THE PROSPERITY GAMBIT

OVERCOMING MIDDLE-INCOME TRAP WITH INNOVATION AND PRODUCTIVITY

The Asian Productivity Organization (APO) is an intergovernmental organization that promotes productivity as a key enabler for socioeconomic development and organizational and enterprise growth. It promotes productivity improvement tools, techniques, and methodologies; supports the National Productivity Organizations of its members; conducts research on productivity trends; and disseminates productivity information, analyses, and data. The APO was established in 1961 and comprises 21 members.

APO Members
Bangladesh, Cambodia, ROC, Fiji, Hong Kong, India, Indonesia, Islamic Republic of Iran, Japan, ROK, Lao PDR, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Turkiye, and Vietnam.

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FOREWORD

After decades of rapid economic growth, many APO members have moved away from the intensive resource-use, low-income category and achieved middle-income ranking. However, passing the low-income threshold is not enough to guarantee economic convergence or transition to the high-income level. The major new challenge is to sustain the pace of high growth and avoid prolonged slowdowns. Identifying new drivers to tackle the diminishing advantage of low-cost labor and declining contribution of total factor productivity to overall GDP growth is imperative for APO members.

Innovation has proven to be an important source of development which can complement capital accumulation in the long run to spur economic growth. Fostering innovation and industrial catch-up is one way for APO members to boost their productivity performance. Specifically, scaling up technological capabilities for higher value-added economic activities and increasing absorptive capacity offer solutions to avoiding the middle-income trap. Pursuing innovation for productivity enhancement is emphasized in the APO Vision 2025.

This research analyzes the specific bottlenecks that each participating middle-income APO member is facing. While their challenges vary from human capital for innovation to trade and FDI-embodied innovation, the commonalities highlighted involve the role of policies to support innovation in country-specific contexts. The findings also confirmed the role of innovation in productivity improvement in the middle-income APO members covered in this research.

The APO hopes that the results of "The Prosperity Gambit: Overcoming Middle-income Trap with Innovation and Productivity" will be useful for researchers and policymakers in leveraging innovation to enhance productivity performance and avoid the middle-income trap. The efforts of the team of experts who contributed to this publication are very much appreciated.

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INTRODUCTION

Drawing upon 60 years of engagement in enhancing productivity in the Asia Pacific region, the Asian Productivity Organization (APO) launched its APO Vision 2025. Vision 2025 highlights "Inclusive, innovation-led productivity growth in the Asia-Pacific". The priorities outlined in the vision document include several broad focus areas, among which are leveraging innovation, advanced technologies, and digitalization. These important components are the drivers of productivity.

As part of the effort to achieve the goals outlined in the Vision document and taking into consideration the different levels of development, situations, and needs for innovation, the APO initiated a study to understand the specific issues faced by its members economies. A group of experts were assigned to: (i) examine the bottlenecks in the economic growth of middle-income APO member economies; (ii) estimate the contribution of innovation to productivity and economic growth in middle-income economies (MIEs); (iii) review the effectiveness of innovation- and productivity-related policies; and (iv) draw implications for middle-income trap avoidance.

The series of empirical working papers by the research team members outline the various challenges, ranging from human capital, trade to FDI-embodied innovation. The findings highlight the supporting role of policies to enable conducive environment and conditions to boost business dynamism. The conclusion also confirms the role of innovation in long-term productivity improvement in the middle-income APO members covered in this research.

This publication, consisting of five working papers, is put together by researchers from participating member economies - India, Pakistan, Sri Lanka, Thailand, and Vietnam. Each paper, using econometric estimation, details the specific issues that impede innovation and productivity in the respective countries. The results are hoped to serve as implications and suggestions for effective productivity and innovation policymaking in relevant member economies.

CHAPTER 1

INDIA

ABSTRACT ON INDIA'S INNOVATION INPUTS AND FIRMS' PERFORMANCE

This research examines the relationship between India's innovation activities and productivity in the last 10 years, using secondary data and nation-wide innovation survey. It is observed that even if there is significant growth in innovation inputs and outputs in recent times, innovation activities in India are still much lower compared to its Asian peers. Though previous empirical literature on India did not find any significant productivity slowdown in recent years, low innovation inputs and outputs may pose a risk for the country to fall into the middle-income trap. To explore this further, researchers used data from India's corporate manufacturing firms for the period 2011–2020 from the CMIE-Prowess database. Findings show that firms that invest in innovation inputs are bigger in terms of output, asset, and pay higher wages to its employees, as opposed to those that do not. Firms' production function estimates show a positive association between output and value added and investments in various innovation inputs, such as R&D and ICT. The results imply that in India's "Decade of Innovation" (2011–20), corporate manufacturing firms that invested in innovation inputs were also able to sustain total factor productivity (TFP) growth.

INTRODUCTION

Economic development and policy literature consider technological advancements and innovation are the driving forces behind better economic performance of a country. They are also the necessary ingredients to "catch up" with high-income countries, especially for economies that have attained middle-income status for a period of time. Economists who first coined the term "middle-income trap" or MIT[1] postulate that most of the economies in Latin America and Middle East are squeezed between low-wage poor-country competitors that dominate in mature industries and the rich-country innovators that dominate in industries undergoing rapid technological transformation [1]. Economists from international organizations[2] as well as academic researchers discussed MIT in great length, providing various working definition and evidence [2–3][3], reasons and policy solutions [4–5]. Using regression and standard growth accounting techniques, it shows that almost 85% of the GDP per capita slowdown in these countries can be explained by TFP growth slowdown [6]. Though MIT literature is divided on the underlying causes of the slowdown, the commonality on lack of technological advancement and innovation appear in almost every article as one of the possible reasons behind this. Agénor [5] pointed out that it is often not quantity, but poor quality of the production inputs (infrastructure, human capital,

1 The concept of MIT is based on an empirical observation that a large number of countries that managed to move up from low-income to middle-income economies in relatively shorter period of time are yet to cross the middle-income threshold though a longer time period has passed.

2 E.g., International Monetary Fund (IMF), World Bank, and Asian Development Bank (ADB).

3 These two authors discussed the multitude of interpretation of the MIT concept based on different criteria found in the literature: descriptive, absolute income thresholds, relative income threshold, time threshold, and index based. Accordingly, India is in MIT, according to two criteria-fixed income criterion of USD5,000–USD10,000 per capita (PPP) and relative income criterion where the benchmark economy is the USA.

etc.) that trap the economies in the middle-income group for years and the fundamental reason for this is the lack of innovation activities. Also, productivity slowdown in OECD countries post-financial crisis rejuvenated the discussion on endogenous growth theories that suggests that any improvements in productivity can be tied directly to faster innovation and more investments in technology and human capital.

Trade liberalization and economic reforms helped India to achieve the path of high growth, high productivity in the last three decades[4]. Although ILO's labor productivity (LP) estimates place India at the bottom among its many Asian peers, domestically, it shows a rising trend in the same time period. Further, the Asian Productivity Organization's (APO) estimates show that India consistently improved its TFP compared to its many Asian peers (Figure 1.2 in Appendix). There is also, there is a large number of academic articles that analyses historical trend of LP and TFP in India using divergent dataset and methodologies. A number of articles estimated productivity of the organized or formal manufacturing sector [7–15] while a few researches were based on data from informal sector [16–17]. Economy-wide productivity estimates were also common [18–22]. These articles consistently highlight productivity growth in the last three decades. Most recent year-on-year growth estimates of economy-wide as well as sector-wise LP and TFP can be found in the KLEMS-India database [23]. This database does not indicate any significant slowdown of productivity growth (Appendix 1). Though a slowdown in India's GDP growth is observed in recent years (Appendix 2), it is perhaps not a result of productivity slowdown as generally argued by the exponents of MIT [24].

It is noteworthy that during the period of high growth and productivity, India also experienced a significant rise in innovation activities as a result of imported technologies and R&D activities by the private sector [25][5]. Rising innovation outcome is also visible in the intellectual property rights (IPR) application and grant data reported by India in recent times (see section on India's Innovation Scenario and Policy Framework). The government designated 2011–2020 as the "Decade of Innovation" with the objective to position the country to be among the top five global scientific powers by 2020[6]. Apart from fiscal incentives to the private sector's R&D and budgetary support to public research organizations, successive governments have tried to boost innovation by making required changes in the IPR laws, bringing new science, technology, and innovation policies (STIPs), connecting technology into entrepreneurship policies or similar efforts. Despite all efforts and reasonable growth in the innovation activities, India's innovation input and output are still low compared to its Asian peers (see section on India's Innovation Scenario and Policy Framework).

With this backdrop, this study attempts to evaluate India's "Decade of Innovation" by examining its various innovation activities, outcomes, and policy framework in last 10 years. This research also examines the investments made by Indian corporate manufacturing firms in innovation in the last decade and their impact on productivity. The section on Literature Review deliberates on existing research on the correlation between innovation inputs, innovation outcomes, and productivity with a special focus on the empirical studies on India. With the help of academic literature, policy documents, published data, and national innovation survey conducted by the Department of Science and Technology (DST) in 2010–11, the section on India's Innovation Scenario and Policy Framework briefly describes India's innovation scenario and policy framework to boost innovation activities in the post-reform period. The section on Empirical Strategy, Data, and Variables briefly outlines the empirical strategy, variables, and data used to analyse the innovation inputs and productivity correlations of the

4 Most commonly used productivity indicators are labor productivity or LP (output per worker) and total factor productivity or TFP (measure of the output of an industry or economy in excess of all of its primary factor inputs).

5 Innovation activities are synonymous with innovation inputs: R&D, ICT, organizational and marketing practices, etc. Innovation outcome, on the other hand, includes new product, process, IPR, etc.

6 The President of India in her address to the Parliament on 4 June 2009 mentioned the "Decade of Innovations" for the first time. India's Prime Minister, in the 97th Session of Indian Science Congress held on 3 January 2010 at Thiruvananthapuram, Kerala, also mentioned in his speech that the government has declared 2010–2020 as the "Decade of Innovations" [26].

formal manufacturing firms in India. The Results and Discussion segment reviews the results obtained from the empirical analysis. Conclusion and Limitations segment concludes and discusses the limitations of the analysis.

LITERATURE REVIEW

According to Schumpeter [27], the process of technological change in a free market consists of three parts: (i) invention or conceiving a new idea or process; (ii) innovation or implementation of an invention in economic terms, and (iii) diffusion or adoption and/or imitation by the people. Therefore, it is observed that the public and private firms play the most crucial role for the process of technological change to succeed. Innovation can be both technological (resulting in new products or processes) and non-technological (resulting in organizational changes and/or new managerial/business practices) [28–29]. Endogenous growth theories [30–31] and augmented Solow growth model [32] establish strong relationship between knowledge capital (technology and innovation) and TFP. Extant literature also finds positive empirical relationship between innovation and TFP in developed and developing countries[7] [29, 33–34]. Most of these studies use National Innovation Survey data and CDM model [35] which is the workhorse model for examining causal relationship between innovation inputs, such as R&D or ICT use, innovation outputs (self-reported product, process, marketing, and organizational innovation undertaken by firms), and productivity. Following Brynjolfsson and Hitt's analysis [36], a stand-alone literature, has also emerged that examines the importance of ICT adoption for organizational innovation and its effects on firms' performance[8] [37]. A growing literature thus examines the relative importance of or complementarity between ICT and the R&D employed by them [38–41][9]. These researches find that ICT investment, not only through innovation, made an important direct impact on productivity of the service sector. While R&D is more important for innovation, ICT is vital for productivity enhancement. In fact, Aboal and Tacsir [38] observe that firms in developing countries often rely on the incremental innovation in the form of ICT, disembodied technology (imported technical know-how), improved managerial practices, etc., instead of taking up prohibitively expensive R&D activities.

In the Indian context, the absence of nation-wide innovation survey makes it harder to establish a causal relationship between innovation inputs, outputs, and productivity as innovation output is not reported in the available firm-level databases. Therefore, the majority of the empirical literature examines the relationship between innovation inputs (R&D, ICT, or imported technologies) and LP or TFP in Indian manufacturing firms. Using firm-level data, a number of researchers [42–46] find that foreign technology purchase (both embodied and disembodied) improves the productivity of manufacturing firms in India[10] . The impact of R&D and ICT investments on productivity, examined by Khanna and Sharma [47–48], find complementarity effect for both types of investments. Positive association between R&D investments and productivity for the pharmaceutical sectors is found by Sharma [49] while positive relationship between ICT investments, infrastructure, and manufacturing productivity is concluded by Mitra, Sharma, and Véganzonès-Varoudakis [50].

A few recent studies examine innovation output-productivity relationship either by using firm-level primary survey data [51] or 2014 World Bank Enterprise Survey data for India which reports firms' innovation outputs [52–53], or by using firm-level patent information [54–55] or economy-wide innovation outputs, such as patent counts, scientific publication, etc. [56]. While a primary survey on a

7 [29, 33–34] on the survey of this literature.

8 [37] on review of the empirical literature on ICT and productivity.

9 All these studies use CIS data and CDM model.

10 Technology is embodied in the purchase of imported capital goods whereas royalties, technical fees, and licensing fees are indicator of disembodied technology import.

number of firms by Kale and Rath [51] shows that innovation has a positive impact on productivity in the Indian manufacturing sector and firms engaged in innovation activities are more productive than non-innovative firms. Another paper that examines India's firm-level innovation and productivity [53] find that while product and process innovation do not impact productivity separately, it has a positive effect when used together. Bhattacharya and Rath [52] find the relationship between innovation and LP is weak for Indian firms and further, they are mostly driven by large firms. Both these studies use World Bank enterprise survey data for the year 2014. Ambrammal and Sharma [55] use patent data reported by the Controller General of Design, Trademark, and Patent for 489 firms and show that patenting has positive effect on productivity, profitability, and Tobin's q (ratio of market value of equity and debt to total asset). However, R&D does not have any significant effect on productivity. In essence, mixed results are seen in both innovation inputs and outputs. It should be noted that studies on innovation outputs are mostly concentrated on IP rights and have much weaker results as opposed to studies on innovation inputs, such as R&D or ICT.

Innovation policy plays an important role in the public policy discourse in recent decades. There are different perspectives on innovation. For example, from discovery/invention to the diffusion of the relevant new products as well as the objectives of innovation policies. In post-World War II, the most important theoretical rationale for innovation policies was "market failure" [57][11]. Many "mission-oriented" and "invention-oriented" innovation policies, such as public production of knowledge, subsidizing or incentivising private R&D through tax credit, IPR protection, etc., stem from the market failure rationale which is still a dominant perspective in many countries, including India. After the 1980s, "innovation system-oriented" policies, such as the National Innovation System (NIS) approach gives more emphasis on network or interconnectedness among relevant institutions more than science and technology [58]. Edler, Gök, Cunningham, and Shapira [59] develop a typology of innovation policy instruments based on their comprehensive study of existing evidences. Policy instruments are distinguished based on whether they cater to demand or supply side of innovation activities. They discuss that most developing countries focus excessively on the small set of supply-side instruments, such as high public expenditure on R&D, fiscal incentives to private firms, skill, and entrepreneurship policies, but ignore the demand-side innovation efforts, such as facilitating private demand for innovative products or public procurement demand for innovative products.

Only a few studies evaluate innovation related policies in India. Researchers such as Ambrammal, Sharma, and others [55, 60–61] examine the IPR policy change (introduction of product patent in India in 2004) and its impact on firms' patenting activities and productivity, respectively. Using R&D and patent count information of 554 high and medium technology firms, a study [55] finds that patent policy changes introduced in India influenced the innovation activities in the manufacturing sector, and foreign firms benefitted more than domestic firms. However, it also noted that in-house R&D does not impact the patenting behaviour of these firms. Using IPR policy change as a natural experiment, Kanwar and Sperlich [61] examine causal relationship between IP intensity, R&D intensity, and technical efficiency and productivity of Indian corporate manufacturing firms. Applying difference in differences (DID) method, they find that IPR policy reform had an impact on technical efficiency but not on productivity. Ivus, Hose, and Sharma [62] examine the change in R&D tax credit norms in 2010–11 (extension and increase in percentage) and its impact on Indian firms' R&D activities using similar methodology. They find a sharp increase in their R&D expenditures, R&D intensity, and the number of patent applications filed at the Indian patent office following registration at the Department of Science and Industrial Research (DSIR) to avail to the tax credit in the post-policy change period.

[11] Knowledge, being a public good requires incentives to invest which might be much lower than what is socially optimal if left to the market forces.

INDIA'S INNOVATION SCENARIO AND POLICY FRAMEWORK

India's innovation scenario has improved substantially in recent years due to sustained R&D activities and rise in innovation outputs, such as patents, trademarks, and others. However, when compared to several Asian middle-and high-income countries, India fares poorly. Table 1.1 reports data on India to five Asian economies and middle- and high-income country averages on a few innovation input and output indicators.

TABLE 1.1

COMPARATIVE ANALYSIS OF INDIA'S INNOVATION SCENARIO

Global Innovation Index Ranking									
Year	**India**	**PR China**	**Japan**	**Malaysia**	**Singapore**	**ROK**			
2011	62	29	20	31	3	16			
2015	81	29	19	32	7	14			
2018	57	10	13	35	5	12			
2021	46	12	13	36	8	5			
Total Patents (by Filling Office)									
Year	**India**	**PR China**	**Japan**	**Malaysia**	**Singapore**	**ROK**	**Middle-income Countries**	**High-income Countries**	
2010	39,762	391,177	344,598	6,383	9,773	170,101	593,800	1,393,900	
2015	45,658	1,101,864	318,721	7,727	10,814	213,694	1,336,700	1,539,500	
2018	50,055	1,542,002	313,567	7,295	11,845	209,992	1,767,700	1,555,500	
Researchers in R&D (per million people)									
Year	**India**	**PR China**	**Japan**	**Malaysia**	**Singapore**	**ROK**	**Middle-income Countries**	**High-income Countries**	**World**
2010	156.22	884.59	5,103.63	1,462.47	6,241.86	5,330.80	652.39	3,830.29	1,282.50
2015	216.00	1,150.82	5,173.03	2,307.95	7,006.63	7,013.49	740.67	4,174.39	1,410.89
2018	252.70	1,307.12	5,331.15	2,184.72		7,980.40			
R&D as Percentage of GDP									
Year	**India**	**PR China**	**Japan**	**Malaysia**	**Singapore**	**ROK**	**Middle-income Countries**	**High-income Countries**	**World**
2010	0.79	1.71	3.14	1.04	1.93	3.32	1.12	2.39	2.02
2015	0.69	2.06	3.28	1.28	2.18	3.98	1.36	2.46	2.09
2018	0.65	2.14	3.28	1.04		4.53	1.46	2.59	2.20

Source: WIPO, World Development Indicators (WDI).

Global Innovation Index (GII) prepared by the World Intellectual Property Organization (WIPO), Cornell University, and INSEAD shows that India's rank improved post 2015 and is at 46 among 132 countries. India's current ranking in R&D output is 35 and ICT infrastructure at 86. Comparatively, India ranks first among central and southern Asian countries and second among the lower middle-income countries after Vietnam. In considering innovation outputs, such as patent applications, India is far behind compared to its peers and few other high-income economies. For example, PR China's patent application, skyrocketed between 2010 and 2018, as reported in Table 1.1. In fact, taking the total export and import of royalties, copyright, and license fees as markers for India's innovation output status, the data indicates that the country is a net importer of IP, as import is growing at a much faster rate than exports in recent years (Appendix 3).

Table 1.1 also reports innovation inputs, such as R&D researchers (per million people) and R&D expenditure as percentage of GDP, which shows India lags behind its peers. In terms of R&D researchers per million population, India is one of the lowest in count (252.7) compared to its Asian neighbours and other developed countries (1,307.1 in PR China, 7,980.4 in the Republic of Korea (ROK), and 5,331.1 in Japan in 2018). Compared to the same countries, India also performs poorly in the growth of R&D expenditure per GDP. It is not only the lowest among the economies, it is also much lower than middle-income country average. More alarming is the fact that there is a divergence in R&D expenditure (as a share of GDP) between India and global trend. While the global trend slopes upward, India's R&D share is going down, even though R&D expenditure is increasing in absolute terms.

Onward, Table 1.2 shows R&D expenditure in India by source of funds. The government's share in total R&D expenditure is still surprisingly very high in India.

TABLE 1.2

INDIA'S R&D EXPENDITURE BY SOURCE OF FUNDS

Year	Private	Public
2001–02	19	81
2004–05	25	75
2010–11	32.1	67.9
2017–18	36.8	63.2

Source: R&D Statistics 2019–2020, DST.

TABLE 1.3

PERCENTAGE SHARE OF R&D EXPENDITURE BY MAJOR PUBLIC AGENCIES (2017–18)

Scientific Agency	Percentage (%)
Defence Research & Development Organisation (DRDO)	31.6
Department of Space (DOS)	19
Indian Council of Agricultural Research (ICAR)	11.1
Department of Atomic Energy (DAE)	10.8
Council of Scientific & Industrial Research (CSIR)	9.5
Department of Science & Technology (DST)	7.3
Department of Biotechnology (DBT)	3.7
Indian Council of Medical Research (ICMR)	3.1
Ministry of Earth Sciences (MES)	2.3
Ministry of Electronics and Information Technology (MEITY)	0.8
Ministry of Environment, Forest and Climate Change (MoEFCC)	0.5
Ministry of New and Renewable Energy (MNRE)	0.1

Source: R&D Statistics 2019–2020, DST.

However, the overall trend shows that it is constantly decreasing with time. A close scrutiny shows that most of the government expenditure in R&D is concentrated in defence (31.6%), space research (19%), agriculture-related research (11.1%), and atomic energy research (10.8%) (Table 1.3). The DST surveys a large number of private-sector units with in-house R&D facilities. In their 2017–18 survey, 2,077 firms responded out of 4,043 firms contacted[12]. The survey showed that three leading industrial sectors by expenditure on R&D were drugs and pharmaceuticals, transportation, and information technology, respectively. This is in contrast with the industrial firms in the public sector where the largest expenditures are incurred in defence, fuels, and industrial machinery, respectively.

Though industrial firms are the driving force of innovation and diffusion activities, and it is important to look into the "black box" of these firms, information on the Indian firms' innovation outputs are rarely available in public domain. To date, India has not conducted any community innovation surveys compared to European and Latin American countries that carry out regularly. The only existing nation-wide firm-level survey was conducted in 2011 by the DST[13]. DST defined innovation as the "application of new knowledge in the production system, and realization of the benefit of the new application from the market". Therefore, innovation here is market oriented and should represent novelty or newness. The changes brought through innovation can be incremental or depend significantly on whether they are only new to the firm, new to the market, or new in India or the world. The survey built a conceptual framework where both technological (R&D, know-how) and non-technological (organizational, marketing) aspects of innovation activities are taken into consideration, along with ICT infrastructure and human resource development (Appendix 3).

TABLE 1.4

CHARACTERISTICS OF INNOVATIVE FIRMS

Size		Age		Ownership		Sectors	
Category	Innovative Firms (%)	Category	Innovative Firms (%)	Category	Innovative Firms (%)	Product Category	Innovative Firms (%)
Workforce below 100	86	Started before 1990s	~ 34	Proprietary	~ 19	Food	12
Workforce between 100–499	11	Started between 1990–2000	~ 34	Partnership	~ 20	Rubber and plastic	10
Workforce between 500–1,000	2	Started after 2000	~ 31	Private limited	~ 48	Fabricated metal	8
Workforce above 1,000	0.72			Public limited	~ 10	Non metallic mineral	8
				Other	~ 3	Basic metals	7

Source: Author's summary of the National Innovation Survey Report, DST, India, 2014.

A subsample of 9,001 out of 208,415 firms was surveyed across 26 states and five Union Territories of India based on the Annual Survey of Industries (ASI) 2009–10 database[14]. Unfortunately, unit-level information of the survey is not available in the public domain. In Tables 1.4–1. 6, some of the important characteristics of the innovative firms, innovation inputs and outputs, and details of technology acquisition reported by the surveyed firms are summarized from the final report published by DST [26]. The surveys reveal the characteristics of innovative firms in India. A total of 3,184 firms (35.37%) have

12 Majority of the firms responded are either in-house R&D units or Scientific and Industrial Research Organisations (SIROs)-recognized by DSIR, as mentioned in the literature review section.

13 A similar survey of big, manufacturing firms will be conducted in 2021 by DST with collaboration with UNIDO. See http://www.nstmis-dst.org/NMIS/index.html for more details.

14 ASI is the sample survey of organized manufacturing sector firms and consists of plant-level data.

been identified as innovative firms in 35 sectors. The survey shows that innovative firms are predominantly small (up to 100 employees), age neutral, privately owned, and are concentrated in food, rubber & plastics, fabricated metal product, non-metallic mineral products, and basic metal sectors. Most of the innovations undertaken are in the category "new to the firm" (57%), mostly to deal with market competition. Only 9% of the innovations were new to India while 4% were new to the world.

The National Innovation Survey Report is detailed in Appendix 4. In terms of nature of innovation, non-technological innovation is higher (59.9%) than technological innovation (40.1%). Predominant technological innovation reported is the acquisition of new machines, predominantly through technology licensing rather than product or process innovation through R&D. Marketing innovation (in the form of newer packaging of goods) dominates non-technological innovators in the sample. One interesting finding is that 63.3% of the innovative firms do not spend any money on R&D. A comparison with the rest of the world shows that in terms of firm-level intra and extra mural R&D, India is lagging behind many OECD countries as well as PR China and South Africa. Also, firms with R&D setup reports more novelty in innovation compared to non-R&D innovators.

TABLE 1.5

TYPES OF INNOVATION INPUTS AND OUTPUTS

Innovation Outputs (Type)	Innovative Firms (%)	Innovation Inputs (Type)	Innovative Firms (%)
Technological Innovation (40.1%)		Intramural R&D	35.05
Product innovation	32.73	Extramural R&D	11.43
Process innovation	34.61	Acquisition of technology (machines)	67.02
Product quality and standard	42.37	Acquisition of other external knowledge	16.36
Saving/efficient use of inputs	25.5	Training	39.20
Alternative material	14.32		
New machines	67.96		
Other	3.64		
Non-technological innovation (59.9%)			
Organizational innovation	43.09		
Marketing innovation	46.48		

Source: Author's summary of the National Innovation Survey Report, DST, India, 2014.

TABLE 1.6

DETAILS OF TECHNOLOGY ACQUISITION

Indicators	Innovative Firms (%)	
Type of acquired technology	Patented technology Know-how Trade secret	3.6 1.4 <1
Source of acquired technology	Acquired from domestic market Acquired through collaboration Acquired from foreign market	Approx. 13 4–5 ~ 4
Mode of acquired technology	Purchased Licensed Borrowed	15 9 1

Source: Author's own summary of the National Innovation Survey Report, DST, India, 2014.

Around 80% of the innovations are sourced internally whereas 37% were acquired externally. Two major barriers that firms face are high costs associated with innovation (cost factor, 39%) and unavailability of skilled manpower and knowledge on technology (knowledge factor, 40%). 21% of the innovative firms also reported lack of infrastructure as the biggest impediment toward innovation.

Therefore, the 2014 National Innovation Survey report reveals that not only overall innovation output is low in the firms surveyed (one third of the firms reported innovation), innovation activities or inputs, such as R&D activities, acquisition of patented technologies, and ICT use in new product development which are necessary ingredients for novel and successful innovation are also quite low compared to many other countries. However, since the completion of the survey in 2011, the innovation activities may have undergone many changes. The next section examines the efforts made by firms using firm-level data on innovation inputs and other economic performance variables.

India's innovation policy framework is also a necessary catalyst in its growth. The government has remained the largest stakeholder in the innovation landscape in India right from the beginning and as shown by the data, public R&D activities always surpasses private initiatives. Scientific Policy Resolution, 1958 (SPR1958), Technology Policy Statement (TPS) 1983, Science and Technology Policy Statement 2003 (STP2003), and Science and Technology and Innovation Policy Statement 2013 (STIP2013) have guided the evolution of India's broad science and technology policy framework. In the 1980s, India had already developed advanced scientific and technological infrastructure in the areas of space, industrial research, nuclear energy, defence research, biotechnology, agriculture, and health [63]. Economic reform and globalization put India on an upward trajectory of growth and openness. Though, accessibility of foreign technology was higher, businesses also felt the need to increase R&D activities to be able to compete globally. The period following STP2003 is characterized by a significant rise in R&D investment (both public and private), increase in research, publication, and institutional capacity [64].

