Public Disclosure Authorized
Public Disclosure Authorized
Public Disclosure Authorized
Public Disclosure Authorized

SEOUL CENTER FOR FINANCE AND INNOVATION



# Diversification through the Application of the Co-evolutionary Framework: Korea and Viet Nam

WORLD BANK GROUP
Finance, Competitiveness & Innovation

Ministry of Economy and Finance

© 2024 International Bank for Reconstruction and Development / The World Bank

**1818 H Street NW**
**Washington DC 20433**
**Telephone: 202-473-1000**
**Internet: www.worldbank.org**

This work is a product of the staff of The World Bank with external contributions. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments they represent.

The World Bank does not guarantee the accuracy, completeness, or currency of the data included in this work and does not assume responsibility for any errors, omissions, or discrepancies in the information, or liability with respect to the use of or failure to use the information, methods, processes, or conclusions set forth. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Nothing herein shall constitute or be construed or considered to be a limitation upon or waiver of the privileges and immunities of The World Bank, all of which are specifically reserved.

**Rights and Permissions**

The material in this work is subject to copyright. Because The World Bank encourages dissemination of its knowledge, this work may be reproduced, in whole or in part, for noncommercial purposes as long as full attribution to this work is given.

Any queries on rights and licenses, including subsidiary rights, should be addressed to World Bank Publications, The World Bank Group, 1818 H Street NW, Washington, DC 20433, USA; fax: 202-522- 2625; e-mail: pubrights@worldbank.org.

World Bank Group
Finance, Competitiveness and Innovation
Global Practice

# Diversification through the Application of the Co-evolutionary Framework: Korea and Viet Nam

**SEOUL CENTER FOR FINANCE AND INNOVATION**
MARCH 2024

# Acknowledgments

The note was prepared by a team led by Anwar Aridi (Senior Private Sector Specialist, World Bank) and Jeong-dong Lee (Professor, Seoul National University), which included Kibum Kim (Private Sector Specialist, World Bank), Kyeyoung Shin (Consultant, World Bank), and Dawoon Jeong (Researcher, SNU), Wonsub Eum (Associate Professor, University of Kitakyushu), and Taewon Kang (Professor, Chungnam National University).

The note benefited from the guidance of the World Bank Management, Zafer Mustafaoglu (Practice Manager) and Jason Allford (Country Manager), and from feedback and comments provided by Jaime Frias (Senior Economist, WB) and Cristian Quijada Torres (Senior Private Sector Specialist, WB).

This knowledge note was made possible by a grant from the Ministry of Economy and Finance of the Republic of Korea, provided through the Seoul Center for Finance and Innovation and the World Bank Group Korea Office.

# Contents

**Acknowledgments** ..... 4

**Abbreviations and Acronyms** ..... 6

**Executive Summary** ..... 7

**01. Introduction** ..... 10

**02. Conceptual Background** ..... 13
2.1. The principle of relatedness analysis ..... 14
2.2. Relationship between product space and technology space ..... 17
2.3. Diversification strategies in multiplex network ..... 21
2.4. Co-evolutionary framework for production and technology ..... 23

**03. Comparing Korea's and Viet Nam's Diversification Paths using the Co-evolutionary Framework** ..... 27

**04. Potential Diversification Path for Viet Nam** ..... 41

**0.5 Conclusion** ..... 47

**References** ..... 51

**Appendices** ..... 56
A1. Data and methodology ..... 57
A2. Diversification patterns for selected countries ..... 62

# Abbreviations and Acronyms

| | |
|---|---|
| **FDI** | Foreign Direct Investment |
| **FIE** | Foreign-invested Enterprise |
| **GDP** | Gross Domestic Product |
| **GERD** | Gross Domestic Expenditure on R&D |
| **GVC** | Global Value Chain |
| **HS** | Harmonized System |
| **ICT** | Information and Communication Technology |
| **IPC** | International Patent Classification |
| **MNEs** | Multinational Enterprises |
| **OECD** | Organisation for Economic Co-operation and Development |
| **PATSTAT** | Patent Statistical Database |
| **R&D** | Research and Development |
| **RCA** | Revealed Comparative Advantage |
| **RTA** | Revealed Technology Advantage |
| **SNU** | Seoul National University |
| **STEM** | Science, Technology, Engineering, and Mathematics |
| **TFP** | Total Factor Productivity |
| **UN COMTRADE** | United Nations Commodity Trade Statistics Database |
| **USPTO** | United States Patent and Trademark Office |
| **WB** | World Bank |
| **WIPO** | World Intellectual Property Organization |

# Executive Summary

**Industry diversification is a driver of economic development.** Many developing countries are attempting in various ways to diversify away from lower-value-added industries and into higher-value-added ones. These efforts are based on the belief that economic development can be achieved by diversifying into higher-value-added industries. During this process, various industrial policies are deployed to foster the target industries, including attracting foreign direct investment (FDI). However, evidence shows that developing countries face challenges in sustaining the diversification of their industry portfolio, and as a result, many stagnate economically.

**The principle of relatedness, which can be used to understand the path of diversification, has been well established theoretically and used empirically to make policy recommendations for developing countries.** This principle suggests that diversification tends to occur into products that are more closely related to the products in which a country currently has a comparative advantage. However, many countries that transitioned from developing to advanced economies proceeded with diversification into unrelated products through jumps that contradict the principle. Thus, although the relatedness principle can generally describe the diversification patterns of many countries, it fails to account for the marked and ostensibly disconnected leaps of other countries that successfully transitioned into the high-income category.

**The primary aim of this study is to examine the industry diversification process by conceptualizing a co-evolutionary framework linking production and technology and applying the framework to the cases of the Republic of Korea (Korea, hereafter) and Viet Nam.** The notion that production capabilities and technological capabilities are interrelated allows us to identify four different diversification patterns: (i) unrelated diversification, (ii) production-based diversification, (iii) technology-based diversification, and (iv) complex diversification that is both production-based *and* technology-based. Korea is chosen as a case study because it has been one of the most successful examples of rapid development through technological progress, while Viet Nam is chosen because it encounters many of the diversification challenges typically faced by economies that are only now beginning to catch up. This research aims to contribute valuable insights not only for Viet Nam but also for developing countries embroiled in the challenges of progressing beyond production-based diversification.

**The co-evolutionary framework has notable strengths in explaining Korea's diversification journey from basic products to complex and high-value-added products.** Korea's diversification to more complex tasks was driven by domestic firms and facilitated by the government's

deliberate efforts to develop technological capabilities, in particular by encouraging investments in domestic research and development (R&D) and in human capital. These investments enabled domestic firms, mainly large manufacturing exporters, to achieve complex diversification through the generation of advanced technologies and products. Thus, the co-evolutionary process was induced and catalyzed by policy interventions, updated diversification strategies as the country developed, and aligned industrial and innovation policies.

**In Viet Nam, by contrast, diversification was led by FDI firms with apparently few spillovers of technological capabilities to domestic firms.** Domestic production was focused on assembly activities, with little processing taking place in the country. The analysis of Viet Nam's product and technology spaces shows a weak relationship between Viet Nam's technological capabilities and its current production portfolio. Thus, Viet Nam has yet to secure the technological capabilities to support its current production activities. Under these circumstances, Viet Nam's future diversification potential, especially into technologically sophisticated products, is by no means assured.

**Based on the results from applying the framework to the two country cases, the report offers the following policy recommendations.** If acted upon, these could contribute to the realization of the Viet Nam 2045 vision of becoming a high-income country. While the recommendations are tailored for Viet Nam, they could also be applied to other emerging economies facing diversification hurdles similar to Viet Nam's.

**First, Viet Nam could use the co-evolutionary framework to identify the technologies best placed to enhance national diversification prospects**. Although Viet Nam has been successful in diversifying its economy through FDI, it faces limitations in assimilating technological capabilities underpinning its current production. Findings from the simulation conducted in this research show that Viet Nam can potentially diversify into 233 products, including 92 new products through technology-based and complex diversifications, if it accumulates capabilities in the 12 identified technologies. This potential shift toward more sophisticated products aligns with Viet Nam's strategic goal of moving up the value chain and achieving further diversification.

**Second, the country would need to invest more intensively in technology and capabilities upgrading to diversify into new complex products.** The top five Vietnamese technologies with a high revealed technology advantage (RTA)—but of low product complexity—have not changed significantly from 2000 to 2018. Korea's experience of shifting the locus of R&D from the public to the private sector and subsequent transitions to complex products suggests that Viet Nam's private sector could amplify its R&D investments and engage in capability building activities. Effective public policies supporting technological development and R&D investments may play a crucial role in overcoming these challenges. In addition, intensifying linkages and facilitating collaborative R&D programs with high-tech multinational enterprises (MNEs) may promote spillovers and help local firms upgrade their technological capabilities.

**Third, Viet Nam needs to evolve its diversification strategy alongside its economic growth and capability building process, recognizing that diversification pathways evolve with a country's development.** An analysis of 99 countries from 1980 to 2018 showed that as countries' GDP per capita increased, there was a greater tendency to pursue technology-based and complex diversification. A large share of unrelated and production-based diversification was taken up by tech-

nology-based and complex diversification. Korea's experience of transitioning from unrelated and production-based diversification to technology-based and complex diversification also suggests that a country with related technological capabilities may be better positioned for diversification into seemingly distant, unrelated products, even beyond its current industrial structure. Thus, if Viet Nam intends to further diversify, it may do so by accumulating technological capabilities, as this may become a viable diversification route as the country develops.

**Fourth, to enhance diversification, the country could align its industrial policies focused on accumulating production capabilities with innovation policies centered on knowledge accumulation.** Korea's experience showed how industrial and innovation policies were coordinated, aligned, and considered in parallel to accelerate growth and economic diversification. On the other hand, there is indirect evidence indicating that the technological capabilities supporting Viet Nam's production remain weak; innovation policy is fragmented, underperforming, and lacks coordination with a more developed and active industrial policy. Effective coordination between industrial and innovation policies can incentivize local firms to invest in R&D, upgrade technological capabilities, and leverage knowledge spillovers from MNEs, consequently enhancing industrial competitiveness.

# 01

# Introduction



# 1. Introduction

**Diversification is considered essential for sustainable long-term growth and for building resilience to the shocks that periodically affect the economic performance of a country (UNCTAD 2018).** Economic growth is usually achieved through diversification into higher value-added industries. However, developing countries frequently find themselves confined to low-value-added sectors such as agriculture, or dependence on their natural resources. They consequently enact various industrial policies to facilitate the diversification of their economic base. In particular, they often rely on FDI to acquire scarce technologies and capital.

**The principle of relatedness has provided a strong theoretical foundation for the question of which industries to target for diversification.** The principle is derived from the empirical observation that when diversifying into a new industry, countries tend to find areas closely related to industries in which they already enjoy a comparative advantage. This underpins an analytical framework called product space analysis (Hidalgo et al. 2007). Its underlying theory involves the identification of more complex products,[1] that is, products with higher value added, related to those in which the country already has comparative advantages. Recently, this analytical framework has been extended from its original conception—targeting products—to selection of target technologies conducive to diversification based on technology space analysis (Boschma et al. 2015; Kogler et al. 2013; Colombelli et al. 2014; Balland et al. 2019).

**A country's comparative advantage can be explained using two interrelated capabilities—production and technological (knowledge) capabilities.** Recent studies have scrutinized the concurrent dynamics between the two (Pugliese et al. 2019; Eum and Lee 2022a; Patelli et al. 2023). This report applies the principle of relatedness to examine a country's diversification path within and between the product and technology spaces. The approach allows diversification into unrelated products to be understood as a process driven by technological capabilities.

**This study compares Korea's successful diversification experience with Viet Nam's recent diversification path to identify how the latter country could further diversify into more value-added products.** To this end, we first present the concept of a multiplex network in which product space and technology space are connected. Second, we present four types of diversi-

1 In the present research, the term 'product' is used to encompass both goods and services, aligning with the classification used by the UN Comtrade database.

fication patterns, namely unrelated diversification, production-based diversification, technology-based diversification, and complex diversification. Third, we show how diversification patterns differ by the level of economic development. Fourth, we compare the diversification paths of Korea and Viet Nam using the co-evolutionary framework and suggest a viable diversification route for Viet Nam going forward. The report concludes with policy lessons that could inform policy makers in Viet Nam and other developing economies facing diversification hurdles. The target audience of this research includes policy makers and researchers interested in leveraging the relatedness analysis and applying the co-evolutionary framework in development studies.

**Korea's experience provides exemplary evidence of how industrial and innovation policies were coordinated, aligned, and considered in parallel to accelerate growth and economic diversification.** While industrial policy tends to focus on promoting specific industries, innovation policy aims to cultivate technological capabilities. Korea's case shows that the diversification potential is greater and more sustainable when industrial policy aimed at building an industrial base is complemented by innovation policy aimed at building technological and human capital capabilities. The recent World Bank (2023a) publication, *Innovative Korea*, concludes that one of the lessons from Korea's successful transition into a high-income country is related to the necessary evolution of its growth paradigm, particularly the transition from targeted industrial policies to technology and innovation policies. Nevertheless, Korea's development experience is unique, and thus it must be regarded as one of many possible developmental pathways. Still, the application of this framework has implications for several developing nations pursuing economic diversification into more value-added, complex products.

**This study is organized as follows.** Section 2 introduces the conceptual background— the principle of relatedness analysis and the relationship between product and technology spaces, diversification strategies and how diversification patterns differ according to the stages of economic development. Section 3 compares the diversification paths of Korea and Viet Nam using the co-evolutionary framework. Section 4 suggests priority technologies where Viet Nam may need to focus to diversify into complex products using a simulation-based approach. Section 5 summarizes the implications of this study.

# 02

# Conceptual Background



# 2. Conceptual Background

## 2.1. The principle of relatedness analysis

**The product space, a network structure consisting of nodes (products) and edges (proximity), represents the relatedness between products.** The concept of revealed comparative advantage (RCA) described by Balassa (1965) and Hidalgo et al. (2007) suggested the concept of proximity based on the conditional probability of the comparative advantage of two products appearing simultaneously. The more two products share common production capabilities, the higher the conditional probability is, and these products are considered as neighboring products. A product space can be constructed using this concept of proximity. The products in the center of a product space are called core products because they are highly related to other products and produced by only a few advanced countries. Conversely, products in the periphery are less interrelated with other products and are characterized as low-value-added, low-complexity products.

**The process of economic development can be understood as a process of constructing a complex product portfolio, starting with comparative advantage in peripheral products and gradually acquiring comparative advantage in core products.** In the product space, developing countries tend to have a comparative advantage in low-complexity products in the periphery, while developed countries tend to have a comparative advantage in high-complexity products in the core (Hidalgo et al. 2007). As developing countries are located at the periphery, specializing in low-complexity products with fewer related products, they tend to face difficulty in diversifying into core products.

**The process of technological development can be described as a process in which the comparative advantage gradually advances from peripheral technologies to core technologies** (Hidalgo et al. 2007; Eum and Lee 2022a). Technology space represents the relatedness between technologies. Following the same logic as RCA, RTA measures comparative advantage of a country for a given technology at a specific time. RTA can be used to construct the technology space, which is a graphical representation of the linkages between technologies. Similar to the countries in the product space, countries that have comparative advantage in peripheral technologies are less likely to diversify into core technologies, as these technologies have fewer connections with other technologies.

**The principle of relatedness can be used to explain the diversification path of a country—what products and technologies are more likely to be developed in relation to those that a**

**country already possesses a comparative advantage.** A new comparative advantage is more likely to arise in a product that is located close to the current production portfolio, because the required production capabilities resemble the existing ones. The same argument can be made for technology space, where new comparative advantages are more likely to emerge in technologies that resemble existing ones. For example, a country active in textile production is likely to expand into apparel manufacturing, leveraging similar skills and supply chains. Similarly, an economy with relative strength in semiconductor manufacturing might diversify into related fields, such as advanced display technology, given its shared expertise in material science and precision engineering. These transitions capitalize on existing comparative advantages, enabling more efficient diversification.

**The principle of relatedness may show the diversification potential that may occur incrementally to nearby products and technologies.** A recommended product diversification strategy based on the principle of relatedness is to identify and develop products that are highly related to products in which a country already has a comparative advantage and a higher level of product complexity (Hidalgo et al. 2007). Similarly, in the technology space, a recommended technology diversification strategy based on the principle of relatedness is to target technologies that are highly related to technologies in which a country has a comparative advantage, that is, a higher density of comparative advantages in neighboring technologies, and concomitant technological sophistication (Boschma et al. 2015; Balland et al. 2019).

**One limitation of the principle of relatedness is that it does not explain how some countries gained capabilities in unrelated products and technologies where they lacked any previous comparative advantage.** For example, agriculture-based countries are advised to produce products that are highly correlated with their existing agricultural products, making it difficult for them to move away from agriculture-related products (Pinheiro et al. 2018; Eum and Lee 2022b). However, countries such as Korea, with its successful development history, show a pattern of 'jumping' from agriculture to unrelated products, for example, the automobile industry (Lin and Chang 2009; Eum and Lee 2022a).

**To fill this research gap, this report proposes a co-evolutionary framework that considers both production and technological capabilities.** A diversification strategy based on product linkages may capture the average characteristics of diversification patterns across countries, but it may not be helpful in identifying strategies for successful diversification, especially those that involve jumping from products with existing comparative advantage to unrelated products.

# Box 1.
## Key Concepts

The concepts below underpin the co-evolutionary framework described in this note. The measures used in this report are normalized indices that can be compared to each other, as the absolute values may not be meaningful.[2] In addition, because these measures indicate dynamic changes in a country's production or technological capabilities, they may differ by time period. For a detailed explanation of these concepts, see Appendix 1.

— **Technology:** Technology can be described as the comprehensive methods, processes, or systems used to create products or services. In a broader interpretation, it encompasses various technological capabilities beyond codified knowledge, including tacit forms of knowledge, know-how, and specialized complementary factors. In this research, technological capabilities are proxied by patents, a measurement of innovation output, highlighting only the explicit and codified aspects of technological capacity.

— **Revealed Comparative Advantage (RCA)**: Following Balassa (1965), RCA measures comparative advantage of a country for a product at a specific time. Using international export data, it measures the export intensity of a country by calculating the ratio of a product's share in the country's export basket to its share in the relevant global trade. If the RCA value is greater than 1, the country is considered to have a comparative advantage in that product.

— **Revealed Technology Advantage (RTA)**: RTA measures comparative advantage of a country for a technology at a specific time. Following the same logic of RCA, it uses international patent data to identify a country's comparatively advantageous technologies. Normally, technology with RTA greater than 1 is considered to have a comparative advantage.

— **Production-based diversification**: Production-based diversification indicates a country's introduction of a new product that was not part of its export basket in the previous time period. This represents gaining a comparative advantage in a product, more specifically, production know-how a country did not previously have. In this research, we say that a country diversified in a certain product if the RCA changed from below 1 at time $t$ to above 1 at time $t+5$.

— **Technology-based diversification:** Technology-based diversification indicates a country's entry into a new technology that was not part of the country's technology space in the previous time period. In this research, we define a country as having diversified into a certain technology if the technology's RTA changed from below 1 at time $t$ to above 1 at time $t+5$.

— **Density (relatedness)**: Density of a country for a product/technology refers to the degree of the country's existing production/technological capability among the nearby products/technologies to that specific product/technology. Higher density around a product means that the country already has experience or capability in related products and is therefore more likely

2 As an example, a product with an RCA value of 3 does not mean that it is three times more competitive than another product with an RCA value of 1.

to advance into this product. For example, if a country already has comparative advantage in all of the products related to a specific product, the density around the product will be 1. The same explanation can be applied to the technological density.

— **Proximity**: Proximity indicates the relative closeness between two products. It is measured by the probability of co-exporting two products in a country, measured between 0 and 1. Higher proximity means that these two products share common capabilities, inputs and infrastructure required for exporting these products.[3] The same calculation can be applied to technological proximity based on the probability of co-occurrence of technological comparative advantage.

— **Complexity:** Complexity measures how difficult it is to acquire production and technology capabilities. The measurement for product complexity index (Hidalgo and Hausmann 2009) has been adapted and applied to technology as well.

— **Core/peripheral products**: Core/peripheral products refer to products that have more/fewer connections with other products.

— **Core/peripheral technologies**: Core/peripheral technologies refer to technologies that have more/fewer connections with other technologies.

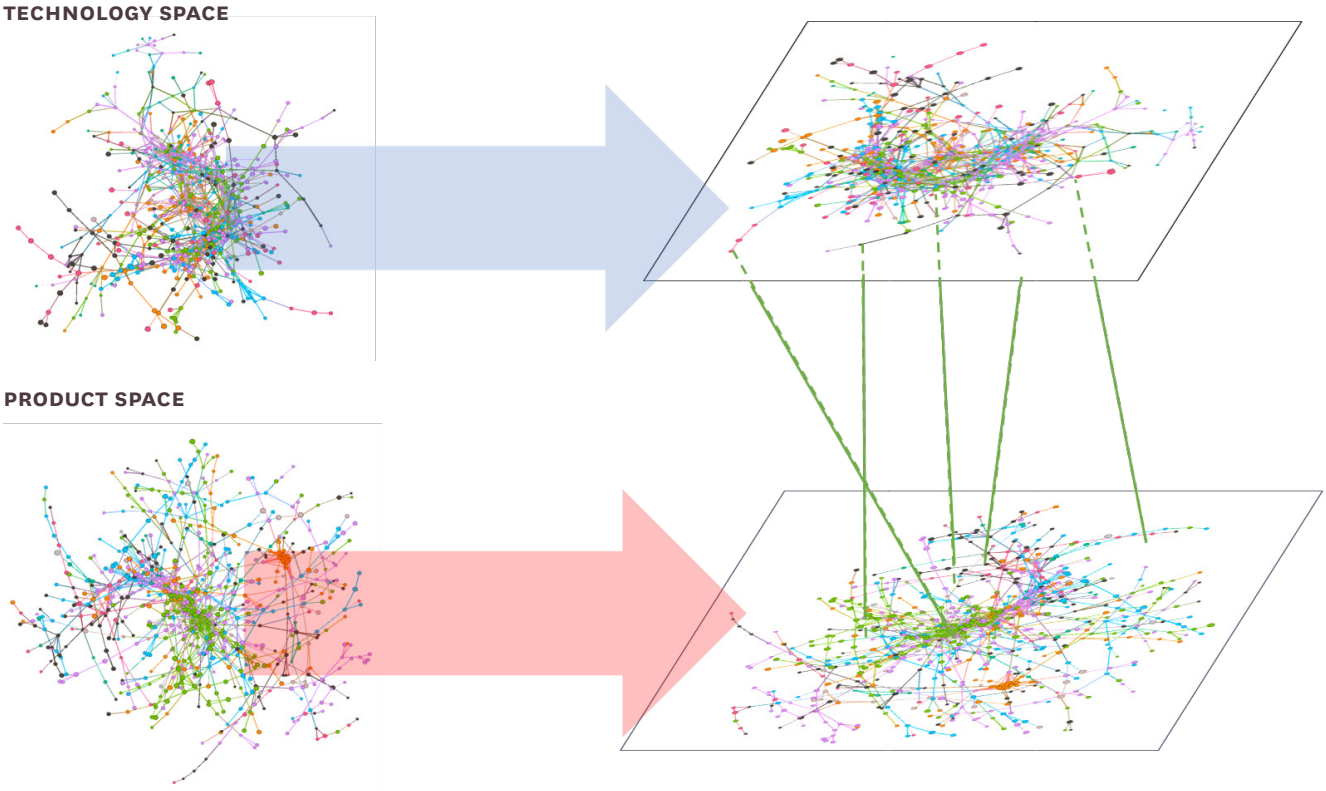
## 2.2.
## Relationship between product space and technology space

**A country's capabilities can be classified into two primary categories: production capabilities and technological capabilities.** It has been argued by various researchers that there are different types of capabilities, among which production capabilities and technological capabilities are representative (Eum and Lee, 2019; Lall, 2000; Kim, 1997; Lee et al., 2021; Yeon et al., 2021). In diversification studies, product portfolio and technological knowledge have been considered two different components of an innovation system that co-evolve over time (Pavitt, 1988; Dosi et al., 2019; Pugilese et al., 2019). Production capabilities encompass the practical proficiency acquired through hands-on experience and learning-by-doing processes and are sources of comparative advantage in the product space. It encompasses activities such as building a plant or operating a production process. On the other hand, technological capabilities pertain to knowledge and innovation proficiency, serving as sources of comparative advantage in the technology space. Technological capability encompasses knowledge from basic science to applied know-how which can be used to understand the logic behind how things work.

