas, interests, and identities*. Sage publications.

Scott, W. R., Ruef, M., Mendel, P. J., & Caronna, C. A. (2000). *Institutional change and healthcare organizations: From professional dominance to managed care*. University of Chicago Press.

Scott, R. W., Scott, W. R., & Meyer, J. W. (1994). *Institutional environments and organizations: Structural complexity and individualism*. Sage.

Seo, M. G., & Creed, W. D. (2002). Institutional contradictions, praxis, and institutional change: A dialectical perspective. *Academy of management review*, *27*(2), 222-247.

Sewell Jr, W. H. (1992). A theory of structure: Duality, agency, and transformation. *American journal of sociology*, *98*(1), 1-29.

Shane, S. A. (2004). *Academic entrepreneurship: University spinoffs and wealth creation*. Edward Elgar Publishing.

Shapin, S. (2008). *The scientific life: A moral history of a late modern vocation*. University of Chicago Press.

Shapiro, B. (2020). *How to clone a mammoth: the science of de-extinction* (Vol. 108). Princeton University Press.

Shove, E., Pantzar, M., & Watson, M. (2012). *The dynamics of social practice: Everyday life and how it changes*. Sage.

Simsek, Z. (2009). Organizational ambidexterity: Towards a multilevel understanding. *Journal of management studies*, *46*(4), 597-624.

Simsek, Z. (2009). Organizational ambidexterity: Towards a multilevel understanding. *Journal of management studies*, *46*(4), 597-624.

Skålén, P. and C. Hackley. 2011. 'Marketing-as-Practice: Introduction to the Special Issue', *Scandinavian Journal of Management*, Vol. 27, No. 2, pp. 189–95.

Smets, M., & Jarzabkowski, P. (2013). Reconstructing institutional complexity in practice: A relational model of institutional work and complexity. *Human relations*, *66*(10), 1279-1309.

Smets, M., Aristidou, A., & Whittington, R. (2017). Towards a practice-driven institutionalism. *The Sage handbook of organizational institutionalism*, 365.

Smets, M., Greenwood, R., & Lounsbury, M. (2015). An institutional perspective on strategy as practice. *The Cambridge handbook of strategy as practice*, *2*, 283-300.

Smets, M., Jarzabkowski, P., Burke, G. T., & Spee, P. (2015). Reinsurance trading in Lloyd's of London: Balancing conflicting-yet-complementary logics in practice. *Academy of management journal*, *58*(3), 932-970.

Smets, M., Morris, T. I. M., & Greenwood, R. (2012). From practice to field: A multilevel model of practice-driven institutional change. *Academy of Management Journal*, *55*(4), 877-904.

Smith, W. K., & Besharov, M. L. (2019). Bowing before dual gods: How structured flexibility sustains organizational hybridity. *Administrative Science Quarterly*, *64*(1), 1-44.

Souitaris, V., Zerbinati, S., & Liu, G. (2012). Which iron cage? Endo-and exoisomorphism in corporate venture capital programs. *Academy of Management Journal*, *55*(2), 477-505.

Stam, E. 2015. Entrepreneurial Ecosystems and Regional Policy: A Sympathetic Critique. *European Planning Studies*, 23(9): 1759–1769.

Stark, D. (1996). Recombinant property in East European capitalism. *American journal of sociology*, *101*(4), 993-1027.

Steenhuysen, J. (2019, March 13). Experts call for halt to gene editing that results in 'designer babies'. REUTERS.

Sternberg, S. H., & Doudna, J. A. (2015). Expanding the biologist's toolkit with CRISPR-Cas9. *Molecular cell*, *58*(4), 568-574.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research*. Sage publications.

Strauss, A., & Corbin, J. (1994). Grounded theory methodology. *Handbook of qualitative research*, *17*(1), 273-285.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research techniques*. Thousand Oaks, CA: Sage publications.

Suchman, M. C. (1995). Managing legitimacy: Strategic and institutional approaches. *Academy of management review*, *20*(3), 571-610.