In the "Decade of Innovation", one of the most important agenda was to create the NIS. STIP2013, in its efforts to position India to be in the top five global scientific powers, advocated public-private partnership in building the STI ecosystem in the country and also sharing the gain with all stakeholders of the society (inclusive innovation). The government of India also announced an umbrella policy for IPR in 2016 [65]. The objective of the policy was to consider all interlinkages and create and exploit synergies between all forms of IP, relevant statutes, and agencies. Emphasis was given on awareness and generation of IP, improvement in the administrative and legal framework, commercialization of IP, enforcement and adjudication, and human development. Abroal [66] criticized the policy for promoting IP rights as private and maximal, without giving due consideration to its social contract.

Two major policy initiatives by the government during this period were expansion of its fiscal incentives to the industrial R&D as well as funding and mentoring innovation-led entrepreneurship program. The R&D tax credit scheme was first introduced in 1999–2000. During the 2001–10 period, it offered a weighted tax deductions of 150% for any capital and revenue expenditure incurred on in-house R&D by firms in select sectors. In the fiscal year 2010–11, the country's R&D tax deduction was increased to 200% and eligibility was extended to firms in all sectors which is one of the most generous fiscal incentives available in the world[15]. Firms' R&D expenditures, R&D intensity, and the number of patent applications show a sharp increase in the post-policy change period [62]. In 2016, the government introduced the "Start-up India" program to foster the culture of entrepreneurship in India. The program aimed at providing funding and mentoring support and facilitating procurement for the new entrepreneurs. A critical analysis [67] evaluated the program with available data and observed that the networking, training, and mentoring facilities provided by the Startup India hub along with the entrepreneurship outreach campaigns in tier 2 and tier 3 cities managed to reduce regional disparities in entrepreneurship.

15 Starting in 2020–21, the tax deduction is reduced to 100% of R&D expenditure.

However, fund allocation was far below the target. Four years after its launch, the scheme had committed merely 31% of its total announced corpus and provided financial support to only 1.1% (merely 320 out of 28,979) of all the start-ups recognized by Start-up India. The policy also did not address the issue of underrepresentation of female and minority entrepreneurs from Scheduled Castes (SCs) and Scheduled Tribes (STs) in the Indian entrepreneurial ecosystem. In 2015, Atal Innovation Mission (AIM) along with Self Employment and Talent Utilisation (SETU) were initiated as one of the flagship programs of the government of India which aimed at promoting innovation-led entrepreneurship though interventions at schools, universities, research institutions, MSME, and industry levels. It provides incubation programs, research support activities, mentoring, etc. The program is extended till 2023.

EMPIRICAL STRATEGY, DATA, AND VARIABLES

The estimation of production function is to assess the impact of innovation activities which is engulfed in various methodological issues. One important problem identified by Griliches and Maitresse [68] is the transmission bias when observed inputs may be correlated with the unobserved productivity shock which results in biased and inconsistent ordinary least square (OLS) estimates[16]. There are two methods that have evolved over the years to address this problem: control function approach [69–71][17] and dynamic panel data generalized method of moments (GMM) approach [72–73] that essentially extends the fixed effects literature to allow for more sophisticated error structures [71].

The production function using dynamic panel data model is estimated at the following form:

$$y_{it} = c + \pi_1 l_{it} + \pi_2 k_{it} + \pi_3 rawmater_{it} + \pi_4 RD_{it} + \pi_5 ICT_{it} + \pi_6 TI_{it} + \omega_{it} + \varepsilon_{it}$$

Where y_{it} is real output or real value added and ω_{it} is the unobserved productivity shock which follows an AR (1) process, such as:

$$\omega_{it} = \rho\omega_{it-1} + \xi_{it}$$

Dynamic panel production function estimation assume that ε_{it} is i.i.d. over time and uncorrelated with input choices, and that ω_{it} is correlated with k and l in time t, but that ξ_{it} is uncorrelated with all input choices prior to t [71]. This model uses lag explanatory variables as instruments for identification.

The variables of interest here are investments in innovation input: R&D, ICT and technology imports (IPR fees and investment in imported capital goods). The source of data is Centre for Monitoring Indian Economy (CMIE) Prowess database for the year 2010–11 to 2019–20. Prowess database is the most exhaustive corporate database available in India and it consists of the financial performance of Indian incorporated firms[18]. Prowess claims to have information on all listed firms and a larger set of unlisted firms which is built from the audited annual reports and information submitted to the Ministry of Company Affairs (MCA). Apart from the financial performance indicators, the database also includes firm filings with stock exchanges and prices of securities listed on the major stock exchanges for the listed firms. The data used for manufacturing firms are only for the author's analysis. Data on Wholesale

16 Fixed effect estimation with panel data may provide consistent estimation if researchers have strong reasons to believe that firm specific unobserved productivity shocks are fixed over time.

17 Olley and Pakes as well as Levinsohn and Petrin [69–70] offered a solution to the endogeneity problem by introducing an investment demand function or input demand function, respectively, to control for the unobserved time-varying productivity shocks in a control function framework. Ackerberg, Caves and Frazer [71] criticized as Levinsohn and Petrin's [70] model's first stage identification and provided an alternative solution where all the inputs (including labor) are identified in the second stage regression. See [71] for a detailed comparison of both approaches.

18 https://prowessiq.cmie.com/.

Price Index (WPI) is taken from the Office of Economic Advisor, Department of Industry and Internal Trade (DPIIT), data on Consumer Price Index for Industrial Workers (CPI-IW) is taken from the Labour Bureau, Ministry of Labour and Employment, and data on Capital goods index (gross capital formation or GCF in current and constant prices) are taken from the National Statistical Office.

The list of variables and details of their construction is provided below:

Output (Y): Prowess does not provide output data. Therefore, the author has added change in stocks or inventory to sales of goods by firms and subtracted purchase of finished goods to arrive at the value of output figure. This value of output is then deflated by the WPI at the appropriate product level. The 2004–05 price series are used for this purpose.

Raw Material (M): The raw material expenses include the value of raw materials, power, and fuel consumption. The nominal value of the raw material cost was deflated using WPI.

Value Added (VA): Value added is defined as the difference between the value of output of a firm and input expenses. Following De and Nagaraj [74], the raw material, power and fuel, packaging and distribution expenses are deducted from the output to arrive at the VA figure.

Labor Input (L): Data on number of employees is not available in Prowess for the majority of the firms. Instead, it provides compensation to employees that includes cash and in-kind offers made by a firm. The nominal values of compensation to employees reported are then deflated by CPI-IW at 2004–05 prices. As mentioned by Sivadasan [75], one of the drawbacks of this measure is that there can be a potential bias in the estimate if the workers share the productivity benefits. Another alternative measurement used by many authors is to divide the total compensation to employees by the average wage rate computed from total emolument at the two/three-digit industry level[19] [76]. This method was also employed as an alternative measure of labor on the basis of available information on number of employees from Prowess. First, the information on salaries and wages and number of employees (average) over NIC 2-digit level is extracted and the average salaries for the relevant industries are calculated. Then the information is used to calculate firm-level labor (firm-level salaries/industry wage).

Capital Stock (K): The capital input is taken as net fixed assets (NFA) which is the difference between gross fixed asset and cumulative depreciation. The real capital stocks were obtained by deflating NFA by capital good price index (at 2011–12 prices). In the author's alternative specification, the revaluation factor of capital is worked out following Balakrishnan, Pushpagadan, and Babu [77].

Innovation Inputs: The innovation inputs here are R&D investments, ICT investments, and technology imports by firms. Technology import contains both embodied (import of capital goods) and disembodied technology or imported technology expenditure in the form of technical know-how fees, license fees, royalties, etc. For ICT, all the expenditure related to computing and internet services are used. R&D expenditure is in accordance to the figures reported by firms. All the innovation input expenses are deflated by WPI indices.

RESULTS AND DISCUSSION

The objective of this level analysis is to examine the efforts firms have made (in terms of money spent) to acquire new technical knowledge and its effect on productivity. Though the study begins with a panel of 13,871 firms for a 10-year period, after removing the observation with missing data and

[19] See [76] for an assessment of this method.

negative/erroneous values of sales, output, and value-added, etc, an unbalanced panel of about 4,500 manufacturing firms were retained for the final analysis. Firms' innovation efforts were captured by four variables: R&D expense, investment in ICT, royalties and fees paid towards technical knowhow, and import of capital goods which embody technical knowledge acquired elsewhere. Figure 1.1 show the 10-year trend of firms' expense on innovation inputs. As seen that till 2016, firms spent most on the import of capital goods. But this trend changed in 2016–17 and in the last four years, most payments went toward license fees, royalties, etc. (IPR fees), followed by R&D expenses. ICT expenses remained comparatively low in all the years.

FIGURE 1.1

INNOVATION INPUT EXPENSES TREND

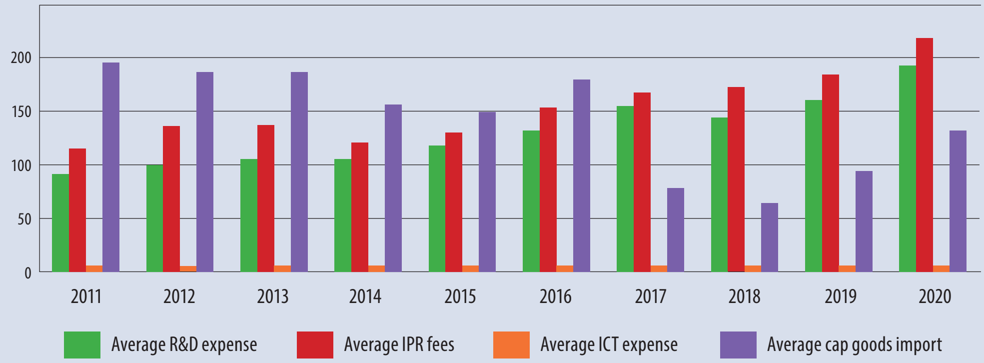
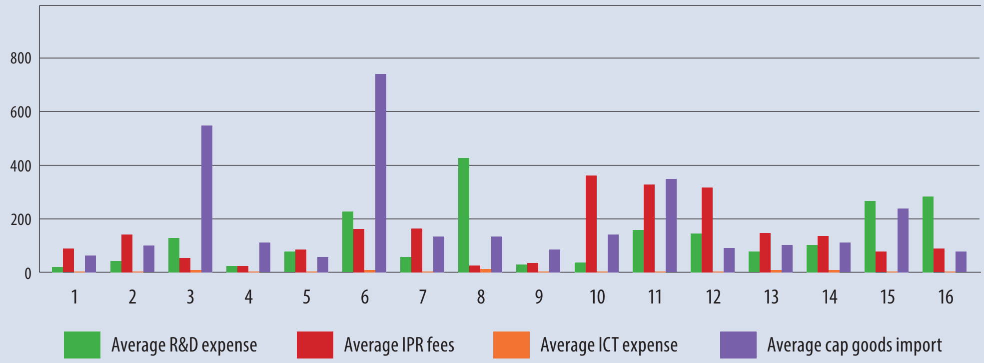


FIGURE 1.2

INNOVATION INPUTS BY SECTOR



Note: Industry sectors are 1. Food products; 2. Beverages; 3: Tobacco; 4. Textiles; 5. Apparel; 6. Leather, wood, paper, and refined petroleum; 7. Chemical products; 8. Pharmaceutical products; 9. Rubber and plastic products; 10. Nonmetallic mineral products; 11. Basic and fabricated metal products; 12. Electronic products; 13. Electrical products; 14. Machinery and equipment; 15. Furniture; 16. Miscellaneous.

Sector-wise innovation inputs are presented in Figure 1.2. The largest innovation input is embodied technology through import of capital goods in tobacco, leather, wood, paper, and petroleum. As expected, R&D expenditure is high in the pharmaceutical sector and maximum IPR fees are made by non-metallic mineral product firms. Last, but not the least, innovation inputs are higher in public limited firms than private limited and other types of firms available in Prowess database. The findings are consistent with the small-scale firm-based innovation survey results presented earlier. There is not much change in the in-house R&D expenditure incurred by the firms whereas licensing technology seems to be on the rise. However, it is also noteworthy that ICT related expenditure has remained a tiny fraction of all innovation expenditure in India. As to be explored later, approximately 40% of the firms in the sample have invested in some form of innovation inputs.

FIGURE 1.3

INNOVATION INPUTS BY TYPES OF ENTITIES

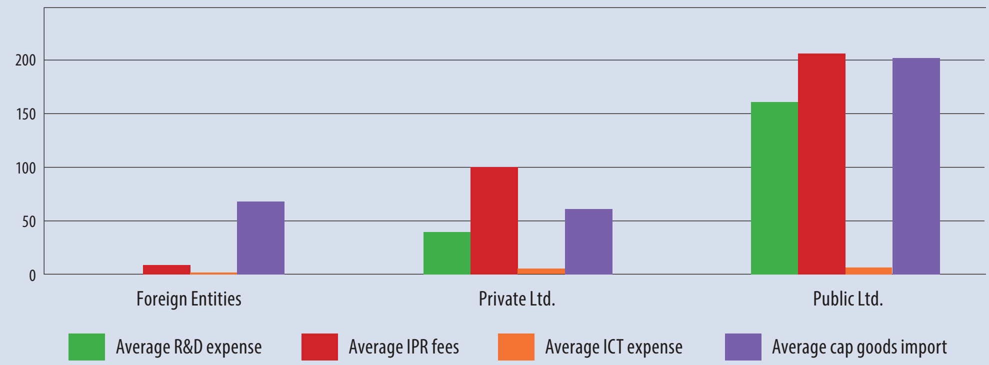


Figure 1.4 shows the trend of output and input expense. The most striking feature is the very low share of compensation to employees to the total input expense. Net fixed asset (gross fixed asset minus cumulative depreciation) is growing at a very fast rate in recent years.

FIGURE 1.4

VALUE OF OUTPUT AND INPUT EXPENSES TREND

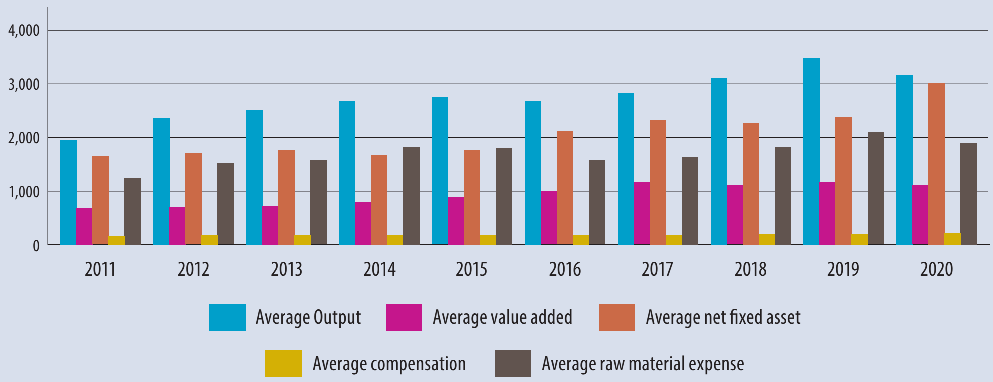


Table 1.7 shows the summary statistics of the variables considered for the analysis. Three sets of summary statistics are shown: for overall sample, for firms without any innovation input expenditure, and firms with innovation expenditure. It is clear that firms that make innovation expense are very different from the ones without. Average real output, value added, capital stock, wages/salaries, and raw material expenses are many times higher in the firms that make innovation-related expenditure compared to the firms that do not make such expenditures.

TABLE 1.7

DESCRIPTIVE STATISTICS

	Total Sample			Firms without Innovation Expense			Firms with Innovation Expense		
	count	mean	sd	count	mean	sd	count	mean	sd
Output	135,904	2,742.90	41,425.61	81,314	364.93	4,623.43	54,590	6,284.99	64,957.60
Value added	135,904	925.57	12,496.32	81,314	106.34	1,646.49	54,590	2,145.85	19,550.94
Raw material expense	135,904	1,718.21	29,397.78	81,314	247.09	3,146.16	54,590	3,909.51	46,138.79
Input expense	135,904	1,817.34	30,464.36	81,314	258.59	3,244.01	54,590	4,139.15	47,810.31
Salaries and wages	68,864	100.07	599.67	14,844	31.70	93.47	54,020	118.85	674.08
Compensation	69,228	119.91	794.87	15,048	36.68	108.17	54,180	143.03	895.32
Labor	68,863	2,223.74	13,305.88	14,844	976.21	3,048.19	54,019	2,566.56	14,919.78
Total asset	76,086	5,875.88	71,158.39	21,498	1,701.15	10,188.52	54,588	7,519.98	83,709.22
Gross fixed asset	72,887	3,012.29	38,809.80	18,714	1,064.66	8,348.11	54,173	3,685.09	44,729.06
Net fixed asset	70,653	2,068.71	24,926.39	17,146	794.60	5,990.09	53,507	2,476.99	28,429.64
Real revalued cap stock	70,652	4,023.97	52,661.42	17,146	1,348.78	11,922.00	53,506	4,881.24	60,111.14
Export	28,602	2,122.50	34,751.01	3,472	823.07	4,438.20	25,130	2,302.04	37,033.79
All innovation expenses	135,904	39.98	686.63	81,314	0.00	0.00	54,590	99.54	1,080.65
IPR fees	9,215	155.28	967.81	0	0.00	0.00	9,215	155.28	967.81
R&D expense	11,409	130.43	745.28	42	0.00	0.00	11,367	130.92	746.62
ICT expense	47,467	3.52	16.26	682	0.00	0.00	46,785	3.58	16.37
Cap goods import	15,568	150.80	1,559.59	199	0.00	0.00	15,369	152.75	1,569.56
Age	135,783	25.69	18.23	81209	25.78	18.62	54,574	25.55	17.62

Table 1.8 shows the results of the production function estimation with total innovation expenses made and the expenses separately. The production function is estimated using both real output and real value added. Column 1–4 are estimated using standard panel data model with firm and time fixed effects. As mentioned previously, to avoid endogeneity, the model is re-estimated again using a two-step system generalized method of moments (System-GMM) proposed by Arellano and Bover, and Blundell and Bond [72–73]. Many observations are lost in the model where individual innovation inputs are presented separately compared to the model where total innovation inputs used by the firms are applied. It is noteworthy that accounting for endogenous productivity shock (ω), the effects are much lower than the standard model in columns 5–8.

TABLE 1.8

ESTIMATION OF PRODUCTION FUNCTION

	(1) Real Output	(2) Real Value Added	(3) Real Output	(4) Real Value Added	(5) Real Output	(6) Real Value Added	(7) Real Output	(8) Real Value Added
Lag dependent					0.74***	0.63***	0.51***	0.52***
					(0.020)	(0.011)	(0.060)	(0.045)
Wage	0.29***	0.66***	0.23***	0.66***	0.20***	0.45***	0.22***	0.68***
	(0.012)	(0.017)	(0.045)	(0.063)	(0.006)	(0.011)	(0.022)	(0.046)
Net fixed asset	0.05***	0.17***	0.05***	0.12**	0.03***	0.09***	0.02	0.07**
	(0.006)	(0.012)	(0.013)	(0.037)	(0.004)	(0.009)	(0.013)	(0.027)
Raw material expense	0.52***		0.60***		0.51***		0.61***	
	(0.014)		(0.070)		(0.003)		(0.012)	
Innovation expense	0.02***	0.04***			0.00**	0.01***		
	(0.002)	(0.003)			(0.001)	(0.003)		
ICT expense			0.05**	0.11**			0.01	0.04
			(0.018)	(0.037)			(0.014)	(0.030)
R&D expense			0.03***	0.05***			0.02***	0.02
			(0.007)	(0.012)			(0.006)	(0.013)
Imported technology			0.01**	0.02*			-0.00	-0.00
			(0.003)	(0.010)			(0.003)	(0.006)
Observations	52595	52809	3684	3684	41825	41989	2442	2442
R^2	0.78	0.35	0.83	0.45				
Sargan stat					331.59	535.46	103.07	109.40
					(0.000)	(0.000)	(0.000)	(0.000)

Note: All variables are in log form. Therefore, coefficients represent elasticity. Firm and time fixed effects are included in first four equations along with robust standard errors (in parentheses). Last are equations are estimated using System-GMM proposed by Arellano, Bover, Blundell, and Bond [72–73]. GMM standard errors are reported in the parentheses. Sargan test examines whether overidentifying moment conditions are valid (H0).
* p < 0.05, ** p < 0.01, *** p < 0.001.

The production is re-estimated by using different definition of labor and capital stock, as mentioned previously, and the results are reported in Table 1.9. Qualitatively, the results are similar. Overall, innovation expenses have a positive and significant effect on output, though the effect is negligible (1%). The separate estimates show that imported technology has a negative and insignificant effect on output and real value added whereas ICT and R&D have positive effects (columns 7–8).

TABLE 1.9

ALTERNATIVE PRODUCTION FUNCTION ESTIMATES

	(1) Real Output	(2) Real Value Added	(3) Real Output	(4) Real Value Added	(5) Real Output	(6) Real Value Added	(7) Real Output	(8) Real Value Added
Lag dependent					0.77***	0.67***	0.48***	0.54***
					(0.020)	(0.011)	(0.058)	(0.049)
Labor	0.28***	0.66***	0.23***	0.67***	0.20***	0.46***	0.23***	0.63***
	(0.012)	(0.017)	(0.045)	(0.063)	(0.006)	(0.011)	(0.021)	(0.046)
Capital stock	0.06***	0.17***	0.05***	0.12**	0.02***	0.09***	0.02	0.09**
	(0.007)	(0.012)	(0.013)	(0.037)	(0.005)	(0.009)	(0.012)	(0.026)
Raw material expense	0.53***		0.60***		0.52***		0.60***	
	(0.015)		(0.070)		(0.003)		(0.012)	
Innovation expense	0.02***	0.04***			0.00**	0.01***		
	(0.002)	(0.003)			(0.001)	(0.003)		
ICT expense			0.05**	0.10**			0.01	0.06*
			(0.018)	(0.037)			(0.013)	(0.030)
R&D expense			0.03***	0.05***			0.02***	0.02
			(0.007)	(0.012)			(0.006)	(0.013)
Imported technology			0.01**	0.02*			-0.00	-0.00
			(0.003)	(0.010)			(0.003)	(0.006)
Observations	52056	52235	3681	3681	41423	41558	2441	2441
R^2	0.79	0.34	0.83	0.45				
Sargan stat					330.43	548.72	104.65	110.50
					(0.000)	(0.000)	(0.000)	(0.000)

Note: All variables are in log form. Therefore, coefficients represent elasticity. Firm and time fixed effects are included in first four equations along with robust standard errors (in parentheses). Last four equations are estimated using System-GMM proposed by [72-73]. GMM standard errors are reported in the parentheses. Sargan test examines whether overidentifying moment conditions are valid (H0).
* p < 0.05, ** p < 0.01, *** p < 0.001.

CONCLUSION AND LIMITATIONS

This paper examines the innovation scenario in India known as the decade of innovation. Though no serious productivity slowdown in India is observed until the strike of the COVID-19 pandemic, GDP growth was slowing down since the mid-2010s. Previous empirical literature, economy-wide data on various innovation inputs and outputs as well as the first firm-level innovation survey at the beginning of the decade provided some valuable insights. India's overall innovation activities and outputs are low compared to other emerging or developed economies in Asia or elsewhere. However, the positive sign is that both innovation activities (inputs) and outputs are rising in India over the years. India's innovation activities are mostly funded and initiated by the public sector (government) though this trend is changing over time. In the industrial sector, most of the innovation is concentrated in a few sectors and are driven mostly by technology licensing and import of capital goods. However, it is observed that this trend is changing in recent years, at least in large firms. The detailed analysis of the corporate firms' performance in the last decade reveals that innovation expenses incurred by firms had a positive impact on firms' output and value added. However, the impact is not very strong, and is mostly driven by ICT and R&D expenses, not by technology imports. Last but not the least, India's innovation policies rely heavily on government support to technology-driven entrepreneurship and fiscal incentives. Demand side policies, such as general or strategic procurement, demand subsidies (e.g., co-financing, etc.) which facilitate diffusion are not adopted widely.

One of the major limitations of this study is the exclusive use of manufacturing data. It is extensively discussed in the literature that though R&D and imported technology may be more valuable for manufacturing firms and technological innovation, ICT investments on the other hand, has stronger impact on non-technological innovations and productivity growth in the service sector. Since India's service sector is growing fast and the last decade was characterized by tremendous growth in ICT use by individuals and firms, the analysis is able to capture only one part of the story. There are also certain methodological limitations associated with R&D, ICT, and productivity analysis which are very common in the literature, but noteworthy. First, TFP measurement here is based on revenue deflated by the industry level price index. Therefore, the "true productivity" (physical productivity) effect at the firm level may differ from the "revenue productivity" effect if the firm-specific output and input prices differ from the industry-level deflator which may bias the estimates. Second, the dynamic panel data model used here rely on internal instruments, i.e., past values of inputs and innovation activities specified. There are circumstances when such instruments can be weak [78].

APPENDIX

TABLE 1.10

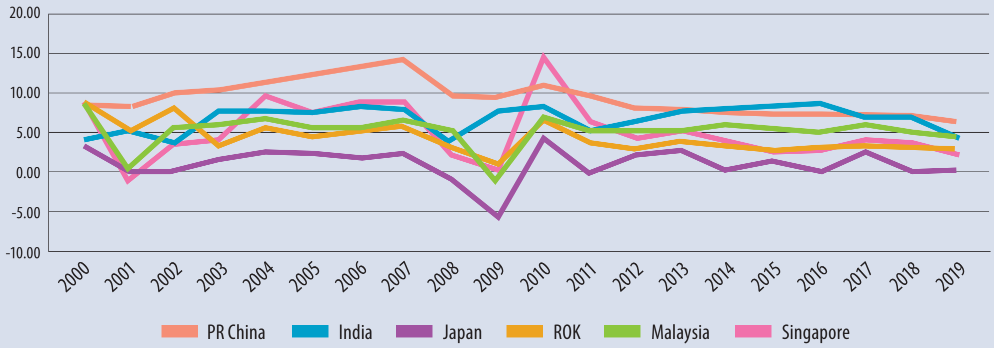
TFP (VALUE ADDED) AND LP GROWTH IN INDIA (KLEMS DATABASE)

Year	TFP Growth (Value added)	LP Growth
2010–11	1.4%	7.0%
2011–12	-1.3%	4.2%
2012–13	-0.8%	5.5%
2013–14	1.1%	6.4%
2014–15	2.4%	7.3%
2015–16	2.9%	8.0%
2016–17	2.9%	7.8%
2017–18	1.6%	6.1%
2018–19	0.0%	3.4%

Source: KLEMS database, RBI.

FIGURE 1.5

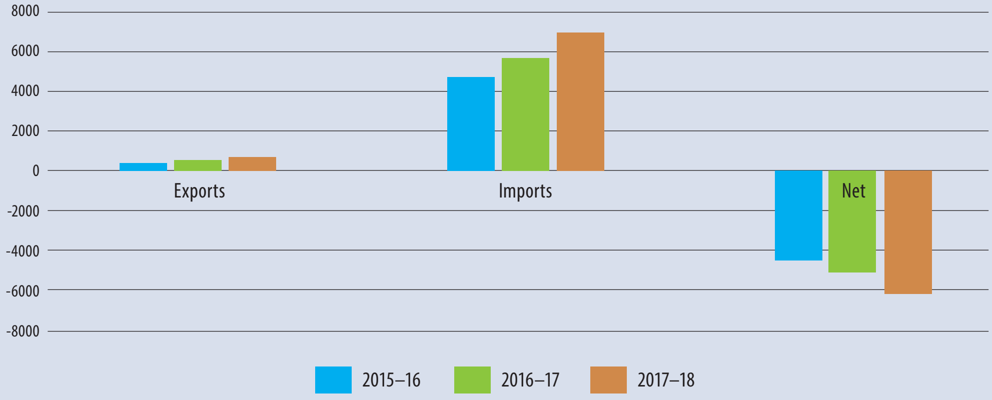
GDP GROWTH TREND: COMPARISON WITH ASIAN PEERS



Source: WDI.