3 For example, if all countries that have comparative advantage in exporting automobiles have comparative advantage in exporting motorcycles and vice versa, the proximity between automobiles and motorcycles is 1.

**The inherently intertwined and dynamic relationship between production and technological capabilities can be depicted in a multiplex network.** As depicted in Figure 1, the product and technology spaces can be connected, forming what is referred to as a multiplex network. The connection between the two spaces can be established using the conditional probability of having a comparative advantage in a particular technology given a comparative advantage in a particular product, and vice versa (see Appendix 1 for detailed methodology).

**FIGURE 1.** MULTIPLEX NETWORK – CONNECTING THE PRODUCT AND TECHNOLOGY SPACES



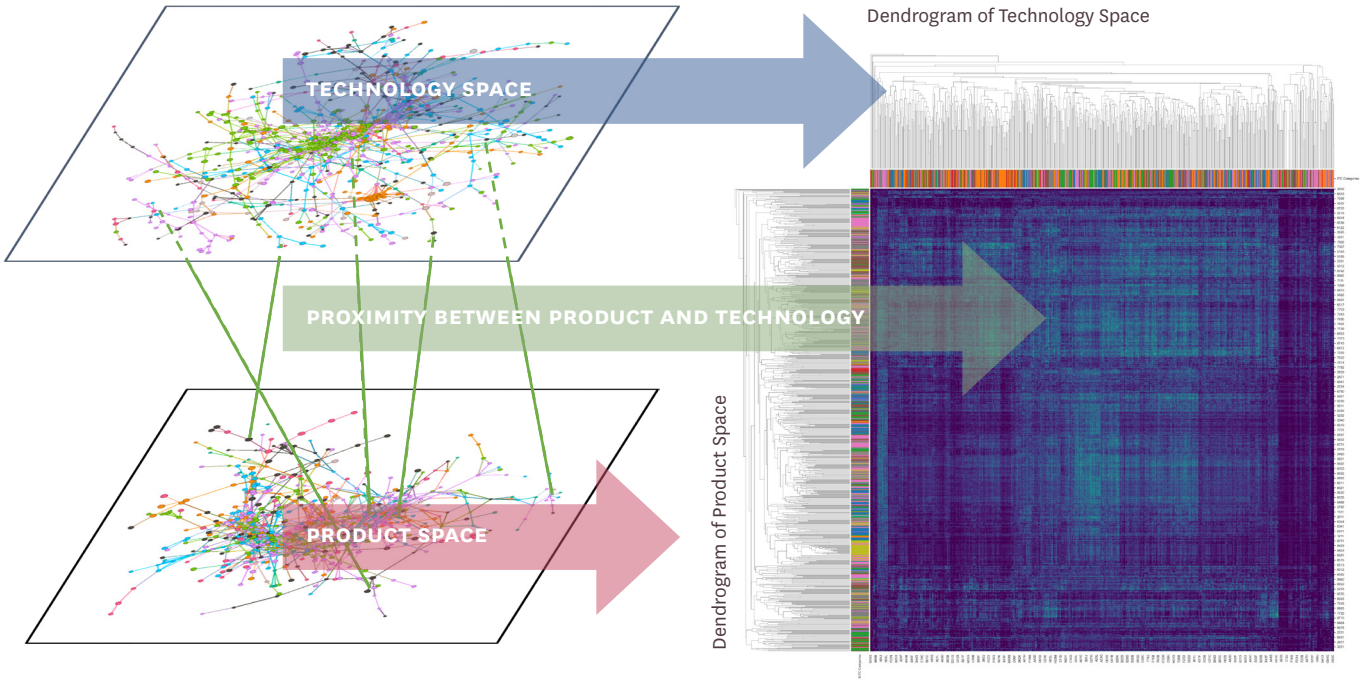

SOURCE: Authors

**The relationship between production and technological capabilities can also be represented as a form of heatmap, based on cross-space proximity.** The relationship between the two capabilities can be shown by displaying the products and technologies on the vertical and horizontal axes, respectively, in the form of a dendrogram. These dendrograms visually organize technology and product hierarchies into an array, grouping related ones. Using the 2018 worldwide product (export) and technology (patent) data, the relationship between the products and technologies is depicted in the form of a heatmap (Figure 2).[4] The comparative advantages of selected countries

4 The use of proxies—exports for production; patents for technology—may limit the scope for applicability of the methodology. This limitation is discussed further in the concluding section.

in the product and technology spaces are depicted in Figure 3. The heatmap shows that different countries have different capabilities portfolios. More vertical blue lines indicate that the country has comparative advantage in a larger number of technology fields, and more horizontal red lines indicate that the country has comparative advantage in a larger number of production areas. For instance, the heatmap for China shows strength in production capabilities compared to technological capabilities, whereas the US has a more balanced portfolio of capabilities in production and technologies alike. Indonesia appears to have some strength in the product space but less so in the technology space. India shows a similar pattern to Indonesia but with more strength in the technology space.

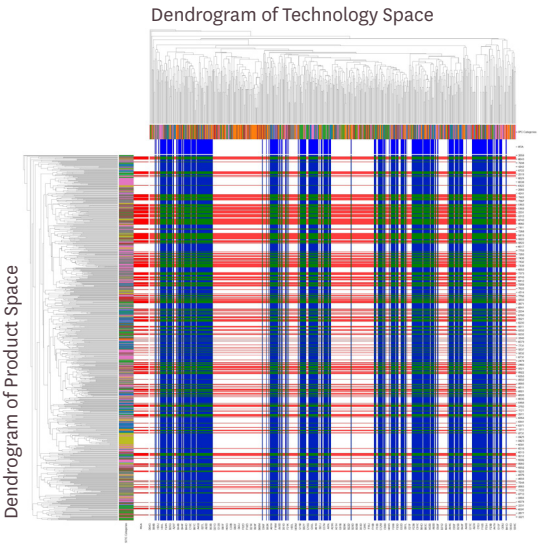
**FIGURE 2.** PRODUCT AND TECHNOLOGY HEATMAP, WORLDWIDE, 2018



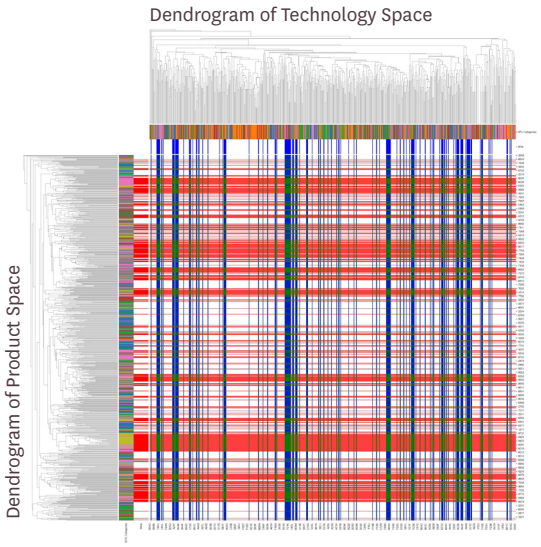

SOURCE: Author's calculation based on data from UN Comtrade, OECD, and WIPO
NOTE: The international export data from the UN Comtrade database were used to construct the product space; the patent data from the OECD patent database were used to construct the technology space; since the OECD patent database covers fewer countries than the UN Comtrade database, supplementary patent databases (PATSTAT, USPTO, WIPO) were also used.

**FIGURE 3.** PRODUCT AND TECHNOLOGY HEATMAPS FOR THE USA, CHINA, INDONESIA, AND INDIA, 2018

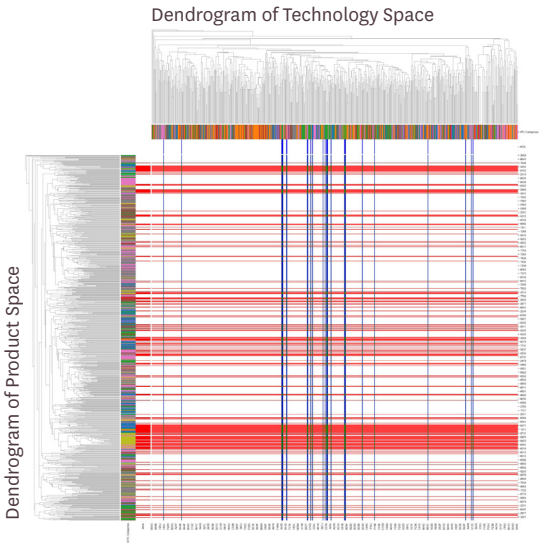
**(A) USA**



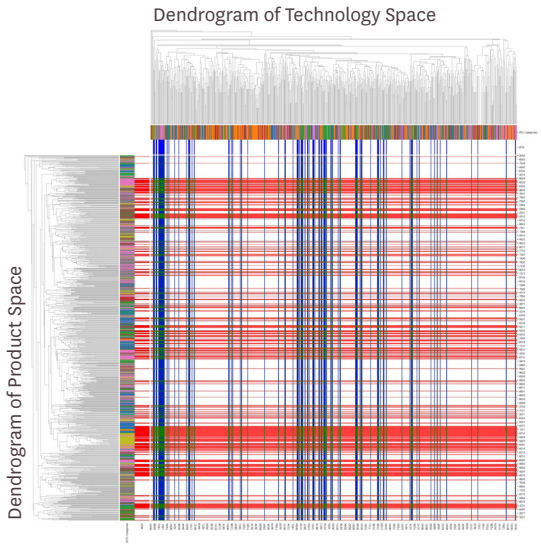

**(B) CHINA**




**(C) INDONESIA**




**(D) INDIA**



## 2.3.
# Diversification strategies in multiplex network

**Using the multiplex network, four diversification strategies can be identified.** In a multiplex network, we can identify three different relationships within and across the product and technology spaces (product–product, product–technology, technology–technology) and four different types of diversification strategies (unrelated, production-based, technology-based, complex diversifications) (Figure 4).

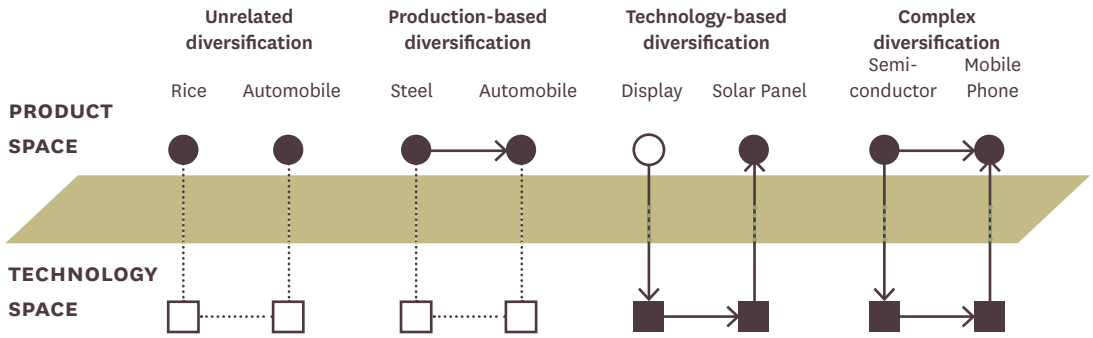
— Unrelated diversification refers to diversification into unrelated products with no production and technological linkages. Jumping directly from rice to automobile production would be an example.

— Production-based diversification refers to diversification into products that are related only in the product space but unrelated in the technology space. As an example, countries that produce steel may be more likely to diversify into automobile production as the two industries share similar production capabilities.

— Technology-based diversification refers to diversification into products that are unrelated in the product space but related in the technology space. Display and solar panel may seem to have low proximity in the product space, but the two share similar underlying technologies.

— Complex diversification refers to a diversification strategy that leverages both production and technological capabilities. Diversifying from semiconductor to mobile phone production would be an example.

**FIGURE 4.** DIVERSIFICATION STRATEGIES IN MULTIPLEX NETWORK



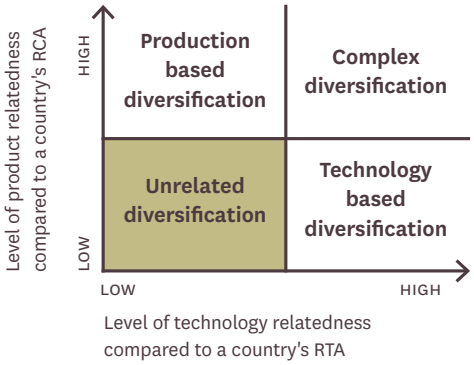

SOURCE: Authors

**A diversification strategy can be identified considering the distance between the capabilities a country possesses and the new capabilities necessary to adopt the target product or technology.** If a country has low capabilities in both products and technologies, its only option is to diversify through an unrelated diversification strategy as shown in Figure 5 (a). If a country has production capabilities, it may diversify into products that have a high degree of relatedness to

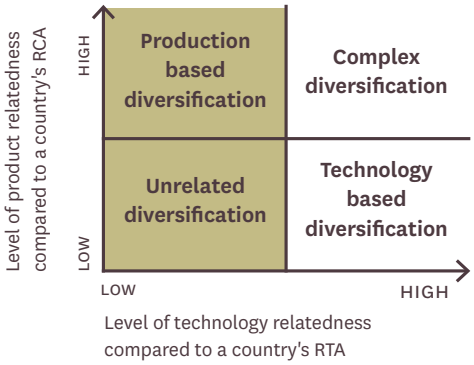
the current production capabilities (Figure 5 (b)). If a country has both production and technological capabilities, the country may pursue technology-based and complex diversification strategies (Figures 5 (c) and (d)) in addition to the production-based diversification.

**FIGURE 5.** DIVERSIFICATION STRATEGIES AVAILABLE TO COUNTRIES WITH DIFFERENT CAPABILITIES

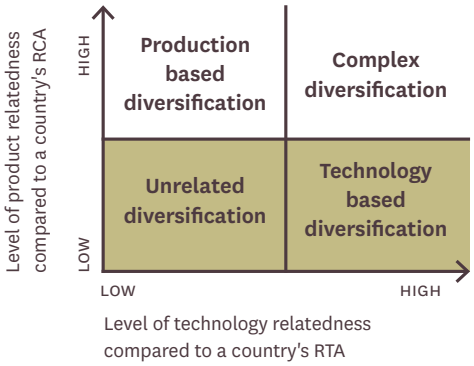
**(A) COUNTRIES WITH LOW PRODUCTION AND TECHNOLOGICAL CAPABILITIES**



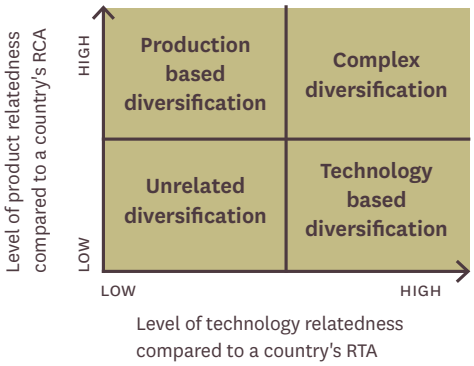

**(B) COUNTRIES WITH HIGH PRODUCTION CAPABILITIES AND LOW TECHNOLOGICAL CAPABILITIES**




**(C) COUNTRIES WITH LOW PRODUCTION CAPABILITIES AND HIGH TECHNOLOGICAL CAPABILITIES**




**(D) COUNTRIES WITH HIGH PRODUCTION AND TECHNOLOGICAL CAPABILITIES**




SOURCE: Authors
NOTE: The shaded areas are the possible diversification strategies available to a country with different production and technological capabilities.

**Technology-based diversification is a diversification pattern that can enable a jump in the product space.** If a country produces a product and simultaneously accumulates technological capabilities that support the current production, the country can diversify into a completely novel product. This is because some unrelated products may share similar technologies. Since technologies can be used to produce different sets of products, distant products with relatively few links in the product space can be connected by leveraging the technological linkages. Using the concept of the multiplex space linking products and technologies, we are able to understand how jumps in the product and technology spaces can occur.

**Once the technological capabilities that underpin production are secured, the range of products that can be diversified is extended.** In the product space, products that are complex and highly related to the product in which a country has a comparative advantage are targets for production-based diversification. If the country has the technological capabilities to support the production, it can identify additional targets for technology-based diversification along the production–technology nexus. Once the technological capabilities are in place, the set of products that can be diversified becomes larger and the country can diversify into more unrelated and complex products. This can increase the average complexity of the production portfolio through diversification. Conversely, without technological capabilities, the potential paths for further diversification, especially toward more complex products, are severely limited.

**While distinguishing the diversification strategies is valuable for understanding their distinct dynamics, they need to be viewed as an interrelated form of diversification rather than as mutually exclusive pathways.** Both existing production portfolio and embedded knowledge provide pathways to diversification (Bottazzi et al., 2001; Teece et al., 1994). Distinguishing between the two is not always straightforward, as they often coexist and interact in complex ways. This study acknowledges the interdependence between technological and production capabilities, underscoring a synergistic relationship where advancements in technology can directly enhance production processes and vice versa.

## 2.4.
## Co-evolutionary framework for production and technology

**Countries can pursue various ways to diversify their economic structures.** While some manufacturing-intensive countries, such as Korea, were able to leverage investments in R&D and technology upgrading, other economies such as countries in the Central and Eastern European region, have managed to achieve high economic growth even with a low level of R&D expenditures (Kravtsova and Radosevic 2012; Radosevic et al. 2019). For example, Poland[5] moved from middle to high-income status in less than 15 years, and its growth model was built on a combination of FDI and export activities based on cheap factors of production. Similarly, the high growth rates attained by Romania and Bulgaria cannot be linked to high R&D investment.[6] Other groups of countries are pursuing a services-led growth model, and some are growing based on their rich natural resource endowments. Considering these various paths, this analysis proposes a co-evo-

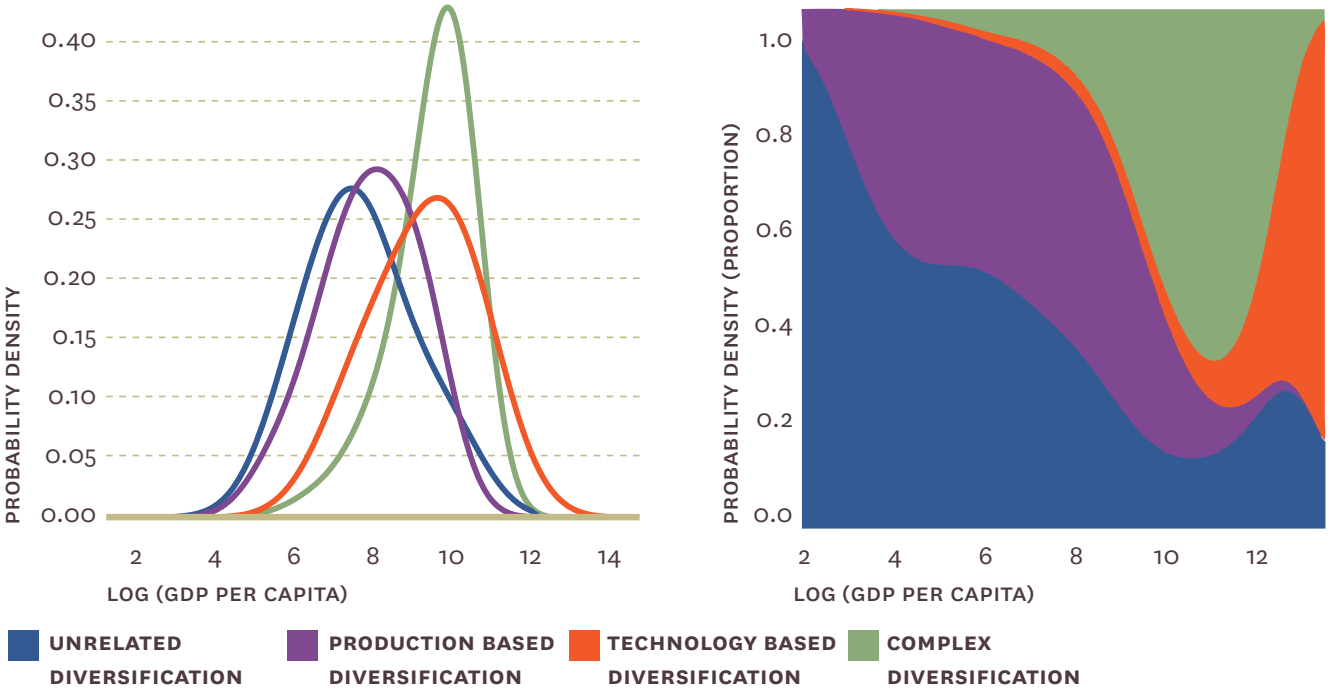
5 The stock of FDI in Poland was below 20 percent of GDP in 2000 when Poland moved to high-income country status, and this share increased to 36 percent of GPD by 2020. R&D expenditure in 2000, when it moved from middle to high-income, was 0.64 percent, and in 2020 Poland's R&D expenditure as a percentage of GDP stood at a mere 1.39 percent. Nevertheless, its economy has achieved a reasonably diversified portfolio, ranking 25th of 133 countries in the Economic Complexity Index in 2021. Poland's main exports are both low and high-complexity products: agriculture, and machinery, respectively.

6 Contrary to the CEE growth model, Southern European countries' growth has been driven primarily by debt and private consumption (Vukov 2023).

lutionary model enabled through deepening the technological capabilities to transition into technology-based or complex diversification.

**Countries facing challenges in progressing toward more advanced and complex products may invest in deepening their technological capabilities to enable further diversification**. Figure 6 shows how the diversification pattern evolves in line with the stages of economic development. An analysis of 99 countries from 1980 to 2018 shows that economies with higher GDP per capita tend to be characterized by technology-based or complex diversification strategies, marking a shift away from unrelated diversification. Diversification patterns for selected economies are included in Appendix 2.