Suddaby, R. (2006). From the editors: What grounded theory is not.

Suddaby, R., Seidl, D., & Lê, J. K. (2013). Strategy-as-practice meets neo-institutional theory.

Teece, D. J. (1998). Capturing Value from Knowledge Assets: The Economy, markets for know-how, and the intangible assets. California Management Review , 40 (3), 55–79. JOUR.

Thompson, E. P. (1967). Time, work-discipline, and industrial capitalism. *Past & present*, (38), 56-97.

Thompson, J. D., & Bates, F. L. (1957). Technology, organization, and administration. *Administrative Science Quarterly*, 325-343.

Thompson, N. A., Verduijn, K., & Gartner, W. B. (2020). Entrepreneurship-as-practice: grounding contemporary theories of practice into entrepreneurship studies.

Thornton, P. H. (2004). *Markets from culture: Institutional logics and organizational decisions in higher education publishing*. Stanford University Press.

Thornton, P. H., & Ocasio, W. (1999). Institutional logics and the historical contingency of power in organizations: Executive succession in the higher education publishing industry, 1958–1990. *American journal of Sociology*, *105*(3), 801-843.

Thornton, P. H., & Ocasio, W. (2008). Institutional logics. *The Sage handbook of organizational institutionalism*, *840*, 99-128.

Thornton, P. H., Ocasio, W., & Lounsbury, M. (2012). The institutional logics perspective. *Emerging trends in the social and behavioral sciences: An interdisciplinary, searchable, and linkable resource*, 1-22.

Tilly, C. (2001). Mechanisms in political processes. *Annual review of political science*, *4*(1), 21-41.

Tolbert, P. S., & Zucker, L. G. (1983). Institutional sources of change in the formal structure of organizations: The diffusion of civil service reform, 1880-1935. Administrative Science Quarterly, 28(1): 22-39.

Townley, B. (2002). The role of competing rationalities in institutional change. *Academy of Management Journal*, *45*(1), 163-179.

Trist, E. (1981). The evolution of socio-technical systems. *Occasional paper*, *2*(1981), 1981.

Tsoukas, H., & Chia, R. (2002). On organizational becoming: Rethinking organizational change. *Organization science*, *13*(5), 567-582.

Vaara, E., & Whittington, R. (2012). Strategy-as-practice: Taking social practices seriously. *Academy of Management Annals*, *6*(1), 285-336.

Vaast, E., & Walsham, G. (2005). Representations and actions: the transformation of work practices with IT use. *Information and Organization*, *15*(1), 65-89.

Van de Ven, A. H., & Lifschitz, A. (2012). Rational and reasonable microfoundations of markets and institutions. *Academy of Management Perspectives*, *27*(2), 156-172.

Van de Ven, A. H., & Poole, M. S. (1990). Methods for studying innovation development in the Minnesota Innovation Research Program. *Organization science*, *1*(3), 313-335.

Van Der Oost, J., Westra, E. R., Jackson, R. N., & Wiedenheft, B. (2014). Unravelling the structural and mechanistic basis of CRISPR–Cas systems. *Nature reviews Microbiology*, *12*(7), 479.

Venkataraman, H., Vermeulen, P., Raaijmakers, A., & Mair, J. (2016). Market meets community: Institutional logics as strategic resources for development work. Organization Studies, 37(5): 709-733.

Vogus, T. J., & Davis, G. F. (2005). Elite mobilizations for antitakeover legislation, 1982–1990. *Social movements and organization theory*, 96-121.

von Krogh, G. (2018). Artificial intelligence in organizations: New opportunities for phenomenon-based theorizing. *Academy of Management Discoveries*.

Walsham, G. (2006). Doing interpretive research. *European journal of information systems*, *15*(3), 320-330.

Washington, M. (2004). Field approaches to institutional change: The evolution of the National Collegiate Athletic Association 1906–1995. *Organization Studies*, *25*(3), 393-414.