FIGURE 1.6

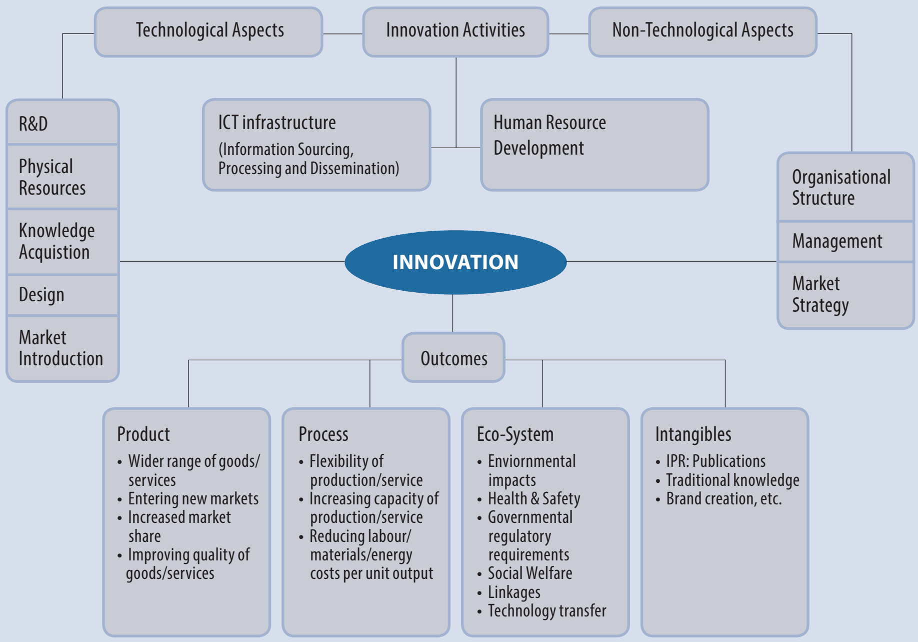
EXPORT, IMPORT OF ROYALTIES, COPYRIGHT, AND LICENSE FEES TO AND FROM INDIA



Source: RBI & DST.

FIGURE 1.7

NATIONAL INNOVATION SURVEY (NIS) FRAMEWORK



Source: http://nationalinnovationsurvey.nstmis-dst.org/measuringInnovation.

CHAPTER 2

PAKISTAN

PAKISTAN'S ECONOMY - AN OVERVIEW

Pakistan is a developing country with GDP growth rate of 3.94% and population of around 215.3 million, according to the Economic Survey of Pakistan 2020–21. The country, though recognized as a high-potential economy, but is faced with strong political, economic, and social challenges. The economy depends mainly on three key sectors: agriculture, industrial, and services. In the sectoral contribution to the GDP, services (61.7%) is the largest contributor to the economy while agriculture is at 19.2% and industrial at 19.1%. In 2020–21, Pakistan recorded growth rates of 2.8% for agriculture, 3.6% for industry, and 4.4% for services. The industrial and service sectors had a revived growth after facing the challenging impacts of the COVID-19 pandemic. As a result of the rising GDP growth rate, per capita income too had increased from USD1,361 to USD1,543. To continue the growth momentum of 2021–22, the government has set 4.8% GDP growth target, based on the agriculture sector's expansion of 3.5%, industrial at 6.2%, and services to grow at 4.7% [1]. Table 2.1 charts the performance of the three important sectors in the last 10 years.

TABLE 2.1

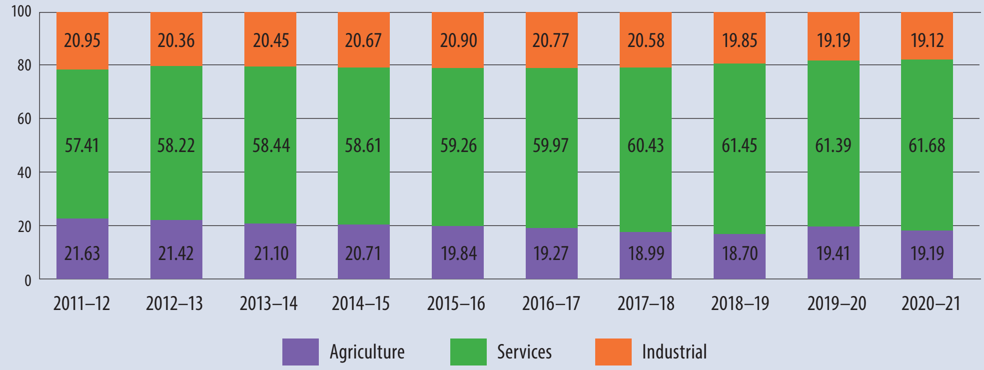
SECTORAL SHARE IN GDP (%)

Years	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21
Agriculture	21.63	21.42	21.10	20.71	19.84	19.27	18.99	18.70	19.41	19.19
Services	57.41	58.22	58.44	58.61	59.26	59.97	60.43	61.45	61.39	61.68
Industrial	20.95	20.36	20.45	20.67	20.90	20.77	20.58	19.85	19.19	19.12

Source: Pakistan Economic Survey.

FIGURE 2.1

SECTORAL SHARE IN GDP (%)



Agriculture is the backbone of Pakistan's economy. The sector is based on important crops, including wheat, rice, cotton, sugarcane, and maize. Other crops include vegetables, fruits, and fodder. Similarly, livestock is another key component with 60% share in agriculture. The other components are forestry and fishing.

The services sector consists of wholesale & retail trade, transport, storage & communication, finance & insurance, housing service, general government services, and other private services.

Pakistan's industrial sector comprises four key components, including mining and quarrying, manufacturing, electricity and gas distribution, and construction. In manufacturing, there are three subsectors: large-scale manufacturing (LSM), small-scale manufacturing (SSM), and slaughtering. The industrial sector is mainly dependent on LSM at 51% with other major contributors, including textile, F&B and tobacco, petroleum products, pharmaceuticals, chemicals, nonmetallic mineral products, automobiles, and fertilizer.

This study is focused on Pakistan's industrial sector as it is the lowest contributor to the economy. It also represents the manufacturing sector which is a key competitive area between countries. The study analyzed substantial factors of economic growth, including productivity, innovation, technological capabilities of key sectors, and the effectiveness of government policies in avoiding middle-income trap in Pakistan.

MIDDLE-INCOME TRAP - SITUATIONAL ANALYSIS AND KEY FACTORS

Each year, the World Bank classifies countries in four key income groups: low, lower-middle, upper-middle, and high-income based on gross national income (GNI) per capita [2]. The key factors that influence GNI per capita may include economic growth, inflation, exchange rates, and population growth. Table 2.2 shows the income level of each group for 2021.

TABLE 2.2

WORLD BANK'S GROUP/COUNTRY CLASSIFICATION AND GNI PER CAPITA

Group/Country Classification	GNI Per Capita (USD)
Low income	< 1,046
Lower-middle income	1,046–4,095
Upper-middle income	4,096–12,695
High income	> 12,695

Source: The World Bank [5].

The term middle-income trap is based on the World Bank's classification that is generally used to present a development phenomenon where rapidly growing economies stagnate at middle-income levels and fail to transition to the status of high-income countries. Several studies confirm this phenomenon. For instance, Larson et al. (2016) noted that out of 101 middle-income countries in 1960, only 13 countries managed to transition to the status of high-income countries by 2008, based on GDP per capita level relative to the USA [3]. Similarly, Flaaen et al. (2013) noted that among the seven countries that could be classified as middle income in 1975, only the Republic of Korea (ROK) managed to reach high-income status by 2005 [4]. This may be the effect of globalization and many countries reaped the benefits of globalized economies that improved their competitiveness and moved to high income level. The following table presents GNI per capita data of Asian countries in USD from 1990 to 2020 with five-year intervals [5].

TABLE 2.3

GNI PER CAPITA LEVELS OF ASIAN COUNTRIES (USD)

Country	1990	1995	2000	2005	2010	2015	2020
Singapore	11,450	23,630	23,680	28,820	44,930	53,160	54,920
Japan	27,820	42,090	36,230	40,560	43,440	38,840	40,770
ROC	6,450	11,820	11,030	18,520	22,290	28,720	32,860
Malaysia	2,400	4,050	3,460	5,270	8,260	10,680	10,580
Turkiye	2,310	2,850	4,320	6,820	10,490	12,030	9,050
Thailand	1,490	2,740	1,980	2,790	4,580	5,710	7,050
Sri Lanka	460	690	870	1,210	2,410	3,760	3,720
Vietnam	130	250	410	630	1,250	1,970	2,660
Bangladesh	320	340	440	550	800	1,220	2,010
India	380	370	440	710	1,220	1,600	1,900
Pakistan	**400**	**470**	**480**	**740**	**970**	**1,260**	**1,280**

Source: WDI - https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html.

The World Development Indicators (WDI) data indicates that Singapore, Japan, and ROK have moved to high-income group while Malaysia, Turkiye, and Thailand are in the upper-middle income group. Sri Lanka, Vietnam, Bangladesh, India, and Pakistan are striving to reach upper-middle income, and in time, move up to the high-income bracket. To date, Pakistan is at the lowest in Asian countries in terms of GNI per capita which is alarming for the fifth largest population in the world. Despite the abundance of natural resources and favorable geographical environment, Pakistan hasn't fully capitalized its potential. Since its independence, the country grappled with political, economic, and social challenges that led to low-income trap for almost six decades, and eventually moved to the lower-middle income cluster (Table 2.4) [6].

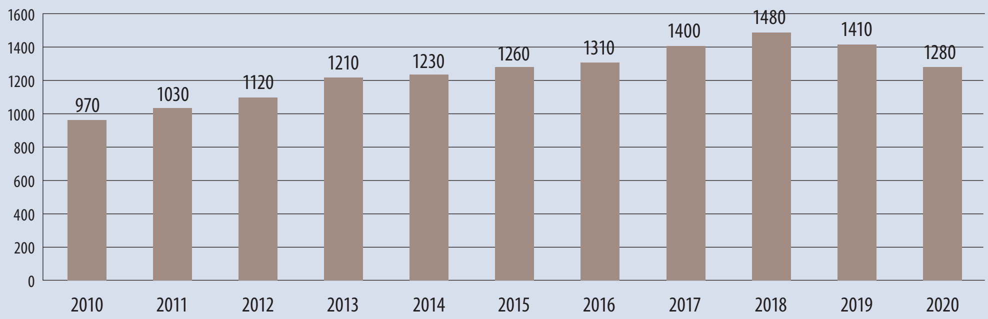
TABLE 2.4

PAKISTAN'S GNI PER CAPITA

Years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
GNI per capita (current USD)	970	1,030	1,120	1,210	1,230	1,260	1,310	1,400	1,480	1,410	1,280

FIGURE 2.2

PAKISTAN'S GNI PER CAPITA (USD)



The key factors that trapped Pakistan in the lower-middle income category include decreasing its agriculture sector output, stagnant industrial sector, and increasing services sector, but lacking foreign investment. Pakistan can learn from other Asian countries which improved their industrial sector by adopting industrial revolutions and bringing innovations and the latest technological developments. Due to low technological and skill base, Pakistan's industrial sector share is very low in GDP as compared to various developing countries thus having a very limited share in the global exports. The comparison of Pakistan with various Asian countries, in terms of industrial sector share in GDP, is highlighted in Table 2.5.

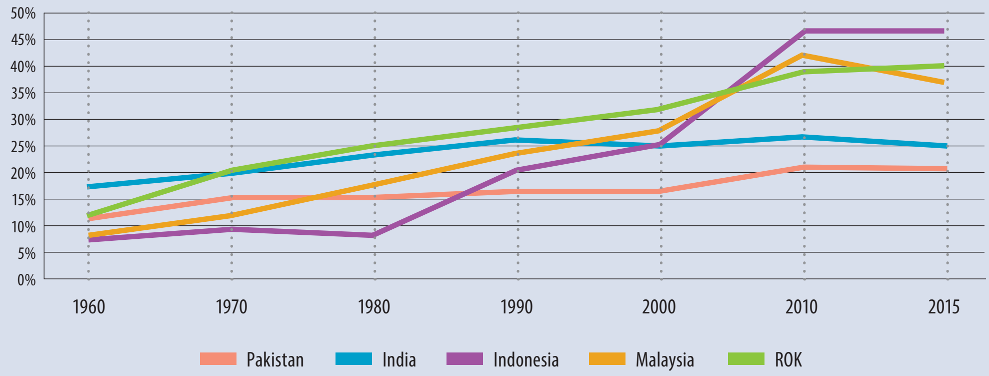
TABLE 2.5

SELECTED ASIAN COUNTRIES' INDUSTRIAL SECTOR SHARE IN GDP (%)

Asian Countries	1960	1970	1977	1990	2000	2010	2015
Indonesia	8	10	9	21	26	47	46.9
ROK	12	21	25	29	32	39.3	39.8
Malaysia	9	12	18	24	28	41.6	36.8
India	18	20	24	27	25	27	25
Pakistan	12	16	16	17	17	21.2	20.67

FIGURE 2.3

INDUSTRIAL SECTOR SHARE IN GDP (%) IN SELECTED ASIAN COUNTRIES



In the initial stages of development, countries like Indonesia, Malaysia, Japan, and ROK had low share of industrial sector in GDP due to the changing economic landscape as agriculture formed the bulk of GDP and employment. These countries improved their performance through industrial innovation, R&D, technological development, and attracting foreign direct investment (FDI) to shift their economy from agro-based to industrial-based while Pakistan remains an agro-based economy. Pakistan's industrial share in GDP rose from 12% to 21% in 57 years whereas Indonesia, Malaysia, Japan, and ROK have moved to around 40% in the same period. Productivity and innovation are two key factors of industrial development and competitiveness among countries. Pakistan's productivity and innovation situation is further analyzed in this chapter in order to suggest the way forward.

Productivity Factor

Productivity is the key to inclusive and sustainable growth. In order to improve the standard of living over time depends almost entirely on the country's ability to raise its output per worker. Productivity depends on physical capital, human capital, and total factor productivity (TFP). The trends of productivity in a country show the efficiency of resource allocation and value creation by the labor force and other productive assets of the economy. Pakistan's productivity indicators in almost 40 years with five-year intervals are shown in Table 2.6 [7].

TABLE 2.6

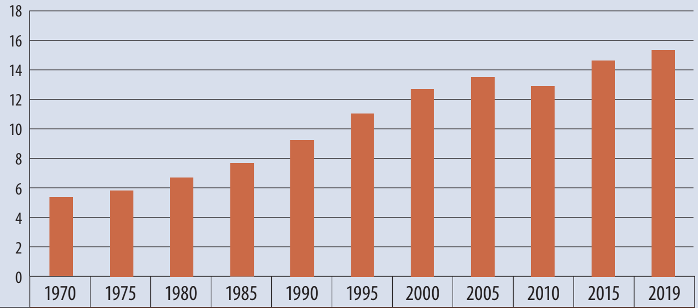
PAKISTAN'S PRODUCTIVITY INDICATORS AT FIVE-YEAR INTERVALS IN 1985–2019

Productivity Indicators	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2019
Per worker labor productivity (USD '000)	5.69	5.9	6.56	7.88	9.59	11.17	12.64	13.7	13.35	14.58	15.57
Per worker labor productivity growth	-1.45	0.20	-0.95	5.03	4.82	6.21	1.53	-3.69	-1.25	2.34	-
Per hour labor productivity (USD)	2.54	2.64	2.95	3.57	4.35	5.06	5.78	6.33	6.27	7.2	8.04
TFP growth (% per year)	-	-5.43	0.74	3.03	-3.04	1.48	2.74	3.16	0.57	2.78	-2.0
Capital productivity growth (%)	-	-6.28	1.19	0.68	-1.8	-0.11	0.52	3.38	0.96	2.3	-2.46
Labor productivity growth in agriculture (%)	-	-0.66	1.44	1.83	2.57	3.06	1.79	1.61	-1.5	1.68	1.99
Labor productivity growth in manufacturing (%)	-	4.78	2.03	7.27	6.22	6.2	-1.08	3.03	1.1	-1.32	-0.54

Source: Asian Economy and Productivity Map, APO.
Unit: USD '000, constant prices 2017 PPP.

FIGURE 2.4

PER WORKER LP (USD '000, CONSTANT PRICES 2017 PPP)

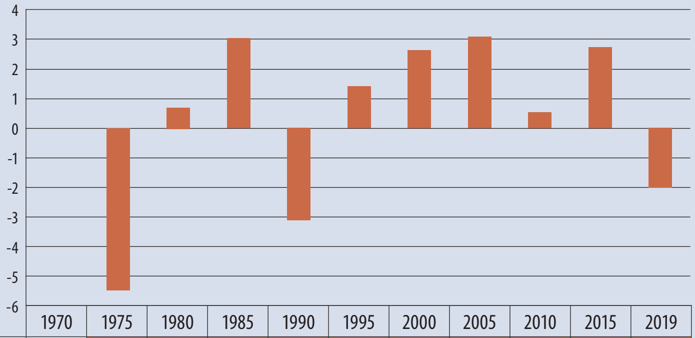


	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2019
Per Worker Labor Productivity (USD '000)	5.69	5.90	6.56	7.88	9.59	11.17	12.64	13.70	13.35	14.58	15.57

In Pakistan, productivity has been low for many years. The data in Figure 2.5 indicates that Pakistan's position is critical as labor productivity (LP) levels, productivity, and TFP growths are very low. The situation grew worse in 2019 as the country faced negative 1.28% labor productivity growth rate and negative 2% TFP growth rate. Unstable economic conditions caused high level deviations and slow progress in productivity performance. These productivity factors consequently hindered economic growth and created the middle-income trap.

FIGURE 2.5

PAKISTAN'S TFP GROWTH (% PER YEAR)



	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2019
TFP Growth (% per year)		-5.43	0.74	3.03	-3.04	1.48	2.74	3.16	0.57	2.78	-2

Innovation Factor

In this modern era of globalization, Pakistan is still lagging due to its socioeconomic challenges. Despite being the fifth most populous country in the world with a huge youth bulge, Pakistan has failed to utilize its physical and human resources. The country has not been able to respond adequately to the challenges unfolding with the wake of the fourth industrial revolution (IR4.0). The fact was also highlighted in Global Competitiveness Report 2019 by World Economic Forum (WEF) [8].

TABLE 2.7

ASIAN COUNTRIES GCI RANKING COMPARISON AND KEY FACTORS

Countries	GCI Rank	Innovation		Technological Readiness		Higher Education and Training		Labor Market Efficiency	
		Rank	Score	Rank	Score	Rank	Score	Rank	Score
Singapore	3	9	5.3	14	6.1	1	6.3	2	5.8
Japan	9	8	5.4	15	6.0	23	5.4	22	4.8
Malaysia	23	22	4.7	46	4.9	45	4.9	26	4.7
ROK	26	18	4.8	29	5.6	25	5.3	73	4.2
Turkiye	53	69	3.3	62	4.4	48	4.8	127	3.4
India	40	29	4.1	107	3.1	75	4.3	75	4.1
Bangladesh	99	114	2.8	120	2.8	117	3.1	118	3.6
Pakistan	**110**	**60**	**3.4**	**111**	**3.0**	**120**	**3.0**	**128**	**3.4**

Pakistan ranks 110 out of 141 countries in the Global Competitiveness Index. This is attributable to poor performance in innovation, technology adoption, labor market efficiency, and skills. Table 2.8 presents Pakistan's ranking in these four key economic growth indicators as per WEF - Global Competitiveness Report.

As per global competitiveness index, Pakistan has improved marginally in Innovation but still has poor ranking as the economic growth is hindered. Key reasons behind the country's slow growth rates of output and exports are its lack of innovation, small levels of investment, technical inefficiencies, and low R&D, resulting in lower productivity and uncompetitive Pakistani products. Low skill level in the labor

TABLE 2.8

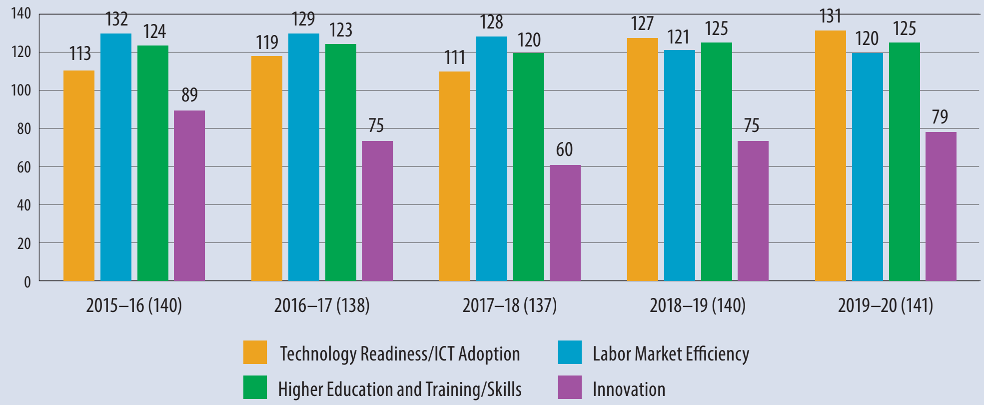
PAKISTAN'S FIVE YEARS PERFORMANCE IN GCI

Pakistan Competitiveness Factors	2015–16 (140)	2016–17 (138)	2017–18 (137)	2018–19 (140)	2019–20 (141)
Innovation	89	75	60	75	79
Technology/ICT adoption	113	119	111	127	131
Labor market efficiency	132	129	128	121	120
Higher education and training	124	123	120	125	125

Source: Global Competitiveness Index, WEF.

FIGURE 2.6

PAKISTAN'S RANKING IN GCI - FOUR KEY PILLARS



force is also a major constraint in achieving economic growth and eliminating poverty in Pakistan. The nation's current base of skills and capabilities are essentially in low-end production while the world trade is dominated by high and medium tech exports (58%) to meet customer demand across the globe. In Pakistan's case, the manufacturing sector is still crowded with low-end products that accounts for more than 72% of total exports.

The innovation factor is also highlighted by World Bank - Global Innovation Index (GII) 2021 which aims to capture the multidimensional facets of innovation based on countries' innovation capabilities and roughly consist of 80 indicators, grouped into innovation inputs and outputs [9]. Pakistan ranks 99th among the 132 economies in GII 2021. Table 2.9 presents Pakistan's innovation ranking between 2019–21.

TABLE 2.9

PAKISTAN'S RANKING IN GLOBAL INNOVATION INDEX (GII)

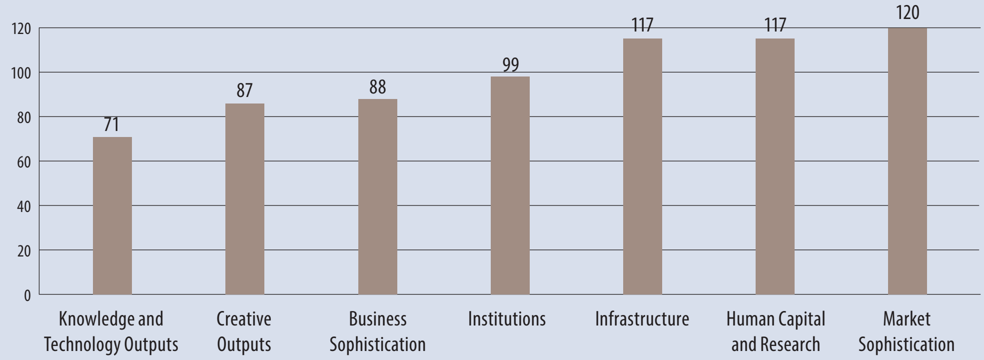
Year	GII Ranking	Innovation Inputs	Innovation Outputs
2021	99	117	77
2020	107	118	88
2019	105	113	89

Key extracts from Table 2.9 are:

- Pakistan performs better in innovation outputs than innovation inputs in 2021
- Pakistan ranks 117th in innovation inputs in 2021, higher than 2021 but lower than 2019
- As for innovation outputs, Pakistan ranks 77th. This position is higher than both 2020 and 2019

FIGURE 2.7

SEVEN GII PILLARS RANKING FOR PAKISTAN



Considering the pillars determining innovation capability of economies, Pakistan is struggling in the areas of market sophistication, human capital and research, infrastructure, and institutions [10].

ROLE OF INVESTMENT AND R&D EXPENDITURE TO ENHANCE PRODUCTIVITY AND INNOVATION

To explore the impact of FDI and R&D expenditure as key factors of productivity enhancement and innovation in Pakistan, this study is based on Solow's Growth Model (1957). The model is a growth accounting framework that decomposes the sources of growth into contributions from factor input and TFP. R&D and FDI are considered key factors of TFP.

Hall and Jones (1999) described that human capital stock can be estimated through labor force and the product of quality from labor force [11]. TFP as a parameter shows the efficiency and factors of production are jointly used in the economy.

This study uses time series data of Pakistan during the period 2000–20. The data is obtained from WDI of World Bank. The data provides information on three key variables, including output which is measured as GDP growth rate. It has a dependent variable and two independent variables, including FDI and R&D expenditure.

This study carried out regression analysis to identify complementary of FDI as percentage of GDP and R&D expenditure to determine the effect of these two on TFP and economic growth. The following are the results of regression analysis.

TABLE 2.10

GDP GROWTH RATE, FDI TO GDP (%), AND R&D EXPENDITURE (% OF GDP)

Year	R&D Expenditure (% of GDP)	FDI to GDP (%)	GDP Growth Rate
2001	0.15	0.48	3.55
2002	0.20	1.03	2.51
2003		0.58	5.78
2004		1.04	7.55
2005	0.40	1.83	6.52
2006		3.11	5.90
2007	0.63	3.67	4.83
2008		3.20	1.70
2009	0.45	1.39	2.83
2010		1.14	1.61
2011	0.33	0.62	2.75
2012		0.38	3.51
2013	0.29	0.58	4.40
2014		0.77	4.67
2015	0.25	0.62	4.73
2016		0.92	5.53
2017	0.24	0.82	5.55
2018		0.55	5.84
2019		0.80	0.99
2020			0.53

FIGURE 2.8

REGRESSION ANALYSIS

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INGDP	0.716147	1.129965	0.633778	0.5496
RD	-2.359124	7.779715	-0.303240	0.7719
C	4.077729	1.544249	2.640591	0.0385

R-squared	0.106407	Mean dependent var	4.185556
Adjusted R-squared	-0.191458	S.D. dependent var	1.377444
S.E. of regression	1.503535	Akaike info criterion	3.914716
Sum squared resid	13.56370	Schwarz criterion	3.980458
Log likelihood	-14.61622	Hannan-Quinn criterion	3.772846
F-statistic	0.357231	Durbin-Watson statistic	0.574509
Prob (F-statistic)	0.713543		

The data analysis in Figure 2.8 denotes to the impact of two independent variables, including FDI to GDP (%) and R&D expenditure to GDP (%) on Pakistan's GDP growth rate. The regression coefficients figures show that FDI has positive impact on GDP growth rate and contributed significantly to the overall economic growth. The R&D expenditure has negative effect on GDP growth which shows that government expenditure on R&D failed to achieve the desired benefits of economic growth. The R-squared figure shows that these two variables only have 10% effect on GDP growth rate and there are many other key factors that have significant impact on the GDP growth rate of the country. These factors linked with Innovation and Productivity are discussed earlier in the chapter.

PAKISTAN'S MANUFACTURING SECTOR

Globally, the manufacturing sector is seen as a key competitive tool to promote domestic production, exports, and employment generation thus stimulating the overall growth of an economy. Pakistan's manufacturing sector contributes 12.79% to GDP and the sector employs 16.1% of the country's labor force.