**FIGURE 6.** DIVERSIFICATION PATTERNS ACROSS DEVELOPMENTAL LEVELS

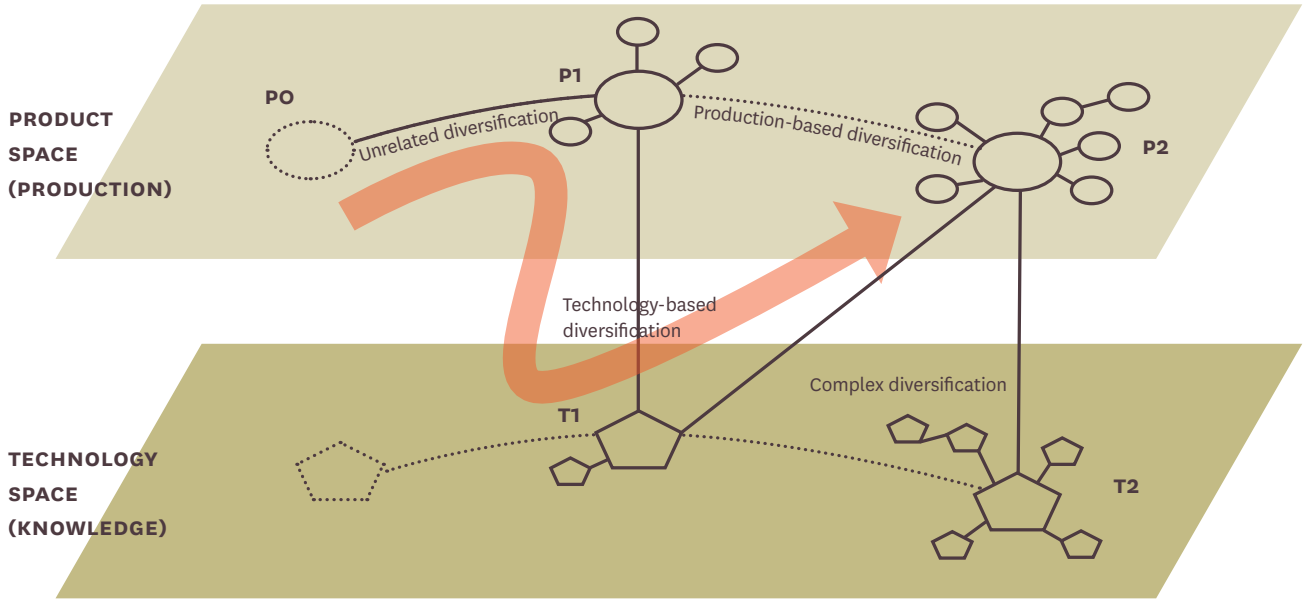



SOURCE: Author's calculation based on World Bank, UN Comtrade, and OECD databases
NOTE: The figure uses GDP per capita, and the y-axis represents the probability density of each diversification type. It uses GDP per capita, patent and export data of 99 countries from 1980 to 2018. The probability density functions are estimated by using kernel density estimation (KDE) method. Detailed mathematical formulas can be found in Appendix 1.

**The above finding can be explained using the co-evolutionary framework for production and technology.** In the early stages of development, simple products are produced without relying on technological capabilities. As the country's economy begins to develop, there is an aspiration for more intricate industries that may not be directly connected to the current production landscape. With the accumulation of production experience, the country develops production capabilities, and the acquisition of technology that supports this production contributes to the development of technological capabilities. Subsequently, leveraging these technological capabilities allows the production of products that may be less related to the existing products, creating what appears as

a jump in the product space. With repeated iterations of this process, production capabilities, and technological capabilities accumulate across diverse products and technologies. As new products are introduced, they are more likely to exhibit connections to existing products or technologies, leading to a trend of complex diversification. This dynamic progression is depicted in Figure 7.

**FIGURE 7.** ILLUSTRATION OF THE CO-EVOLUTIONARY FRAMEWORK FOR PRODUCT AND TECHNOLOGY




SOURCE: Author's illustration based on Eum and Lee (2022a)
NOTE: P0, P1, and P2 represent a country's production capabilities, and T1 and T2 represent a country's technology capabilities at different stages. The yellow line depicts the development of a country's capabilities in both production and technology using the co-evolutionary framework.

**As GDP per capita increases, economies tend to favor a shift from production-based diversification to technology-based and complex diversification.**[7] This shift is desired because, in the course of economic growth, innovation increasingly becomes a crucial driver of productivity growth. In the early stages of development, capital accumulation and labor inputs dominate the contributions to productivity growth; however, over time the returns of physical capital per worker diminish, especially in middle- and high-income countries (World Bank 2023a; World Bank 2024). That is when innovation, spurred by technological adoption and advancements, becomes the wellspring of continued productivity growth. The return on innovation hinges on the ability of firms and the ecosystem overall to reap returns from their investments in technology and R&D,

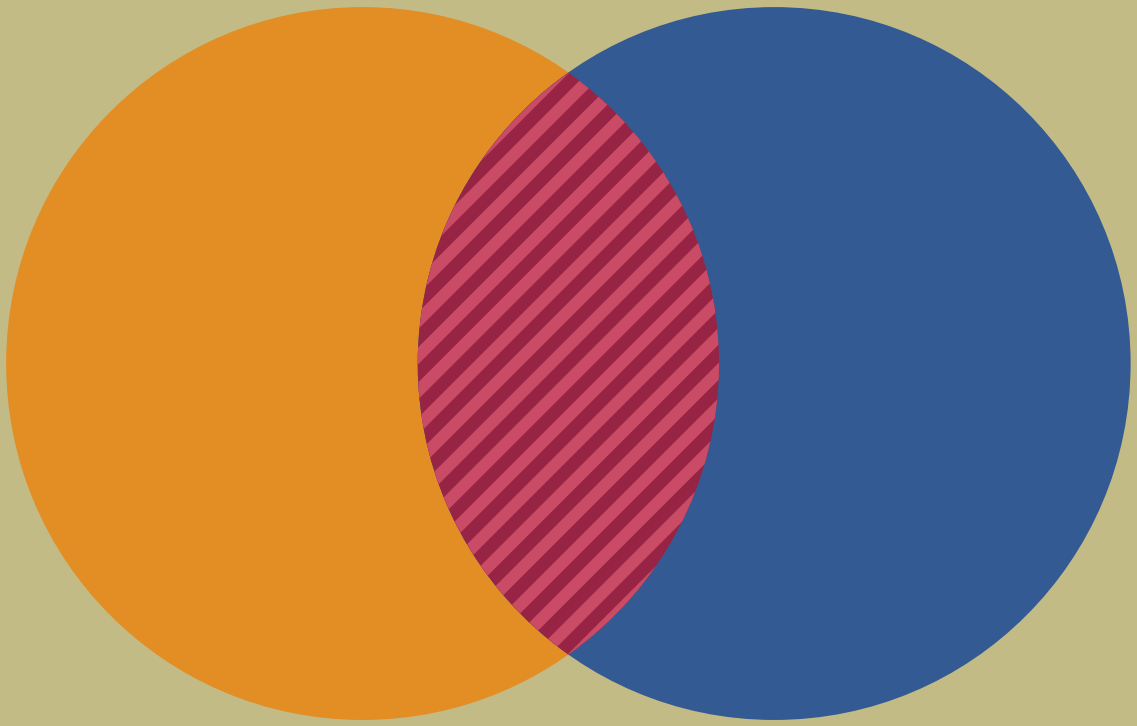
7 The observed trend of countries transitioning from product-based diversification to technology-based and complex diversification in tandem with increasing GDP per capita may be partly explained by the methodology employed to measure technological diversification, which uses patent data as a proxy for technological capability. Patent activities tend to be more prevalent in developed countries than in developing economies with much less investment in knowledge activities.

which can be constrained in smaller firms or emerging ecosystems that lack extensive resources and complementarities (Cirera et al. 2017). These innovation constraints could potentially lead to a low-innovation equilibrium or a middle-income trap (World Bank 2024). This risk highlights the necessity for resource consolidation and supportive public policies that can influence the direction of technological change toward embracing technology-based or complex diversification.

**In the following two sections, we apply the co-evolutionary framework to compare the diversification pathways of Korea and Viet Nam—retrospectively in the case of Korea, and to chart a forward-looking diversification path for Viet Nam.** The analysis in section 3 below shows that the co-evolutionary framework can illuminate the mechanisms behind Korea's diversification journey. We revisit Korea's diversification path because the country offers us an exemplary case study for understanding the intricate dynamics of the co-evolution of production and technological capabilities. This choice is underscored by the availability of comprehensive data on Korea's historical development, as well as the relevance of Korea's developmental experiences as a benchmark for many catching up economies. We contrast the Korean experience with Viet Nam's diversification journey thus far, identify current and future challenges, and suggest potential diversification paths. Viet Nam presents a compelling case given its status as a fast-growing industrializing economy grappling with diversification challenges that resonate with many other emerging economies. By delving into the case of Viet Nam, this research aims not only to contribute valuable insights to the understanding of its specific circumstances but also to offer lessons applicable to a broader spectrum of developing countries facing similar diversification hurdles.

# 03

# Comparing Korea's and Viet Nam's Diversification Paths Using the Co-evolutionary Framework



# 3. Comparing Korea's and Viet Nam's Diversification Paths Using the Co-evolutionary Framework

**Korea and Viet Nam both achieved rapid growth early in their development experience.** Korea is one of the few countries that successfully transitioned from a low-income to a middle-income and subsequently to a high-income economy within a short period of time. Korea's successful transition from a middle- to high-income economy was built on previous decades of high levels of investments in physical and human capital and the promotion of manufacturing exports by large conglomerates (World Bank 2023a). As the stock of physical and human capital reached OECD levels in the 1990s, new productivity-led drivers of growth increasingly became an economic imperative. The productivity-led growth during the late stages of the country's growth was driven mainly by technology upgrading in the capital, technology, and R&D-intensive manufacturing sector, leading to a rapid increase in total factor productivity (TFP) (World Bank 2023a) (See Box 2 for more information).

**Viet Nam has experienced one of the fastest GDP growth rates in the world**. From 1990 to 2022, Viet Nam's GDP per capita (constant 2015 US$) grew at an average annual rate of 5.4 percent, reaching US$ 4,163.5 (current US$) in 2022. This remarkable performance has been driven by three engines of growth: fast capital accumulation, a plentiful labor supply, and high productivity growth, which were underpinned by improvements in the business environment, increases in the quality of human capital, large inflows of FDI, among other factors (World Bank 2021b). The question is whether Viet Nam will be able to sustain these high growth rates to secure its transition to high-income country status by 2045, and if so, what key drivers will achieve that.

## Box 2.
## Drivers of Korea's Economic Growth

A recent World Bank (2023a) publication, *Innovative Korea: Leveraging Innovation and Technology for Development*, provides an analysis of Korea's successful transition from a middle- to a high-income economy. It finds that Korea's transition was underpinned by a combination of factors: accumulation of physical capital, enhancement of human capital, and high TFP growth driven by technology upgrading, specifically within the export manufacturing sector.

First, Korea's journey to a high-income economy was marked by substantial investments in physical capital. Between 1990 and 1997, during its transition, Korea's gross capital formation averaged

38 percent of its GDP, significantly higher than the OECD average of 22 percent during the same period. This high investment rate was primarily driven by the private sector, which contributed more than 80 percent of investment.

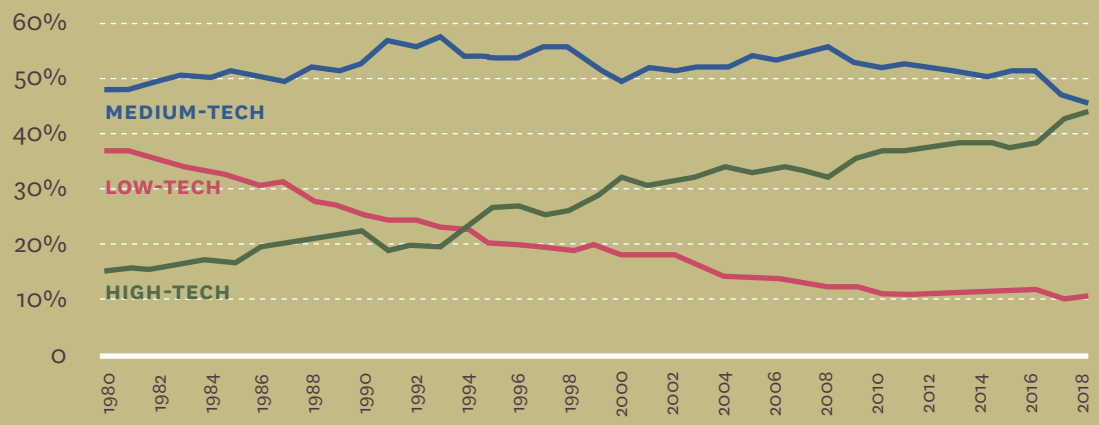
Second, human capital investment played a crucial role, accounting for about 10 percent of the country's GDP growth between 1990 and 1997. This human capital contribution, despite a decline from the levels seen in the 1980s, was still higher than many observed in OECD countries. The sustained focus on human capital, across various government administrations, laid a strong foundation for the country's later stages of development when it transitioned to a high-income economy.

Third, Korea's rapid TFP growth was driven by the transition to more advanced technologies. Between 1999 and 2008, after transition, Korea's TFP contribution to GDP growth was nearly equivalent to the contribution of capital. This increase in TFP growth, especially in the wake of the Asian financial crisis, was a response to significant reforms targeting structural flaws, with the manufacturing sector deriving most of its TFP growth from internal productivity improvements.

Fourth, Korea's productivity convergence since the 1990s has been driven by its shift toward capital-, technology-, and R&D-intensive manufacturing, marked by a transition from low- to high-tech industries. This shift is reflected in the increased value-added shares of capital-intensive industries with higher labor productivity and the growth in export shares of sectors like electronics, automobiles, and ships. The share of the high-technology sector in real manufacturing value added rose from 22 percent in 1990 to 44 percent in 2018, and the share of low- and medium tech sectors fell from 37 and 48 percent respectively to 11 and 44 percent (Figure 8).

Korea's development journey demonstrates the importance of adapting industrial and innovation policies and strategies to changing global and domestic circumstances, as seen in its transition from a reliance on government-led investment to a more market-driven, innovation-led growth paradigm. This adaptation was vital in moving beyond the limitations of the developmental state model and embracing an approach that promotes technology and innovation more broadly.

**FIGURE 8.** VALUE-ADDED SHARE, BY LEVEL OF TECHNOLOGY, 1980-2018




SOURCE: World Bank, 2023a
NOTE: Based on data from OECD STAN Industrial Analysis Database

**Despite its stellar performance, Viet Nam's growth engine is gradually losing steam, and the threat of the middle-income trap is increasing (World Bank 2021c).** Despite rapid growth, labor productivity levels are still very low relative to peers. In 2020, Viet Nam's labor productivity amounted to only about one-sixth of Korea's levels and only two-thirds of the productivity level in the Philippines (World Bank 2023c).[8] In addition, average firm TFP grew by less than two percent between 2014 and 2018, below the levels seen in many East Asian economies (IMF 2022). The low level of labor productivity implies that domestic capabilities have not been well developed.

**Global experience, including that of Korea's, suggests that capital accumulation and TFP were the important drivers for fast-growing countries when they were at Viet Nam's level of development.** Capital accumulation in Viet Nam, however, is constrained by relatively low public investment due to a conservative fiscal policy and implementation challenges (World Bank 2023b). This leaves private-sector productivity growth as the primary growth engine for sustaining Viet Nam's economic miracle (World Bank 2023c) and achieving the aspiration to attain high-income status by 2045.[9] Technology adoption and innovation are key contributors to productivity growth within private companies and investments in knowledge capabilities enable firms to leverage existing and new knowledge. Then, how did Korea manage to leverage these knowledge capabilities to sustain its growth?

**Korea's development trajectory is characterized by its shift from production-based diversification to technology-based and complex diversification.** Whereas many developing countries remain entrenched in the production of simple products, such as agricultural or mining products, Korea expanded its production portfolio in the 1970s, diverging from its existing production capabilities in the agriculture sector. Korea moved from exporting raw materials and agricultural products in the 1960s to chemical industries, shipbuilding, and electronics in the 1980s, and now to producing high-value added products such as electronics or microcircuits (Table 1).

**TABLE 1.** KOREA'S TOP 10 EXPORTING PRODUCTS, 1963–2020

| RANK | 1963 | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| 1 | Coated Iron | Ships | Electronic Microcircuits | Electronic Microcircuits |
| 2 | Plywood | Footwear | Automobiles | ICT |
| 3 | Iron Ore | Clothing (Underwear) | Computer Parts | Automobiles |
| 4 | Raw Silk | Clothing (Outerwear) | Ships | Transport |
| 5 | Clothing | Clothing (Leather) | TV and Radio Transmitters | Petroleum Products |

8 Calculation based on the Asian Productivity Organization database.

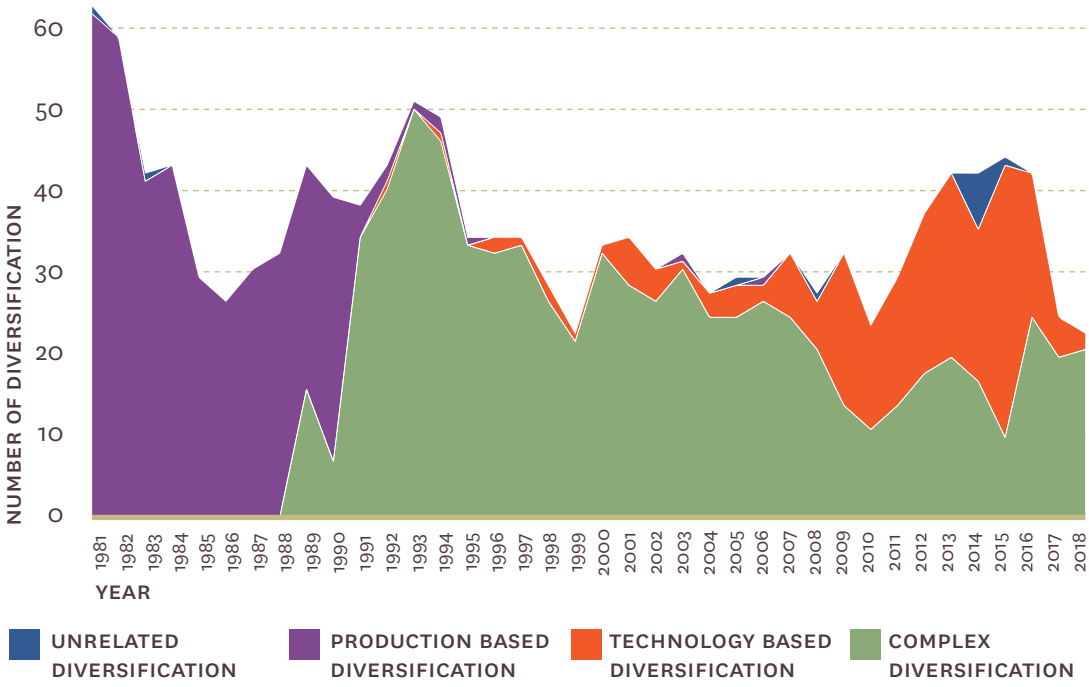
9 Productivity can grow through three main channels by (i) improving efficiency of existing firms, including by improving managerial practices, adopting new technologies and enhancing access to markets and finance (Cirera et al. 2022), (ii) reallocating resources between firms and sectors from less efficient to more efficient firms and industries, and (iii) allowing higher-productivity firms, mostly innovative startups, to enter and low-productivity firms to exit the market. This underscores the potential role of technology and innovation in driving productivity growth in Viet Nam beyond the role and contributions of production capabilities.

| RANK | 1963 | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| 6 | Nonferrous Ore | Electronic Microcircuits | Data Processor Parts | Parts and Accessories for Apparatus |
| 7 | Cotton Fabric | Iron Tubes and Pipes | Synthetic Fabrics | Ships |
| 8 | Vegetables | Fish | Telecom Parts | Vehicle Parts |
| 9 | Fish | Plywood | Electronics Valves and Tubes | Machine Parts |
| 10 | Swine Hair | Clothing (Jackets) | Display | Machinery for Specialized Industries |

SOURCE: UN Comtrade database

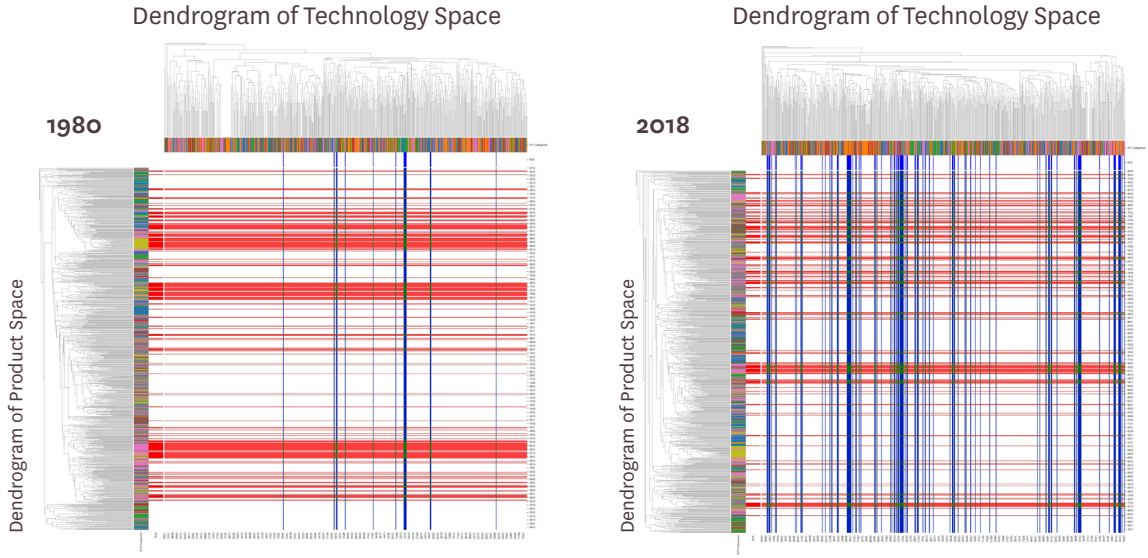
**Korea's transition from production-based to technology and complex diversification took place over the decades since the late 1980s.** As illustrated in Figure 9, prior to the 1990s, Korea's diversification strategy was limited to production-based diversification. This means that Korea's capabilities were concentrated more on production-relatedness rather than technology during the early stages of industrial development. However, since the late 1980s, Korea's diversification strategy has shifted from production-based to technology-based and complex diversification. During this period, industries became more complex, embarking on output unrelated to existing production expertise. Figures 9 and 10 illustrate a noteworthy shift in Korea's capabilities. Initially concentrated in the product space, the country successfully transitioned toward achieving a more balanced portfolio of capabilities in both production and technology.