Washington, M., & Ventresca, M. J. (2004). How organizations change: The role of institutional support mechanisms in the incorporation of higher education visibility strategies, 1874–1995. *Organization science*, *15*(1), 82-97.

Weber, M. (1924/1968). Economy and Society: An Interpretative Sociology, Vol. 3.

Weber, M. (1946/2009). *From Max Weber: essays in sociology (1946)*. Routledge.

Weick, K. E. (1995). *Sensemaking in organizations* (Vol. 3). Sage.

Whittington, R. (2006). Completing the practice turn in strategy research. *Organization studies*, *27*(5), 613-634.

Whittington, R. (2019). *Opening strategy: Professional strategists and practice change, 1960 to today*. Oxford University Press.

Winner, L. (2001). Where technological determinism went. *Visions of STS: Counterpoints in science, technology and society studies*, 11-17.

Woodward, J. (1965). Industry organization: Theory and Practice. London: Oxford University Press.

Woolgar, S., & Grint, K. (1991). Computers and the transformation of social analysis. *Science, Technology, & Human Values*, *16*(3), 368-378.

Wooten, M., & Hoffman, A.J. (2017). Organizational fields: Past, present and future. *The SAGE handbook of organizational institutionalism, Hrsg. Royston Greenwood, Christine Oliver, Kerstin Sahlin und Roy Suddaby*, *2*, 120-147.

Wright, A. V., Nuñez, J. K., & Doudna, J. A. (2016). Biology and applications of CRISPR systems: harnessing nature's toolbox for genome engineering. *Cell*, *164*(1-2), 29-44.

Wyatt, S. (2008). Technological determinism is dead; long live technological determinism. *The handbook of science and technology studies*, *3*, 165-180.

Yates, J., & Orlikowski, W. J. (1992). Genres of organizational communication: A structurational approach to studying communication and media. *Academy of management review*, *17*(2), 299-326.

Yin, R. K., & Campbell, D. T. (2009). Case study research, 2003. *Design and Methods*.

York, J. G., Hargrave, T. J., & Pacheco, D. F. (2016). Converging winds: Logic hybridization in the Colorado wind energy field. *Academy of Management Journal*, *59*(2), 579-610.

Zammuto, R. F., Griffith, T. L., Majchrzak, A., Dougherty, D. J., & Faraj, S. (2007). Information technology and the changing fabric of organization. *Organization science*, *18*(5), 749-762.

Zietsma, C., Groenewegen, P., Logue, D. M., & Hinings, C. R. (2017). Field or fields? Building the scaffolding for cumulation of research on institutional fields. *Academy of Management Annals*, *11*(1), 391-450.

Zilber, T. B. (2007). Stories and the discursive dynamics of institutional entrepreneurship: The case of Israeli high-tech after the bubble. *Organization Studies*, *28*(7), 1035-1054.

Zilber, T. B. (2014). Beyond a single organization: Challenges and opportunities in doing field level ethnography. *Journal of Organizational Ethnography*.

Appendices

Appendix 1: CRISPR uses per company

Company code	Application	'CRISPR uses' *(Technology-as-practice)*	Year founded	Location	
1	Human therapeutics	CRISPR therapeutics	2013	US	*Wave 1*
2	Human therapeutics	CRISPR therapeutics	2013	US	
3	Human therapeutics	CRISPR therapeutics	2011	US	
4	Human therapeutics	CRISPR therapeutics	2014	CH/US	
A1	Intracellular delivery system	CRISPR therapeutics	2015	NL	*Wave 2*
A2	Drug discovery system	CRISPR therapeutics	2017	NL	
A3	Human therapeutics	CRISPR therapeutics	2012	NL	
B1	AI powered CRISPR library	CRISPR AI	2012	UK	
B2	Software tool	CRISPR AI/Software	2011	UK	
B3	AI tool for genomic data analysis	CRISPR AI/diagnostics	2011	UK	
C1	Sequencing of microbiome	CRISPR consumable/diagnostics	2016	US	
C2	Gene editing based xenotransplantation	CRISPR therapeutics	2014	US	
C3	Human emulation system	CRISPR diagnostics/therapeutics	2013	US	

A detailed overview of the companies in the sample is available but has been omitted for reasons of anonymity.