As highlighted earlier, the manufacturing sector consists of three subsectors: large-scale manufacturing (LSM), small-scale manufacturing (SSM), and slaughtering. According to the Pakistan Economic Survey 2020–21, LSM at 9.73% of GDP dominates the overall manufacturing sector, accounting for 76.1% of the sectoral share, followed by SSM, which accounts for 2.12% of total GDP and 16.6% sectoral share. The third component, slaughtering, accounts for 0.94% of GDP with 7.4% sectoral share [12].

TABLE 2.11

MANUFACTURING SECTOR IN GDP (%)

Year	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21
Manufacturing	13.83	14.02	13.57	13.54	12.79	12.08	12.00	12.18	12.46	11.55

Source: Pakistan Economic Survey.

TABLE 2.12

MANUFACTURING INDUSTRIES/SUBSECTORS AND THEIR EXPORT POTENTIAL

Pakistan Exports	FY 2019–20		FY 2020–21		% Change	Industry Category
Sector	Export Value (USD billion)	Share in Total Exports (%)	Export Value (USD billion)	Share in Total Exports (%)		
Textile	12.53	58.55	15.4	60.86	22.94	Low tech
Food	4.40	20.29	4.39	17.36	0.74	Low tech
Chemical & pharma goods	1.01	4.71	1.15	4.54	13.94	Medium high & high
Leather	0.66	3.08	0.72	2.86	10.13	Low tech
Petroleum & coal	0.27	1.28	0.18	0.72	-33.28	Medium low
Sports goods	0.26	1.23	0.29	1.10	5.84	Low tech
Engineering goods	0.17	0.81	0.23	0.89	30.91	Medium high & high
Footwear	0.13	0.59	0.13	0.52	4.72	Low tech
Misc.	0.80	3.78	3.47	13.70	14.17	Low tech
All other items	1.20	5.59	1.86	7.36	55.63	Low tech
	21.43	100%	**25.30**	100%		

Source: Pakistan Business Council.

Table 2.12 shows the share of potential manufacturing industries in Pakistan's total exports [13]. It shows that most of the industry groups are in the low tech category. These are the country's key sectors that are less competitive in international export market due to gaps in productivity, innovation, and technology. The following is a summary of sectoral gaps:

Textile

Pakistan is the eighth largest exporter of textile products in Asia, fourth largest producer, and third largest consumer of cotton. The textile sector comprises 46% of the total manufacturing sector and provides employment to 40% of the total labor force. There are approximately 423 textile industries operating in the country and the sector consists of 11.3 million spindles, 3 million rotors, 350,000 power looms, 18,000 knitting machines, and a processing capacity of 5.2 billion square meters. Also, it has about 700,000 industrial and domestic stitching machines. There are 21 filament yarn units with a capacity of 100,000 tons. The textile sector has a complete value chain in the country, unlike many other countries that possess only the primary or the finished base. In Pakistan, the abundance of raw materials, such as cotton, rayon, and others, is a big advantage for Pakistan due to its beneficial impact on cost and operational lead time. It has a significant opportunity to earn foreign exchange currency through textile exports. The country can also produce goods at a cheaper cost, compared to western countries and hence is a good location for outsourcing production.

Despite its strong potential, the Pakistan textile industry is facing strong pressures in a fast-changing business environment due to aggressive competition and market volatility. The industry needs to enhance its capability to manufacture and market high quality and value-added products (technical textiles) while the value addition textile (nonwoven) sector need to diversify their respective production pattern in order to face intense global competition and maintain sustainable growth. Value-added textiles (technical textiles) are the traditional textiles to which novel advanced technology characteristics have been added. They are mainly applied in the market to meet the new needs of end users. Technical textiles are primarily manufactured for their technical performance and functional properties, rather than for their aesthetic and decorative characteristics. Innovation in the production, composition, and application of new textiles will lead to new products, subsequently, to an expansion of the traditional textile industries both in terms of supply and production.

In the past few years, Pakistan's textile sector has been adversely affected and sees a decline in the exports. Out of the many critical factors, one crucial factor is that there is an absence of research and testing laboratory for textile and allied products. Resultant to that is the lack of innovation, quality, and standardization which is restricting Pakistan's exports to many international prospective markets. Production of value-added products, e.g., technical textiles, can enhance the country's production and exports. The global technical textiles market is expected to reach USD213 billion in 2023 and Pakistan has the opportunity to gain a significant share by prioritizing technical textiles.

Electrical/Electronics

Electronics is one of the emerging sectors in most developed countries and is considered to be one of the world's largest industries with a global revenue worth trillions of dollars per annum. Despite the huge growth potential, Pakistan has lagged in the development of its electronics industry. It has not achieved self-sufficiency by reducing dependence on foreign sources of products, materials, components, and equipment. In 2016, Pakistan imported electronics equipment worth USD4.7 billion, which is continually increasing due to huge demand. The electronics sector is facing the following challenges:

- Lack of technology base
- No Common Facility Centre (CFC) for modern technology of surface-mount technology (SMT)
- Weak supply chain where sourcing systems are not established and lack of specifications

- Insufficient R&D capabilities and skilled engineers
- Lack of quality standards

Food Processing

Food processing is an emerging sector as global food retail sales are about USD4 trillion annually. Pakistan is home to the world's fifth largest population with a growing middle class. The food and beverage processing industry is the second largest industry in the country after textiles, contibuting 27% of the value-added production and 16% of employment in the manufacturing sector. The industry accounted for an annual average of USD223.5 million in FDI from 2012–18. Pakistan was awarded the Generalized Scheme of Preferences (GSP) Plus Status (Zero to Low Duty) by the European Union in 2014 which has the potential to greatly uplift the exports of processed food products. Food processing firms are further categorized into either informal/cottage establishments or formal establishments. The three major industry groups are: (i) frozen food, (ii) value addition in major food crops, and (iii) fruits, vegetables, and intermediate products. There are approximately over 2,500 food processing units in Pakistan.

Pakistan food processing industry has a minimal share in the overall food production and exports. For example, the combined production of all fruits stands is at around 7 million tons while vegetables at around 6 million tons. Of these, a miniscule 5% is processed while the remaining is either marketed in the raw form or is lost post-harvest. Similarly, Pakistan is the fifth largest milk producer in the world with an estimated production of 48 million tons of milk per annum, out of which less than 5% milk is processed. In the same vein, Pakistan holds the eighth largest herd of livestock in the world but inefficient uses of livestock resources cause huge losses due to primitive home-based slaughtering mechanism and processing techniques. The pattern is extended to the country's poultry sector, which fares among the high producers in Asia, yet it is still disorganized and not performing as per its full potential. The size of global processed food industry is estimated to be valued around USD3.5 trillion and accounts for three-fourth of the global food sales.

Engineering

Engineering goods are considered a key contributor in strengthening the manufacturing sector. Self-reliance in the engineering industry reduces dependence on imports and enhancing volume of exports. The comprehensive range of engineering goods made in Pakistan cover industrial plants, ships, railway equipment, small aircrafts, automobiles and other transport equipment, electrical motors, telecommunication equipment, road construction machinery, material handling equipment, power generation, transmission and distribution machinery, machine tools, domestic appliances, electric fans, and defense equipment. Unfortunately, the export of machinery is limited to boilers and parts, diesel engine and parts, hand pumps, water pumps, parts of aircrafts and ships, electric motors, electric fans, refrigerators, washing machines, and such items, whereas hand tools, cutlery, blades/razors, etc., are also covered under the category of engineering goods.

At present, Pakistan's engineering sector is facing a high technological gap as compared to developed countries. Domestic engineering holds a total negligible share of 1% in the total trade as compared to the world trade dominated by the engineering goods with a share of 55%. There is a dire need to provide technical assistance and infrastructural support to enhance productivity and competitiveness of light engineering sector at both the local and global levels.

Leather

Pakistan's leather industry is one of the leading exporting sectors. Leather consists of five subsectors; namely, tanning leather, leather shoe uppers & footwear, leather garments, leather gloves, and leather goods. The tanning industry plays a vital role in the progress of these subsectors by supplying the basic material, i.e., leather. The leather industry is the one of the largest export earners in Pakistan. The total export of leather and related products was worth about USD1.04 billion in 2015. The sector requires facilitation and support to diversify its product range in order to exploit a large untapped international export potential. Besides earning foreign exchange, leather garments and footwear also provide employment to a large segment of the society.

Registration, Evaluation, Authorization, & Restriction of Chemical Substances (REACH) is an environmental and human safety standard. This EU standard is applicable to leather and leather products exported to EU markets. Other major importing countries of Pakistan's leather products, namely the USA and China also require tests which are covered under the REACH regime. Presently there is no such testing laboratory for leather in the country and the exporters have to send samples for testing to laboratories in other countries that causes loss of time and also results in high testing and courier costs. Simultaneously, the footwear sector is also facing issues in the manufacturing of soles and lasts (mechanical form shaped like human foot) locally as the molds have to be imported. There is a need to establish a dedicated local facility for designing and making shoe molds.

Surgical

Pakistan's surgical sector is mainly in Sialkot, having large, medium, and small industries supported by the vendor industry. These industries are in the formal and informal sectors. The country's share in surgical export stood at 0.14% in 2015, valued at USD356 million against the world's surgical export of USD247.71 billion. The share in electro medical surgical equipment was 0.06% in 2015 which in value was USD7.89 million compared to the global export of USD28.29 billion. Implants export was 0.001% in 2015 at a of value USD379 million while the global export was worth USD50.14 billion. Electro medical surgical equipment is high value instrument thus require modern technology and highly skilled work force to manufacture them, which poses a huge potential to Pakistan. Perceived high cost, absence of technology demonstration, and lack of skills to develop prototype products are the major entry barriers for the local industry in entering high-end surgical instruments market.

Automobile

The automobile industry in Pakistan contributes 2.8% to GDP and PKR30 billion to the national exchequer in terms of taxes and duties. The industry is one of the fastest growing in Asia, owing to growing domestic demand. The production and sales have grown by 171% and 172.5%, between 2014 and 2018, respectively. The average annual FDI received in the automotive sector between 2008 and 2018 has been USD50 million.

As the sixth largest manufacturing subsector of the economy, the automobile industry employs 3.5 million workers. There are approximately 1,600–1,700 firms operating in the automotive parts market in Pakistan. A large number of these are involved in the production of repair parts. Between 200–240 firms supply parts for OEM (original equipment manufacturer) production. These firms basically supply single unit parts, however some make components combining multiple parts. Hence, the parts industry resulted in a steady growth in terms of production volume with the objective to obtain international competitiveness in terms of quality and various other factors. The Pakistani automobile industry faces the major issue in terms of improving its competitiveness, e.g., digitization, automation, and reverse engineering.

Sports Goods

Pakistan's sports goods industry has a great potential to contribute to the national economy, but earns only about 3.7% of Pakistan's total exports. The main raw material for the sports goods industry is leather and mulberry wood that are readily available in Punjab. Football, hockey ball, hockey sticks, cricket bats, and rackets are mostly manufactured by hand. Manual manufacturing processes of sports products make it very challenging to compete against high-tech international firms. International importers add significantly more value in their products than the local manufacturers.

Local manufacturers' inability to develop sales points abroad or their own brand names are taking away a huge chunk of the value added. In comparison, Pakistan's competitors, like India and PR China, have much stronger ground presence and local brands in their export target countries. To grow further, the industry needs technical assistance in process improvement, operations management, and new product development. Moreover, product improvement through R&D activities and an emergence of e-commerce is likely to fuel growth in the sports equipment market in the near future.

CASE STUDIES - PRODUCTIVITY AND INNOVATION IN THE MANUFACTURING SECTOR

Sapphire Textile Mills Limited

Sapphire Textile Mills Limited is Pakistan's leading private firm and a key exporter in the textile sector. The company has a large-scale manufacturing setup and its key products include greige and dyed yarn, greige and dyed fabric, bleached, printed and finished fabric, and home textile products. The company spends a large percentage of its annual turnover on R&D activities that led to strong innovation activities at the firm level. Following are some key innovation features and best practices the firm:

- PDCA quality checks
- 5S Sigma Tool
- Quality Assurance Tests performed by following ASTM methods
- Fully automated laboratory-testing instruments to ensure fiber quality, strength, content, fineness, maturity, elongation variations, etc. Sapphire's spinning mill is the only one among all textiles spinners in Pakistan to have BALEXPERT. It consists of FSC (fiber classifying system) stations - FIBROTEST, FIBROFLOW, and OPTOTEST - to ensure all quality control measures and management functions are carried out before commencing production, which significantly impacts productivity
- Technology Advancement - Installed Murata Vortex Spinner (MVS) system that allows many globally famous apparel firms to produce high-value added products
- Fully automated and advanced processing and dyeing from color kitchen, paste preparation, chemical loading, dosing systems, etc.
- Online monitoring systems that ensure real-time control system with time and energy efficiency, ultimately reducing production losses and increase profitability (utilizing monitoring software, like V-Labo III, Visual Manager III – MSS, Data Logger, and Oracle)
- Best Practices and Best Available Techniques (BATs) were implemented throughout the supply chain (caustic recovery plant, heat recovery system, installation of heat exchangers, automated synchronizing systems, energy efficient power engines with DIA.NE software for online monitoring and troubleshooting, etc.)

- Energy Efficient Technology - Electrical Busbar System for power distribution with online monitoring system SYNERGY

- Wastewater treatment plant and recycling - Biological treatment is carried out, followed by chemical treatment enhanced with Dissolved Air Flotation (DAF). The treated water is recycled (25% only) through RO and reused in production processes. The remaining water is directed to local agricultural farms

- Renewable energy resources, including solar power and biomass energy from wood and rise husk

- Product & process innovation which is part of Circular Design Strategies and Sustainable Production and Consumption Practices that allows Sapphire to move toward circular economy. One of the primer initiatives is to regenerate fiber from PCW (pre- and post-consumer wastes). An eco-friendly plant is installed to recycle PCW, regenerate fibers, and give them new life. Both natural and synthetic fibers can be shredded to regenerate PCW fiber

Sapphire Textile Mills practices innovative measures and international standards, including SA 8000:2014, ISO 9001:2015, ISO 14001:2015, GOTS (Global Organic Textile Standard), OCS (Organic Content Standard), GRS (Global Recycled Standard), RCS (Recycled Claim Standard), Fairtrade Europe, Egyptian Cotton, CMiA (Cotton Made in Africa), EU Ecolabel, OEKO-TEX STANDARD 100, STeP by OEKO-TEX (Made in Green), SMETA (Sedex), BCI (Better Cotton Initiative), C-TPAT (Customs-Trade Partnership against Terrorism), Supima Cotton, Cotton USA, US Cotton Trust Protocol, HIGG Index (FEM, FSLM), Inditex (Join Life), Inditex (GTW), Zero Discharge Hazardous Chemicals (ZDHC), Fairtrade USA, WRAP, and Social & Labor Convergence Program (SLCP).

The organization believes that government policies (taxes, regulations, and processes), compliance and sustainability, internal processes, and technology are the key factors that crucially affect its Innovation and Productivity. Other factors also include skilled workforce and competition. Some key government policies that affect Sapphire Textile Mills are Textile Policy 2020-25, Environmental Policy, National Climate Change Policy of Pakistan, government-subsidized power rate policy, and State Bank of Pakistan's Temporary Economic Refinance Facility (TERF). The management of Sapphire Textile Mills believes that Pakistani firms can strongly support the domestic textile and industrial sector with the government's measures and actions, such as:

- Increase cultivation of organic cotton in Pakistan to avoid import

- Manage the country's energy crisis that severely hit productivity, mainly gas shortages in winter which the textile sector is heavily reliant on and uses up to 90% as energy source

- Install combined/collective municipal/district wastewater treatment plants, mainly in industrial zones

- Provision of modern machinery and equipment to influence the machinery import

- R&D support, mainly for textile recycling

Firms like Sapphire Textile Mills Limited are significant contributors to the local economy as manufacturers, exporters, and employers. Their success is tied to the management's strong commitment toward innovation and productivity practices by allocating significant budgets for R&D activities, inclusion of technical staff, applying innovation tools/techniques, and international quality standards. The company's efforts supported by effective policies and government initiatives can help increase local manufacturing, enhance trade, and global competitiveness as way to come out of long-term middle-income trap.

Gujranwala Tools, Dies and Moulds Centre (GTDMC)

GTDMC is a large-scale public-sector enterprise (PSE) established in 2008 to support the private sector and small and medium enterprises (SMEs) through the manufacturing of dies, molds, and engineering components. Along with technology services, the company also provides skill training to industry workforce and youth in the latest technologies as to prepare them for jobs. The center has implemented innovation and quality tools, such as 5S and Design for Manufacturing (DFM) as well as apply the Kaizen approach to improve its quality of services.

GTDMC receives low budgetary support from the government for R&D activities and has a small R&D staff. Along with this, the organization's productivity is highly affected by other key factors - outdated internal processes, skill gaps of workforce, government policies (taxes, regulations), and competing firms. On the innovation front, GTDMC is also affected with the same issues that include obsolete technology and complex purchasing process for equipment and machinery.

GTDMC urgently requires the government's support in funding the purchase of the latest technology and equipment as well as reduced duties and taxes for such machineries which can support the local engineering industries and manufacturing sector. GTDMC aims to broaden its marketing on OEM services in the automobile and home appliances sectors along with developing and upskiling the local workforce on upgraded technologies and equipment. Government policies to support R&D activities with technology upgrades and provision of regular operational funds can elevate and enhance GTDMC's productivity and innovation situation. Such PSEs play an important role in supporting local SMEs to increase their manufacturing capacity, enhancing competitiveness, and increase revenues.

Elite Engineering (Pvt.) Ltd.

Elite Engineering (Pvt.) Ltd. is a large-scale private firm providing specialized services, including oil and gas (O&G) plant construction, oil depot construction, gas field development & construction, cement & sugar plant construction, high-rise building construction, and civil construction for O&G. The company adopted best engineering practices and health, safety & environment policy and is also recognized as Shell Pakistan Limited Qualified Vendor. The company is currently following international standards, including ISO 9001, API 510, API 650, and ASME Sec VIII Div. I.

Elite Engineering believes that government policies (taxes, regulations, and processes), skilled workforce, customer feedback, and competing firms are the key factors that affect productivity. Along with these, other factors, including technology and internal processes, also have a minor effect.

Infinity Engineering Pvt. Ltd.

Infinity Engineering Pvt. Ltd. is a profitable, large-scale private firm that contributes to Pakistan's industrial sector. The company focuses mainly on automobile manufacturing and provide engineering services to the local industry. Channeling approximately 20% of its annual turnover into R&D, the company has a strong base with a team of almost 70 personnel in the department. The company has lent a strong, positive impact to the formation of the nation's automobile policy and seeks technological and financial assistance from the government to support the local automobile manufacturers/ assemblers.

To enhance its productivity and innovation capabilities, the company aims to upgrade its operations with new technology, install robots, and learn from the world's best practices and technologies.

Kashf Foundation

Kashf Foundation is a private not-for-profit microfinance company in Pakistan since 1996. In just two decades, the company has developed a large scale nonbanking microfinance setup that provide microcredit loans, trainings, insurance, and social advocacy interventions. The company has four key R&D personnel and spends around 0.35% of its annual turnover on R&D.

Kashf Foundation has become a strong organization with the highest number of women microcredit borrowers in Pakistan. It became a market leader (over 25% market share) in intermediation of microinsurance and innovative gender-centric loan products as well as providing transformational approach in increasing capacities and capabilities of women entrepreneurs through training and development.

The foundation identifies key productivity enhancement areas in process improvement, technology upgrades, and innovation. Factors that affect the foundation's innovation are outdated internal processes, low-skill workforce, competing firms, lack of government policies (regulations and processes), and obsolete technology.

The organization faces serious risk factors, including economic recession and lockdown due to unavoidable circumstances, such as the COVID-19 pandemic, increase in KIBOR (Karachi Inter Bank Rates - the average interest rate in which banks lend money to other banks), and regulatory hurdles set by the government of Pakistan.

Government policies, including branchless banking (BB) and AML/CFT (anti-money laundering/ combating the financing of terrorism) regulations have affected the organization in a big way. Kashf Foundation believes that the government support is crucial in terms of having Regulatory Sandbox, grants, and TA for innovative pilots, and sustainable/scalable projects that can enhance the organization's innovation and productivity. Its objectives are to use machine learning and algorithms to improve efficiency in credit decisions, introduce more demand-based products, process enhancement, and optimization and expansion of its services through branch expansion.

Peshawar Light Engineering Centre (PLEC)

PLEC is a public-sector nonprofit entity registered in 2016. The center offers cutting-edge solutions and fabrication solutions, training, and technical assistance. It also provides new product development services to the local industry, including SMEs as per their requirement to support the local manufacturing industry. PLEC implements ISO 9001 and has identified key factors affecting productivity and innovation which include low skilled workforce, use of old technology, and lack of customer feedback. Some serious challenges that PLEC experiences include the complicated and time-consuming procurement processes and HR policies. Identified key improvement areas include bringing in the most advanced machines, professional designing, and high-level tech-based skills trainings to the industry workforce.

INNOVATION POLICIES FOR PRODUCTIVITY GROWTH

The COVID-19 pandemic has changed the socioeconomic landscape all over the world. Pakistan is no exception as this pandemic increased economic distresses of the industrial sector already facing contraction challenges during FY 2019–20. The government developed responsive Annual Plan 2020–21 that envisaged the industry sector to grow by 0.1%, but it grew 3.6% in the said time frame. The manufacturing sector recorded a high growth of 8.7%, owing to 9.3% increase in LSM. Smart lockdown protocols contributed significantly in the overall improved performance of the sector. A generous incentive package for the construction sector during the pandemic further invigorated economic activity in construction and its allied sectors. Despite below-target growth in mining and quarrying as well as electricity generation and gas distribution, the overall industrial sector growth surpassed its target due to several policy initiatives. This growth momentum is expected to be maintained through several policy initiatives, such as three years' relief package for industrial sector electricity tariff, disbursement of rebate to the exporters, and Textile and Apparel Policy 2020-25 over the medium term.

Current Policies and Initiatives

The government has put forward a systematic approach for developing Pakistan's innovation capabilities and productivity enhancement initiatives to support its industrial sector in moving toward sustainable growth and development. Several current, ongoing, and new high-level initiatives are expected to make an impact to the industry.

Task Force on Technology Driven Knowledge Economy

The government of Pakistan formulated a "Task Force on Technology Driven Knowledge Economy" as a cross ministerial initiative with members from relevant ministries, the private sector, and academia in 2019. This key forum aims to trigger knowledge-based industrial development through technology innovation, dissemination, and commercialization. As the chairman of the Taskforce, the Prime Minister had strongly emphasized on the critical role of technology for economic growth and experiences from other countries, such as Singapore, ROK, and Malaysia that were developed by focusing on education, science, technology, innovation, and productivity. The taskforce has been working on developing Pakistan's technological and innovation base by regularly identifying and proposing innovative initiatives under various ministries, private sector, and academia.

Improving Competitiveness through Sustainable National Productivity (SNP)

The government is keen and serious in improving its competitiveness and productivity as they are key to economic prosperity. The only viable solution to overcome economic challenges (low exports and higher imports through influx by countries that have higher productivity levels) is by having higher productivity. In this regard, the National Productivity Organization (NPO) developed the SNP Initiative which the federal government approved. The project is part of the "National Productivity Master Plan of Pakistan", developed and initiated by the NPO through the support of the APO that also offers a network of 21 Asia-Pacific member economies. There are four stages in achieving competitiveness and economic growth through sustainable national productivity - awareness, product design & development, implementation, and continuous improvement. SNP project is also focused on improving the awareness among key stakeholders.

National Strategic Programme for Acquisition of Industrial Technology (NSPAIT)

The Pakistani government launched the NSPAIT initiative that is aimed at acquiring, assimilating, and improving the technology used in various industrial sectors across Pakistan, including the critically important industrial sectors, i.e., textiles (with particular reference to technical textile), construction (including cement, ceramics, marble, and granite), and engineering & technology (including light engineering, cutlery, and gems & jewelry). Approved in 2022, the NSPAIT project will support local manufacturing, exports, and the competitiveness of key economic sectors, including textile, construction, and engineering.

Draft Industrial Technology Acquisition Policy 2020–25

To cope up with the challenges of industrial competitiveness based on technology, the Technology Upgradation and Skill Development Company (TUSDEC) under the Ministry of Industries & Production has developed the “Draft Industrial Technology Acquisition Policy”. The policy aims to benchmark, acquire, assimilate, and improve the technologies used in various industrial sectors across all major clusters nationwide. This national level policy proposed various interventions, such as Technology Upgradation Fund (TUF), joint ventures (JVs), establishment of regional ITPO offices, technology upgradation centers (TUCs), skill development centers (SDCs), and technology incubation centers (TICs). The approval and implementation of the policy will expand horizontally to upgrade Pakistan’s industrial technology in the long run.

National SME Policy 2020

Small, Medium Enterprises Development Authority (SMEDA) is the federal government’s key entity to encourage and facilitate the development and growth of Pakistan’s SMEs. SMEDA formulated and proposed the National SME Policy 2020 to particularly focus on industrial development. It also aims to assist the SMEs with interventions to solve market failure arising from externalities and information asymmetries, reduce cost of doing business by improving the regulatory environment, and ease coordination problems arising from the lack of supply of critical infrastructure, such as roads, energy, ICT services, etc. that impede SME growth. The policy enhances the capacity of local SMEs in order to support investment climate, business environment, and competitiveness of local firms.

National Business Development Programme for SMEs

SMEDA, under the purview of the Ministry of Industries and Production (MoIP), supports the SMEs through training programs, facilitation by providing loans, and assistance in developing pre-feasibility studies and business plans.

Textile and Apparel Policy 2020–25

Textile is a key sector in Pakistan’s economy and contributes more than 50% exports of the country. To further strengthen the sector, the Ministry of Textile Industry devised the “Textile and Apparel Policy 2020–25” which looks into rationalization of tariff structure for textiles and apparel value-chain, improvement in fiber mix, creation of brand development, fund acquisition, and mass level training in industrial stitching for women.

Electric Vehicles Policy

The Ministry of Climate Change established the Electric Vehicles (EV) Policy to support the country’s automobile sector. The objective is to facilitate investment in automobile sector through various tax relaxations, i.e., imposing a low 1% GST (goods and services tax) on sales for five years, registration exemption for two- and three-wheelers, and annual token tax. The policy had also reduced the toll tax by 50% for EVs, zero percent VAT, and duty-free import of plant and machinery for EVs.

Digital Pakistan Policy

The Digital Pakistan Policy was developed and introduced by the Ministry of IT & Telecom. The need for the policy arose due to the emerging role of ICT in industrial, social, agricultural, and other sectors and it became urgent to digitize processes to resolve socioeconomic issues and capitalize the digitization. Pakistan focused “to become a knowledge-based economy through accelerated digitization ecosystem”. The aim of this policy is to adopt the latest technologies emerging with IR4.0.