**FIGURE 9.** DIVERSIFICATION PATTERN OF KOREA, 1980-2018




SOURCE: Author's calculation based on data from UN Comtrade, OECD, and WIPO

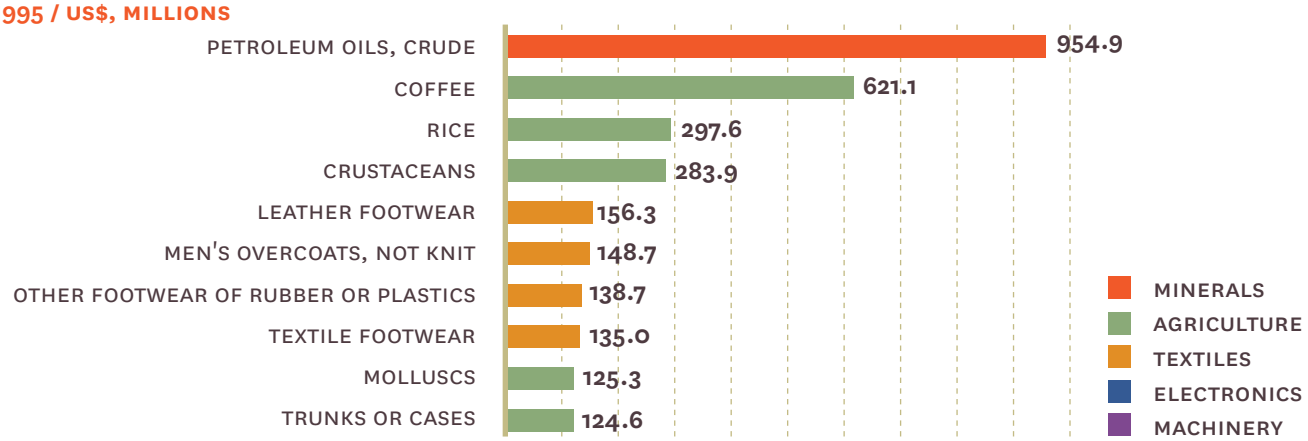
**FIGURE 10.** PRODUCT AND TECHNOLOGY HEATMAP OF KOREA, 1980 AND 2018

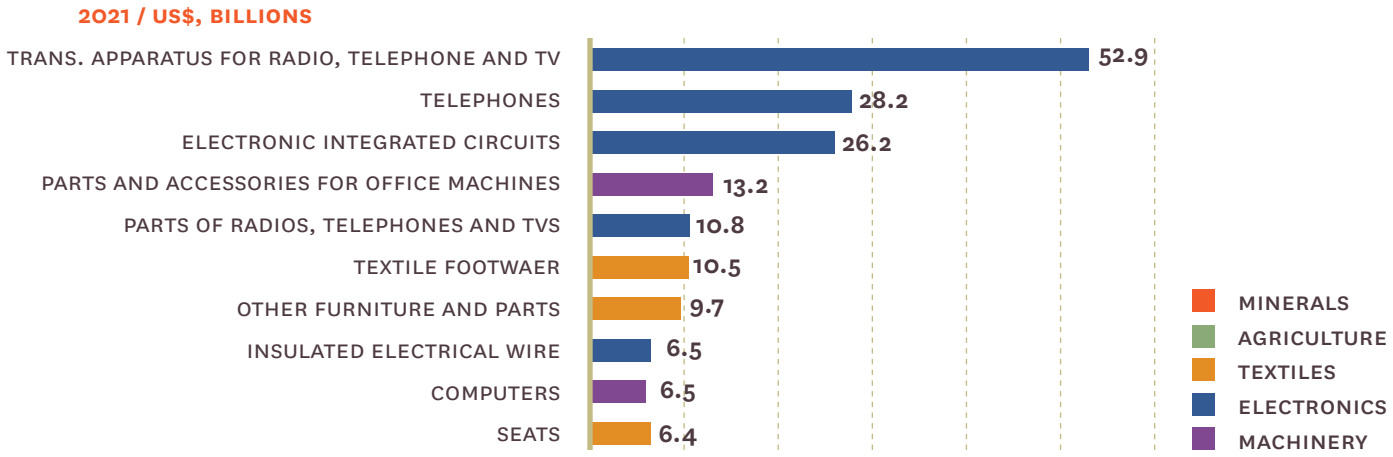



SOURCE: Author's calculation based on data from UN Comtrade, OECD, WIPO
NOTE: The red line signifies products that have a revealed comparative advantage in the product space, while the blue line denotes technologies that have a revealed technological advantage in the technology space. More vertical blue lines indicate that the country has comparative advantage in technology, and more horizontal red lines indicate that the country has comparative advantage in production.

**Viet Nam expanded its export product portfolio from simple, low value-added to complex and high value-added products.** Figure 11 compare Viet Nam's top 10 exports in 1995 and 2021 respectively. Whereas Viet Nam's exports in 1995 focused on minerals (brown), agriculture (green), and textiles (yellow), Viet Nam's top export in 2021 is mainly focused on electronics (blue), textiles (yellow) and machinery (orange). Only one product, textile footwear, appears on both lists, while the other nine products were supplanted by more complex products. Clearly, Viet Nam's production portfolio has achieved successful leaps into unrelated products.

**FIGURE 11.** VIET NAM'S TOP 10 EXPORTS, 1995 AND 2021






SOURCE: Atlas of Economic Complexity
NOTE: 4-digit HS code

**Viet Nam's transition into a market economy, FDI inflows, and participation in the global value chain (GVC) were behind its successful diversification into products with higher value-added.** FDI can provide needed foreign investment capital for upgrading facilities, equipment, and labor. Viet Nam has received substantial FDI inflows since the early 1990s, following its transition to a market economy, fueling growth in labor-intensive manufacturing sectors. The net inflows of FDI increased at a moderate pace from US$ 180 million in 1990 to US$ 2.4 billion in 2006, and powered ahead since then, reaching 17.9 billion in 2022.[10] In 2011, to fully integrate into the global economic system, Viet Nam sought to transform into a manufacturing-based and export-oriented economy with access to the US market through the Bilateral Trade Agreement. Through such efforts, Viet Nam was able to participate more actively in the GVC, and its export volume and its share as a percentage of GDP have continuously increased.[11] In 2022, the export volume reached US$ 384.2 billion (current US$), and the share of exports relative to GDP reached 94.0 percent.[12]

**Nevertheless, the product and technology heatmaps indicate an imbalance between Viet Nam's production capabilities and its technological capabilities.** The blue lines in Figure 12, which represent technologies with an RTA greater than 1, are less in evidence than the red lines, which represent products with an RCA greater than 1. The disproportional results in all four periods (1990, 2000, 2010, 2018) suggest that although Viet Nam managed to expand its product space successfully, its expansion in the technological space remains relatively limited. Viet Nam in 2018 had 42 technologies with RTA greater than 1 (the blue lines in the 2018 figure). In comparison, Korea had 70 technologies with RTA greater than 1 in 1987 when it was at the same income level as Viet Nam today. In terms of product and technology complexity, among the top five products with a high RCA in 2018 were pulpwood, cotton yarn, and leather goods, all of which exhibit low product complexity. The 42 technologies with RTA greater than 1 are also predominantly of low

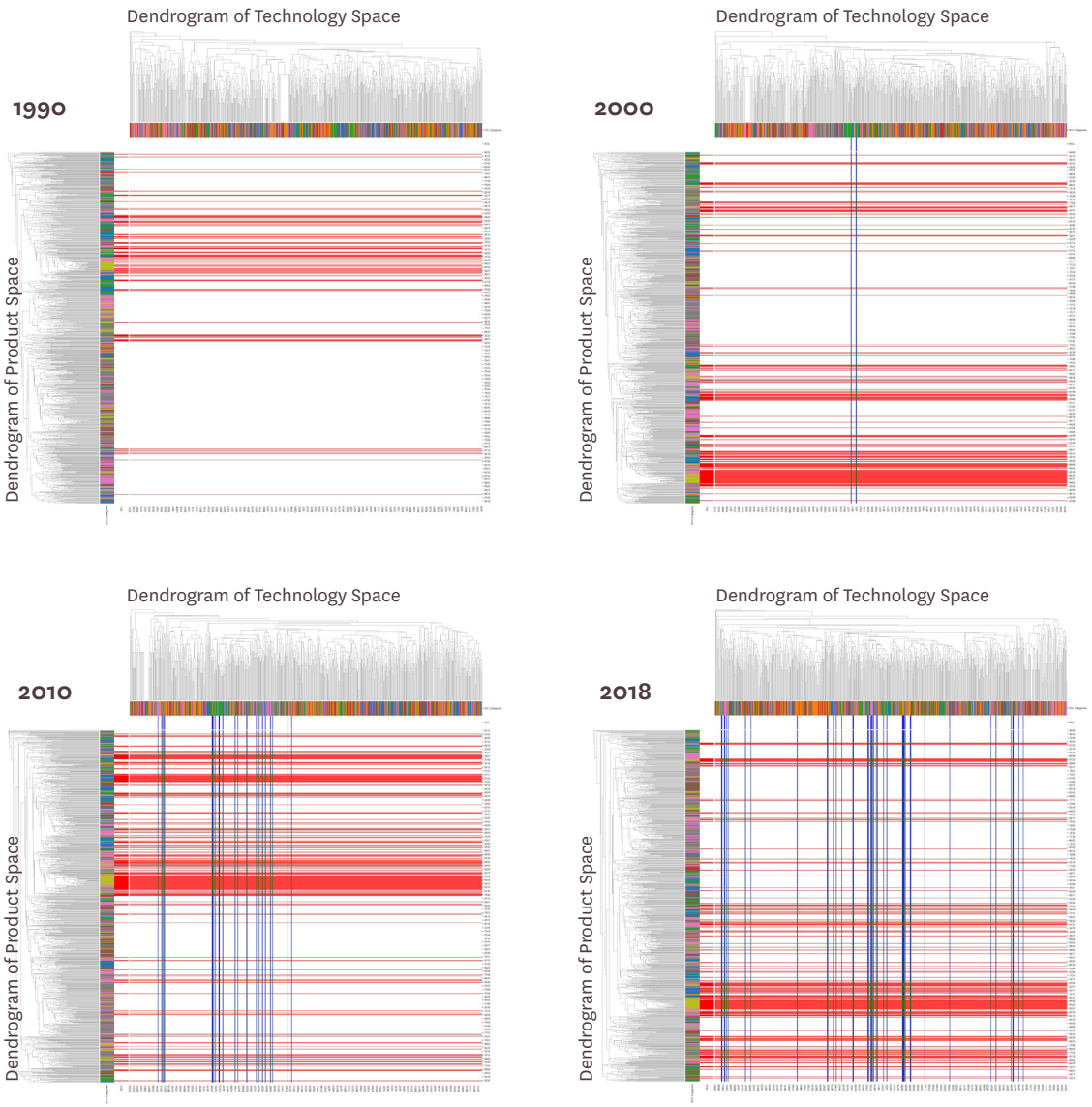
10 World Bank. "Foreign direct investment, net inflows (BoP, current US$) – Viet Nam" https://data.worldbank.org/indicator/BX.KLT.DINV.CD.WD?locations=VN

11 Xuan and Xing (2008) find that a one percent increase in FDI inflow is associated with a 0.13 percent increase in Viet Nam's exports.

12 World Bank. "Exports of goods and services (percent of GDP) – Viet Nam." https://data.worldbank.org/indicator/NE.EXP.GNFS.ZS?locations=VN

technology complexity and the top five technologies with a high RTA have not changed significantly from 2000 to 2018.

**FIGURE 12.** PRODUCT AND TECHNOLOGY HEATMAPS OF VIET NAM, 1990, 2000, 2010, 2018



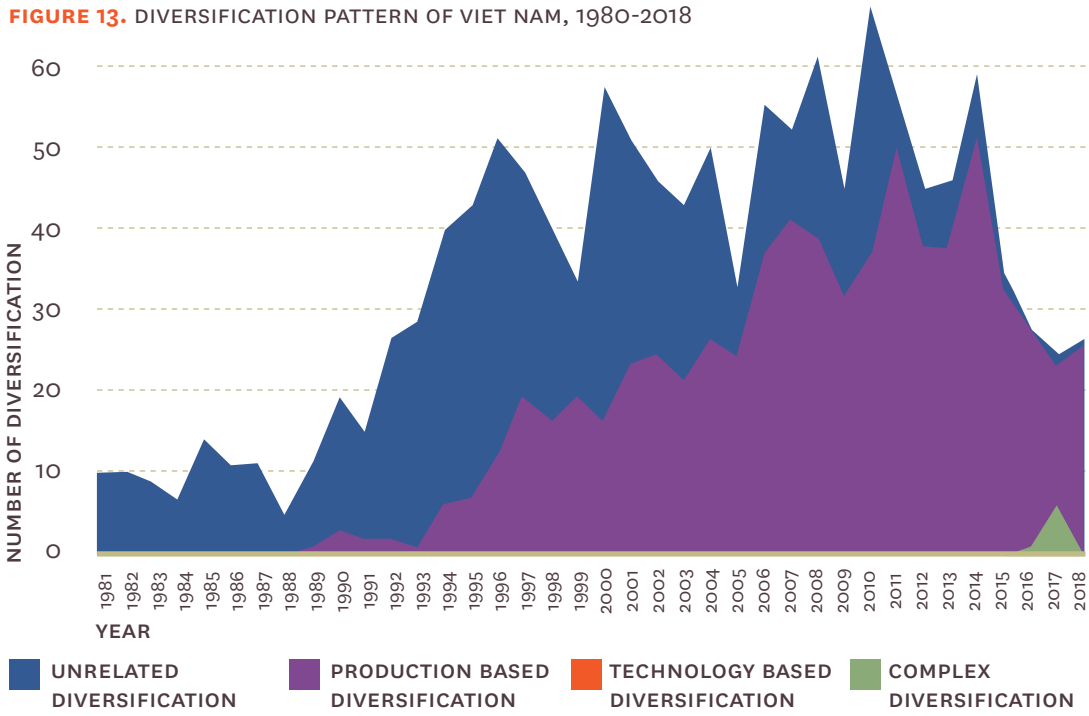

SOURCE: Author's calculation based on UN Comtrade, OECD, WIPO database
NOTE: The red line signifies products that have a revealed comparative advantage in the product space, while the blue line denotes technologies that have a revealed technological advantage in the technology space. More vertical blue lines indicate that the country has comparative advantage in technology, and more horizontal red lines indicate that the country has comparative advantage in production.

**Viet Nam's products with a comparative advantage were mainly concentrated in low-complexity products.** The top five products with a high RCA in 2018 were pulpwood, cotton yarn, and leather goods, all of which exhibit low product complexity. The top five technologies with a high

RTA did not change significantly from 2000 to 2018. These findings suggest that Viet Nam has not been able to build technological capabilities and transition to domestic production of more complex products. This corroborates evidence that Vietnamese private sector companies are less innovative and productive in comparison to foreign-invested enterprises (FIEs). FIEs are almost five times more productive and have much higher returns on assets and profits than domestically owned enterprises (World Bank 2021a).

**When Viet Nam's most recent diversification pattern is compared to Korea's early growth period, its performance today resembles that of Korea in the late 1980s.** Until the early 1990s, Viet Nam's diversification was driven by unrelated diversification, but as Viet Nam accumulated production capabilities, its diversification strategy shifted toward production-based diversification (Figure 13). In 2015, Viet Nam started to show a slow transition toward technology-based and complex diversification, but it is far from being a mainstream diversification pattern.

**FIGURE 13.** DIVERSIFICATION PATTERN OF VIET NAM, 1980-2018



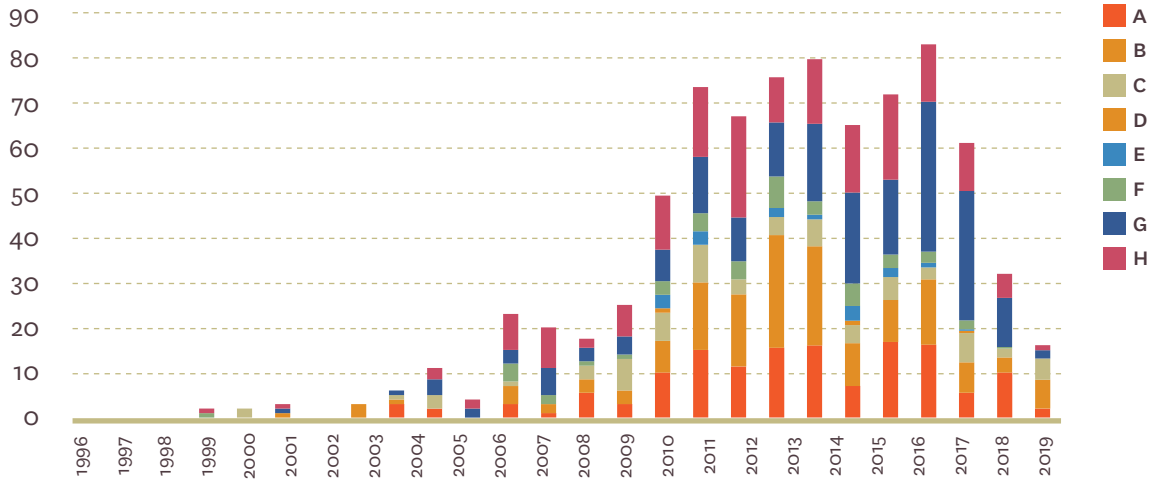

SOURCE: Author's calculation based on UN Comtrade, WIPO, OECD database
NOTE: The figure uses patent applications to USPTO by the Vietnamese nationals

**Behind Korea's successful transition from production-based diversification to technology-based and complex diversification in the 1980s was a deliberate effort to increase the country's knowledge capabilities.** Korea focused on building domestic R&D capabilities, with R&D investments rising from a mere 0.3 percent of its GDP in the early 1970s to 5.2 percent in 2022, highlighting Korea's commitment to fostering a robust domestic R&D landscape. The private sector's contribution to R&D, in particular, saw a remarkable rise, from 28.1 percent in 1976 to 79.1 percent in 2021, encouraged by government policies which promoted the establishment of corporate research institutes and private R&D centers. The number of corporate R&D centers skyrocketed from 46 in 1981 to 42,155 in 2020, and their role shifted from helping to absorb foreign technology to developing new products and services (World Bank 2023a).

**In comparison, Viet Nam's investments in its knowledge capabilities remain minimal.** Viet Nam's gross domestic expenditure on R&D (GERD) was 0.4 percent of GDP in 2021,[13] significantly lower than Korea's 1.54 percent in 1987 when its GDP per capita was at a comparable level. R&D undertaken by public institutions in Viet Nam suffers from low quality and little relevance to the private sector, with the share of total R&D funding allocated to universities and research institutes having declined substantially over time (World Bank 2023c, World Bank 2021). For example, in 2017, Viet Nam allocated only US$ 69 million for direct support to business innovation, a figure markedly lower than comparable investments in other countries, such as the Philippines, which allocated US$ 237 million in the same year. The underinvestment in Viet Nam's knowledge capabilities may impede the country's ability over the long term to further diversify into more complex and technologically advanced products.

**Viet Nam's international patent applications have been increasing, and its performance ranks above the per capita income group.** Vietnamese annual patent applications to USPTO in the past 10 years have been increasing and averaged around 65 patents annually from 2010 to 2019 (Figure 14). Viet Nam's patent portfolio is concentrated in IPC section G (physics), accounting for around half of the total patents in 2019. When compared with other countries in similar income groups, Viet Nam's performance in patent applications is near predicted levels (Figure 15). Nevertheless, Viet Nam's production capabilities are far more advanced, representing an opportunity for further diversification into more complex products. The question becomes: which areas of knowledge should Viet Nam pursue, with reference to its growing production capabilities, to allow for further technology-based and complex diversification? (*This question will be addressed in section 4*).

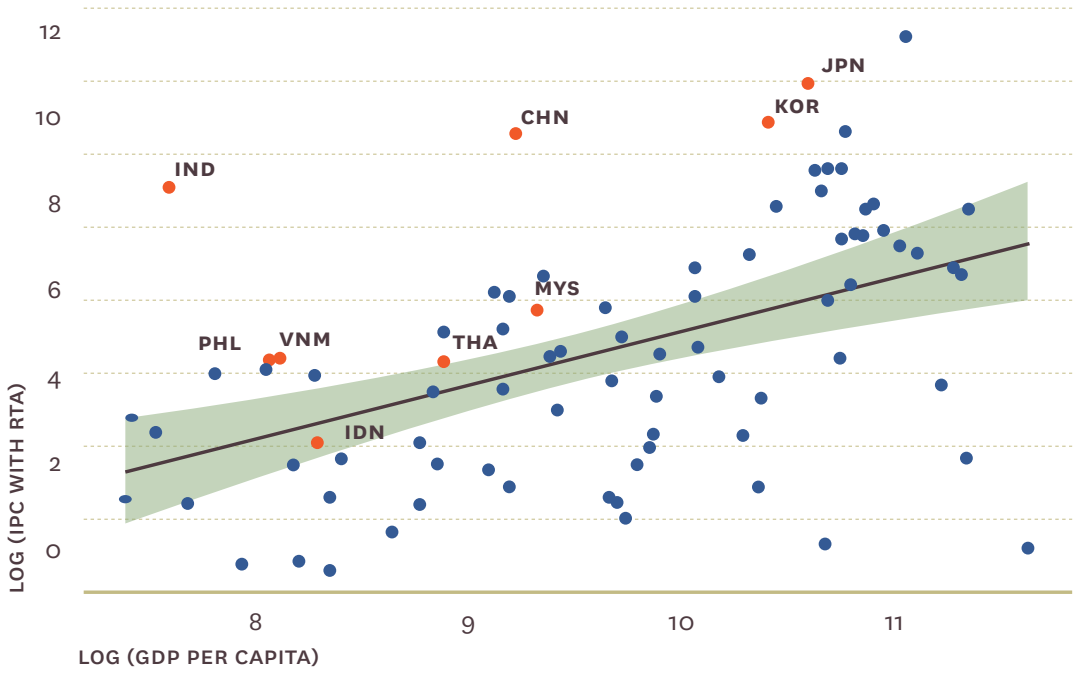
**FIGURE 14.** PATENT APPLIED TO USPTO BY THE VIETNAMESE NATIONALITY, BY IPC SECTION




SOURCE: Author's calculation based on WIPO database
NOTE: Patent application to USPTO by the Vietnamese nationality.

13 Viet Nam's expenditures are below the average of its income group—the lower-middle-income group average is 0.52%. The world average GERD in 2021: 1.93%; lower middle-income countries: 0.52%; middle-income countries: 1.25%; upper-middle-income countries: 1.56%; high-income countries: 2.76%; Korea 4.93%. Data available at http://data.uis.unesco.org/index.aspx?queryid=74

**FIGURE 15.** PATENT FILING PERFORMANCE ACROSS INCOME LEVEL, 2018

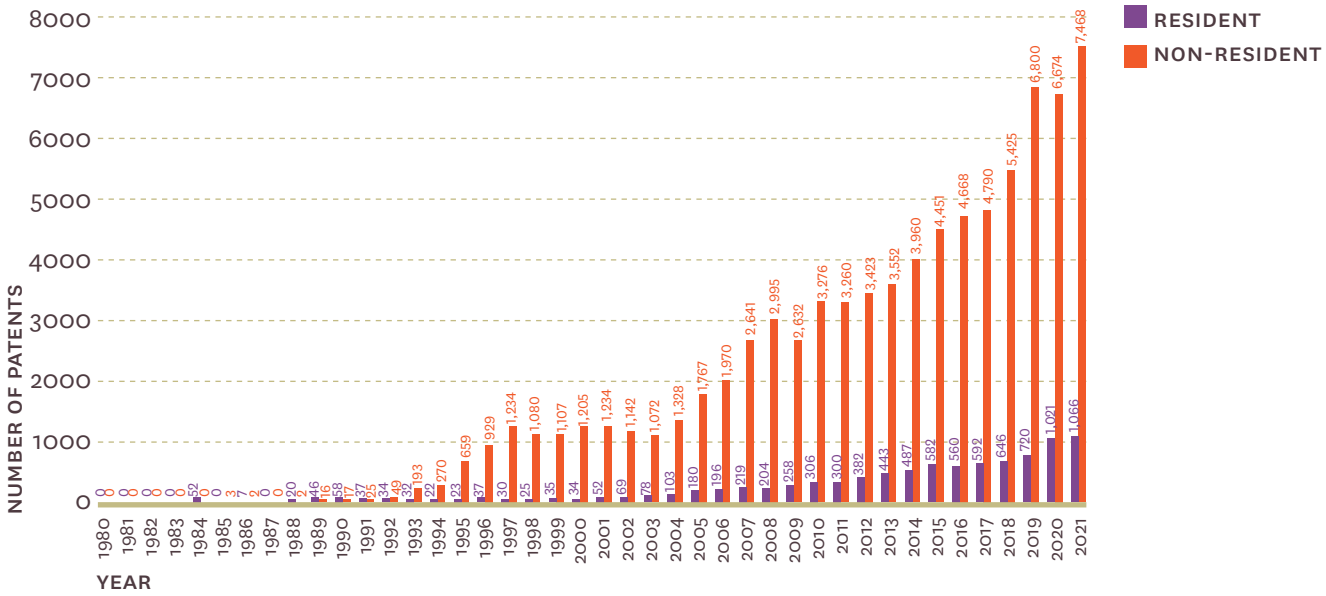



SOURCE: Author's calculation based on data from World Bank, OECD, WIPO databases

**The total number of patents filed in the Intellectual Property Office of Viet Nam[14] has been increasing rapidly since the 2000s, but this can be attributed to a large number of patents filed by non-resident individuals and firms.** Patents filed by local Vietnamese entities remain small (Figure 16). In 2022, among 8,707 patents filed through the Viet Nam IP Office, only 10.3 percent (895 patents) originated from Vietnamese residents, with the remaining 89.7 percent (7,812 patents) being filed by non-residents. The country origin of nonresident applications was spread across four countries, with the US having the biggest share (25.5 percent), followed by Japan (20.5 percent), China (17.5 percent), and Korea (13.4 percent) (Figure 17). This implies that a large proportion of knowledge generated in Viet Nam is owned by foreign entities, with little spillover to domestic firms. This is not surprising given the current orientation of the country's public support to the innovation agenda. Viet Nam's largest public innovation program tends to favor FIEs with R&D tax incentives, while support for domestic private sector innovation remains insignificant (World Bank 2021a).