Appendix 2: Overview and description of interviewees

Overview and description of interviewees		
Interviewee Number (#)	**Role**	**Location**
1	Industry insider, CEO of international digital health and drug discovery company	Boston (US) / Bicester / London (UK)
2	CEO & founder spinout company from Harvard	Boston (US)
3	Chief Business Officer Broad Institute	Boston (US)
4	Co-founder of Harvard spinout / assistant professor	Boston (US)
5	CEO first wave CRISPR company	Boston (US)
6	CEO & co-founder CRISPR spinout	Utrecht (NL)
7	COO & founder digital CRISPR company	London (UK)
8	Business development specialist, Harvard Office of Technology Development	Boston (US)
9	Industry insider / Science Park Director / Commercial Development Specialist	Oxford (UK)
10	Bioethicist in world leading CRISPR laboratory	Boston (US)
11	Industry insider & science commercialisation expert / professor	Boston (US)
12	Specialist on new biotechnology related policy / Harvard Kennedy School professor	Boston (US)
13	US government advisor on science policy & industry / MIT Professor	Boston (US)
14	PhD candidate on CRISPR related technologies	Boston (US)
15	Specialist on dissemination of CRISPR / professor	Boston (US)
16	World renowned biotechnology policy specialist, Harvard Kennedy School professor	Boston (US)
17	Industry insider / specialist in biomanufacturing / MIT professor	Boston (US)
18	World leading CRISPR expert, MIT media lab	Boston (US)
19	Industry advisor to a large world leading life science VC	Oxford (UK)
20	Wealth creation lead, local science network	Oxford (UK)
21	World leading CRISPR scientist	Wageningen (NL)
22	Biotechnology commercialisation expert / assistant professor	Oxford (UK) / Boston (US)
23	CRISPR expert at the World Economic Forum	Cologny (CH)
24	Oncologist	Rotterdam (NL)
25	Investor in biotechnology companies at £600M fund	Oxford (UK)
26	Professor in biomedical ethics / Senator	Utrecht (NL)
27	Senior lobbyist for biotechnology industry	The Hague (NL)
28	Leadership science park	Leiden (NL)
29	Leadership science park	Leiden (NL)
30	Serial entrepreneur / CEO NASDAQ listed science company / Founder / Professor	Utrecht (NL)
31	Senior policy advisor, National Institute for Public Health and the Environment	Bilthoven (NL)
32	Science policy advisor, National Institute for Public Health and the Environment	Bilthoven (NL)
33	Senior researcher National institute for Public Health and the Environment / Assistant professor	Bilthoven (NL)
34	CEO & Founder science company spinout	Leiden (NL)
35	Senior scientist bioinformatics / innovation officer at an industrial multinational	Delft (NL)
36	CEO & Founder CRISPR company, Professor in Pharmacogenetics	Amsterdam (NL) / Oxford (UK)
37	Co-founder of Harvard Lab for Entrepreneurship and Development	Boston (US)
38	Co-founder NASDAQ listed science companies / serial entrepreneur	Leiden (NL)
39	Head of government funded initiative aiding the development of regional STEM companies	The Hague (NL)
40	Partner at an advisory firm / expert on commercial biotechnology	Amsterdam (NL)