Prime Minister’s Youth Skill Development Programme (Kamyab Jawan Initiative)

To develop and prepare a workforce for the latest and emerging technologies, the government launched the “National Youth Development Framework” that also implements the “Prime Minister Hunarmand

Pakistan-Kamyab Jawan Programme". The program aims to address the skill development capabilities issues through mass training in high-tech/end technologies. This strategic program consists of different schemes, including:

- The Prime Minister's Youth Entrepreneurship Scheme (YES)
- National Employment Exchange as a technology-based platform
- 75 smart tech labs for distance learning
- Incubation centers to support Startup Pakistan movement
- Establishing a national accreditation council
- Accreditate 2,000 TVET (Technical and Vocation Education and Training) institutes and 70 labs workshops in madrassa(s)
- Master training of TVET teachers to acquire knowledge about the latest technologies
- Development of 200 TVET qualifications for international recognition
- Increase employment prospects of skilled workers
- Apprenticeship training of 25,000 youth
- International accreditation and joint-degree programs to develop skills as per international standards
- 10 country-specific facilitation centers for Pakistani workers in international waters, especially in the Gulf Cooperation Council (GCC) countries
- Recognition of prior learning of 50,000 youth
- Prime Minister's National Internship Program
- Startup Pakistan for Empowering the Next Generation

Public Sector Development Programme (PSDP) Initiatives for 2021–22

Along with these key strategic initiatives, the government has allocated PKR3.07 billion to industries division as per the Annual Plan 2021–22. Key PSDP initiatives for 2021–22, proposed by Industries & Production Division, are:

- Support center for dental and surgical equipment in Sialkot
- Research, regulatory insight, and advocacy assistance for SMEs
- Establishment of high tensile sheet metal dies manufacturing and titanium coating setup at Karachi
- Development of Karachi Industrial Park on a 1,500-acre of Pakistan Steel Mills Land at Karachi
- Agro-food processing facilities in Mirpurkhas

Past Polices and Initiatives

Pakistan Productivity, Quality & Innovation (PPQI) Initiative

The PPQI make a good foundation for new businesses and new jobs thus are important drivers of economic growth and development. Innovative- and quality-oriented economies are more productive, resilient, and adaptable to change and better able to support higher living standards. They also lead to value creation that generates rewards for human, physical, and knowledge-based capital. Aggregate incomes are also increased with a positive impact on overall living standards. These potential and considerations led the Ministry of Planning Development & Reforms to launch "Pakistan Productivity, Quality & Innovation (PPQI) Initiative". Key objectives of the project are:

- Development of a PPQI framework and policy
- Mass awareness campaign on PPQI
- Pilot training programs leading to productivity improvement
- Initiation of the Prime Minister Excellence Award

Science, Technology & Innovation Strategy 2014–18

The government of Pakistan developed the Science, Technology and Innovation (STI) Strategy 2014–18 to shift toward a realistic and fast-moving science and technology (S&T) strategy. The initiative aimed to address the key challenges faced by Pakistan in the fields of energy, water, food security, health, unemployment, and export enhancement through:

- Rapid human capital development to meet the country's current and future human resource needs
- Improving communication, coordination, and collaboration among S&T, ICT, and other sectors of socioeconomic development
- Support emerging technologies through R&D, commercialization of R&D results, exploring innovative solutions, and establishing new enterprises
- Ensure acquisition of emerging technologies, i.e., biotechnology, nanotechnology, and renewable energy and fuel cell to gain world-class expertise and global competitiveness
- Promote indigenous technology development, innovation, and entrepreneurship by establishing innovation incubators, holistic technology clusters, and technology fund
- Establishment of S&T think tanks to support policy research
- Enhancement of R&D expenditure by up to 2.0% of GDP by 2018
- Creation of one million employment opportunities in the five-year period

National Science, Technology and Innovation (ST&I) Policy 2012

Pakistan's Ministry of Science and Technology introduced the "National Science, Technology and Innovation Policy" in 2012 with the principal objective of improving socioeconomic development, human resource development, R&D infrastructure, promotion of ST&I in the society, and S&T management system. The key trends impacting ST&I in Pakistan included:

- Technology - Low technology base
- Financing - Lack of access to finance due to limited lending programs
- Marketing - Lack of information to market players
- HRD - Integrated skilled workforce as per modern technology
- Regulatory - Impediments in government rules
- Low productivity - Uncompetitiveness

CONCLUSION

Pakistan is trapped in the middle-income bracket since the last decade. This is due to unstable macroeconomic conditions, decreasing agriculture sector, stagnant industrial sector, and increasing services sector but lacking foreign investment. This study is focused on Pakistan's industrial sector as it is the lowest contributing sector in the economy. The sector is further represented by manufacturing which is a key competitive area between countries. The study analyzed substantial factors of productivity and economic growth, including the innovation practices of key sectors and firms. The study identified that Innovation and Productivity are the key areas that should be strengthened at the macro and company levels. Firms with strong R&D base and adhere to international quality standards are more competitive and successful. Government support is also key to successful enterprises and policies should be aimed at enhancing productivity, innovation, and competitiveness of public and private organizations while limited engagement and lack of awareness of key stakeholders also effect productivity, consequently becoming a key factor of middle-income trap.

- At the macro level, decreasing agriculture sector share and stagnant industrial sector that lack productivity and innovation are the key factors of middle-income trap. Based on the data captured from the case studies, 70% of the responding organizations believe that government policies highly affected their productivity and innovation
- Despite policies like the Science, Technology & Innovation Strategy 2014–18 that focuses on R&D, the government's investment in R&D has remained very low, at less than 1%. As a result, R&D failed to contribute any significant impact on the overall GDP growth. This also shows that the government policies lack effectiveness
- FDI is a key factor that enhances productivity and GDP. However, Pakistan's FDI to GDP percentage is also very low, at less than 1%. The government needs to design innovation policies focused at improving investment climate to attract FDI. Attracting FDI focused on bringing the latest technologies in the manufacturing sector can significantly enhance manufacturing share in GDP
- Private sector's limited engagement and lack of awareness in government policies do not benefit them. 70% of the firms believe that government policies negatively affect their productivity and innovation. Based on firms' feedback, government policies should be more supportive and facilitating in terms of regulations for taxes and trade, R&D, technology, production inputs costs (energy and raw material), etc.

- Current innovation management practices are based on limited R&D staff and budget leading toward innovation challenges in both public and private organizations. Large firms that spend more on R&D and adhere to international standards gain competitive advantage locally and internationally while small firms that lack these face survival and competitiveness challenges. Government agencies and authorities should work with these firms more effectively by providing standardization and certification support for domestic and international compliance. Also developing R&D incentives for protection of small productive enterprises will also help current and new firms to grow and contribute in the overall manufacturing sector

- Government needs to increase development allocations to strengthen public and private institutions through initiatives focusing on the latest technology acquisition and high tech-based skills trainings

- Considering Pakistan's strength and weakness analysis in the Global Innovation Index 2021, the current policies have improved innovation capabilities in key pillars, including knowledge and technology inputs, creative outputs, business sophistication, and institutions. Future policies need to be focused on infrastructure, human capital and research, and market sophistication that will improve productivity and competitiveness capabilities at macro and micro levels.

CHAPTER 3

SRI LANKA

EXECUTIVE SUMMARY

Total Factor Productivity (TFP) growth is crucial in avoiding middle-income trap (MIT). This paper examines the role of human capital and innovation on TFP growth in Sri Lanka by employing a TFP growth regression model of Park - a modified version of Bosworth and Collins (see Empirical Strategy section). Despite being a welfare state and providing free education since 1945, the human capital displays a significant negative impact on TFP growth in Sri Lanka. In addition, only the inflation and the GDP per capita are identified as significant sources of TFP growth. The innovation strategy is, however, insignificant. Further, the quality of education is in jeopardy and this issue is observed both at secondary and tertiary level enrollments. The results highlight the necessity in reforming both education and innovation sector policies. Thereby, the improved TFP growth would facilitate avoiding MIT to achieve strong growth momentum in Sri Lanka.

INTRODUCTION - AVOIDING MIDDLE-INCOME TRAP: SRI LANKAN PERSPECTIVE

Sustained and rapid economic growth allows developing countries to reach high-income economic status. The failure of a middle-income country in becoming a high-income country in a timely manner is referred to as 'middle-income trap' (MIT). Many developing countries have fallen into this trap and shows stagnant economic growth. Sri Lanka is no different and currently experiencing the worst economic crisis since its independence. Sri Lanka moved to lower-middle income category in 1997 and then to upper-middle income category in 2019. However, after only one year, the country has downgraded to lower-middle income category again in 2020 due mainly to the COVID-19 pandemic and persistent macroeconomic instabilities. Sri Lankan economy has constantly been subjected to numerous internal shocks: tsunami disaster in 2009, 30-year long separatist civil war that ended in 2009, and Easter bombing in 2019. Hence, the economy is yet to reach its full potential. Sri Lanka has remained a relatively long period in lower-middle income category compared to many other emerging economies. Thus introducing necessary structural reforms is crucial to avoid MIT and to achieve strong growth momentum.

There is rising attention in searching for the causes of ongoing growth slowdown. There are many factors that affect economic growth: inefficient resource allocation, diminishing returns to physical capital, insufficient quality of human capital, misallocation of talent, lack of access to advanced infrastructure, and lack of access to finance [1]. Further, the accumulation of factors of production - physical capital and labor - is critical but, explains only part of the economic growth. The balance is explained by the technological developments in production and processes which is known as the TFP. Different income groups have different levels of TFP and the transition to high-income level depends on TFP growth. Correspondingly, understanding what drives TFP growth is vital to avoid MIT.

According to literature, the quality of human capital and level of innovation are identified as key drivers of TFP growth [2]. Understanding the relationship of these two factors on TFP growth would provide the necessary impetus for avoiding economic stagnation for Sri Lanka. Sri Lanka is yet to reach high-income status despite being a welfare state and provide free education since 1945. The main objective of this paper is to examine the importance of quality of human capital and innovation on TFP growth. The comprehensive empirical analysis and the suggested implementable policy implications on the link between human capital and innovation on TFP growth would provide a significant contribution to MIT literature in Sri Lanka.

The results indicate that human capital has not been an effective contributing factor in improving the TFP growth in Sri Lanka. Inflation and GDP per capita appear to be the other two key discriminatory variables. These findings are in line with literature that manifests the need for further improvements in education and innovation policies in stagnated middle-income economies. Hence, the research findings further imply that the existing education and innovation policies are insufficient in supporting the growth process in Sri Lanka. Literature also suggests that for low-income countries, the majority of the growth comes from capital accumulation while it is TFP growth for middle- and high-income countries. Sri Lanka's transition to high-income level therefore depends largely on the effectiveness of its education sector reforms. In addition, TFP is determined by contextual factors, such as institutional quality, cognitive skills, teacher training, and property rights. Sri Lanka is facing much deterioration in all these factors over the years. Therefore, failure to address these challenges could further delay Sri Lanka's graduation to higher-income level.

Disaggregated results reveal that both secondary and tertiary education have negative yet insignificant impact on TFP growth. Innovation variables - number of patents and R&D expenditure - show mixed results. Transition from middle to high income must be fuelled by innovation-led growth. Hence, the quality of education is important at middle- to high-income levels. Moreover, tertiary education is more important for the escapees of the lower-middle income levels while patents are more prevalent for the escapees at the upper-middle income levels. For Sri Lanka, both these factors are in conflict with the expectation.

The remainder of the paper is organized as following: the first section presents the background which includes recent literature on MIT, Sri Lanka's economic overview, and existing educational and innovation policies followed by a cross-country assessment of TFP. The empirical strategy and data comes after which is the estimation results and discussions. The final section presents the concluding remarks and policy implications.

BACKGROUND

Recent Literature on MIT

Growth slowdowns are common among middle-income countries. This means rapidly growing economies are stagnated at middle-income level and fail to graduate into high-income level. In avoiding MIT, the risks and opportunities arising from growth turning points are more interesting than the drivers of very long-run growth.

Clear theoretical and empirical evidence on MIT is very limited. Perez-Sebastian [3] identifies "imitation" as the main driver of technological catch-up at early stages of development while it is "innovation" at a later stage. Innovation requires more complex and harder-to-implement framework conditions, such as high-quality innovation and regulatory or tertiary education policies. According to Agenor and Canuto [4], the growth path of the economy is driven by the availability of certain key inputs/policies required for innovation. Empirically, Eichengreen et al [5] found that fast-growing middle-income economies slowed down at income levels of USD10,000–USD11,000 and USD15,000–USD16,000 before these countries reached high-income status. It is reported that at this level, on average, the growth rate of

GDP per capita declined by 3.5 percentage point. These growth slowdowns are essentially productivity declines with a drop in TFP growth accounting for about 85%.

According to Lewis-type development process, the factors and advantages that generate high growth during an initial phase of rapid development, i.e., low-cost labor and imitation of foreign technology, disappear when middle-income levels are reached. Thereafter, new sources of growth are required to maintain sustained increases in per capita income. During the first phase, low-income countries compete in international markets by producing labor-intensive, low-cost products using technologies imported from abroad. These countries can achieve large productivity gains initially through a reallocation of labor from low-productivity agriculture to high-productivity manufacturing. However, once these countries reach middle-income levels, the pool of underemployed rural workers drains and wages begin to rise, thereby eroding competitiveness. Productivity growth from sectoral reallocation and technology catch-up is eventually exhausted while rising wages make labor intensive exports less competitive on world markets. This is precisely at the time when other low-income countries get themselves engaged with a phase of rapid growth.

Henceforth, growth slowdowns coincide with the point in the growth process where it is no longer possible to boost productivity by shifting additional workers from agriculture to industry and where the gains from importing foreign technology diminish. This process is well supported by the evidence on productivity slowdowns provided by Eichengreen et al. [5]. It is also consistent with the results in Perez-Sebastian [3], where imitation is the main source of productivity growth at early stages of development, whereas broad-based innovation, which is defined as the application of new ideas, technologies, or processes to productive activities, becomes the main engine of growth as the economy approaches the technology frontier. The implication then is that to avoid falling into a middle-income trap, countries must address its root structural cause early and find new ways to boost productivity. The main sources of higher productivity are a shift to high value services and the promotion of home-grown innovation, rather than continuing to rely on imitation of foreign technology. Therefore, the key issue that needs to be addressed is how to switch from “imitation” activities to a broad-based “innovation strategy”.

It is fundamentally agreeable that productivity slowdown is the main cause for growth stagnations. Hence, this study examines the link between productivity and economic growth and the policy reforms required to promote a broad-based innovation strategy in escaping the MIT.

Households contribute to economic growth primarily through human capital accumulation, most of which is accounted by investment in the education for children. Educated individuals work in industries. Human capital accumulation contributes to economic growth through industrial development. Industrial upgrading may be difficult to take place because of inadequate human capital, inadequate industrial policy, or interference from old firms. Even if industrial development was successful in the past, it might lead to deterioration in equality and social cohesion, which might in turn undermine political stability. Instability may reduce state capacity to collect taxes and implement policies effectively, thereby hindering human capital accumulation and industrial development.

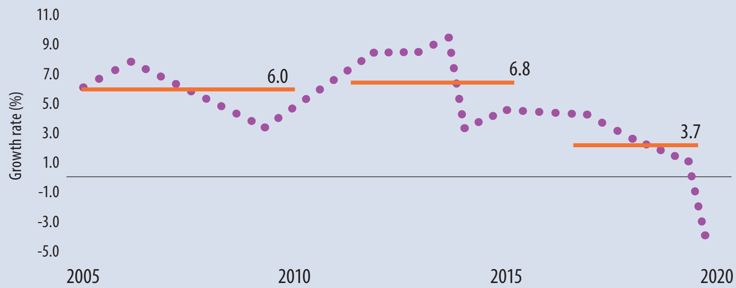
Economic Overview of Sri Lanka

Sri Lanka is a lower-middle income country with GDP per capita of USD3,600 (2020). The country has considerably superior social welfare indicators, on par with developed economies as to other countries with comparable income levels. The country maintains relatively high growth rates before 2015. Average growth rate dropped to 3.7% during 2015–19 in comparison to 6% and 6.8% growth during 2005–09 and 2010–14, respectively (Figure 3.1). The growth decline was attributed to a number of shocks, including in 2016/17 droughts, floods, and Easter bombing in 2019. The 2020 pandemic further deteriorated the economy and recorded the deepest contraction of 3.6% since independence in 1948. Further, this economic contraction moved the country from upper-middle income to lower-middle income category in 2019.

The process of structural change accompanying Sri Lanka's economic development has been largely conventional (Figure 3.2). The traditional agricultural economy has gradually transformed into a service-oriented economy. Since 1950, the share of agriculture had shrunk rapidly, from about 40% of GDP to 8% in 2020. Following trade liberalization reforms in 1977, the share of industry sector increased from 18% in 1950s to 30% during the 2005–09 period. Meanwhile, the services sector continues to grow and share 60% of GDP in 2020. During this period, until about 2005, the major contributor to the increase of industry's share was manufacturing. The share of manufacturing in GDP increased from 3% in the 1970s to 19% in 2005–09.

FIGURE 3.1

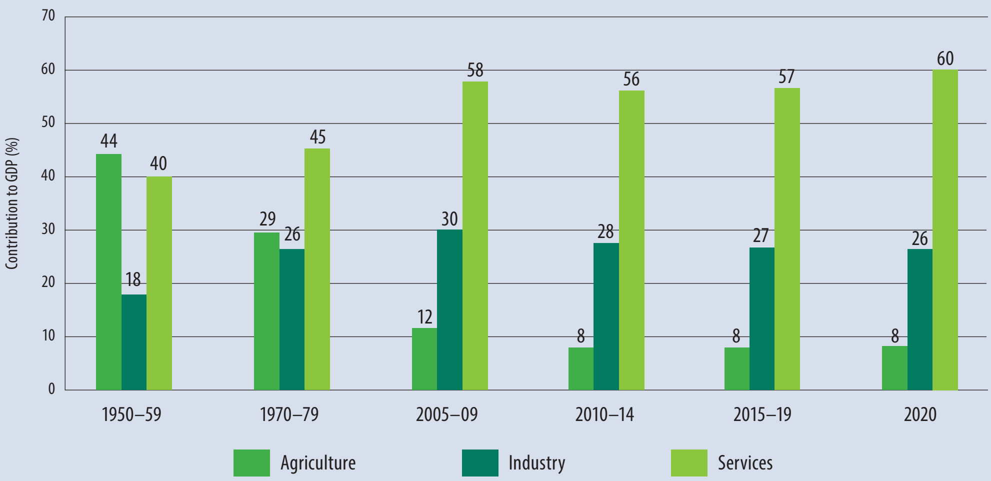
GROWTH PERFORMANCE



Source: Central Bank of Sri Lanka.

FIGURE 3.2

SECTORAL COMPOSITION OF GDP



Source: Central Bank of Sri Lanka.

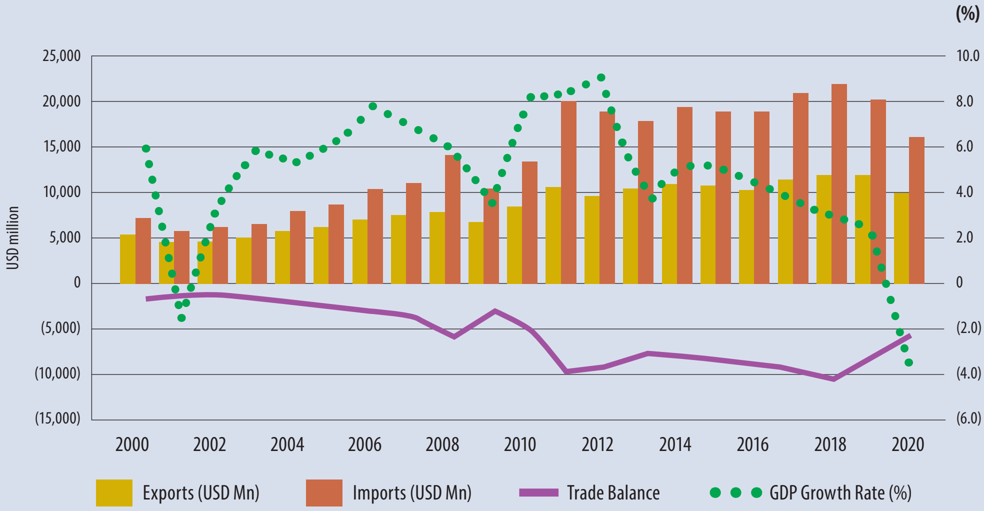
Poverty has declined from 9.2% in 2019 to 4.1% in 2020. However, the lockdowns had considerably decreased the labor market activities. Labor force in the industry sector are the worst affected than the agriculture and services sector. Lower-middle income earners, workforce in urban areas, private-sector employees, and own-account workers faced the biggest impact of the pandemic. Improved trade balance and increased inflow of remittances narrowed down the current account deficit from 2.2% of GDP in 2019 to 1.3% in 2020. Improvement in trade balance in 2020 is USD6 billion and this is mainly due to the drop in imports of USD4 billion was greater than that of exports. Remittances grew by 5.8% to USD7.1 billion resulting from the enhanced receipts of savings from the overseas workers.

Increased openness made countries vulnerable to global conditions. External sector performance was directly influenced by the recent global pandemic situation. Both exports and imports dropped to significantly low levels in 2020 compared to those of the previous year. The drop in imports of USD4 billion in 2020 was greater than that of exports mainly due to restriction of nonessential imports and low crude oil prices. As a result, trade balance showed a significant improvement of USD6 billion in 2020 which is the lowest ever recorded since 2010 (Figure 3.3).

Improving investment efficiency is challenging as the pandemic has hit hard most of the economic activities. Hence, labor and capital should be used more innovatively without limiting to traditional approaches. Use of technology and innovation-driven growth by means of a knowledge-based economy is the key to economic revival thus making re-prioritization of development activities top of the economic recovery agenda. Table 3.1 shows that during the period 2017–20 and 2021–24, public investment allocation to education lies on average around 10% and 2%, respectively. The main share of public investment is for infrastructure development and it accounts to nearly 40% to 60% of public investment during the specified two reference periods.

FIGURE 3.3

GROWTH AND TRADE PERFORMANCE IN 2000–20



Source: Central Bank of Sri Lanka.

TABLE 3.1

SECTORAL COMPOSITION OF PUBLIC INVESTMENT PROGRAMME (PIP) 2017–20 AND 2021–24

As a % of Public Investment

Sector	PIP 2017–20					PIP 2021–24				
	2017	2018	2019	2020	Average 2017/20	2021	2022	2023	2024	Average 2022/24
Commercial Infrastructure	**37.9**	**40.3**	**43.7**	**45.0**	**41.7**	**59.8**	**59.3**	**59.2**	**61.9**	**60.2**
Transport-related	21.5	22.9	26.6	28.6	24.9	39.5	32.9	30.4	36.6	34.9
Irrigation	9.5	9.5	9.5	8.9	9.4	4.7	6.2	6.1	5.7	6.0
Utility & housing	6.8	7.9	7.6	7.5	7.4	12.0	12.4	16.1	15.2	14.7
Social Infrastructure	**21.7**	**21.3**	**21.2**	**21.5**	**21.4**	**17.2**	**17.7**	**17.7**	**17.6**	**17.7**
Health	6.1	6.2	6.2	6.4	6.2	8.0	8.8	8.7	8.1	8.5
Education	10.7	10.7	10.6	10.8	10.7	2.3	1.9	2.0	2.2	2.0
Governance	10.2	10.0	9.6	8.9	9.7	7.2	8.8	7.7	6.1	7.5
Regional development	9.7	9.0	8.4	8.3	8.8	7.0	4.8	5.9	6.0	5.5
Agriculture	5.0	5.6	4.9	5.0	5.1	4.2	5.2	5.5	4.8	5.2
Industry/Trade/Tourism	3.0	2.5	2.4	2.4	2.6	2.0	2.3	2.2	1.9	2.1
Social protection	2.0	1.4	0.9	0.7	1.2	1.6	1.4	1.3	1.1	1.3
Environment	1.3	1.3	1.3	1.3	1.3	1.0	0.5	0.6	0.6	0.5

Source: Department of National Planning.

Educational and Innovation Policies in Sri Lanka

Sri Lanka has a free education policy since 1945 and states that every child from the age of five to sixteen has the right to free education. The policy has facilitated an unprecedented social upliftment in Sri Lanka. The 1972 educational reforms further expanded the facilities and the quality of free education with the introduction of English, mathematics, and science education to all schools. Besides the higher socioeconomic indicators, the education sector faces many challenges and could not meet the changing needs of the labor market. Heavy examination and academic orientation, deficiencies in education delivery methods, and lack of employable skills and innovation among graduates are some of the major challenges that need critical improvements.

The contribution of innovation-led growth was not visible in Sri Lanka. Major sources of foreign exchange earnings continue to be low tech, such as apparel, remittances from unskilled migrant labor, tourism, and commodity exports (especially tea, rubber, coconut), with very little value addition. High-tech manufactured exports constitute only 1% of total exports in Sri Lanka, indicating a poor high-end innovation culture in the country. This is mainly due to: (i) limited capacity and low investment in science and technology (S&T); (ii) poor research infrastructure; (iii) low numbers of R&D personnel; (iv) inadequate operational and support mechanisms for the national innovation and research system; and (v) poor patenting and research commercialization culture. However, though insufficient, several commendable attempts were made to improve innovation-led growth in the country.

- **National Science and Technology Policy 2008 by the Ministry of Science and Technology**

  Main objective/s: Foster a science, technology and innovation (ST&I) culture that effectively reaches all citizens of the country and enhance S&T capability for national development, make use of S&T expertise in the national planning process, and strengthen governance and policy implementation mechanisms.

- **National Biotechnology Policy 2009 by the Ministry of Science and Technology, National Science Foundation, and the National Science and Technology Commission**

  Main objective/s: The commitment for research in biotechnology and the commercialization of those research outcomes, influencing public awareness and perceptions about biotechnology.

  Human resources development in the area of biotechnology, the sustainable use of bio-diverse resources, fostering entrepreneurship in biotechnology, and establishing centers of excellence in biotechnology parks.

- **Science, Technology, and Innovation - Strategy for Sri Lanka 2011–2015 by the Ministry of Technology and Research**

  Main objective/s: Harness innovations and technologies to generate and improve products and services as a way of increasing exports and establish a world-class research and innovation ecosystem.

- **Unstoppable Sri Lanka 2020: Public Investment Strategy 2014–2016 by the Ministry of Finance and Planning**

  Main objective/s: Sri Lanka becoming a USD100 billion economy by 2016 and USD185 billion economy by 2020. Sri Lanka increasing per capita annual income to USD4,470 by 2016 to USD8,500 by 2020 and building a culture of innovation and research.

- **Investment Framework for R&D 2015–2020**

  Main objective/s: Sri Lanka's growth should be one that is innovation-driven and the following requirements are outlined for such a strategy to be successful: (i) investments should be mainly on applied and developmental research and innovation; (ii) an environment conducive for research and innovation should be created; (iii) investments and market stimulation for commercialization of innovations should be promoted; (iv) a consistent percentage of Sri Lanka's GDP should be invested in R&D; and (v) a stable innovation environment is established.

The implementation of the above policies has not been successful due to poor leadership and insufficient commitment. A lot more still needs to be done. While the objectives are well articulated, it lacks financial resources and implementation plan. The government has not been able to allocate funds for innovation-led growth due to limited resources and high demand in other key sectors, such as health, education, agriculture, and infrastructure development. There is also a lack of prioritizing the country's limited investible resources, looking at the future growth prospects and big picture in the economy.

Developing countries, like Sri Lanka, undertake the referred balancing tasks with greater difficulty than other countries. Clearly, more resources need to be invested in ST&I if it is to contribute to Sri Lanka's economic development and improve the lives of Sri Lanka's people. Marginal or incremental increases in resources are unlikely to have an impact. A large, significant investment in ST&I with comparable follow-on investments in succeeding years however, will make a difference and have an immediate impact. It could also be the catalyst to provoke cultural change to create one of innovation and commercialization.

Education in Focus

Human capital accumulation is positively related to long-run economic growth. The relationship between education and growth is complicated as the processes of economic catch-up and educational catch-up works is an unresolved query. Further, education attainment is measured by the average number of years of schooling in adult population and economic development is measured by GDP per capita.

Table 3.2 shows that on average, in any of the time periods during 1961–2017, Sri Lanka has the highest number of mean years of schooling to that of PR China, Malaysia, and Thailand (Figure 3.6 in the Appendix). However, this achievement has not clearly translated into economic gains as Sri Lanka has the lowest GDP per capita of the four countries. It is clear that Sri Lanka's education policy has not been able to provide the necessary impetus required for the economic development in the country.

TABLE 3.2

SCHOOLING AND ECONOMIC DEVELOPMENT IN MIDDLE-INCOME COUNTRIES

Period	PR China		Malaysia		Thailand		Sri Lanka	
	Schooling (Mean years)	GDP per capita (USD)	Schooling (Mean years)	GDP per capita (USD)	Schooling (Mean years)	GDP per capita (USD)	Schooling (Mean years)	GDP per capita (USD)
1961–70	2	100	3	301	2	144	4	160
1971–80	3	162	4	966	2	409	6	242
1981–90	5	269	5	2,072	3	980	7	367
1991–2000	6	631	8	3,749	5	2,259	9	713
2001–10	7	2,340	9	6,134	7	3,291	11	1,499
2011–17	8	7,394	10	10,505	8	5,986	11	3,684

Source: World Development Indicators, World Bank.