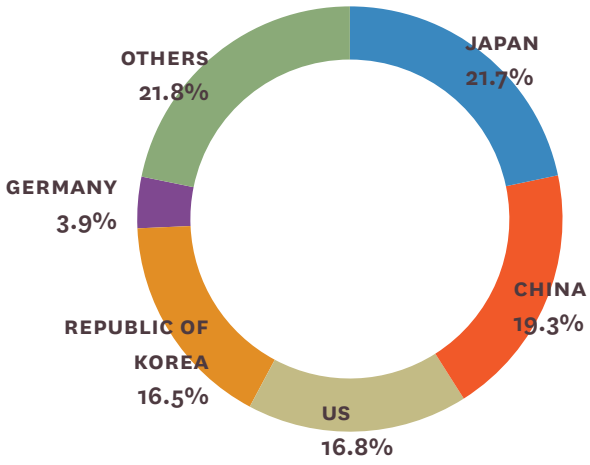
14 Generally, there is a quality difference between patents filed locally and those filed with the United States Patent and Trademark Office (USPTO) or European Patent Office (EPO). MNEs usually register their patents in developing countries to be protected from infringement in local markets. The same applies here to patents filed with Viet Nam's IP office and those filed with the USPTO, whereby the latter tend to be of higher quality and significance; that is, serving as a proxy for the country's knowledge capabilities.

**FIGURE 16.** PATENTS FILED IN VIET NAM IP OFFICE, BY RESIDENT AND NON-RESIDENT APPLICANTS




SOURCE: Intellectual Property Office of Viet Nam
NOTE: This figure represents patent application to the Intellectual Property Office of Viet Nam.

**FIGURE 17.** SHARE OF NON-RESIDENT PATENT APPLICATIONS, BY COUNTRY OF ORIGIN, 2021



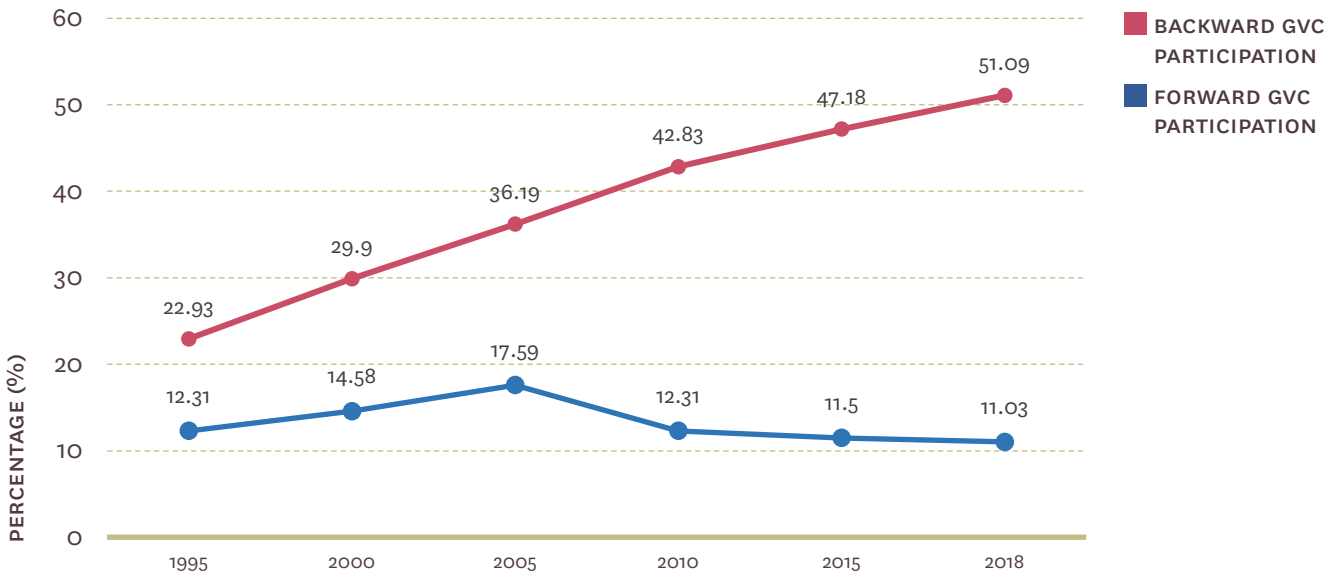

SOURCE: Intellectual Property Office of Viet Nam, WIPO
NOTE: This figure represents patent application to the Intellectual Property Office of Viet Nam.

**There is indirect evidence indicating that the technological capabilities supporting Viet Nam's current production remain weak.** Viet Nam emerged as a global manufacturing hub with several foreign MNEs building manufacturing sites in Viet Nam's industrial zones motivated by the competitive labor costs and its strategic geographical advantage. Foreign companies invested in Viet Nam typically engage in simple tasks such as assembling parts or engaging in simple production processes that do not require sophisticated technological skills and then export the assembled

products. As an example, Viet Nam's backward GVC participation ratio has been increasing significantly from 22.9 percent in 1995 to 51.1 percent in 2019. By contrast, forward GVC participation has been on a decreasing trend since 2005 (Truong 2022) (Figure 18). This may imply that Viet Nam is not progressing into more sophisticated functions within the production value chains.[15]

**Over the past two decades, the majority of the Vietnamese workforce in exporting industries has remained engaged in production activities with little change over time.** Kruse et al. (2023) used occupation data to show how the activity content of exports has changed over time. The data from 59 countries shows that at lower levels of economic development, production activities account for a major share of export income. However, that share steadily decreases as countries grow richer. On average, the share of production activity was around 30 percent at levels above US$ 40,000 in GDP per capita, and other occupations including engineering, managerial, and support activities account for the majority of labor income from exporting. However, Viet Nam has maintained a relatively high level of production activities over the period from 2000 to 2018 (Figure 19).[16] Moving forward, Viet Nam would want to increase the share of nonproduction activities, especially engineering and management.

**FIGURE 18.** VIET NAM'S FORWARD AND BACKWARD GVC PARTICIPATION, 1995–2018

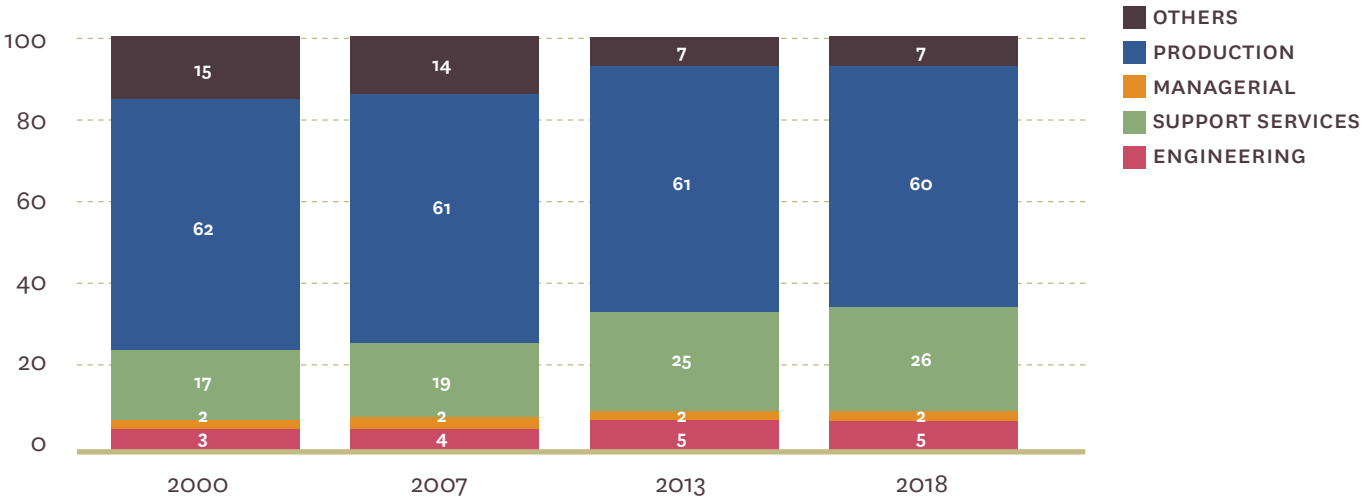



SOURCE: Truong, 2022
NOTE: Author's calculation from OECD-WTO TIVA database

15 Backward GVC participation refers to foreign value-added embodied in exports, as a proportion (%) of gross exports of the exporting country. Forward GVC participation refers to domestic value-added embodied in foreign exports as a proportion (%) of total gross exports of the value-added source country.

16 Whereas China's production share gradually decreased from 59 percent to 51 percent, Viet Nam's share of production decreased only very slightly, from 62 percent in 2000 to 60 percent in 2018.

**FIGURE 19.** ACTIVITY CONTENT OF EXPORTS FROM VIET NAM, BY ACTIVITY GROUPS (% OF EXPORT INCOME), 2000–2018

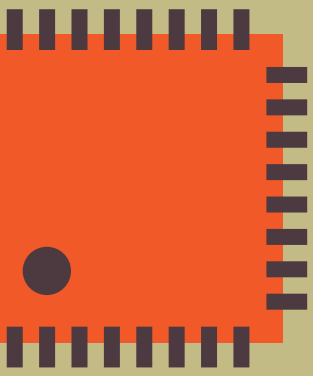



SOURCE: Kruse et al., 2023
NOTE: Percentage shares of activities in export incomes.

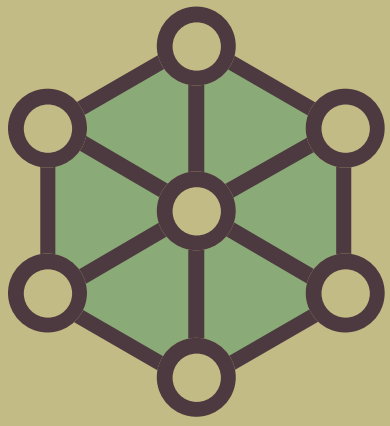
**Viet Nam's diversification strategy to date, although successful, may have limitations moving forward.** The low level of innovation activities by domestic firms and low comparative advantage in technologies indicate that Viet Nam may face limitations in diversifying further into sophisticated products. The weak technological capabilities of Vietnamese firms and the underinvestment in R&D may constrain the country's ability to further diversify into technology-based and complex products and consequently secure new sources of productivity growth in the medium to long term. Contributions to productivity growth are essential for achieving Viet Nam's aspiration of reaching high-income status by 2045. To be able to diversify into more complex and technology-intensive products, Viet Nam may need to increase its investments in accumulating technological capabilities in areas where it is now producing. All of this shows the clear need for a renewed approach to diversification.

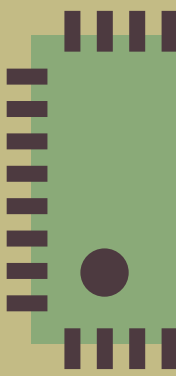
# 04

# Potential Diversification Path for Viet Nam





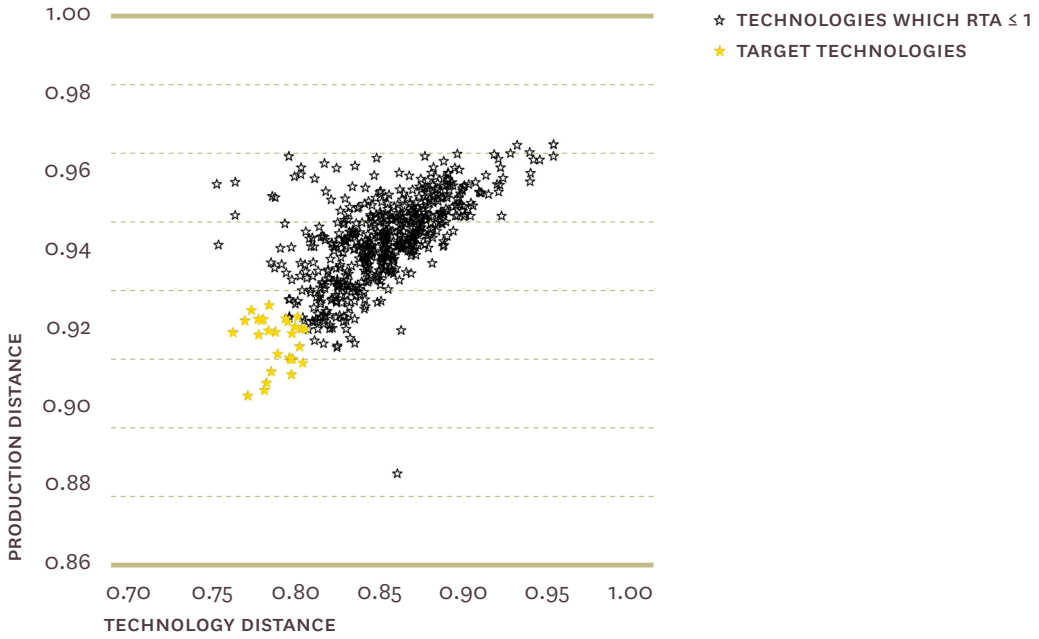


# 4. Potential Diversification Path for Viet Nam

**Using a simulated scenario approach, we outline potential future trajectories wherein Viet Nam attains enhanced technological capabilities, facilitating subsequent diversification.** In this simulation, we first identify target technologies and then products into which Viet Nam could strategically expand, leveraging its production and technological capabilities.[17] We shortlisted technologies that Viet Nam can strategically target based on technological complexity and proximity to the country's current capabilities (Figure 20). By selecting technologies that are high in complexity (greater than 0.5) and close to Viet Nam's current capabilities (distance below 0.15), we identified 12 technologies (listed in Table 2).

**FIGURE 20.** DISTRIBUTION OF TECHNOLOGIES VIET NAM COULD TARGET FOR DIVERSIFICATION




SOURCE: Author's calculation based on data from UN Comtrade, OECD, and WIPO
NOTE: Technologies are distributed on a coordinate plane with technology distance on the x-axis and production distance on the y-axis. Points are technologies (IPC codes) with an RTA less than 1 that have a complexity score greater than 0.5. Details on metrics in Appendix 1.

17 The products and technologies in this section are measured by exports (UN Comtrade database) and patents (WIPO, OECD databases), respectively, following the same methodology used in the previous sections.

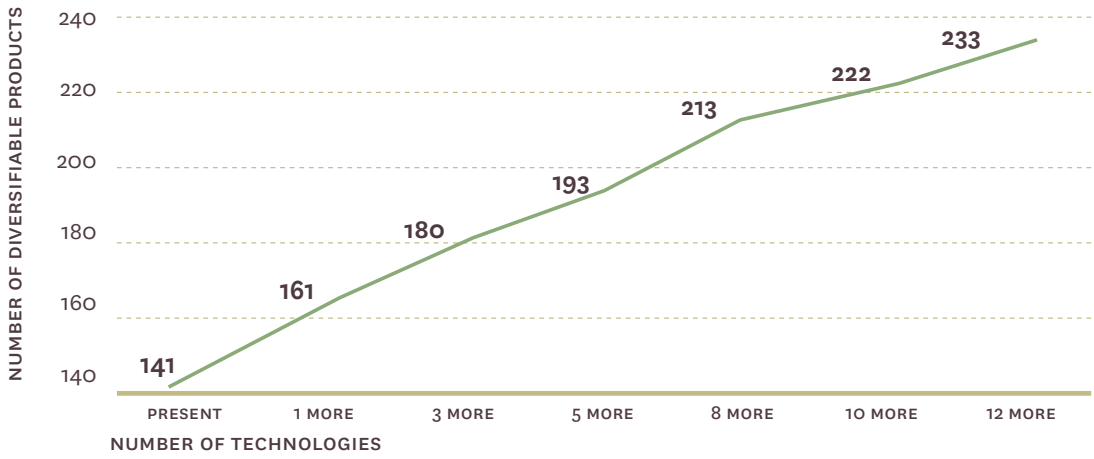
**TABLE 2.** LIST OF TECHNOLOGIES VIET NAM COULD TARGET FOR DIVERSIFICATION

| IPC CODE | DESCRIPTION | DISTANCE (MAXMIN SCALE) | COMPLEXITY |
|---|---|---|---|
| H04W | Wireless communication networks | 0.027 | 2.097 |
| H04L | Transmission of digital information | 0.069 | 2.097 |
| H02J | Circuit arrangements or systems for supplying or distributing electric power | 0.074 | 1.195 |
| G06Q | Information and communication technology | 0.082 | 2.750 |
| A61K | Preparations for medical, dental or toiletry purpose | 0.106 | 1.675 |
| H05K | Printed circuits | 0.114 | 0.535 |
| H04N | Pictorial communication | 0.125 | 1.939 |
| H01L | Semiconductor devices | 0.141 | 0.669 |
| C09K | Materials for applications | 0.142 | 1.468 |
| C07D | Heterocyclic compounds | 0.144 | 0.966 |
| G09B | Educational or demonstration appliances | 0.146 | 1.268 |
| E21B | Earth or rock drilling | 0.149 | 1.532 |

SOURCE: Author's calculation based on data from OECD and WIPO
NOTE: The lower distance value means the target technology is closer to the current production and technological capabilities. The higher complexity value implies that the target technology requires more sophisticated technological capabilities.

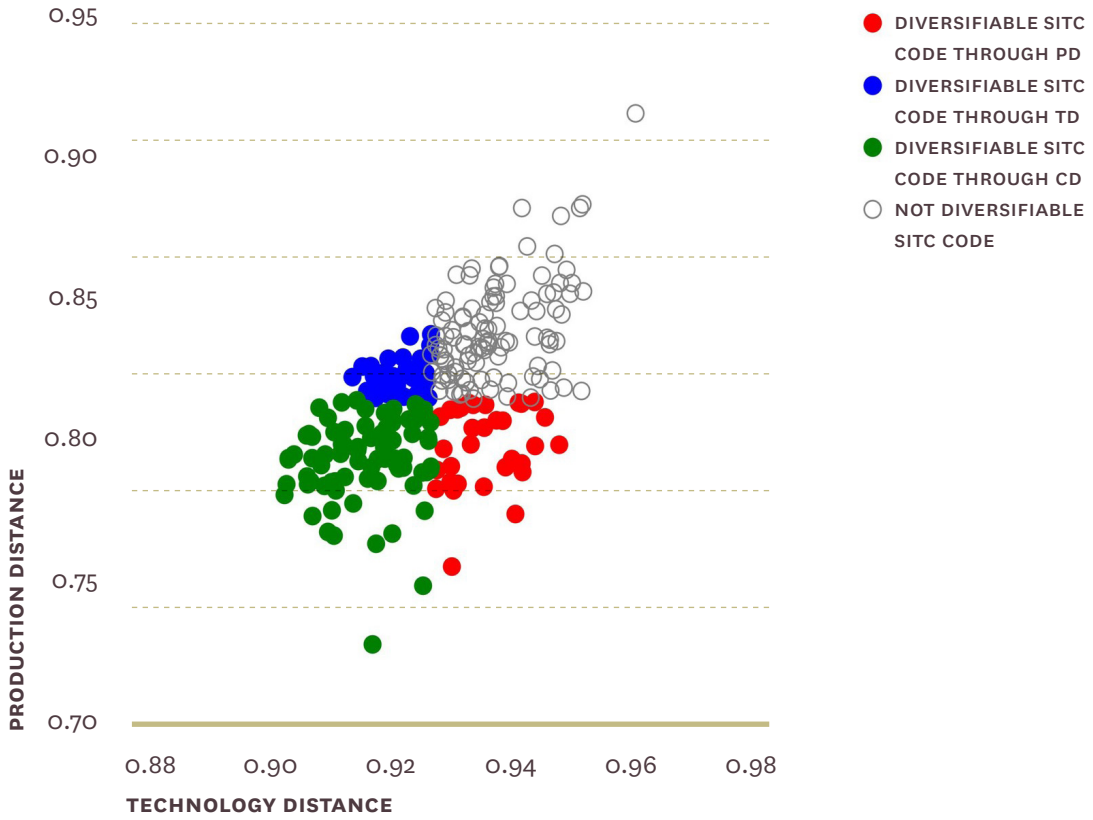
**The simulation shows that if Viet Nam accumulates technological capabilities in the aforementioned 12 target technologies, it can broaden its range of products.** With the current level of capabilities (business as usual), Viet Nam can diversify into 141 products (Figure 21). Assuming the development of capabilities in the 12 target technologies, the simulation results show that the country may diversify into a total of 233 products; that's an additional 92 new complex products through technology-based and complex diversification (Figure 22).

**FIGURE 21.** NUMBER OF DIVERSIFIABLE PRODUCTS AFTER ACQUIRING TARGET TECHNOLOGIES




SOURCE: Author's calculation based on UN Comtrade, OECD, and WIPO databases

**FIGURE 22.** PRODUCTS THAT CAN BE ACQUIRED IF VIET NAM ACQUIRES THE 12 TARGET TECHNOLOGIES IN YELLOW BOX




SOURCE: Author's calculation based on UN Comtrade, OECD, and WIPO database
NOTE 1: PD = Production-based Diversification; TD = Technology-based Diversification; CD = Complex Diversification
NOTE 2: Points are SITC codes which have greater than 0.5 complexity

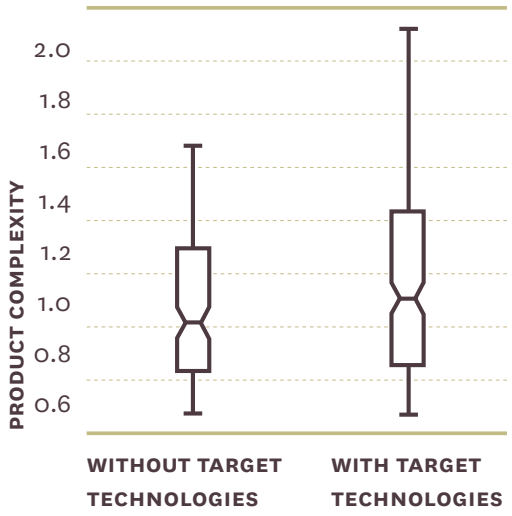
**Additionally, the simulation shows the average product complexity is likely to increase.** The top 10 complex products that Viet Nam can diversify into using technology-based and complex diversification are compared to those of the baseline condition of business as usual (Table 3). Comparing the level of complexity of the products before and after accumulating the 12 technologies, the median value of product complexity increases by 12.4 percent from 0.873 to 0.981 (Figure 23).