41	Business development leader and industry specialist	Amsterdam (NL)
42	CEO / Founder digital drug discovery company SME	Amsterdam (NL)
43	Senior policy advisor at Dutch Ministry of Economic Affairs / General Secretary at Dutch Royal Academy of Arts & Sciences (KNAW)	The Hague (NL)
44	Head Intellectual Property and IP owner, NASDAQ listed science company	Leiden (NL)
45	Partner at large Chinese-American international investment fund in biotech	Oxford (UK)
46	Lead at large British investment fund	London (UK)
47	Director Public Policy & Reimbursement at digital drug discovery company SME	Amsterdam (NL)
48	PhD on CRISPR, VP at diagnostics company	Oxford (UK)
49	Royal Society Entrepreneur in Residence	Oxford (UK)
50	CEO & owner of world leading Pharmaceutical	Oxford (UK)
51	Fellow at the Parliamentary Office of Science & Technology	London (UK)
52	World leading and founding CRISPR Expert	Boston (UK)
53	Partner at Big Tech owned global investment firm	Oxford (UK)
54	Oncology researcher University of Oxford	Oxford (UK)
55	PI genomics laboratory University of Oxford	Oxford (UK)
56	CEO of a multinational pharmaceutical company	Oxford (UK)
57	CEO of a multinational pharmaceutical company	Oxford (UK)
58	Vice Chairperson of a multinational pharmaceutical company	Oxford (UK)
59	Technology Transfer Office representative	Oxford (UK)
60	Cabinet Officer / policy maker	London (UK)
61	Investor / partner at large Chinese-American international investment fund in biotechnology	Oxford (UK)
62	Director of Safety and Security for a genomics consortium	Oxford (UK)
63	Founder scientists' collective	Oxford (UK)
64	Founder of STEM start-up competition	Oxford (UK)
65	Senior Associate at consultancy firm supporting CRISPR companies	London (UK)
66	Founder at biotechnology hardware company	London (UK)
67	Director of Biohacking space	London (UK)
68	Business development manager world renowned genomics institute	Cambridge (UK)
69	President and CEO first wave CRISPR company	Cambridge (UK)
70	Innovations manager large UK based trust	Cambridge (UK)
71	Senior Director Intellectual Properties & Legal Affairs first wave CRISPR company	Cambridge (UK)
72	Science policy officer Association of the British Pharmaceutical Industry	Cambridge (UK)
73	Director of Genomic Services second wave CRISPR/AI company	Cambridge (UK)
74	Chief Clinical Officer of a network that aims to enhance UK's innovation capabilities	Cambridge (UK)
75	Health policy think tank and foundation	Cambridge (UK)
76	Investor at a $2bln health venture capitalist fund	London (UK)
77	Leadership at Imperial College / professor / science entrepreneur	London (UK)
78	Chief of translation medicine AI / genomics company	London (UK)
79	CEO start-up accelerator and foundation	Amsterdam (NL)
80	Investor at a €300mln health venture capitalist fund	Amsterdam (NL)
81	Researcher biotechnology commercialisation	Amsterdam (NL)
82	CEO and founder second wave CRISPR/software company	London (UK)
83	CSO and founder second wave CRISPR company	Boston (US)
84	Visionary and philosopher of science	Oxford (UK)
85	Academic scientist working with CRISPR	Oxford (UK)
86	Academic scientist working with CRISPR	Oxford (UK)
87	Academic scientist working with CRISPR	Boston (US)
88	Investor at UK focused VC firm	Oxford (UK)

Abbreviations and Acronyms

AI	Artificial Intelligence
CEO	Chief Executive Officer
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
CRO	Clinical research organisation
CSO	Chief Scientific Officer
DNA	Deoxyribonucleic Acid
EMA	European Medicine Association
EU	European Union
FDA	Food and Drug Administration (in the US)
GM	Genetically Modified
GMO	Genetically Modified Organism
IP	Intellectual Property
IPO	Initial Public Offering
IS	Innovation Studies
MD	Medical doctor
MPV	Minimal Viable Product
NHS	National Health Service
NL	The Netherlands
PCR	Polymerase Chain Reaction
PE	Private Equity
PI	Principal investigator
R&D	Research and Development
rDNA	Recombinant Deoxyribonucleic Acid
RIVM	Rijksintituut voor Volksgezondheid en Milieu
ROI	Return On Investment
STEM	Science, Technology, Engineering, and Mathematics
TTO	Technology Transfer Office
UK	United Kingdom
US	United States of America
VC	Venture Capitalist