TABLE 3.3

SCHOOLING AND ECONOMIC DEVELOPMENT IN HIGH-INCOME COUNTRIES

Period	Japan		ROK		Singapore		Sri Lanka	
	Schooling (Mean years)	GDP per capita (USD)	Schooling (Mean years)	GDP per capita (USD)	Schooling (Mean years)	GDP per capita (USD)	Schooling (Mean years)	GDP per capita (USD)
1961–70	7	1,153	4	182	3	503	4	160
1971–80	8	5,398	6	871	4	2,648	6	242
1981–90	9	15,471	8	3,603	5	7,805	7	367
1991–2000	10	36,313	10	10,461	7	21,548	9	713
2001–10	11	37,665	11	18,471	10	32,453	11	1,499
2011–17	12	41,505	12	28,090	11	56,805	11	3,684

Source: World Development Indicators, World Bank.

Table 3.3 shows that there is a clear link between mean years of schooling and GDP per capita for Japan, Republic of Korea (ROK), and Singapore (Figure 3.7 in the Appendix). With increasing number of years in schooling, GDP per capita has increased significantly for all three countries, except for Sri Lanka. However, on average, the number of years in schooling of Sri Lanka is comparable to that of these three high-income economies. Moreover, during the period 1961–2010, mean years of schooling is always higher even to that of Singapore. This shows that Sri Lanka had not followed a similar economic development, but rather an increase in number of years in schooling.

In Sri Lanka, educational catch-up accelerated as early as the 1980s but economic catch-up took place much later. A possible interpretation is that the early spurt in educational development was an investment with a very long gestation period. It shows that the length of the investment gestation period varies greatly. This could be due to many reasons. While the quality of education may be what really matters to economic growth, but it is not reflected in Tables 3.2 and 3.3. The years of schooling measures the quantity of education, not the quality. It may well be that when the quality of education was low, a gap widened between educational and economic catch-up levels, and the gap narrowed as the quality improved gradually.

International port-city states like Singapore would have thriving services sectors, such as international commerce and financial services. They could offer jobs compatible with high education even in early stages of economic development. By contrast, Sri Lanka began its economic development as an agrarian economy, where the effect of education on productivity would be more limited.

Moving forward, to elevate Sri Lanka means reforms in the education sector is mandatory. For example, the Republic of China (ROC) has labor-intensive, light-manufacturing industries and micro and small enterprises mushroomed to form industrial clusters in and around major cities. ROC was called a "boss island" because there were many business owners relative to the population. They tend to be more educated than their employees. Thus what matters may be the level of education plus distribution of job types. International connectivity may also be critically important. Portugal is not a city-state but its location is close to rich western European countries. Its strong agriculture, forestry, fishery, and diversified manufacturing are all export-oriented. This is at least one reason why this country could have managed to have a relatively high level of economic catch-up for its relatively low level of educational catch-up.

EMPIRICAL STRATEGY

Model Specification

To examine the role of TFP growth on economic growth, the study employs TFP growth regression model following Park [6] which is a modified version of Bosworth and Collins [7] to include human capital and R&D as additional determinants of TFP growth. The model is based on two-input production function with Cobb-Douglas technology and constant returns to scale. The model assumes human capital (*H*) to improve the quality of labor as follows:

$$Y = AK^{1-a_L}(HL)^{a_L}$$

Therefore, the baseline model which is to be used in the empirical analysis is as follows:

$$\Delta\ln(TFP)_{it} = \beta_0 + \beta_1 \ln Y_{it} + \beta_2 H_{it} + \gamma' Z_{it} + \eta_t + \mu_i + \varepsilon_{it} \text{ ------------------------------- (1)}$$

TFP_{it} is the dependent variable, TFP for Sri Lanka in year t. A set of control variables is to be used as the other explanatory variables: educational attainment level (H_{it}) as the level of human capital, GDP per capita (Y_{it}), and other potential determinants (Z_{it}) that include the population density, inflation, and debt to GDP ratio. The variable of interest is H_{it}. The unobserved heterogeneity is controlled using year and country specific fixed effects, η_t and μ_i, respectively. The year fixed effects account for various economic and political changes evolve over time. The country-specific fixed effects capture the effect on TFP of time-invariant traits, such as culture, population preferences, and history. The model (1) will be later augmented with innovation. The innovation was proxied through two variables -the number of patent applications (P_{it}) and R&D expenditure (RD_{it})

$$\Delta \ln(TFP)_{it} = \beta_0 + \beta_1 \, lnY_{it} + \beta_2 \, P_{it} + \gamma' \, Z_{it} + \eta_t + \mu_i + \varepsilon_{it} \text{ --------------------------------- } (2)$$

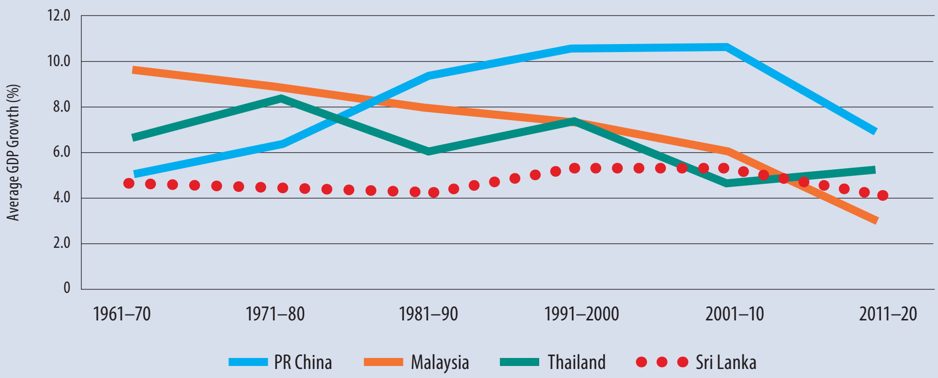
$$\Delta \ln(TFP)_{it} = \beta_0 + \beta_1 \, lnY_{it} + \beta_2 \, RD_{it} + \gamma' \, Z_{it} + \eta_t + \mu_i + \varepsilon_{it} \text{ ------------------------------- } (3)$$

Data and Variables

The study uses annual data, covering the period 1990–2019. TFP growth estimates were calculated using equation (1) to (3). First, it is calculated only for Sri Lanka and then for a balanced panel of four countries, including PR China, Malaysia, and Thailand. These three countries were selected as they are in the Asian region and trapped in middle-income level for a long period of time. This study uses data at country-level only.

FIGURE 3.4

VARIATION IN AVERAGE GROWTH

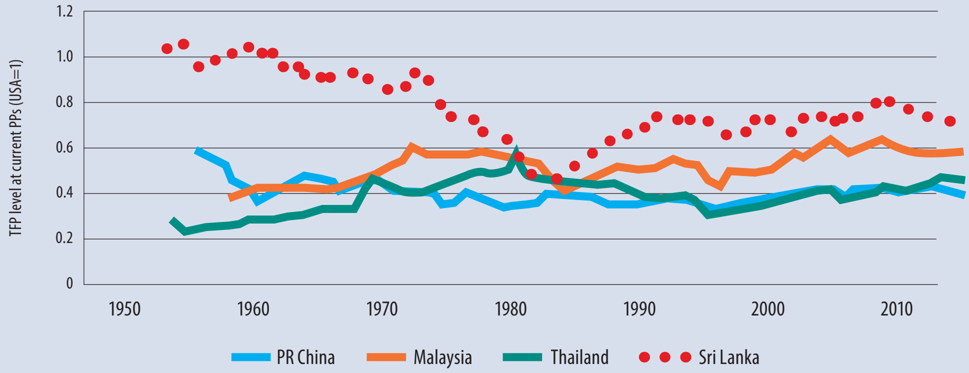


Source: World Development Indicators, World Bank.

The data on the outcome variable, the TFP, were obtained from the Penn World Tables (PWT 10.0). In addition, TFP data of the APO-productivity database 2021v1 were used as a robustness check. TFP is defined as the portion of output not explained by the number of inputs used in production. It is expressed at current purchasing power parity (PPP) rates, relative to the USA. Figures 3.4–3.5 show trends in GDP growth and TFP for Sri Lanka and other selected Asian economies. Figure 3.4 indicates that comparatively, Sri Lanka's average GDP growth is lower than to that of China, Malaysia, and Thailand. However, Sri Lanka has maintained considerably high TFP levels, as indicated in Figure 3.5.

FIGURE 3.5

VARIATION IN TFP



Source: Penn World Tables (PWT 10.0).

The choice of covariates follows Park's [6] TFP growth regression model is a modified version of Bosworth and Collins [7]. Human capital index, GDP per capita, population density, inflation, and debt to GDP ratio are thus considered important drivers of TFP at the national level. Data on covariates were extracted from Penn World Tables [8] (human capital index) and World Bank's World Development Indicators (GDP per capita, population density, inflation, and debt to GDP ratio) [9].

Human Capital Index is based on years of schooling and returns to education. It is believed that human capital plays a significant role in enhancing growth through TFP. To account for the level of economic development's effect (at least in a quantitative sense), the GDP per capita was used. It is acknowledged that at high-income levels TFP tend to increase due to intangible factors, such as technological change, education, R&D, etc. [1]. In the context of middle-income countries, GDP per capita cannot be a significant factor in TFP growth if they are caught in a middle-income trap. Beyond a certain income, GDP per capita may improve TFP thus it should have significant impact for high-income economies. The estimation was replicated for a panel of upper-middle income Asian economies as clarification.

Considering the importance of population pressure on TFP growth, population density (people per sq km of land area) is built in to the analysis. This explains the impact of population structure on TFP growth. It is assumed that population growth reduces the natural resources and capital (physical and human) per worker and the greater population size and density affect productivity [10]. An increase in inflation causes a decrease in TFP [10]. High debt imposes a negative impact on both physical capital accumulation and TFP growth [11]. Debt constrains growth by lowering TFP growth. Highly indebted countries are less willing to undertake policy reforms as future benefit in terms of higher output will accrue partly to foreign creditors. A similar condition is currently witnessed in Sri Lanka. A description of all variables and corresponding summary statistics are given in Appendix's Table 3.6.

ESTIMATION RESULTS AND DISCUSSIONS

Human capital and innovation are key drivers of TFP. The role of TFP growth in overcoming the middle-income trap in Sri Lanka is studied by estimating equation (1) in the earlier section. The human capital variable (years of schooling) at primary, secondary, and tertiary enrollments is used in the estimations to understand the disaggregated impacts. Innovation is proxied based on the number of patent applications and the expenditure on R&D (equation (2) and (3) in the Empirical Strategy section). First,

TABLE 3.4

SRI LANKA'S ESTIMATES OF TFP GROWTH MODEL

Variable	(I)	(II)	(III)	(IV)	(V)	(VI)
	Equation 1	Equation 2	Equation 3	Primary	Secondary	Tertiary
Human capital index	-2.080** (0.694)			0.001 (0.004)	-0.0001 (0.002)	-0.001 (0.003)
Patent		-0.003 (0.004)				
R&D			0.013 (0.470)			
GDP per capita	-0.100** (0.033)	-0.016 (0.017)	-0.017 (0.018)	-0.017 (0.018)	-0.017 (0.018)	-0.016 (0.018)
Population density	-0.003 (0.006)	-0.006 (0.007)	-0.003 (0.007)	-0.003 (0.007)	-0.003 (0.006)	-0.003 (0.006)
Inflation	-0.003* (0.001)	-0.002* (0.001)	-0.002* (0.001)	-0.002* (0.001)	-0.002* (0.001)	-0.002* (0.001)
Debt to GDP ratio	0.001 (0.001)	-0.0002 (0.001)	-0.0003 (0.002)	-0.0002 (0.002)	-0.0003 (0.002)	-0.0001 (0.002)
Observations	29	29	29	29	29	29
R^2	0.389	0.189	0.161	0.162	0.161	0.163

Note: Covariates include human capital index, GDP per capita, population density, inflation, and debt to GDP ratio. Number of patents and R&D expenditure are the proxies for innovation. Robust standard errors are in parenthesis. ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

the analysis is conducted only for Sri Lanka. Then, Sri Lanka in a panel setting with three other upper middle-income economies is studied for comparison.

Table 3.4 presents the ordinary leased squares (OLS) estimates of TFP growth model for Sri Lanka. Column I, II, and III in Table 3.4 are for human capital, number of patents, and R&D expenditure (equations (1), (2) and (3) in the Empirical Strategy section), respectively. Columns IV, V, and VI show the estimates for school enrollments decomposed at three levels: primary, secondary, and tertiary.

TFP growth is the dependent variable. The estimates show that human capital has significant negative impact on TFP growth. While innovation, proxied by patents and R&D expenditure, is not a significant contributory factor for TFP growth in Sri Lanka (Table 3.4). This indicates that despite the initiatives in implementing a free education policy since 1945, Sri Lanka has not been able to translate its education achievements into economic progression of the country.

Among other potential determinants, GDP per capita and inflation show significant negative impact on TFP growth. The same is observed when innovation is included in the estimation, except the GDP per capita. The decomposed estimates in Column IV, V, and VI (Table 3.4) are not significant, however secondary and tertiary enrollments have negative signs that indicate issues of education quality in the Sri Lankan education system.

Though intuitively, human capital accumulation should promote growth, the empirical evidence of this study provides no support for such assertion. This finding is in line with Miller and Upadhyay [12] who claimed that human capital plays a smaller role in enhancing growth through TFP. However, Romer [13], Black and Lynch [14], and Loko and Diouf [15] claimed that human capital accumulation (education) plays a key and positive role in determining technological innovation. Henceforth, it is understood that quantitatively the Sri Lankan education policy may have a desirable influence on economic growth, and therefore, the issue might be in its quality.

Factor accumulation and TFP are principal determinants of growth. Basic inputs in production directly affect output growth through indirect influence of factors that change the efficiency of those basic inputs. Those other indirect factors determine TFP.

Innovation is a significant factor for economic growth and it affects the growth through TFP [16]. Technological innovation and non-technological innovation factors are two main divisions of innovation. New production and services are related to the technological innovation. While organizational or marketing modifications are non-technological innovations. In this study, the main consideration is on technological innovations as the study employs total number of patents and R&D expenditure as proxy variables for innovation.

The estimates in Column IV and VI in Table 3.4 show that secondary and tertiary education enrollments have negative but insignificant impact on TFP. Liu and Bi [2] indicated that higher education is significant for TFP rather than primary education. Further, higher education increases employability and improves the safety of society. Hanushek [17] showed that extending the years of education without improving the human capital does not improve the economic productivity. Although, the years of schooling of Sri Lanka is similar to that of advanced economies, it is yet to move into high income status. This highlights the deficiencies in qualitative improvements in Sri Lanka's education system. Thus it is mandatory to implement policy reforms to improve the quality of education, especially at secondary and tertiary level.

Cross-country comparison of TFP growth in Figures 3.8 and 3.9 in the Appendix show that Sri Lanka is behind most Asian countries in TFP growth, especially in recent years. As a country, there was a considerable decline in Sri Lanka's TFP growth from 2.1% in 1990–2010 to -0.5% in 2010–18. Sri Lanka's GDP growth in 2010–18 relied heavily on capital accumulation, but insignificantly on labor (Figure 3.10 in the Appendix). This implies that the country's growth model underutilizes its human capital potential. If capital accumulation drives growth more than technological adaptation, this model is less effective for developing countries. Although, capital accumulation is necessary for growth in early and middle stages of development, TFP growth is the engine of growth thereafter. For example, the dominant driver of growth in Japan and Hong Kong is the TFP growth.

Industry-wise, the international division of labor - production activities of one industry completed within the country and only final goods are traded - is common in the past. Country specialization depends on its technological level and factor endowments. Developing countries import manufactured goods (or machinery) and export primary products (or garments). Hence, only one-way trade pattern was observed. International labor division had then shifted from industry-wise to task-wise in the late 1980s. As indicated in Figure 3.11 in the Appendix, countries that are involved in task-wise international labor division (like Japan and ROK), has significantly higher export share than imports. However, Sri Lanka made no progress on promoting the machinery industry, which is considered an important driver of industrialization, over the past three decades. As a result, many countries, including Cambodia, have surpassed Sri Lanka on this measure.

Low levels of investment in R&D and IT (Figure 3.12 in the Appendix) could be a problem for Sri Lanka to promote through innovation and digital transformation. R&D capital is regarded as the basis of scientific knowledge and crucial input for innovation. For example, the ratio of R&D to GDP is very high for high-income economies, like Japan (18.2%), ROC (15.6%), USA (13.8%), and Singapore (9.7%). Whereas the figure for Sri Lanka is only 0.5%, highlighting a big gap in R&D capital between economies that have reached the high-income level and those that have not. Innovation capability backed by R&D capital in a well-organized national innovation system is essential for stepping up from upper-middle income to fully developed economies.

In contrast, the IT capital investment (i.e., IT hardware which includes computers and communication equipment, like TV, radio, mobile phones, and computer software) is much larger in many developing countries, including Sri Lanka. The IT capital investment is 2.4% whereas R&D investment is only 0.5%

for Sri Lanka. These investments are more or less the same in many advanced economies. (Japan: IT 10.3% and R&D 18.2%; ROC: IT 5.7% and R&D 15.6%; USA: IT 9.9% and R&D 13.8%; Singapore: IT 18.1% and R&D 9.7%). This indicates that applications of new technologies are common rather than using innovation leading the economic growth in Sri Lanka.

Furthermore, it is observed that Sri Lanka would have a much higher per capita income if it embraces an economic growth model that better utilizes its human capital potential (Figure 3.13 in the Appendix).

Table 3.5 shows cross-country comparison of TFP growth estimates. Here, Sri Lanka is included in a balanced panel with three other Asian upper-middle income countries to observe the effectiveness of human capital and innovation on productivity. Columns I, II, and III show the estimates for the full panel. Columns IV, V, and VI are for the interaction variable of Sri Lanka*human capital or innovation variable. Accordingly, human capital and number of patents show negative impact on TFP growth. However, the effect is not significant. Thus the estimates of the single country study were confirmed in the cross-country comparison.

TABLE 3.5

ESTIMATES OF TFP GROWTH MODEL FOR UPPER-MIDDLE INCOME ECONOMIES

Variable	(I)	(II)	(III)	(IV)	(V)	(VI)
	Human Capital	No. of Patents	R&D Expenditure	Human Capital	No. of Patents	R&D Expenditure
Human capital/innovation	0.185 (0.386)	-0.000 (0.0002)	0.042 (0.062)			
Sri Lanka*Human capital/ innovation				-0.236 (0.729)	-0.006 (0.004)	0.111 (0.480)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	116	116	116	116	116	116
R^2	0.522	0.520	0.523	0.522	0.532	0.523

Note: Covariates include human capital index, GDP per capita, population density, inflation, debt to GDP ratio. Number of patents and R&D expenditure are the proxies for innovation. Robust standard errors are in parenthesis. ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Economic development in PR China is not a surprise as the country ranks first in patent filings since 2011 [18]. WIPO reports that China filed 1.4 million patents or 43.4% of the world's total patent applications in 2019. That is more than twice the number of filings in the USA. PR China accounts for an even bigger portion of the world total filings in utility models (96.9%), trademarks (51.7%), and industrial designs (52.3%).

Further, the fact that human capital/innovation is not TFP-growth friendly is supported by literature. Wolfe [19] revealed that the number of higher education graduates does not significantly affect economic productivity for advanced economies. Vedder [20] showed that states with greater public investment on higher education did not provide support for economic growth in the USA. Moreover, Liu and Bi [2], using a two-step human capital accumulation model, showed that higher education effect on economic productivity is ambiguous.

CONCLUSION AND POLICY IMPLICATIONS

Sri Lanka, being a traditional agrarian economy, has turned into a service-oriented economy since the 1980s. However, the economic growth shows persistent deterioration in the last few decades. Although, TFP growth has been empirically investigated, the literature has not yet been conclusive. Theoretically, human capital can improve TFP. Increasing the number of innovative talents further aids economic growth. Henceforth, this study examines the role of human capital and innovation in TFP growth in Sri Lanka. The results reveal that although the country enjoys free education since 1945, it has not been able to provide decent living standards for its citizenry. The quality of education is in jeopardy and this issue is observed both at secondary and tertiary level enrollments. The results highlight the necessity in reforming both the educational and innovation sector policies. Thereby, the improved TFP growth would facilitate avoiding MIT to achieve strong growth momentum in Sri Lanka. Further, both inflation and GDP per capita appear not to be in supportive of TFP growth. The results of this empirical analysis suggest that to stimulate TFP growth, to avoid economic stagnation per se, and to avoid the middle-income trap, the policy makers may focus on improving the quality of education by introducing appropriate policy reforms to the education system.

The economic growth is highly dependent on the potential ability of the country to move up on the innovation scale to remain globally competitive. This needs the allocation of more resources for R&D as underinvestment in R&D impedes innovation activities. Moving forward, allocation of limited government resources from unproductive sectors to productive sectors like R&D is encouraged. According to the APO database, the R&D share of high-income economies is, on average, 15% of GDP whereas it is only 0.5% for Sri Lanka.

Asian economies that escaped MIT, like Japan, ROK, and Singapore share two main characteristics: developed advanced infrastructure networks (including high-speed communication and broadband technologies) and moved from imitating and importing foreign technologies to innovating technologies of their own. These countries have very strong intellectual property rights that allow patenting of their own technologies. Therefore, implementing policies to enhance the protection of property rights is vital.

MIT is not an inevitable outcome. Avoidance of MIT requires better understanding and early action. Sri Lanka no longer has the access to cheap labor nor imitating foreign technology. Henceforth, economic growth acceleration requires timely implementation of the mentioned policies and building up of local and international knowledge networks.

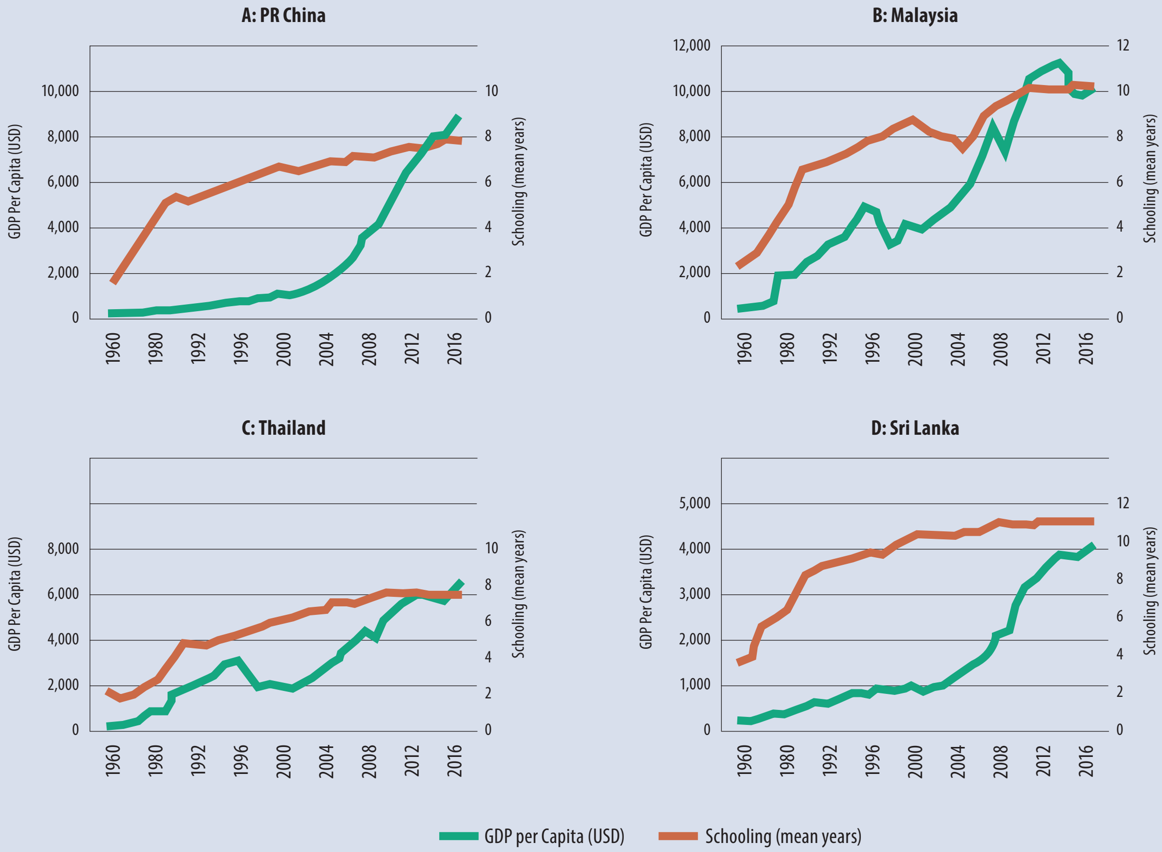
Currently, there is limited literature on the nexus between education/innovation and TFP in Sri Lanka. Improving TFP, which is a measurement of efficiency of all production factors, can solve the sustainability as TFP growth can promote economic growth continuously and steadily. Higher education provides training of critical thinking, technological skills, and literacy. This increases the employability of educated workers as they can implement tasks more efficiently. Thus improving the country’s TFP aids sustained growth.

Decomposing the human capital variable into different disciplines, degrees, etc. may provide a more comprehensive explanation to the reasons Sri Lanka could not elevate the quality of its education to support economic progression. Further, digging into province-wise or subnational data could also give robust understanding to this query. Hence, these two areas are suggested as potential future research areas. However, the data availability at subnational level and different levels of decompositions may be a hindrance.

APPENDIX

FIGURE 3.6

SCHOOLING AND ECONOMIC DEVELOPMENT - SRI LANKA AND SELECTED UPPER-MIDDLE INCOME ECONOMIES



Source: World Development Indicators, (PWT 10.0).

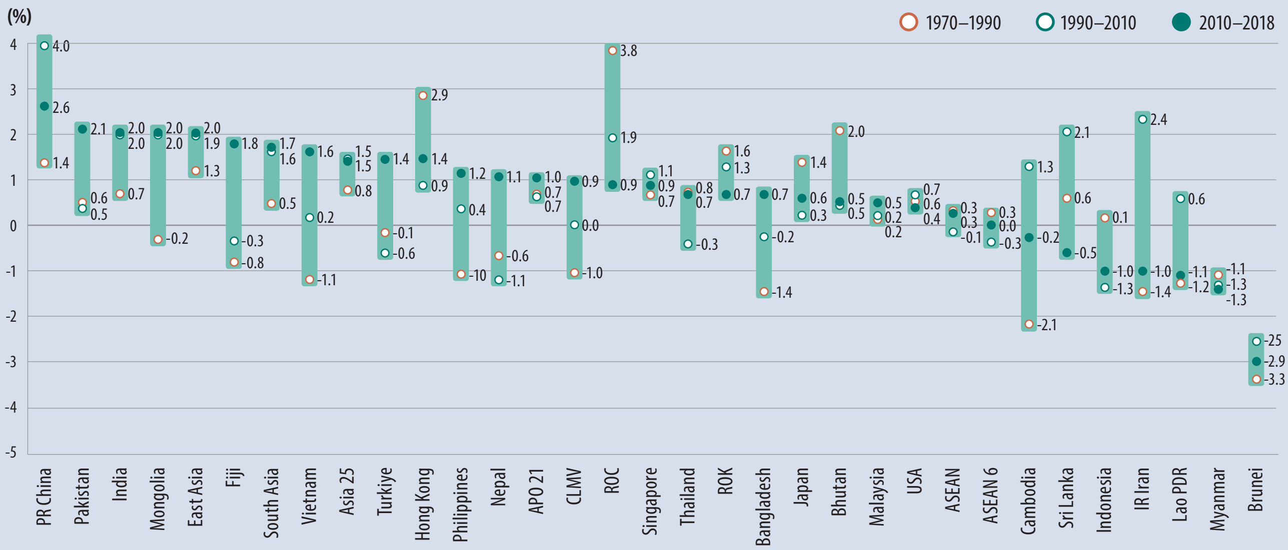
FIGURE 3.7

SCHOOLING AND ECONOMIC DEVELOPMENT - SRI LANKA AND SELECTED HIGH-INCOME ECONOMIES

Source: World Development Indicators, (PWT 10.0).