**TABLE 3.** SIMULATED RESULTS OF VIET NAM'S DIVERSIFIED PRODUCT, WITH AND WITHOUT TECHNOLOGICAL CAPABILITIES FROM TARGET TECHNOLOGIES

| | BASELINE CONDITION WITHOUT TECHNOLOGICAL CAPABILITIES (UNRELATED AND PRODUCTION-BASED DIVERSIFICATION) | | | SIMULATED RESULT WITH TECHNOLOGICAL CAPABILITIES (TECHNOLOGY-BASED AND COMPLEX DIVERSIFICATION) | | |
|---|---|---|---|---|---|---|
| **RANK BY COMPLEXITY** | **SITC CODE** | **NAME** (3-DIGIT SITC CODE) | **COMPLEXITY** | **SITC CODE** | **NAME** (3-DIGIT SITC CODE) | **COMPLEXITY** |
| **1** | 7432 | Pumps and compressors; fans and blowers | 1.588 | 5163 | Other organic chemicals | 2.043 |
| **2** | 6631 | Mineral manufactures | 1.572 | 5838 | Polymerization and copolymerization products | 1.997 |
| **3** | 8743 | Measuring, checking, analyzing and controlling instruments and apparatus | 1.535 | 7361 | Machine-tools for working metal or metal carbides | 1.957 |
| **4** | 7369 | Machine-tools for working metal or metal carbides | 1.496 | 7373 | Metalworking machinery and parts | 1.905 |
| **5** | 5824 | Condensation, polycondensation and polyaddition products | 1.479 | 5826 | Condensation, polycondensation and polyaddition products | 1.883 |
| **6** | 7499 | Nonelectric parts and accessories of machinery | 1.467 | 8744 | Measuring, checking, analyzing and controlling instruments and apparatus | 1.840 |
| **7** | 7188 | Power-generating machinery and parts | 1.461 | 8742 | Measuring, checking, analyzing and controlling instruments and apparatus | 1.801 |
| **8** | 7416 | Heating and cooling equipment | 1.449 | 7284 | Machinery and equipment specialized for particular industries | 1.781 |
| **9** | 6645 | Glass | 1.444 | 7913 | Railway vehicles and associated equipment | 1.769 |
| **10** | 8935 | Articles described in division 58 (artificial resins and plastic materials, and cellulose esters) | 1.438 | 7492 | Nonelectric parts and accessories of machinery | 1.756 |

SOURCE: Author's calculation based on data from UN Comtrade, OECD, and WIPO.
NOTE: The names of the SITC products are based on the SITC Revision 2.

**FIGURE 23.** LEVEL OF PRODUCT COMPLEXITY, BASELINE VERSUS AFTER ACCUMULATING THE 12 TARGET TECHNOLOGIES



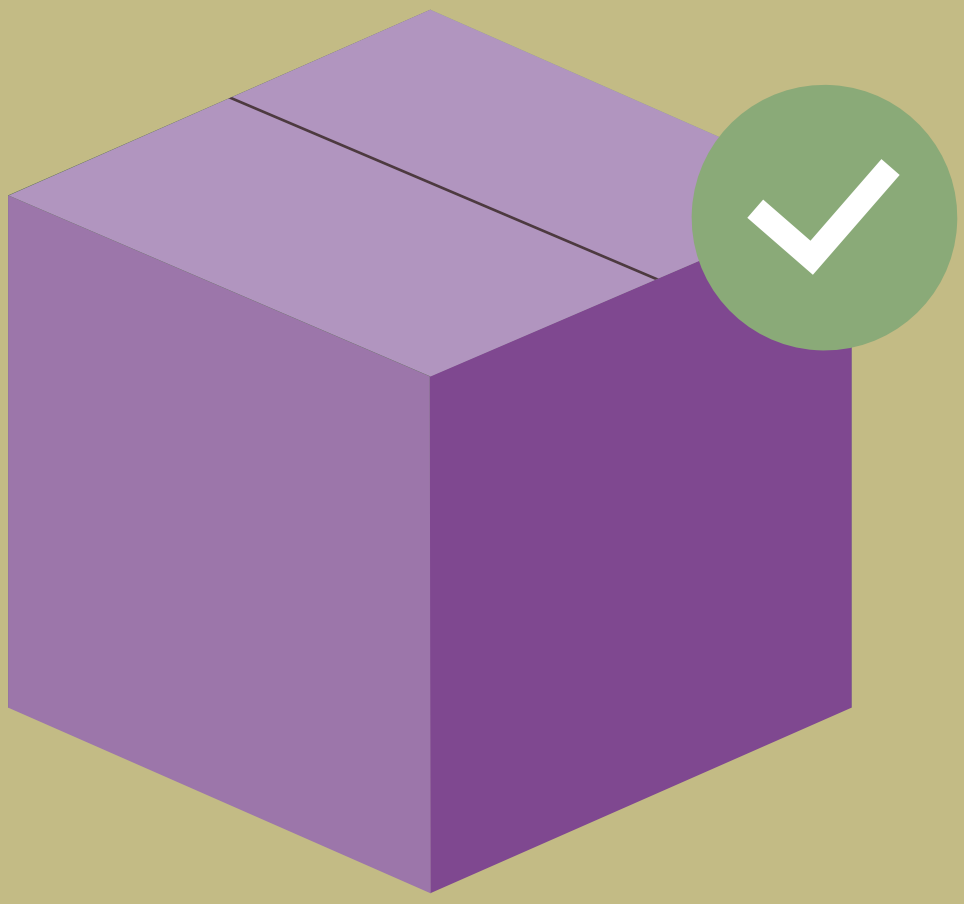

SOURCE: Author's calculation based on UN Comtrade, OECD, and WIPO database

**Viet Nam's strategic targeting of specific technologies for diversification can present a pathway toward the development of complex products with enhanced technological capabilities.** Within the scope of our analysis, for instance, Viet Nam's strategic focus on advanced technologies such as semiconductor devices and information and communication technology (ICT) could significantly enhance Viet Nam's product offerings. The advancements in semiconductor technology are integral to the development of sophisticated measuring instruments. By bolstering its capabilities in semiconductor fabrication, Viet Nam could elevate the complexity and precision of its measuring and controlling instruments, catering to a higher-end market segment. In the case of ICT, by leveraging digital and wireless technologies associated with ICT, Viet Nam could gain capabilities to produce sophisticated products such as instruments or apparatus related to physical or chemical analysis.

**From a policy perspective, fostering the connection between technology and product diversification requires a systematic approach with concerted efforts at various levels.** Public policy can play a pivotal role by incentivizing domestic R&D in targeted technologies through direct and indirect policy instruments (matching grants, fiscal incentives, infrastructure and technology parks, and so forth) that encourage investments in innovation and collaboration between research institutions, domestic firms, and foreign industry. For example, R&D partnerships or technology licensing with MNEs investing in Viet Nam could help facilitate knowledge and technology transfer and skill development to domestic firms. Similarly, policy support for innovative startups can help develop the entrepreneurial ecosystem along with a critical mass of innovative entrepreneurs (World Bank 2023c). From the skills perspective, improving the Science, Technology, Engineering, and Mathematics (STEM) education and increasing the supply of skilled labor into growing domestic industries would be essential for this agenda. Such an ecosystem approach can propel Viet Nam toward technology-based diversification, contributing to the development of a competitive, technologically advanced product portfolio.

# 05

# Conclusion



# 5. Conclusion

**This report presents a co-evolutionary framework that encompasses both production and technological capabilities and employs it to analyze the diversification pathways of Korea and Viet Nam.** This framework stipulates that advances to new products and technologies can be understood as the outcome of the co-evolution of production and technological capabilities. The Korean development experience is a model case of advancing from a least developed economy to an advanced economy through the co-evolutionary development of the two capabilities.. We argue that the Korean experience of diversifying its product portfolio is aligned with what the co-evolutionary framework would predict starting from production capabilities and later moving to technological capabilities. Viet Nam is one of the fastest growing economies in Asia. Although Viet Nam has been successful in diversifying its product portfolio, its diversification was mainly led by FDI firms focusing on simple production activities and did not lead to the accumulation of domestic technological capabilities. We argue that this may pose a risk of slowing the country's future diversification into more complex, technology-intensive products. Underinvestment in Viet Nam's technological capabilities today may prove to be limiting to the country's ability to advance into more sophisticated products in the medium to long term. Moreover, the lack of domestic technological capabilities might deprive the country of potential sources of productivity growth within its firms and industries in the long term. Through the application of the co-evolutionary framework, we identify several technologies that the country could invest in to help diversify into more complex products.

**The paper concludes with a few policy recommendations aimed at enhancing Viet Nam's diversification potential.** Collectively, these recommendations would contribute to the realization of the Viet Nam 2045 vision of transition to a high-income country. Although these recommendations are specific to the case under study, they could also inform policy in other emerging economies with an evolutionary path similar to Viet Nam's.

**First, the application of the co-evolutionary framework could be used to offer insights on how Viet Nam could further improve its diversification prospects.** Although Viet Nam has been successful in diversifying its economy through FDI, it has been less successful in assimilating the technological capabilities underpinning the current production. Without accumulating technological capabilities, the chances of further diversification into complex products may be constrained. Technological capabilities could expand the possibilities for future diversification through technological relatedness. Findings from the simulation conducted in this research show that Viet Nam can potentially diversify into 233 products if it accumulates capabilities in the 12 identified tech-

nologies. When limiting the analysis to complex products with a complexity score greater than 0.5, Viet Nam could potentially tap into 92 new products through technology-based and complex diversification. This potential shift toward higher complexity products, predicated on the successful acquisition of the 12 related technologies, aligns with Viet Nam's strategic goal of moving up the value chain and achieving further diversification.

**Second, to diversify into new complex products, Viet Nam would need to increase its investments in upgrading technological capabilities.** Viet Nam's R&D intensity stands at 0.4 percent (2021), significantly lower than Korea's 1.54 percent in 1987 when it had a similar GDP per capita. Currently, the majority of Viet Nam's private R&D spending and patent filing are carried out by FDI firms. Korea's experience, where the private sector played an increasingly important role in R&D investments, suggests that the Vietnamese private sector could bolster its R&D investments and, subsequently, engage in building technological capabilities. The underinvestment of the domestic private sector in enhancing its technological capabilities could pose challenges in advancing toward more sophisticated products. Effective public policies supporting technological development and R&D investments may play a crucial role in overcoming these challenges. In addition, intensifying linkages and facilitating collaborative R&D programs with MNEs may promote spillovers and help local private firms further develop their technological capabilities.

**Third, Viet Nam needs to evolve its diversification strategy alongside its economic growth and capability building process, recognizing that diversification pathways evolve with a country's development.** The pathways of diversification and subsequent productivity growth for countries vary depending on their respective stages of economic development. Korea's experience showed that it gradually moved from unrelated and production-based diversification to technology-based and complex diversification. This suggests that countries that lack technological capabilities may be constrained to diversifying into nearby products solely through production-based diversification, potentially missing opportunities to 'jump' into more complex, unrelated products. On the other hand, a country with related technological capabilities may find itself better positioned to diversify into seemingly distant, unrelated products, even if such products appear to be removed from the current industrial structure.

**Fourth, to enhance diversification, Viet Nam could align industrial policies focused on accumulating production capabilities with innovation policies centered on knowledge accumulation.** The simulation results show that Viet Nam's potential for technology-based diversification could be greatly expanded if it secured the technological capabilities to support its production. However, Viet Nam's current science, technology and innovation (STI) policy framework is not aligned to the key national priorities, including fostering innovation in enterprises (World Bank 2021). Effective coordination between industrial and innovation policies can incentivize local firms to invest in R&D, upgrade technological capabilities, and consequently enhance industrial competitiveness in more value-added sectors.

**This report has a few caveats that could be addressed in future research. First, the research is based on export and patent data, and this may not fully represent a country's actual production and technological capabilities.** The production capabilities are measured based on the RCA a country has among its exporting products, and the technological capabilities are proxied based on the RTA in terms of patenting activity. Products that are in domestic use are not consid-

ered, and patents, which are often a function of the country's ability to invest resources into R&D and maintain a coherent intellectual property rights regime, may not fully represent a country's technological capabilities (other proxies include technology licenses, quality certifications, and so on). Moreover, since patenting is more prevalent in developed countries, the reliance on patent data in measuring technological capabilities might lead to a misunderstanding of diversification patterns.

**Second, the analysis did not consider who in the country is producing and who owns the patent.** This may not be an issue in Korea's analysis given that Korean firms play the leading role in the export and patenting space. Given that FDI firms and MNEs in Viet Nam produce a large portion of exported goods, it is possibile that Viet Nam's production capabilities are overestimated. As a practice, MNEs file patents in Viet Nam to protect their product's intellectual property, and thus Viet Nam's local patent portfolio may not fully represent the country's indigenous private sector capabilities. Thus, future analysis should consider additional proxies to better capture the country's production and knowledge capabilities.

**Third, the co-evolutionary framework is designed based on Korea's specific case.** Korea's growth model was based on manufacturing exports, and even today, Korean manufacturing accounts for a significant portion of the country's GDP (25.6 percent in 2022). The empirical analysis in Figure 6 shows that as countries' GDP per capita increases, a larger share is taken up by technology-based and complex diversification—but this pattern cannot be applied to all countries alike. The framework may be more applicable to manufacturing-based countries, and less so to countries pursuing services-led growth. More rigorous analysis and evidence will be needed to examine the applicability of this framework.

# References

# References


Arrow, K. J. (2000). Increasing returns: Historiographic issues and path dependence. *The European Journal of the History of Economic Thought*, *7*(2), 171–180.

Balassa, B. (1965) Trade Liberalization and Revealed Comparative Advantage. The Manchester School of Economic and Social Studies, 33, 99–123. https://doi.org/10.1111/j.1467-9957.1965.tb00050.x

Balland, P. A., Boschma, R., Crespo, J., & Rigby, D. L. (2019). Smart specialization policy in the European Union: Relatedness, knowledge complexity and regional diversification. *Regional Studies*, *53*(9), 1252–1268.

Balland, P. A., & Boschma, R. (2021). Complementary interregional linkages and Smart Specialisation: An empirical study on European regions. *Regional Studies*, *55*(6), 1059–1070.

Boschma, R., Minondo, A., & Navarro, M. (2013). The emergence of new industries at the regional level in Spain: A proximity approach based on product relatedness. *Economic Geography*, *89*(1), 29–51.

Boschma, R., Balland, P. A., & Kogler, D. F. (2015). Relatedness and technological change in cities: The rise and fall of technological knowledge in US metropolitan areas from 1981 to 2010. *Industrial and Corporate Change*, *24*(1), 223–250.

Bottazzi, G., Dosi, G., Lippi, M., Pammolli, F., & Riccaboni, M. (2001). Innovation and corporate growth in the evolution of the drug industry. *International Journal of Industrial Organization, 19*(7), 1161-1187.

Cirera, Xavier; Maloney, William F. (2017). The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up. World Bank. Washington, DC.

Cirera, Xavier; Comin, Diego; and Cruz, Marcio. (2022). Bridging the Technological Divide: Technology Adoption by Firms in Developing Countries. The World Bank Productivity Project. World Bank. Washington, DC.

Colombelli, A., Krafft, J., & Quatraro, F. (2014). The emergence of new technology-based sectors in European regions: A proximity-based analysis of nanotechnology. *Research Policy*, *43*(10), 1681–1696.

Deegan, J., Broekel, T., & Fitjar, R. D. (2021). Searching through the Haystack: The relatedness and complexity of priorities in smart specialization strategies. *Economic Geography*, *97*(5), 497–520.

Dosi, G., Grazzi, M., & Moschella, D. (2017). What do firms know? What do they produce? A new look at the relationship between patenting profiles and patterns of product diversification. *Small Business Economics, 48*, 413-429.

Eum, W., & Lee, J. D. (2019). Role of production in fostering innovation. *Technovation*, 84, 1–10.

Eum, W., & Lee, J. D. (2022a). The co-evolution of production and technological capabilities during industrial development. *Structural Change and Economic Dynamics*, *63*, 454–469.

Eum, W., & Lee, J. D. (2022b). Alternative paths of diversification for developing countries. *Review of Development Economics*, *26*(4), 2336–2355.

Ferreira, G. F., & Harrison, R. W. (2012). From coffee beans to microchips: Export diversification and economic growth in Costa Rica. *Journal of Agricultural and Applied Economics*, *44*(4), 517–531.

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., & Simoes, A. (2014). *The Atlas of Economic Complexity: Mapping paths to prosperity*. MIT Press.

Hausmann, R., Santos, M., Barrios, D., Taniparti, N., Tudela, J., & Lu, J. (2022). The Economic Complexity of Namibia: A Roadmap for Productive Diversification. *CID Faculty Working Paper,* No. 410.

Hidalgo, C. A., Klinger, B., Barabási, A. L., & Hausmann, R. (2007). The product space conditions the development of nations. *Science*, *317*(5837), 482–487.

Hidalgo, C. A., & Hausmann, R. (2009). The building blocks of economic complexity. *Proceedings of the National Academy of Sciences*, *106*(26), 10570–10575.

Jewell, C. (2021). Global innovation index 2021: Tracking innovation through the COVID-19 crisis. *WIPO Magazine*, (3), 9–15.

IMF. (2022). Viet Nam 2022 Article IV Consultation. Washington, DC: International Monetary Fund.

Kim, L. (1997). *From Imitation to Innovation: The Dynamics of Korea's Technological Learning*. Harvard Business Press. Boston, MA

Kogler, D. F., Rigby, D. L., & Tucker, I. (2013). Mapping knowledge space and technological relatedness in US cities. *European Planning Studies*, *21*(9), 1374–1391.

Keun, Lee. 2019. The Art of Economic Catch-Up: Barriers, Detours, and Leapfrogging in Innovation Systems. Cambridge University Press.

Kravtsova, V., & Radosevic, S. (2012). Are systems of innovation in Eastern Europe efficient? *Economic Systems*, *36*(1), 109–126.

Kruse, H., Timmer, M. P., De Vries, G. J., & Ye, X. (2023). Export Diversification from an Activity Perspective: An Exploration Using Occupation Data. Policy Research working paper; no. WPS 10463 Washington, D.C.: World Bank Group.

Lall, S. (2000). The Technological structure and performance of developing country manufactured exports, 1985-98. *Oxford Development Studies*, *28*(3), 337–369.

Lee, J. D., Lee, K., Meissner, D., Radosevic, S., & Vonortas, N. S. (2021). Local capacity, innovative entrepreneurial places and global connections: An overview. *The Journal of Technology Transfer*, *46*, 563–573.

Lin, J., & Chang, H. J. (2009). Should Industrial Policy in developing countries conform to comparative advantage or defy it? A debate between Justin Lin and Ha-Joon Chang. *Development Policy Review*, *27*(5), 483–502.

Martin, R., & Sunley, P. (2006). Path dependence and regional economic evolution. *Journal of Economic Geography*, *6*(4), 395–437.

OECD. 2021. "Guide to OECD's Trade in Value Added Indicators." 2021 Edition.

Patelli, A., Napolitano, L., Cimini, G., Pugliese, E., & Gabrielli, A. (2023). Capability accumulation patterns across economic, innovation, and knowledge-production activities. *Scientific Reports, 13*(1).

Pavitt, K. (1998). Technologies, products and organization in the innovating firm: What Adam Smith tells us and Joseph Schumpeter doesn't. *Industrial and Corporate Change*, *7*(3), 433-452.

Pinheiro, F. L., Alshamsi, A., Hartmann, D., Boschma, R., & Hidalgo, C. (2018). Shooting low or high: Do countries benefit from entering unrelated activities? *Papers in Evolutionary Economic Geography*, 18(07).

Pugliese, E., Cimini, G., Patelli, A., Zaccaria, A., Pietronero, L., & Gabrielli, A. (2019). Unfolding the innovation system for the development of countries: Coevolution of Science, Technology and Production. *Scientific Reports, 9*(1).

Radosevic, S., Yoruk, D. E., & Yoruk, E. (2019). Technology upgrading and growth in Central and Eastern Europe. In *Social and Economic Development in Central and Eastern Europe* (pp. 178–204). Routledge.

Ruttan, V. W. (1997). Induced innovation, evolutionary theory and path dependence: Sources of technical change. *The Economic Journal*, *107*(444), 1520–1529.

Stanley, D. L., & Bunnag, S. (2001). A new look at the benefits of diversification: Lessons from Central America. *Applied Economics*, *33*(11), 1369–1383.

Teece, D. J., Rumelt, R., Dosi, G., & Winter, S. (1994). Understanding corporate coherence: Theory and evidence. *Journal of Economic Behavior & Organization, 23*(1), 1-30.

Truong, H. Q. (2022). Viet Nam's Global Value Chains Participation and Policy Implications for South Korea–Viet Nam Economic Cooperation. *KIEP Research Paper, World Economy Brief*, 22–37.

United Nations Conference on Trade and Development (UNCTAD). (2018). Diversification and value addition. UNCTAD secretariat.

Yeon, J. I., Lee, J. D., & Baek, C. (2021). A tale of two technological capabilities: Economic growth revisited from a technological capability transition perspective. *The Journal of Technology Transfer*, *46*, 574–605.

Wong, J., Quach, U., Thorsteinsdóttir, H., Singer, P. A., & Daar, A. S. (2004). South Korean biotechnology—a rising industrial and scientific powerhouse. *Nature Biotechnology, 22* (Suppl 12), DC42-DC47.

World Bank. (2021a). Viet Nam: Science, Technology, and Innovation Report 2020. World Bank, Washington, DC.

World Bank. (2021b). Creating Markets in Viet Nam: Country Private Sector Diagnostic. World Bank, Washington, DC.

World Bank. (2021c). How will Viet Nam Blossom? Reforming institutions for effective implementation. World Bank, Washington, DC.

World Bank. (2023a). *Innovative Korea: Lessons on Leveraging Innovation and Technology for Development*. World Bank, Washington, DC.

World Bank. (2023b). Viet Nam: Making public investment work for growth. World Bank, Washington, DC.

World Bank. (2023c). Promoting Innovative Entrepreneurship in Viet Nam: An Ecosystem Diagnostic. World Bank, Washington, DC.

World Bank. (2024). World Development Report 2024: Economic Growth in Middle-Income Countries. World Bank, Washington, DC. [forthcoming]

Xuan, N.T. and Xing, Y., 2008. Foreign direct investment and exports The experiences of Viet Nam 1. *Economics of Transition*, *16*(2), pp.183–197.

Vukov, V. (2023). Growth models in Europe's Eastern and Southern peripheries: between national and EU politics. *New Political Economy*, 1–17.

# Appendices

# Appendix 1. Data and methodology

## A1.1.
## Data

International export data from the UN Comtrade database was used to construct a product space. The data is classified by Standard International Trade Classification 4 digits (SITC-4) and covers more than 200 countries from 1980 to 2018. In this research, SITC Revision 2 was used, and the dataset includes around 700 products.

Patent data from the OECD patent database was used to construct a technology space. International Patent Classification 4 digits (IPC-4) was used, covering roughly 600 technologies. The database records granted patents by applicant's nationality. Since the OECD patent database covers fewer countries than the UN Comtrade data, supplementary patent databases, additional data sources from the Worldwide Patent Statistical Database (PATSTAT), United States Patent and Trademark Office (USPTO), World Intellectual Propety Organization (WIPO) were used to fill the gap. For Viet Nam's international patent (USPTO), WIPO database was used.