FIGURE 3.8

TFP GROWTH IN THE LONG RUN

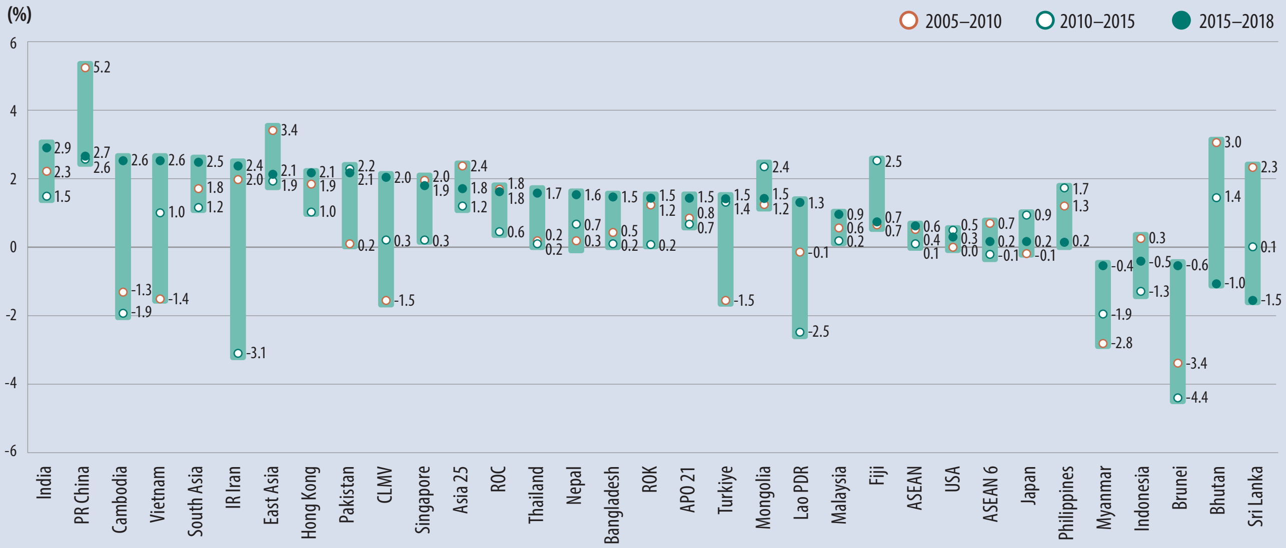


Source: APO Productivity Database 2020.

Note: Average annual growth rate of TFP in 2010–18, 1990–2010, and 1970–90.

FIGURE 3.9

TFP GROWTH IN THE RECENT PERIODS



Source: APO Productivity Database 2020.

Note: Average annual growth rate of TFP in 2015–18, 2010–15, and 2005–10.

FIGURE 3.10

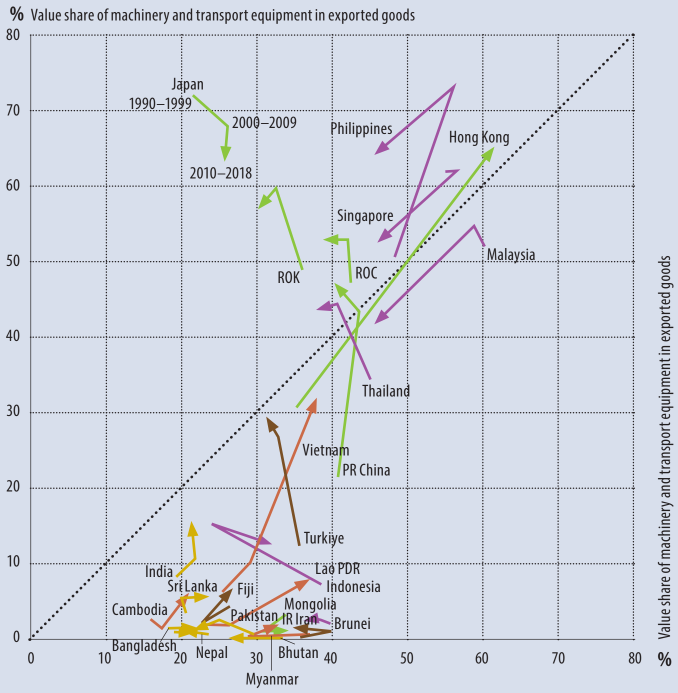
COMPARISON OF SOURCES OF ECONOMIC GROWTH WITH OECD COUNTRIES

Source: APO Productivity Database 2020.

Note: Average annual growth rate of constant-price GDP and contributions from labor, capita; and TFP in 2000–10 and 2010–18. The impacts of labor quality changes are included in capital inputs. The ending years for Ireland and Portugal are 2014 and 2017, respectively.

FIGURE 3.11

EXPORT AND IMPORT SHARES OF MACHINERY

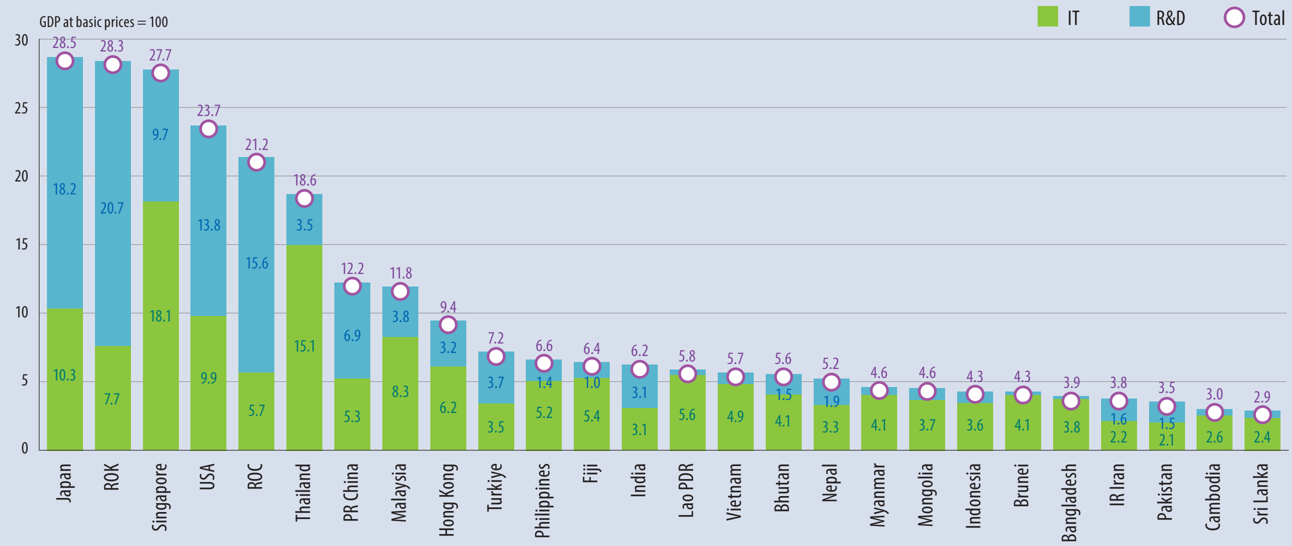


Note: Average value shares in 1990–99, 2000–09, and 2010–18. The arrows are colored in light green, brown, purple, orange and yellow for East Asia, South Asia, ASEAN6, CLMV, and other Asian countries, respectively.

Source: APO Productivity Database 2020.

FIGURE 3.12

STOCK OF IT AND R&D CAPITAL, RELATIVE TO GDP IN 2018



Source: APO Productivity Database 2020.

Note: Ratios of end-of-year capital stocks of IT and R&D to the basic-price GDP in 2018.

FIGURE 3.13

GDP PER CAPITA PROJECTIONS

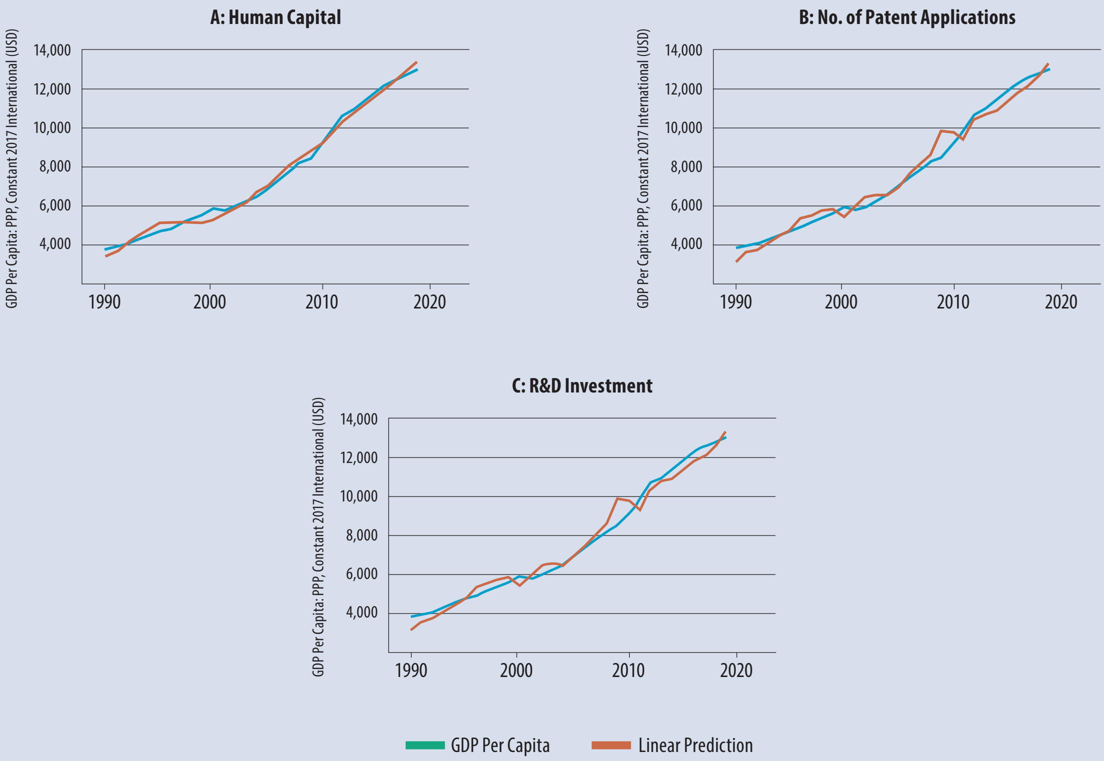


TABLE 3.6

DESCRIPTION OF VARIABLES

Variable	Description	Source
TFP growth	The log difference of TFP level at current PPPs (USA=1)	PWT
Human capital index	Based on years of schooling and returns to education	PWT
GDP per capita	GDP per capita based on purchasing power parity (PPP) (constant 2017 international USD). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates.	WDI
Population density	Population density (annual %)	PWT
Inflation	Inflation, consumer prices (annual %)	WDI
Debt to GDP ratio	Central government debt, total (% of GDP)	WDI

Notes: PWT - Penn World Tables (10.0); WDI - World Development Indicators of the World Bank.

TABLE 3.7

SUMMARY STATISTICS FOR MIDDLE-INCOME COUNTRIES

Variable	Mean	Std. Dev.	Min	Max
Sri Lanka				
TFP growth	0.003	0.040	-0.054	0.085
Human capital index	2.807	0.118	2.505	2.900
GDP per capita	7,716	3,028	3,878	13,070
Population density	311.727	21.629	276.284	352.434
Inflation	9.049	5.076	2.135	22.565
Debt to GDP ratio	87.563	11.090	68.710	105.525
Asia: Upper-Middle Income Country Group*				
TFP growth	0.004	0.044	-0.160	0.100
Human capital index	2.565	0.285	1.956	3.079
GDP per capita	11,332	6,183	1,424	28.364
Population density	162.794	90.301	54.877	352.434
Inflation	4.696	4.702	-1.401	24.257
Debt to GDP ratio	47.500	27.208	3.673	105.525

Note: This includes three upper-middle income countries - PR China, Malaysia, and Thailand.

CHAPTER 4

THAILAND

ABSTRACT ON THAILAND'S EXPORTING, R&D INVESTMENT, AND PRODUCTIVITY: FIRM-LEVEL EVIDENCE

Using Thailand's Research Development and Innovation (RDI) survey data between 2011–18, this paper empirically investigates the relationship between exporting, R&D, and productivity in Thai manufacturing firms. The paper finds that firms investing in R&D in the said period have 5.9% higher productivity level while firms that export in the same period displayed an even larger productivity gain of 16.5% gained from experience and learning curve of exporting. The results show, for the same time frame, that firms that do both R&D and export have 11.8% higher productivity than those that do neither. The findings provide evidence in support of the role played by exporting and R&D in conjointly enhancing firms' productivity performance. This is particularly important for policymakers to foster innovation and promote trade openness for a successful productivity-led growth model. Last but not least, the paper provides a thorough analysis of firm-level innovation in relation to government policy to promote R&D investment. While product and process innovations are significant, this paper highlights how marketing and organization innovations are found to be far more familiar among Thai firms. Distinguishing between types of innovations in examining policy awareness and adoption provide further insights into how Thai firms respond to different R&D policy stimulus, and therefore how to better design policy recommendations for successful innovation and productivity enhancement both at firm as well as national levels.

INTRODUCTION

After years of high growth rate and rapid rise in per capita income, Thailand was officially declared an upper middle-income country (UMIC) by the World Bank in 2011. Since then, Thailand has remained UMIC and like many other similar income bracket countries, the country has fallen into a middle-income trap, amid economic growth slowdown, stalled key growth drivers, and declining productivity growth. To escape from the middle-income trap, the Thai government has put in place a series of policy reforms in an attempt to leap Thailand toward becoming a high-income country by 2037. These plans include a 20-year national development strategy (2018–37), Thailand 4.0 economic model of transforming into a "value-based" digital economy, and the National Science, Technology and Innovation Policy Plan (2011–21) with priorities given to innovation. An important question is whether these structural reforms would be enough to propel Thailand to achieve its growth trajectory.

Turning to R&D investment climate and technological innovation capability, Thailand's gross domestic expenditure on R&D (GERD) has stalled at about less than 1% of GDP, compared with 2%–3% GERD by the most advanced nations, including PR China. At a macro level, Thailand's GERD is predicted to be 0.91%, 0.94%, and 0.96% of GDP for 2020, 2021, and 2022, respectively. At a micro level, very few Thai firms innovate compared to their neighboring countries. Using the latest Enterprise Survey data, a recent report on innovation in developing East Asia [1] finds that less than 15% of Thai firms report having a product or service innovation, a process innovation, positive R&D spending, or license technology from foreign firms. The rate finds Thailand is much lower compared to its neighboring

ASEAN countries at around 40% in the Philippines, Cambodia, Malaysia, and Vietnam. This shortfall in R&D and innovation at both the macro and micro levels pose a serious challenge for Thailand to achieve its development vision through R&D and innovation.

The next important question is, what drives firms to undertake R&D investment and innovation in the first place. In a recent paper by Melitz and Redding [2], the authors stress how international trade is a key determinant of firm profitability and survival as well as the return on innovation investments mainly through four different channels. First, international trade expands the market size accessible to firms, thereby raising firms' incentives to innovate as fixed costs of innovation can be spread over larger production units. Secondly, international trade increases product market competition so that relationship between innovation and competitive pressure can give rise to an inverted U-shaped relationship, as in Aghion et al [3]. Third, as countries trade and specialize according to their comparative advantage, rates of innovation and growth depend on change in sectoral composition as sectors also differ in their rates of innovation. Finally, international trade facilitates knowledge spillovers and hence the country's economic growth.

Given an indispensable role of export in driving Thailand's economic growth, with the value of goods and services exported are about 60%–70% of GDP, it is crucial to understand how these two complementary forces between trade and innovation intertwined, and how they affect productivity performance in the context of Thai firms[1]. The probability that firms will invest in R&D may depend on whether the firms export their products/services as export status may affect the return to R&D from successful innovation. The objective of this paper is to empirically investigate the nature of the link between exporting, R&D investment, and productivity using firm-level data from Thailand's Research Development and Innovation (RDI) survey collected by the Office of National Higher Education Science Research and Policy Council (NXPO) between 2011–18.

In the next section, the paper first highlights the main feature of the dataset, especially discussing the R&D mindset observed among Thai firms that are categorized into different size, age, ownership structure, industry, types of manufacturer, and particularly, their export status. Interestingly, the proportion of firms with positive R&D investment range from a high of 50% of the sample in 2016 to 26% in 2018. As expected, larger-sized firms and older firms make the higher proportion of firms with R&D investment. In contrast to the general pattern observed in OECD countries, there are no differences found between the proportions of firms with R&D investment in high-tech versus low-tech industries. More importantly, the data showed a much higher number of exporting firms that practise R&D at 48.1%, compared to only 21.6% of non-exporters. Also, original brand manufacturers (OBM) and original equipment manufacturers (OEM) have equally high proportion of firms with R&D investment, suggesting possible R&D spillover obtained from being OEM.

Moving beyond the data, the second part of the paper seeks to understand how do Thai firms conduct R&D and become innovative. The researchers for this paper attempted to shed light on these questions: (i) which firms are more likely to carry out R&D?; (ii) which firms spend more on R&D?, and especially, (iii) do firms that invest more in R&D are more likely to report innovations and result in higher productivity level? All these questions are tackled by empirical models utilizing firm characteristics as well as business environment, such as obstacles and cooperation among firms with educational institutes. The results confirmed the positive role of size, export status, obstacles regarding knowledge, and cost in determining R&D decision found in previous studies. The negative effect of being part of foreign ownership could imply how R&D may be carried out at the company's headquarters, as suggested in

[1] Thailand labor productivity (LP) growth fell from the pre-Asian Financial Crisis (AFC) period at 7.8% to -0.6% during the AFC, and to 3.4% (2001–07), 2.0% (2008–13) to 2.5% (2014–16) (Paweenawat, Chucherd, and Amares, 2017). As for total factor productivity (TFP), average TFP growth yoy (relative to the USA) fell from 1.5% between 1969–96 to 0.5% between 1997–2014 (Source: Feenstra, Robert C., Robert Inklaar and Marcel P. Timmer (2015), "The Next Generation of the Penn World Table" American Economic Review, 105(10), 3150–3182, available for download at www.ggdc.net/pwt.).

Jongwanich and Kohpaiboon [4]. In a similar vein, size, FDI, and public support are found to influence R&D expenditure. However, the coefficient on a firm's export status turns insignificant when R&D expenditure is studied, possibly signaling complex relationship between export-R&D nexus to be further identified. Importantly, a positive linkage is seen between innovation as measured by turnover from new products and firm's productivity.

To better understand the transmission mechanism through which international trade can affect innovation and productivity gains, the paper exploits the panel feature of the RDI dataset and estimates a dynamic structural model developed by Aw, Robert, and Xu [5] in the Empirical Methods and Estimation Results section. Firms that invest in R&D in the past period witness a 5.89% higher productivity whereas, the productivity of past exporters is 16.5% higher, suggesting an even larger productivity impact from learning by exporting. Notably, firms that export and innovate have a 11.8% higher productivity than firms that do neither. Essentially, firms' decisions to export or invest in R&D do have the capability and capacity to improve the country's future productivity. For this reason, government policies that facilitate trade openness and foster innovation are crucial for a successful productivity-led growth strategy.

Last but not least, the paper seeks to provide lessons learnt on R&D and innovation practices among Thai firms with the aim at productivity improvement, specifically in relation to government support policies. This research departs from previous ones by extending general division of innovation into not only product and process innovation, but also marketing and organizational innovation. It is found that while about 50% of the participating firms in the survey are aware of R&D policy incentives, only 23% actually participate in any of the 33 initiatives offered by various government agencies. In addition, participation in policy support programs does not necessarily translate into positive innovation. Observation is made that firms that participate in government programs report greater marketing and organizational innovations. However, government programs seem to be weakly correlated with product and process innovation. The effectiveness of government incentive schemes also varies by firm size and types of innovation. Therefore, understanding a firm's heterogeneity in responding to government incentive schemes could better help in designing policy recommendations to promote successful innovation and productivity enhancement on both firm and national levels.

DATA DESCRIPTION AND VARIABLES

To analyze the role of R&D investment and export market participation in determining productivity performance, the research uses firm-level data between 2011–18. These firm-level data are from RDI survey that were collected by the NXPO. The RDI survey is conducted annually since 2011 and encompasses firms from the manufacturing, service, and wholesale and retail trade sectors. Sample firms were drawn from Thailand's Ministry of Commerce database, containing details of registered Thai firms[2]. To limit the scope of this study, the focus is only on manufacturing firms[3].

Due to data collection problems, the RDI survey in 2012 and 2013 were converged into one single survey. However, a separate dataset was constructed for 2012 and 2013 by observing reports for the consecutive years' information as required in the questionnaire. For the purpose of productivity estimation, sample firms that only appear only once in the whole sample period spanning eight years are dropped. The exercise leaves the survey with 23,611 firm-year observations. The unique feature of this dataset is they contain measures of both innovation inputs, as measured by the firms' R&D investment decision and spending as well as innovation outputs which can be subdivided into four broad categories, namely

[2] For sampling methodology, please refer to RDI Survey Report 2018 (http://stiic.sti.or.th/work/rdi-survey-report-2018/).

[3] R&D and innovation patterns are usually found to be different for the manufacturing sector vs service sector. The scope of this study is limited to focus only on the manufacturing sector.

product innovation, process innovation, marketing innovation, and organizational innovation[4]. In addition, detailed firm information is also provided, such as age, ownership structure, export status, employees, capital, and sales figures, which are crucial for productivity estimation. To give an overview of the RDI dataset, the paper begins with presenting R&D investments that are categorized according to firms and types of industry.

Table 4.1 shows the distribution of firms by survey year while Figure 4.1 displays the proportion of firms with R&D investment between 2011–18. For R&D measure, a discrete R&D variable is used, by a question in the survey that directly ask "For this survey year, does your firm conduct any R&D investment (both in-house and outsourced)?". The R&D variable receives the value of one if the firm's answer is yes, and zero otherwise.

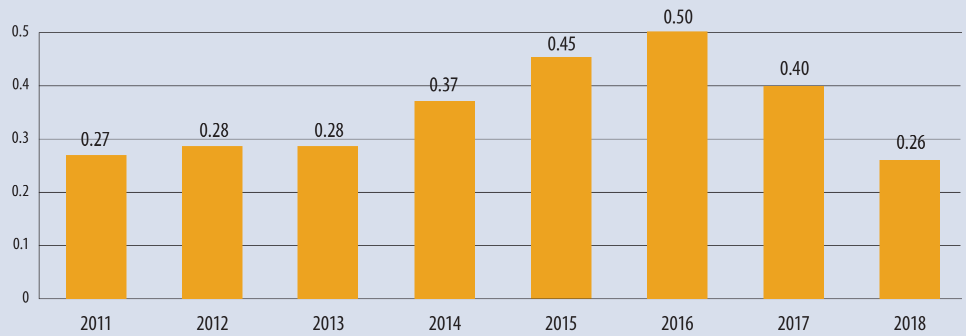
TABLE 4.1

DISTRIBUTION OF FIRMS BY SURVEY YEAR

Year	No. of Observations
2011	1,962
2012	2,831
2013	2,831
2014	2,743
2015	2,957
2016	3,369
2017	3,578
2018	3,340
All sample	**23,611**

FIGURE 4.1

PERCENTAGE OF FIRMS WITH R&D INVESTMENT IN 2011–18



[4] Product innovation refers to new product/service or significantly improved existing product/service. Process innovation also refers to new production process or significantly improved existing production process, new or significantly improved logistics and distribution channel, and procurement. Marketing innovation refers to change or development in marketing strategy including product design or packaging, online marketing, franchising, direct sales, strategic pricing, and big data analytics. Organizational innovation refers to change or development in strategy and organizational structure, including 6 sigma, Just-In-Time (inventory management), TQM, ISO 9000 ISO 14000, management system, and working with other public or private firms.

The R&D investment in a number of sample firms has been high, hitting 26% in 2018 and even recording the highest at 50% in 2016. Figure 4.2 focuses on the distribution of firms based on size. The research's sample data contains comparable fractions of firm sizes, categorized into small, medium, and large. It is evident that larger firms have a much higher percentage of R&D investment and activity. These firms, when further segregated (Figure 4.4), show that a significant number of firms in the sample (86%) are

FIGURE 4.2

DISTRIBUTION OF FIRMS BY SIZE

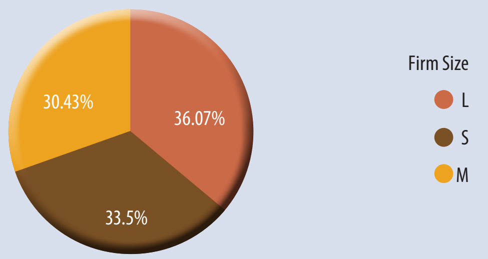


FIGURE 4.3

PERCENTAGE OF FIRMS WITH R&D BY SIZE

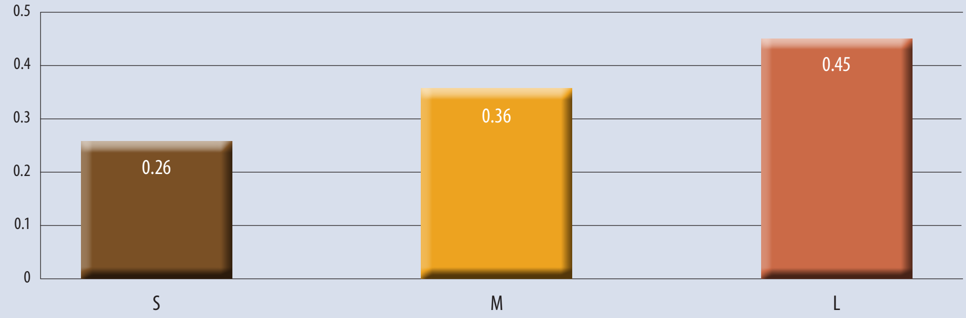
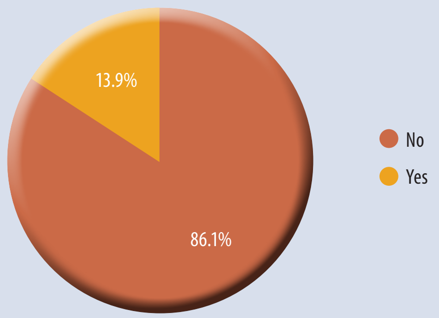


FIGURE 4.4

FIRMS BELONGING TO MNC



part of multinational corporations (MNC). No difference is detected in R&D activities between firms that are part of MNC (34.4%) and those that are not (36.2%) in Figure 4.5. The study also looked into firms that are categorized by ownership structure. Figure 4.6 shows that the majority of participant firms in the

FIGURE 4.5

PERCENTAGE OF FIRMS WITH R&D BY MNC

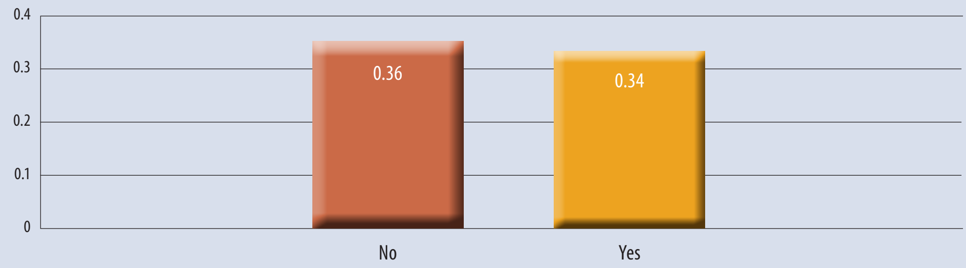


FIGURE 4.6

DISTRIBUTION OF FIRMS BY OWNERSHIP STRUCTURE

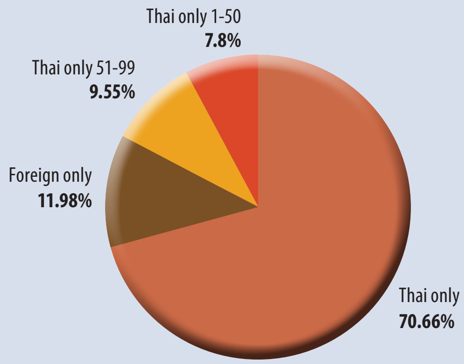
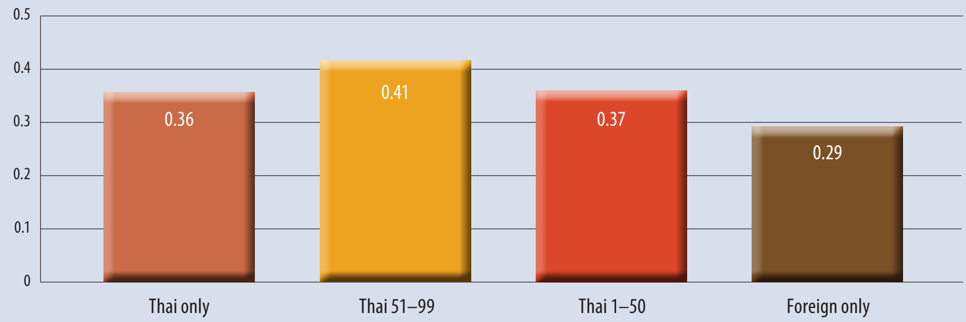


FIGURE 4.7

PERCENTAGE OF FIRMS WITH R&D BY OWNERSHIP STRUCTURE



survey are owned by Thai nationals (70.7%), followed by foreign-owned firms (12%), majority owned by Thais (9.6%), and majority owned by foreigners (7.8%). In Figure 4.7, the highest number of firms with R&D investment is in the majority owned by Thais (41%) and equal proportions of R&D activities are reported by fully Thai firms (36.2%) and majority owned by foreigners (36.7%). Surprisingly, the smallest number of firms with R&D investment is observed among foreign firms (29.4%). On the distribution of firms by age of establishment, the firms are categorized in 10 years apart, at 1–10 years, 11–20 years, 21–30 years, 31–40 years, 41–50 years, and over 50 years old. In Figure 4.8, it is perceived that the more R&D firms carry out, the longer they are in business, as the proportion of firms with R&D investment among older firms are higher than younger ones.