## A1.2.
## Key metrics for product and technology space

**Revealed Comparative Advantage (RCA) and Revealed Technology Advantage (RTA)**

If a country (c) has capability in a product (SITC code i), the RCA of the country (c) at the product (i) is greater than 1, otherwise RCA is less than one. Similarly, if a country (c) has capability in a technology (IPC code i), the RTA of the country (c) at the technology (i) is greater than 1, otherwise RCA is less than one. $x^{sitc}(c,i)$ is export value of country c for product (SITC code) i, and $x^{ipc}$ is patent value of country c for technology (ipc code) i.

$$RCA_{c,i} = \frac{x^{sitc}(c,i)/\Sigma_i x^{sitc}(c,i)}{\Sigma_c x^{sitc}(c,i)/\Sigma_{c,i} x^{sitc}(c,i)}$$

$$RTA_{c,i} = \frac{x^{ipc}(c,i)/\Sigma_i x^{ipc}(c,i)}{\Sigma_c x^{ipc}(c,i)/\Sigma_{c,i} x^{ipc}(c,i)}$$

### PROXIMITY

The proximity ($\phi_{ij}$) between activity *I* and activity *j* is the minimum of the pairwise conditional probabilities of a country's capability.

$$\phi_{ij}^{production}=min\{P(RCA_i>1|\ RCA_j>1),\ P(RCA_j>1|\ RCA_i>1)\}$$
$$\phi_{ij}^{technology}=min\{P(RTA_i>1|\ RTA_j>1),\ P(RTA_j>1|\ RTA_i>1)\}$$

### DENSITY

Density ($w$) measures relatedness of a country to production (or technology). $x_i$ is 1 if $RCA_{c,i}>1$ (or $RTA_{c,i}>1$) otherwise 0.

$$w^{production}(c,j)=\sum_i x_i\phi_{ij}^{production}\Big/\sum_i \phi_{ij}^{production}$$
$$w^{technology}(c,j)=\sum_i x_i\phi_{ij}^{production}\Big/\sum_i \phi_{ij}^{production}$$

### CROSS-SPACE PROXIMITY

The proximity ($\phi_{ij}^{cross}$) between product *i* and technology *j* is the minimum of the pairwise conditional probabilities of a country's capability.

$$\phi_{ij}^{cross}=min\{P(RTA_i>1|\ RCA_j>1),\ P(RCA_j>1|\ RTA_i>1)\}$$

### CO-EVOLUTIONARY DENSITY FROM PRODUCTION

Co-evolutionary density from production ($w^{production\rightarrow technology_j}$) measures relatedness of a country ($c$) to technology ($j$) from production; $x_i$ is 1 if $RCA_{c,i}>1$, otherwise 0

$$w^{production\rightarrow technology_j}(c,j)=\sum_{i\in\ SITC\ codes} x_i\phi_{ij}^{cross}\Big/\sum_{i\in\ SITC\ codes}\phi_{ij}^{cross}$$

### CO-EVOLUTIONARY DENSITY FROM TECHNOLOGY

Co-evolutionary density from technology ($w^{technology\rightarrow production}(c,j)$) measures relatedness of a country ($c$) to production ($j$) from technology; $x_i$ is 1 if $RTA_{c,i}>1$, otherwise 0

$$w^{technology\rightarrow production}(c,j)=\sum_{i\in\ IPC\ codes} x_i\phi_{ij}^{cross}\Big/\sum_{i\in\ IPC\ codes}\phi_{ij}^{cross}$$

# A1.3.
# Metrics for diversification pattern

**Unrelated diversification:** Conditions for unrelated diversification for product (i) of a country (c) are as follow.

*Country (c) diversifies to product(i) through unrelated diversification if...*

(*Condition* 1) $RCA_{c,i,t}\geq 1$ and $RCA_{c,i,t}>1$

(*Condition* 2) $w_{t\text{-}5}^{production}(c,i)<$ *global median of production density*

(*Condition* 3) $w_{t\text{-}5}^{technology\rightarrow production}(c,i)<$ *global median of coevolutinary density from technology*

**Production-based diversification:** Conditions for production-based diversification for product (i) of a count (c) are as follow.
*Country (c) diversifies to product(i) through production-based diversification if...*
(*Condition* 1) $RCA_{c,i,t\text{-}5} \leq 1$ and $RCA_{c,i,t} > 1$
(*Condition* 2) $w_{t\text{-}5}^{production}(c,i) \geq$ *global median of production density*
(*Condition* 3) $w_{t\text{-}5}^{technology \rightarrow production}(c,i) <$ *global median of coevolutinary density from technology*

**Technology-based diversification:** Conditions for technology-based diversification for product (i) of a count©(c) are as follow.
*Country (c) diversifies to product(i) through technology-based diversification if...*
(*Condition* 1) $RCA_{c,i,t\text{-}5} \leq 1$ and $RCA_{c,i,t} > 1$
(*Condition* 2) $w_{t\text{-}5}^{production}(c,i) <$ *global median of production density*
(*Condition* 3) $w_{t\text{-}5}^{technology \rightarrow production}(c,i) \geq$ *global median of coevolutinary density from technology*

**Complex diversification:** Conditions for complex diversification for product (i) of a count©(c) are as follow.
*Country (c) diversifies to product(i) through complex diversification if...*
(*Condition* 1) $RCA_{c,i,t\text{-}5} \leq 1$ and $RCA_{c,i,t} > 1$
(*Condition* 2) $w_{t\text{-}5}^{production}(c,i) \geq$ *global average of production density*
(*Condition* 3) $w_{t\text{-}5}^{technology \rightarrow production}(c,i) \geq$ *global median of coevolutinary density from technology*

## A1.4.
## Probability distribution of diversification type

The probability distribution of each of the four diversification types (unrelated diversification; production-based diversification; technology-based diversification; complex diversification) by GDP per capita is derived by dividing the frequency of each diversification type that occurs at a certain GDP per capita level by the total number of diversifications.

As an example, the probability of unrelated diversification at certain GDP per capita follows the following equation.

$$P^{\,unrelated\ divdersification}(GDP\ per\ capita) = \frac{Number\ of\ unrelated\ diversifications\ at\ the\ GDP\ per\ capita}{Total\ Number\ of\ diversifications\ at\ the\ GDP\ per\ capita}$$

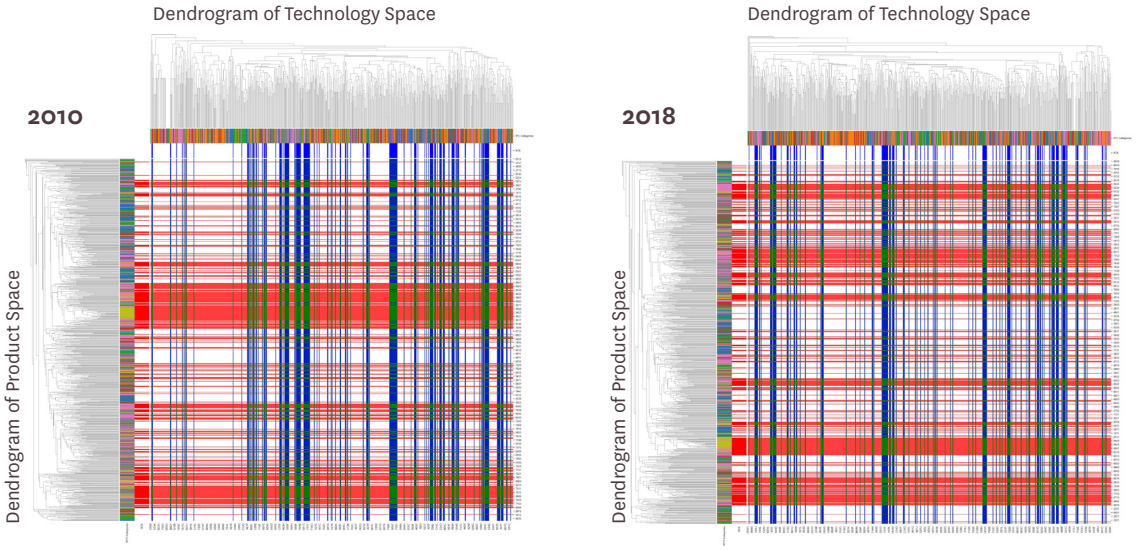
## A1.5.
## Product and technology heatmap

It is possible to depict a country's strengths and weaknesses in both production and technology by representing a country's production capability (RCA>1) and technological capability (RTA>1) on

the heatmap. Figures A1-1, A1-2 and A1-3 show the product and technology capability heatmaps of China, the United States, and Indonemisa for 2010 and 2018, respectively. The blue vertical line represents technologies with RTA greater than 1, and the red horizontal line represents products with RCA greater than 1. The green color appears when both RTA and RCA are greater than 1.

The heatmap for China in Figure A1-1 shows that China has high production capabilities but relatively weak technological capabilities. China's production capabilities are presented in thick red lines which implies that China has capabilities in highly similar products. On the other hand, China's technology capabilities show a relatively thin line, meaning that China's production capabilities surpass technological capabilities.

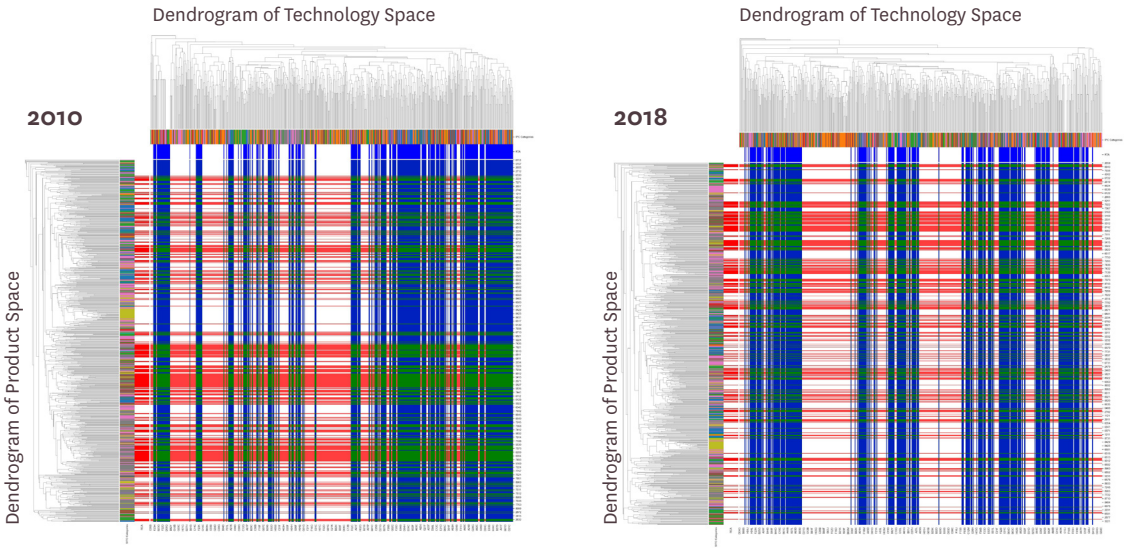
**FIGURE A1-1** PRODUCT AND TECHNOLOGY HEATMAP FOR CHINA, 2010 AND 2018




SOURCE: Author's calculation based on data from UN Comtrade, OECD, and WIPO

The product and technology capability heatmap of the United States show a different pattern. As shown in figure A1-2, the United States has a thick layer in both production and technology. Whereas the United States' technological strength was concentrated in technologies with high proximity in 2010, the 2018 heatmap shows that the country then built capabilities in a wider range of technologies.

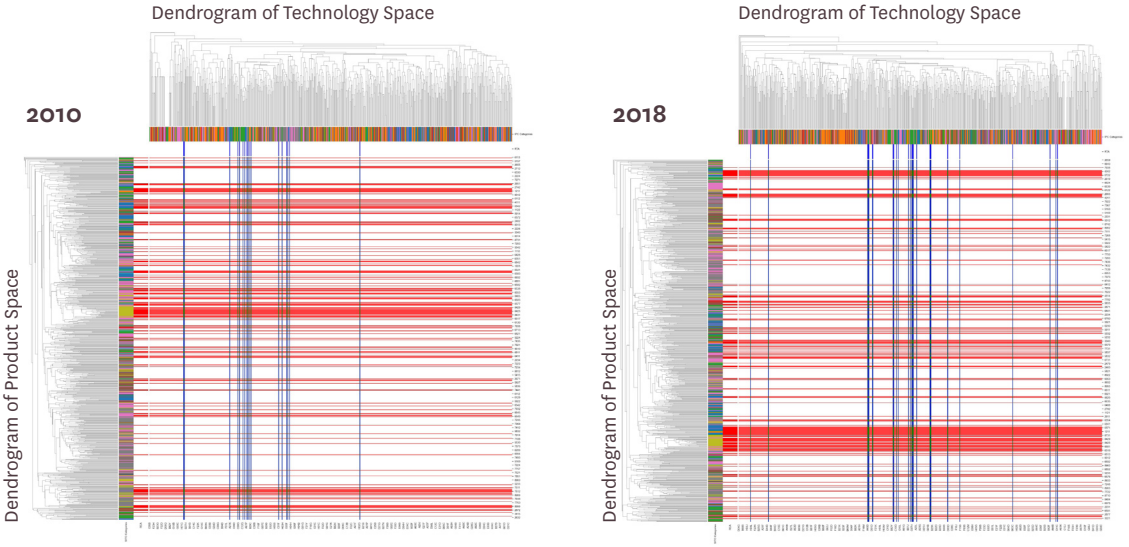
**FIGURE A1-2.** PRODUCT AND TECHNOLOGY HEATMAP FOR THE UNITED STATES, 2010 AND 2018




NOTE: Author's calculation based on data from UN Comtrade, OECD, and WIPO

Figure A1-3 shows the heatmap for Indonesia in 2010 and 2018. Although one or two thick red lines stand out, overall, the country has far fewer lines than China or the United States, reflecting Indonesia's comparatively rudimentary production and technological capabilities.

**FIGURE A1-3.** PRODUCT AND TECHNOLOGY HEATMAP FOR INDONESIA, 2010 AND 2018

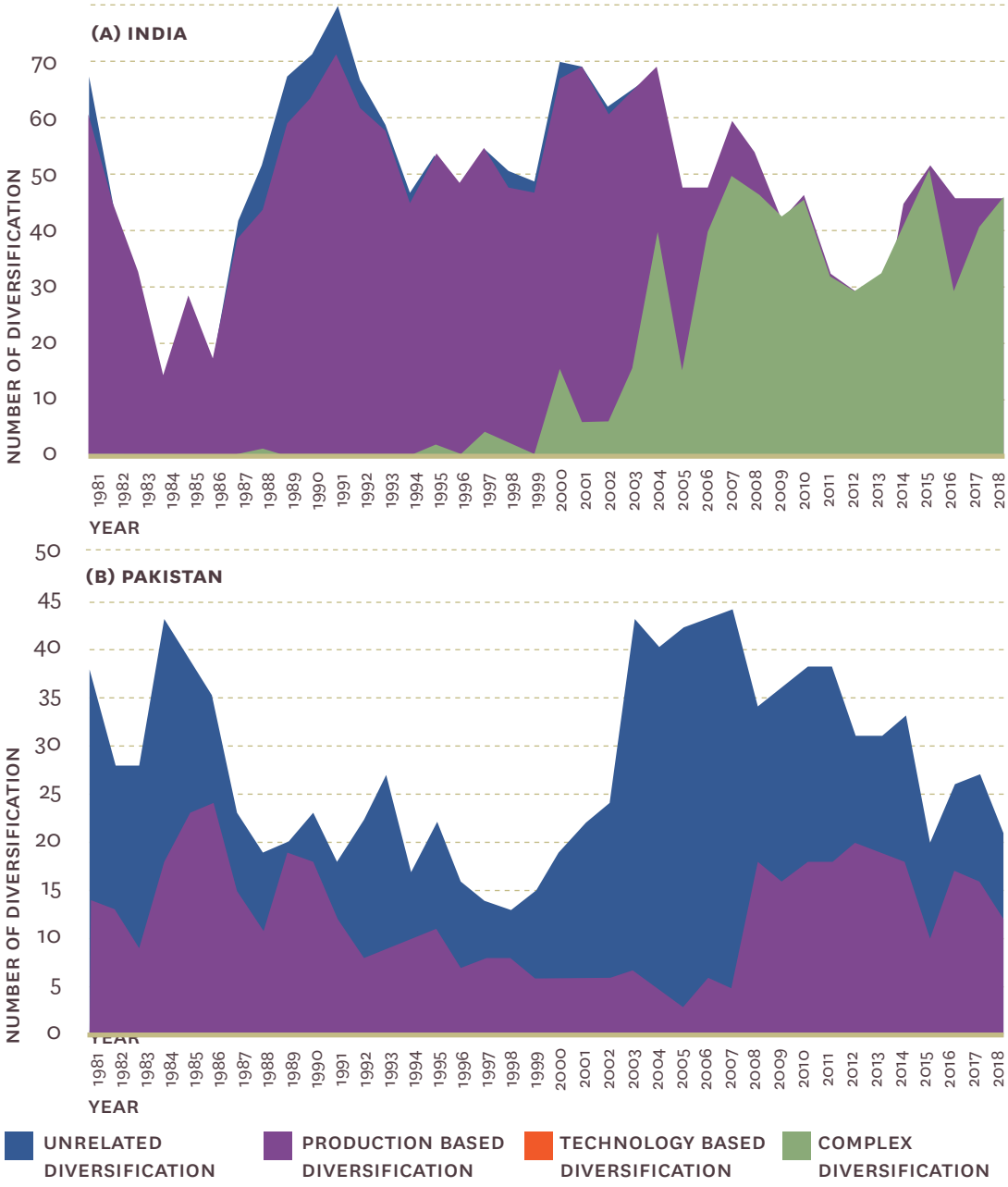


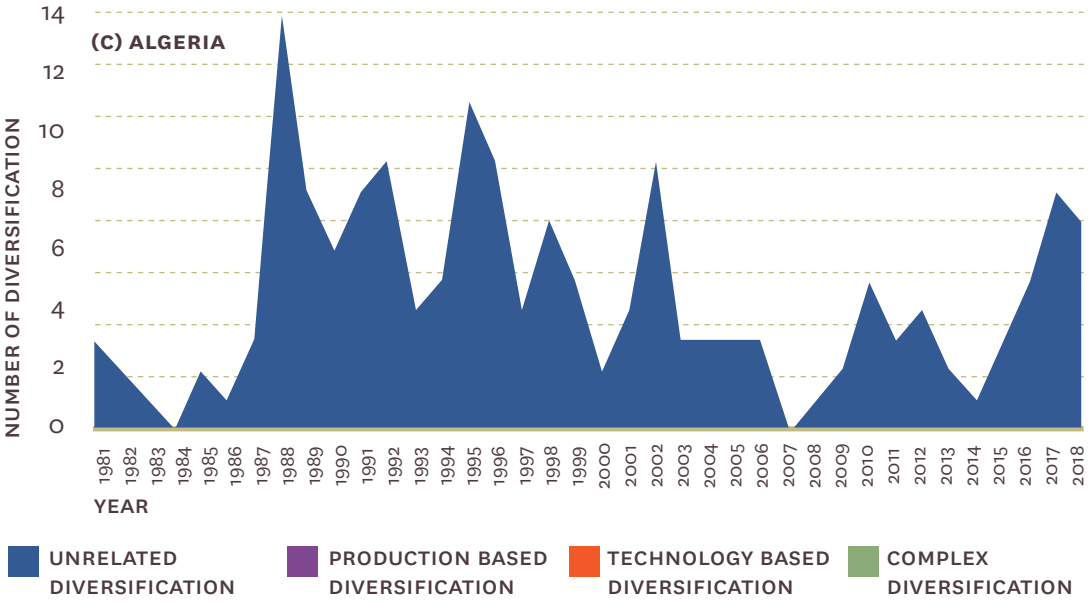

NOTE: Author's calculation based on data from UN Comtrade, OECD, and WIPO

# Appendix 2. Diversification patterns for selected countries

## A2.1.
## Lower-middle-income economies

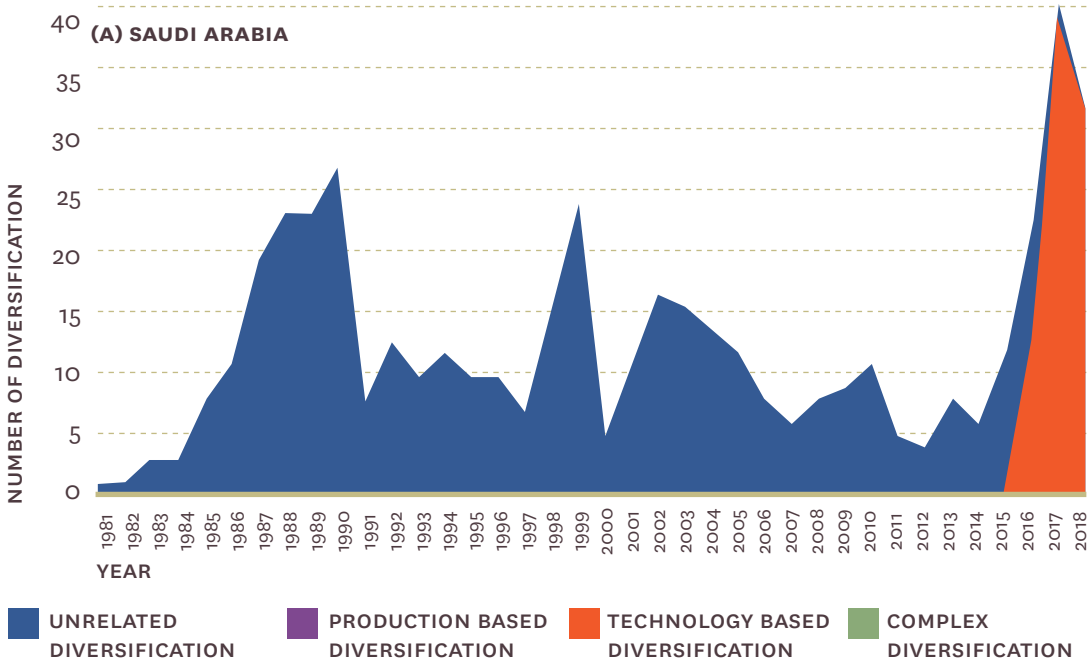
**FIGURE A2-1.** DIVERSIFICATION PATTERNS OF (A) INDIA, (B) PAKISTAN, (C) ALGERIA

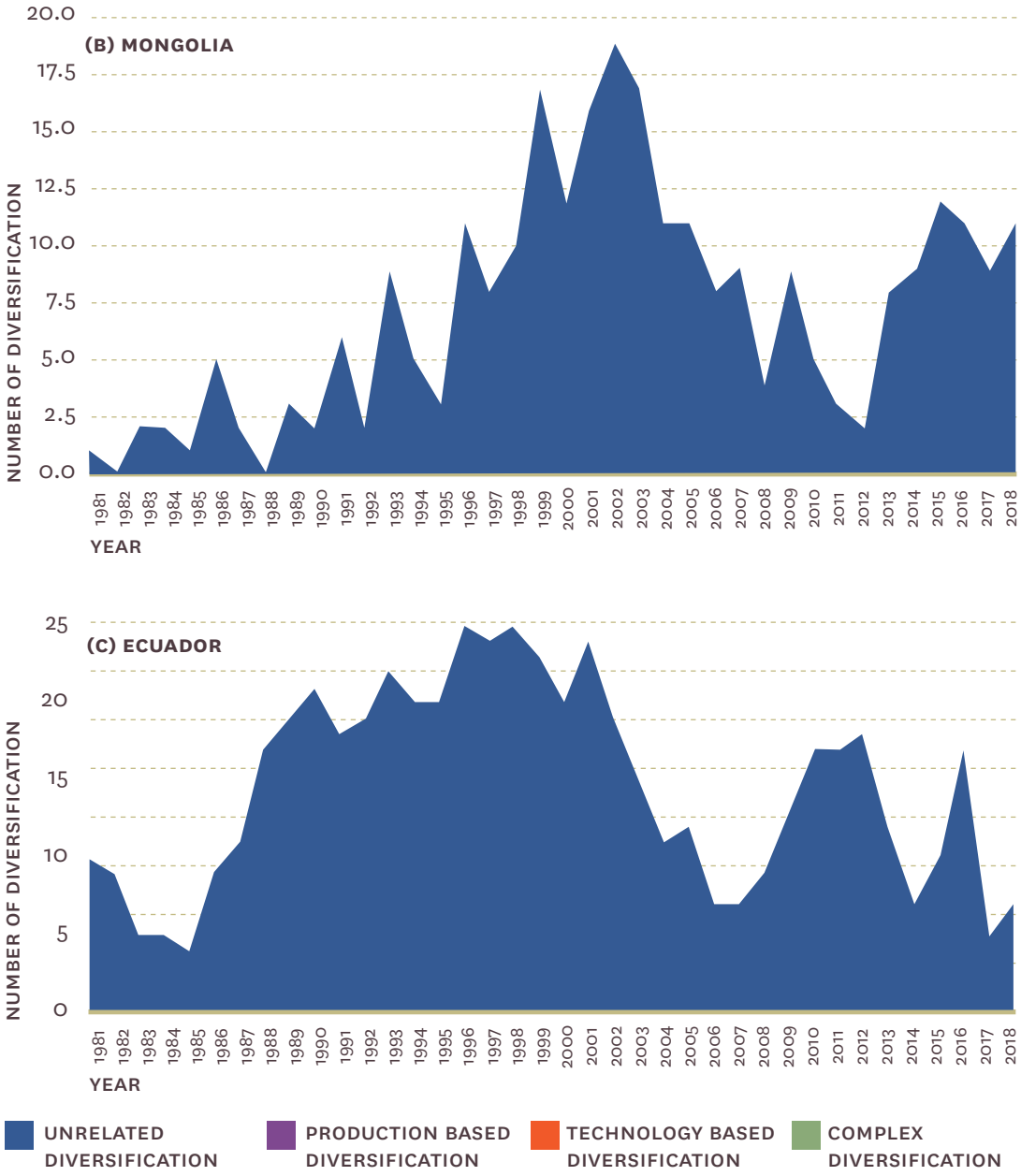


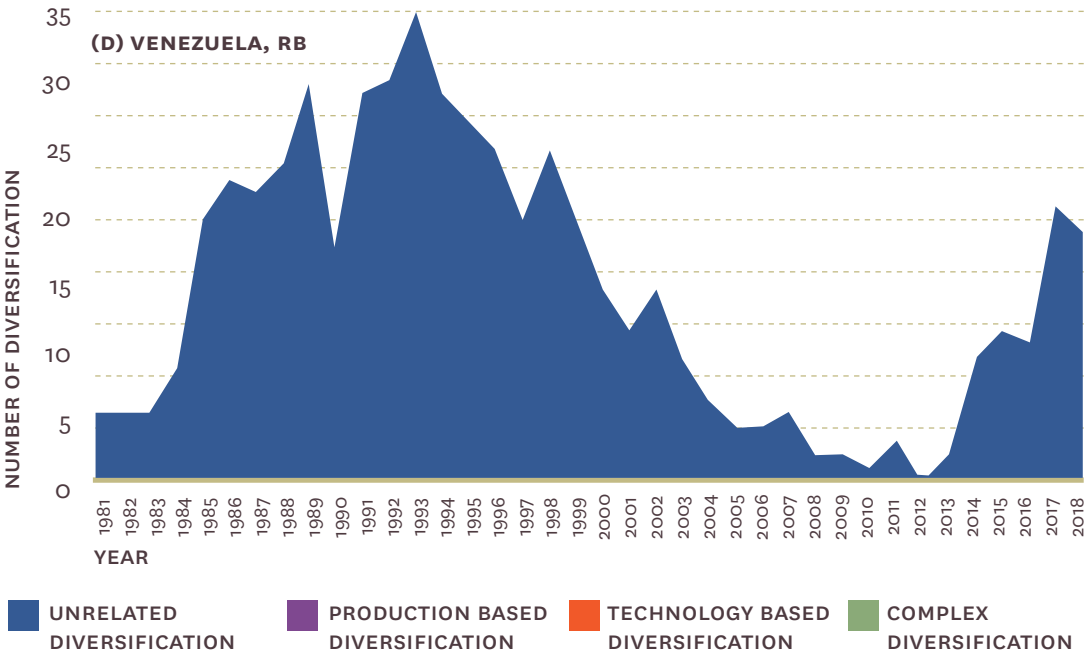



# A2.2.
# Resource-dependent economies

**FIGURE A2-2.** DIVERSIFICATION PATTERNS OF (A) SAUDI ARABIA, (B) MONGOLIA, (C) ECUADOR, (D) VENEZUELA, RB

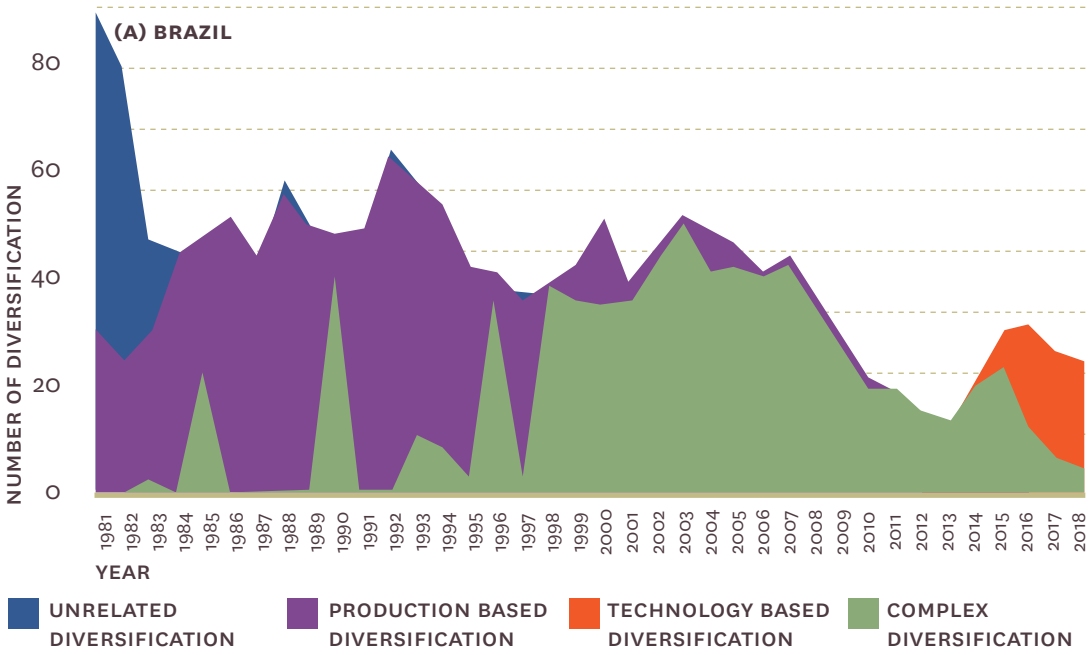


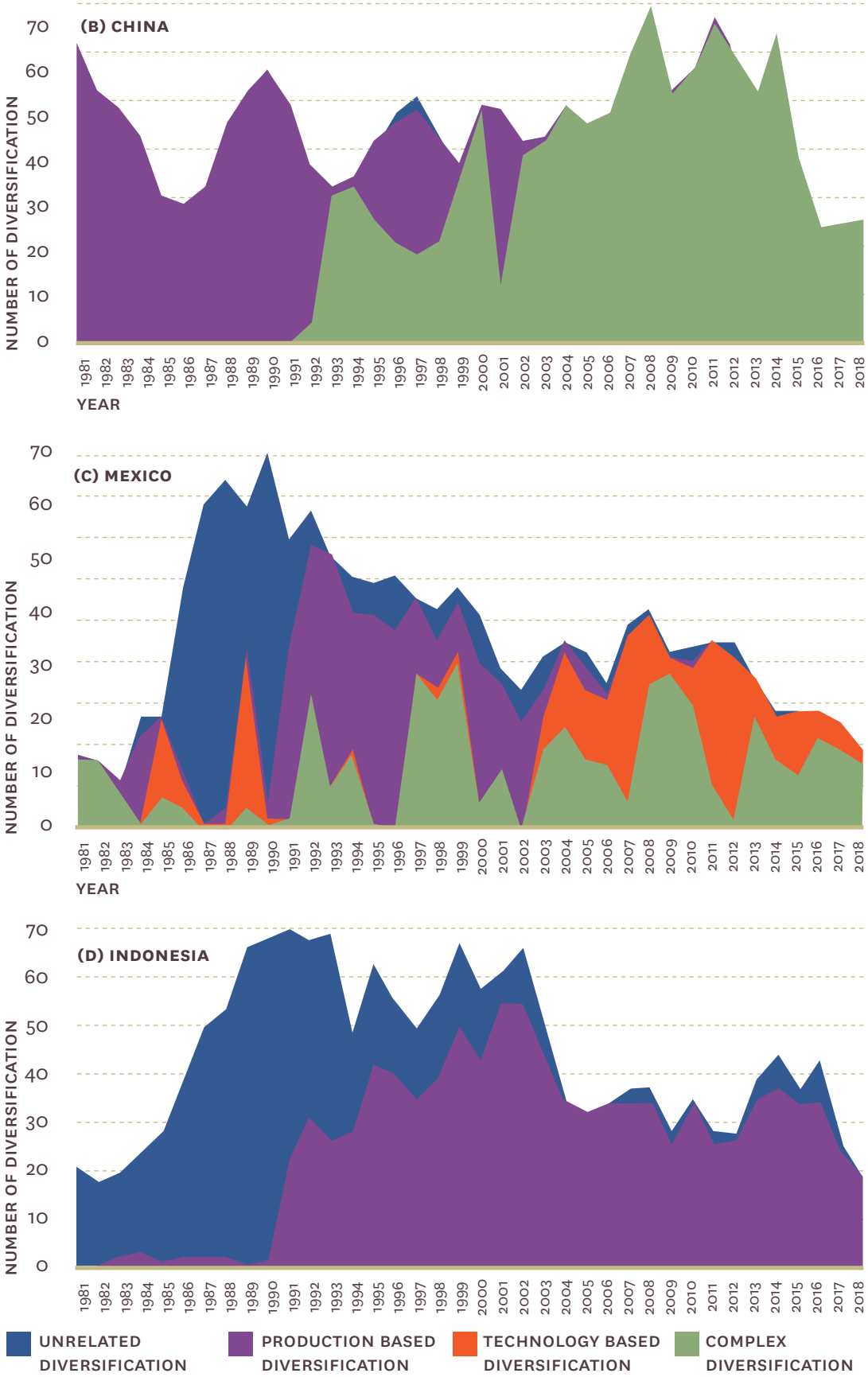

(B) MONGOLIA
NUMBER OF DIVERSIFICATION
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
YEAR
(C) ECUADOR
NUMBER OF DIVERSIFICATION
25
20
15
10
5
0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
YEAR
UNRELATED DIVERSIFICATION
PRODUCTION BASED DIVERSIFICATION
TECHNOLOGY BASED DIVERSIFICATION
COMPLEX DIVERSIFICATION




# A2.3.
# Upper-middle-income economies

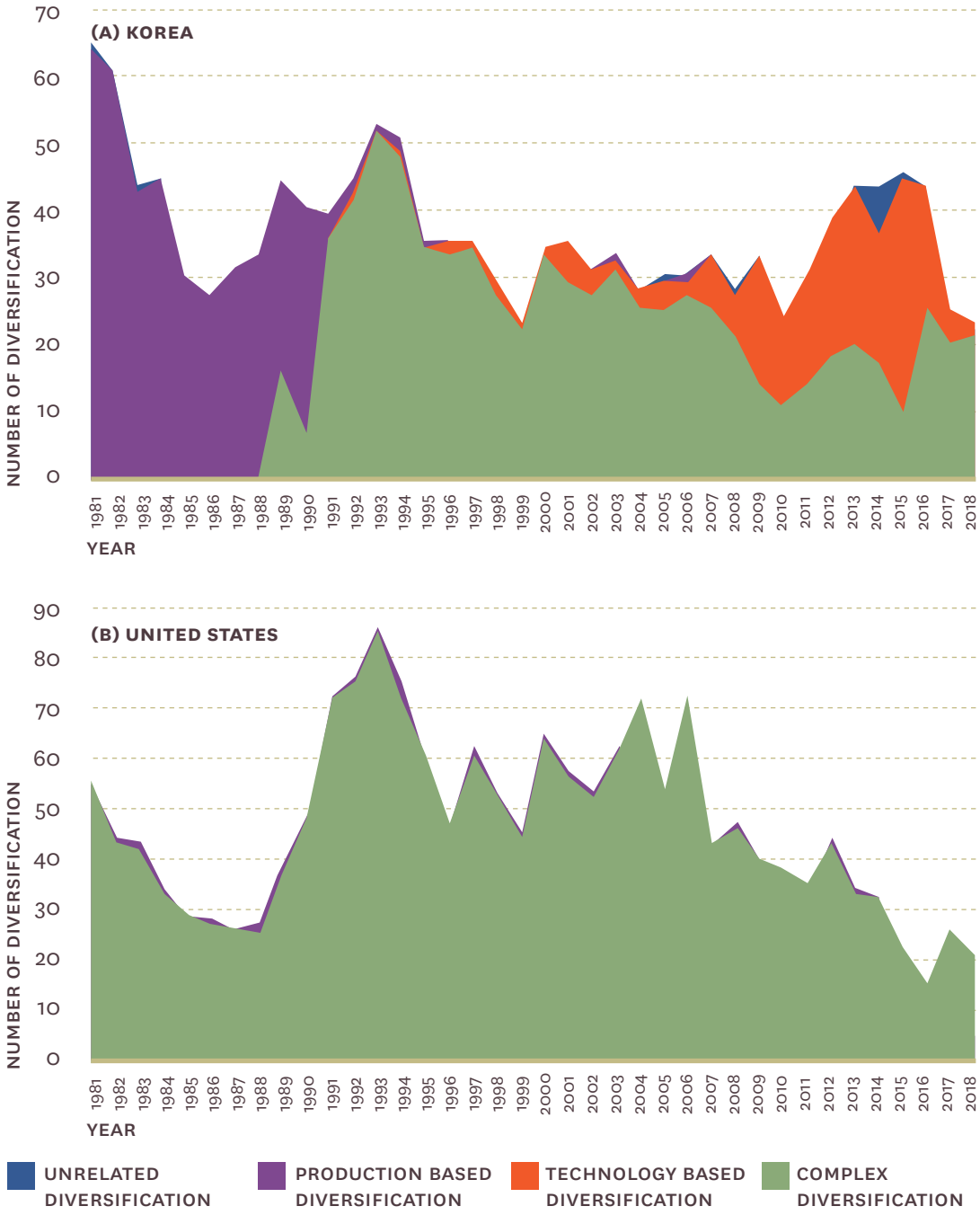
**FIGURE A2-3.** DIVERSIFICATION PATTERNS OF (A) BRAZIL, (B) CHINA, (C) MEXICO, (D) INDONESIA

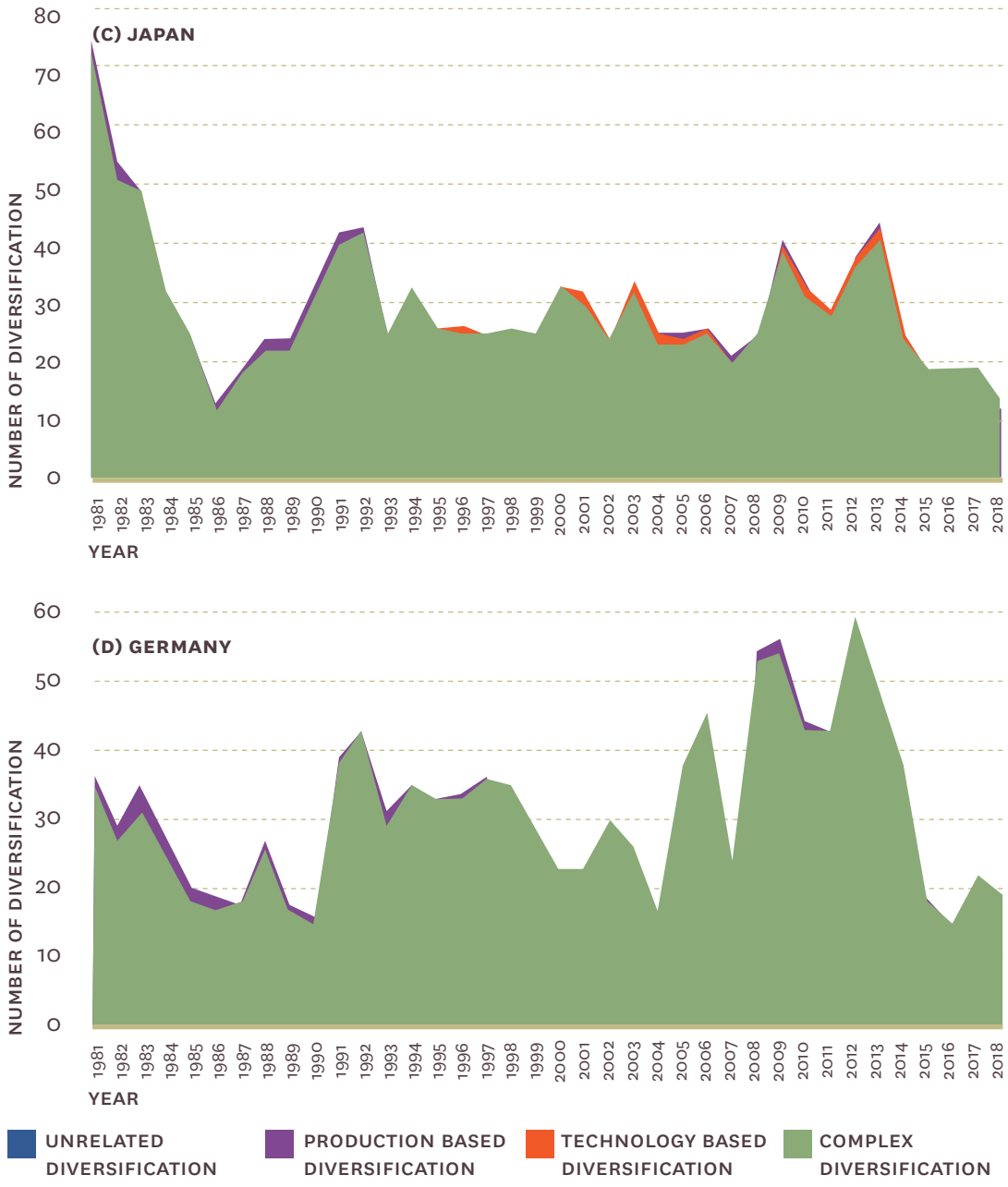


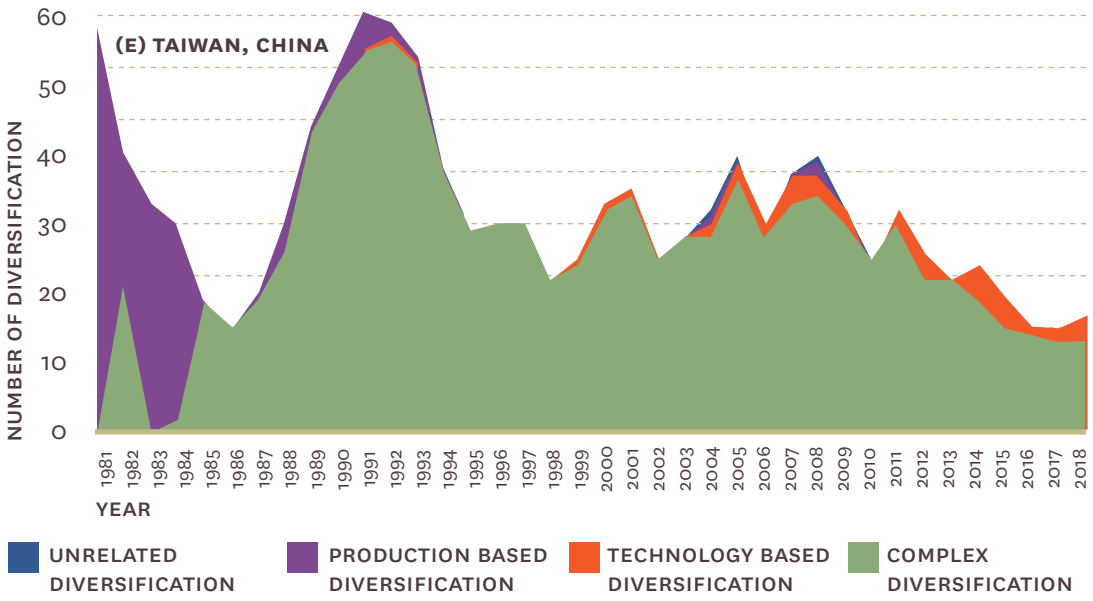

(B) CHINA
NUMBER OF DIVERSIFICATION
YEAR
(C) MEXICO
NUMBER OF DIVERSIFICATION
YEAR
(D) INDONESIA
NUMBER OF DIVERSIFICATION
UNRELATED DIVERSIFICATION
PRODUCTION BASED DIVERSIFICATION
TECHNOLOGY BASED DIVERSIFICATION
COMPLEX DIVERSIFICATION

# A2.4.
## High-income economies

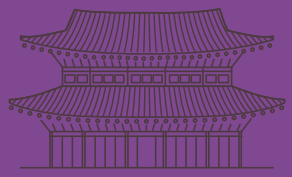
**FIGURE A2-4.** DIVERSIFICATION PATTERNS OF (A) KOREA, (B) UNITED STATES, (C) JAPAN, (D) GERMANY, (E) TAIWAN




(C) JAPAN
NUMBER OF DIVERSIFICATION
0
10
20
30
40
50
60
70
80
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
YEAR
(D) GERMANY
NUMBER OF DIVERSIFICATION
0
10
20
30
40
50
60
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
YEAR
UNRELATED DIVERSIFICATION
PRODUCTION BASED DIVERSIFICATION
TECHNOLOGY BASED DIVERSIFICATION
COMPLEX DIVERSIFICATION


(E) TAIWAN, CHINA
NUMBER OF DIVERSIFICATION
60
50
40
30
20
10
0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
YEAR
UNRELATED DIVERSIFICATION
PRODUCTION BASED DIVERSIFICATION
TECHNOLOGY BASED DIVERSIFICATION
COMPLEX DIVERSIFICATION

**SEOUL CENTER FOR FINANCE AND INNOVATION WEBSITE:**
**http://www.worldbank.org/seoulcenter**



SEOUL CENTER FOR FINANCE AND INNOVATION

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP
East Asia & Pacific