Figure 4.9 shows the distribution of firms by aggregated ISIC Rev. 4 (International Standard Industrial Classification for All Economic Activities) industry and sample of firms have the biggest representation

FIGURE 4.8

DISTRIBUTION OF FIRMS BY AGE AND PERCENTAGE OF R&D ACTIVITY

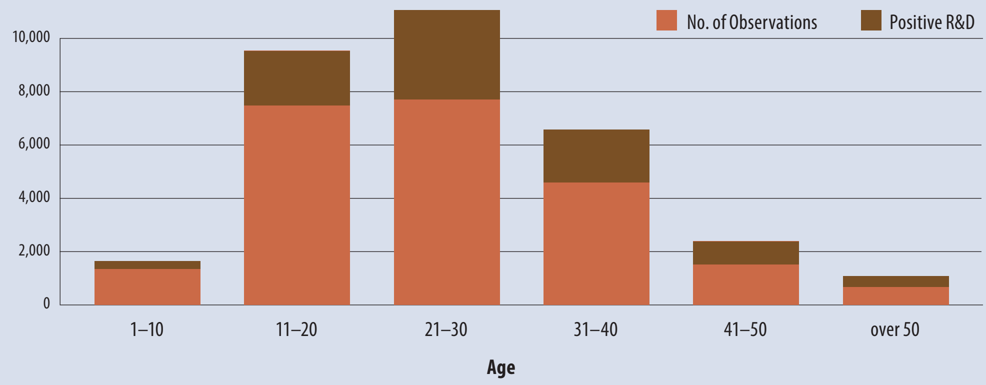
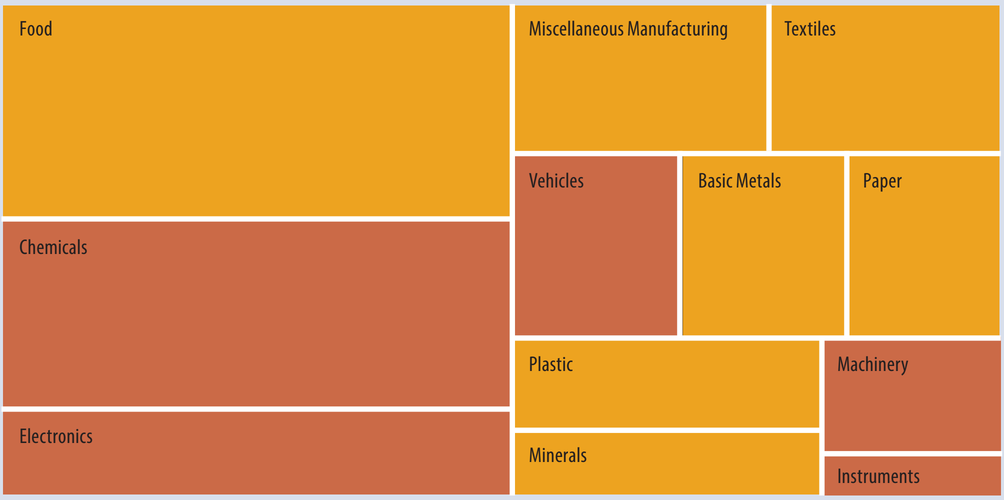


FIGURE 4.9

DISTRIBUTION OF FIRMS BY INDUSTRY



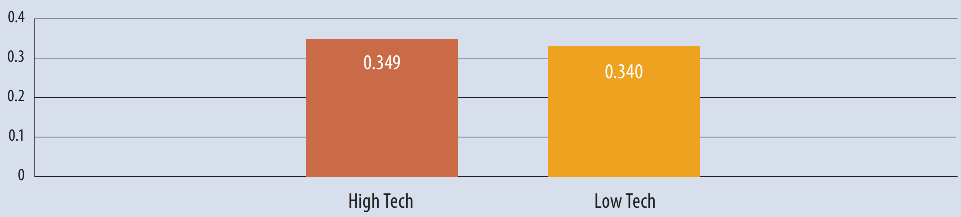
from the following sectors: food (22.7%), chemicals (19.4%), and electronics (9.1%)[5]. Similarly, the sectors with the highest R&D investment are also food (47.5%), chemicals (45.2%), and plastic (42.3%). Electronics (32.7%) is ranked the fifth among 12 industry group and the lowest is apportion to instruments (21.2%). The firms are further divided into high-tech industry group and low-tech industry group, following Peters et al [6]. Firms in high-tech industry group are represented by the five aggregated industries, namely, chemicals, nonelectrical machinery, electrical machinery (electronics), instruments, and motor vehicles. Firms in the low-tech industry group are in the seven aggregated industries, comprising food, textiles, paper, plastic, nonmetallic minerals, basic metals, and miscellaneous manufacturing. Interestingly, there aren't any differential R&D investment behaviors among firms in high-tech group (34.9%) versus low-tech group (34.0%) in Figure 4.11. This finding is in contrast to the usual pattern observed in the OECD data, whereby the proportions of firms with R&D expenditure are usually higher for high-tech industries compared to low-tech industries. A high fraction of firms that invest in R&D among low-tech group points toward a potentially different kind of R&D investment habits in Thai firms that might be concentrated in labor-intensive industries which are Thailand's top export industries. Alternatively, this could possibly be an indication of firms responding to a policy stimulating innovation, such as "food for the future" under the S-curve industry that is worth further investigation.

FIGURE 4.10

PERCENTAGE OF FIRMS WITH R&D BY INDUSTRY

FIGURE 4.11

PERCENTAGE OF FIRMS WITH R&D BY HIGH TECH VS LOW TECH



[5] Aggregated industries are grouped using two digit ISIC Rev. 4 industrial classification as follows: food (10, 12), textiles (13, 14, 15), paper (16, 17, 18), chemicals (19, 20) plastic (22), nonmetallic minerals (23), basic metals (24, 25), electrical machinery (26, 26.5, 27), nonelectrical machinery (28), motor vehicles (29, 30), instruments (32), and miscellaneous manufacturing (31, 35).

More importantly, the researchers investigated the pattern of export market participation among firms and their R&D investment habits. It shows that there is a slightly higher proportion of firms that export (53.6%) that make R&D investments compared to firms that sell only to the domestic market or non-exporter (46.4%), as seen in Figure 4.12. In line with trade and innovation literature, Figure 4.13 displays a much higher number of exporting firms that conduct R&D activity (48.1%) compared with only 21.6%

FIGURE 4.12

DISTRIBUTION OF FIRMS BY EXPORT STATUS

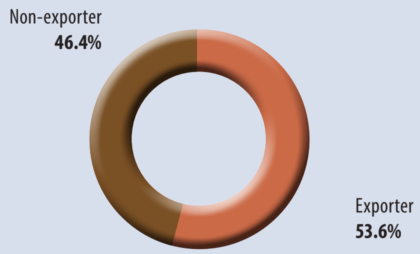


FIGURE 4.13

PERCENTAGE OF FIRMS WITH R&D BY EXPORT STATUS

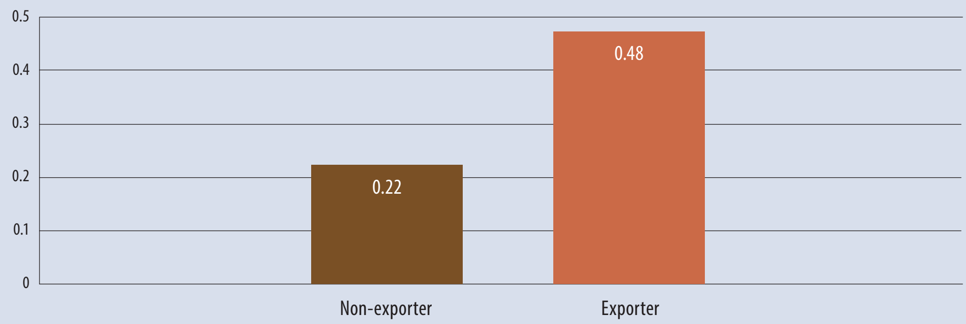


TABLE 4.2

FIRMS' R&D AND EXPORT CHARACTERISTICS BY AGGREGATE

Firms' R&D Investment	Firms' Export Status	
	No	Yes
No	0.364	0.278
Yes	0.100	0.258

of non-exporters that invest in R&D. In addition, Tables 4.2 and 4.3 summarize aggregate and yearly patterns of firms that invest in R&D, export, or combination of both activities. The largest fraction of firms reports no investment in R&D nor participate in export market (36.4%). The proportion of firms that do not export but conduct R&D is the smallest at 10%. Firms that export but do not conduct R&D is 27.8% and firms that export as well as invest in R&D is 25.8%. The proportions vary from year to year but the same patterns persist with the largest group of firms conducting neither activities and the smallest percentage are firms that only invest in R&D but do not export. Further, the research looks into the

TABLE 4.3

FIRMS' R&D AND EXPORT CHARACTERISTICS IN 2011–18

Year	Neither	Only R&D	Only Export	Both
2011	0.359	0.070	0.373	0.197
2012	0.445	0.067	0.270	0.217
2013	0.445	0.067	0.270	0.217
2014	0.343	0.093	0.293	0.272
2015	0.318	0.123	0.228	0.331
2016	0.317	0.168	0.183	0.332
2017	0.324	0.121	0.272	0.283
2018	0.374	0.069	0.368	0.189

Source: Author's calculation.

connection between types of manufacturers and firms' R&D investment. They are classified into four types: (i) product design by parent company (OWN); (ii) OEM; (iii) original design manufacturer (ODM); and (iv) OBM. It is evident that OBM and OEM types have the highest number of firms that invest in R&D, as shown in Figures 4.14 and 4.15, which plausibly imply knowledge spillover or accumulated experiences obtained from being OEM.

FIGURE 4.14

DISTRIBUTION OF FIRMS BY TYPES OF MANUFACTURERS

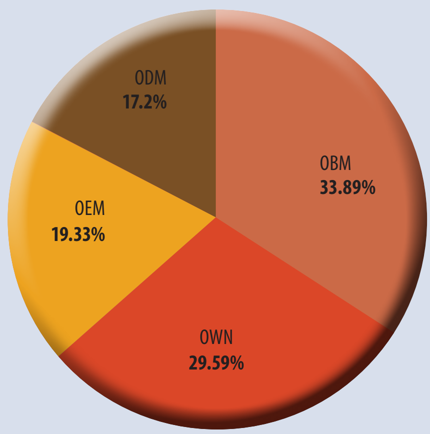
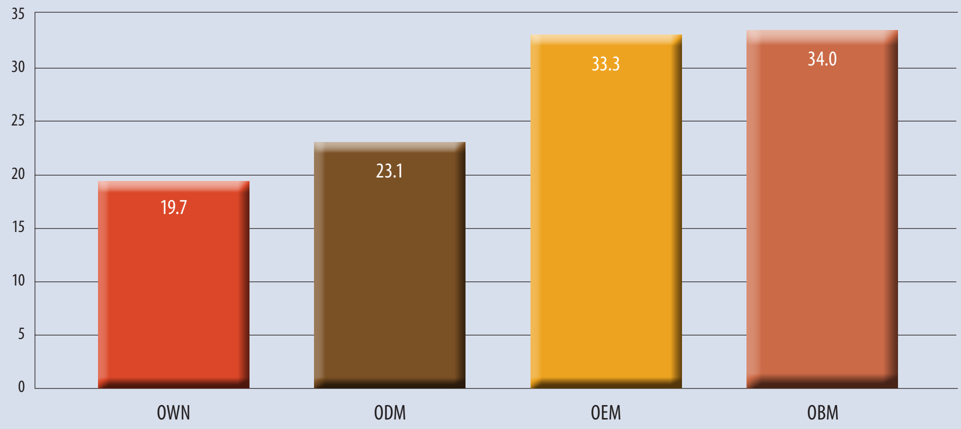


FIGURE 4.15

PERCENTAGE OF FIRMS WITH R&D BY TYPES OF MANUFACTURERS



EMPIRICAL METHODS AND ESTIMATION RESULTS

Before empirically examining the relationship between exporting, R&D, and productivity at the firm-level, first, the basic yet important questions are asked - “What firm characteristics determine its innovation inputs as well as innovation outputs?” and, “Essentially, how are these determinants influence firm’s productivity?”. Following Berger[6] [7], the following simple Probit and OLS regression models is estimated using the latest year data available to the study:

(i) Which firms are more likely to invest in R&D?

$$P(\text{R\&D dummy})_{ij} = \beta_1 + \beta_2 \ \ln(\text{employment}_{ij}) + \beta_3 \ \text{FDI}_{ij} + \beta_4 \ \text{EXP}_{ij}$$

$$+ \beta_5 \ \text{Obstacle\_knowledge}_{ij} + \beta_6 \ \text{Obstacle\_market}_{ij} + \beta_7 \ \text{Obstacle\_cost}_{ij} + \gamma_j + \varepsilon_{ij}$$

(ii) Which firms spend more on R&D investment?

$$\log(\text{R\&D expenditure})_{ij} = \beta\__1 + \beta\__2 \ \ln(\text{employment}_{ij}) + \beta_3 \ \text{FDI}_{ij} + \beta_4 \ \text{EXP}_{ij} + \beta_5 \text{Cooperation}$$

$$+ \beta_6 \text{Public\_support} + \gamma_j + \varepsilon_{ij}^{6}$$

(iii) What is the role of innovation in labor productivity?

$$\log(\text{labor producitvity})_{ij} = \beta_1 + \beta_2 \ \ln(\text{employment}_{ij}) + \beta_3 \ \text{FDI}_{ij} + \beta_4 \ \text{EXP}_{ij}$$

$$+ \beta_5 \ \text{Process\_innovation}_{ij} + \beta_6 \ \text{Innovation\_output}_{ij} + \gamma_j + \varepsilon_{ij}$$

[6] Following Berger (2010), different sets of explanatory variables is used in explaining the probability of a firm to carry out R&D in equation (i) and R&D expenditure in equation (ii).

where:

- ij denotes firm i in sector j
- R&D dummy equals to 1 if firms conduct R&D investment and 0 otherwise
- $Employment_{ij}$ variable measures total number of firms' employees
- FDI_{ij} is a dummy variable equals to 1 if a firm is foreign owned and 0 if firms are 100% owned by Thai nationals
- EXP_{ij} is a dummy variable equals to 1 if a firm exports and 0 otherwise
- $Obstacle\_knowledge_{ij}$ is a dummy variable equals to 1 if a firm identifies lack of qualified R&D personnel, lack of information on technology, or lack of information on markets as obstacles to R&D and innovation, and 0 otherwise
- $Obstacle\_market_{ij}$ is a dummy variable equals to 1 if a firm identify lack of competition in the domestic market, lack of customer interests in innovation, or uncertainty in demand for product/service innovation as obstacles to R&D and innovation, and 0 otherwise
- $Obstacle\_cost_{ij}$ is a dummy variable equals to 1 if a firm identifies limited financial resources or too high costs as obstacles to R&D and innovation, and 0 otherwise

TABLE 4.4

SUMMARY STATISTICS OF MAIN VARIABLES

Part I: RDI (2018) for Cross-sectional Analysis					
Variable	**Observation**	**Mean**	**Std. Dev.**	**Min**	**Max**
ln(R&D expenditure)	1,966	14.71	1.58	8.62	22.79
ln(Labor productivity)	3,358	14.57	1.39	1.62	27.56
ln(employment)	3,532	4.95	1.43	0	11.16
FDI dummy	3,755	0.27	0.45	0	1
EXP dummy	3,755	0.54	0.50	0	1
Obstacle_knowledge	3,755	0.38	0.49	0	1
Obstacle_market	3,755	0.15	0.36	0	1
Obstacle_cost	3,755	0.29	0.45	0	1
Cooperation	3,755	0.29	0.45	0	1
Public_support	3,755	0.07	0.25	0	1
Process_innovation	3,753	0.25	0.43	0	1
Innovation_output	1,027	0.47	0.39	0	1
Part II: RDI (2011–18) for Panel Analysis					
Variable	**Observation**	**Mean**	**Std. Dev.**	**Min**	**Max**
ln(Domestic market revenue)	23,092	17.90	5.06	0	32.16
ln(Capital stock)	25,363	15.90	2.65	0	25.60
R&D dummy	23,611	0.36	0.48	0	1
Export dummy	23,415	0.54	0.50	0	1
ln(Total variable cost)	23,241	19.53	1.85	7.61	32.33

Source: Author's calculation.

- $Cooperation_{ij}$ refers to external collaboration a firm has with public institutions or educational institutions on R&D and innovation activities and 0 otherwise

- $Public\_support_{ij}$ captures various supportive measures by government sectors, including National Science and Technology Development Agency (NSTDA)[7], Board of Investment (BOI), National Innovation Agency (NIA), National Science Technology and Innovation Policy Office (STI), National Research Council of Thailand (NRC), Thailand Science Research and Innovation (TSRI), Agricultural Research Development Agency (ARDA), or regional science parks

- $Process\_innovation_{ij}$ is a dummy variable equal to 1 if a firm reports having implement any process innovations, including introduction of new/significantly improved production process/services, new/significantly improved logistics management, or new/significantly improved supporting systems

TABLE 4.5

RESULTS OF PROBIT AND OLS REGRESSIONS FOR R&D INVESTMENT DECISION, R&D EXPENDITURE, AND LABOR PRODUCTIVITY IN 2018

Independent Variables	(I) P(R&D investment=1)	(II) ln(R&D expenditure)	(III) ln(Labor Productivity)
ln(employment)	0.155*** (0.019)	0.470*** (0.025)	
FDI	-0.344*** (0.059)	0.272*** (0.073)	0.896*** (0.116)
EXP	0.554*** (0.055)	-0.011 (0.070)	-0.060 (0.115)
Obstacle_knowledge	0.117** (0.053)		
Obstacle_market	-0.906*** (0.080)		
Obstacle_cost	0.133** (0.055)		
Cooperation		-0.067 (0.063)	
Public_support		0.191** (0.063)	
Process_innovation			0.032 (0.102)
Innovation_output			0.685*** (0.132)
Constant	-1.935*** (0.144)	11.90*** (0.207)	17.26*** (0.321)
Observations	3,532	1,764	983
R-squared		0.214	0.205
Industry FE	yes	yes	yes

Source: Author's estimation.
Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

[7] R&D investment promotion measures by NSTDA include "Innovation and Technology Assistance Program (ITAP), 300% Tax exemption for R&D expenses, low interest loan, etc.

- $Innovation\_output_{ij}$ is measured by sales from new/significantly improved products from innovation activities

- $Labor\_productivity_{ij}$ is turnover divided by employment in 2018

Part I of Table 4.4 provides the summary statistics of main variables analyzed in this section.

Table 4.5 reports the results of simple Probit and OLS regressions of equation I, II, and III for the year 2018. In column I, the results show that the propensity of a firm to invest in R&D increases with firm size, export status, and obstacles regarding knowledge and cost which confirm the results found in previous studies. However, being part of foreign ownership and obstacles due to market have negative effects on the probability to invest in R&D. The reason may be that foreign-owned firms choose to keep R&D at their headquarters in parent company. In terms of a firm's R&D spending, column II shows that size, foreign ownership, and receiving public support increase the amount of R&D expenditure, whereby participating in innovation cooperation has no impact on R&D expenditure. Column III investigates how innovation affects labor productivity at the firm level. The coefficient estimates on innovation output as measured by turnover from new products or services is positive and statistically significant which implies a positive linkage between innovation and productivity. Again, the findings confirm the positive role of innovation in influencing productivity at the firm-level found in the literature. In contrast, successful process innovation has insignificant impact on labor productivity. However, the initial results must be interpreted with caution as not all firms carry out R&D and innovation activities thus could lead to a sample section bias. Further, the potential problem of endogeneity arises from explanatory variables being simultaneously determined with dependent variable and must be carefully treated with proper econometric techniques going forward.

Exporting, R&D, and Productivity

Instead of using the structural CDM model by Crepon, Duguet, and Mairesse [8] to study the link between R&D, innovation, and productivity commonly used in previous studies, this paper adopts a dynamic structural model developed by Aw, Roberts, and Xu [5] to empirically explore firms' decisions to invest in R&D or to participate in export market, and how these two choices could endogenously affect firms' future productivity. As it might be the case that firms investing in R&D will result in higher productivity and self-selection of more productive firms into export market, the paper first quantifies the first stage estimates of the underlying process for firms' productivity (ω_{it}). The researchers assume that productivity evolves according to a Markov process that depend on firm's past investments in R&D (d_{it-1}) and its past export market participation (e_{it-1}) and random shock (ε_{it}) as follows:

$$\omega_{it} = \alpha_0 + \alpha_1 (\omega_{it-1}) + \alpha_2 (\omega_{it-1})^2 + \alpha_3 (\omega_{it-1})^3 + \alpha_4\ d_{it-1} + \alpha_5\ e_{it-1} + \alpha_6\ d_{it-1}\ e_{it-1} + \varepsilon_{it} \quad (1)$$

where past R&D and export market participation capture how a firm can improve its future productivity by choosing to invest in R&D or to learn by exporting from customers or suppliers through knowledge spillover. Researchers continue to assume a cubic functional form of lagged productivity as in Aw et al [5] and the interaction between past R&D and export activities.

The paper first estimates the domestic demand, marginal cost, and productivity evolution parameters. The log of domestic market revenue function r_{it}^D can be written as follows:

$$\ln r_{it}^D = (E_D + 1)\ \ln\left(\frac{E_D}{E_D + 1}\right) + \ln \varnothing_t^D + (E_D + 1)(\beta_0 + \beta_k \ln k_{it} + \beta_w \ln w_t - \omega_{it}) + u_{it} \quad (2)$$

Firm productivity ω_{it} is contained in the composite error term $(E_D + 1)(-\omega_{it}) + u_{it}$ in which the researchers can rewrite the unobserved productivity in terms of observables, as in Olley and Pakes [9]. Elasticity of demand E_D can be combined into an intercept term γ_0 and time varying aggregate demand shock

($\varnothing_t^D$) and market level factor prices (w_t) into a set of time dummies. The researchers can rewrite the log of domestic revenue function as

$$\ln r_{it}^D = \gamma_0 + \sum_{t=1}^{T} \gamma_t D_t + (E_D + 1)(\beta_k \ln k_{it} - \omega_{it}) + u_{it} \quad (3)$$

Let θ_{it} be an estimate of $(E_D + 1)(\beta_k \ln k_{it} - \omega_{it})$, which can be rewritten as

$\omega_{it} = -(1/(E_D + 1)\ \theta_{it} + \beta_k \ln k_{it}$. Substitute this into equation 1 for productivity evolution yield

$$\theta_{it} = \beta_k{}^* \ln k_{it} - \alpha_0{}^* + \alpha_1 (\theta_{it} - \beta_k{}^* \ln k_{it-1}) - \alpha_2{}^* (\theta_{it-1} - \beta_k{}^* \ln k_{it-1})^2 + \alpha_3{}^*$$

$$(\theta_{it-1} - \beta_k{}^* \ln k_{it-1})^3 - \alpha_4{}^*\ d_{it-1} + \alpha_5{}^*\ e_{it-1} + \alpha_6{}^*\ d_{it-1}\ e_{it-1} + \varepsilon_{it}{}^* \quad (4)$$

Notes that * refers to how α and β_k coefficients must be multiplied by $(E_D + 1)$. The researchers estimate equation 4 using non-linear least squares. Next, equation (5) is used to estimate the two demand elasticity parameters E_d and E_x from total variable cost (tvc_{it}) equation which is a function of elasticity-weighted combination of revenue in domestic as well as in export markets rewritten.

$$tvc_{it} = r_{it}^D \left(1 + \frac{1}{E_d}\right) + r_{it}^X \left(1 + \frac{1}{E_x}\right) + \varepsilon_{it} \quad (5)$$

The static part of the empirical model involves estimating firm productivity from its domestic revenue function. Summary statistics is presented for panel analysis in part II of Table 4.4. In Table 4.6, coefficient estimates from the first stage estimation of equation 4 and 5 are reported. The implied values of E_d and E_x are -2.02 and -1.75, respectively. Coefficients α_1 ,α_2 ,α_3 reflect cubic powers of relationship between past period productivity ω_{it-1} and current productivity level ω_{it}. Interestingly, a positive and significant coefficient estimate α_4 implies that firms that invest in R&D in the past period have a 5.89% higher

TABLE 4.6

PRODUCTIVITY ESTIMATION

1+1/Ed	0.505*** (0.003)
1+1/Ex	0.428*** (0.003)
Bk	0.213*** (0.014)
α_0	0.267*** (0.033)
α_1	0.920*** (0.023)
α_2	0.033*** (0.005)
α_3	-0.005*** (0.000)
α_4	0.059*** (0.020)
α_5	0.165*** (0.017)
α_6	-0.106*** (0.026)
Sample size	**15,097**

Source: Author's estimation.
Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

productivity. Turning to the effect of past period export status α_5, the productivity of past exporters is 16.5% higher, suggesting an even larger productivity impact from learning by exporting. Lastly, the interaction term between past period R&D and export activities indicates that firms that do both have 11.8% higher productivity compared to firms that neither export nor invest in R&D. The empirical exercise in this section provides evidence in support on how firms' decisions to export or invest in R&D do have capability in improving future productivity. This is particularly important for the policy formulation to foster innovation as well as promoting trade openness to increase the level of competition for a successful productivity-led growth policy strategy.

Government Policy, R&D, and Innovation in Thailand

In this section, the paper tackles questions concerning government policy to promote R&D and innovation, and to evaluate its effectiveness in enhancing R&D and innovation outputs. First, an overview is provided on ways Thai firms attempt to become innovative by focusing on the latest survey year data for the purpose of an up-to-date policy packages. In 2018, out of 3,755 surveyed firms, 24.1% report having positive R&D investment. As for innovation measures, this paper further distinguishes innovation into four types in order to capture qualitative differences between the nature of innovation activities undertaken. The majority of firms are found to focus mostly on organizational innovation (64.9%), followed by marketing organization (53.7%), and to a lesser extent, on product innovation (37.6%) and process innovation (24.5%). This insight is crucial as different types of innovation could lead to different degrees of productivity improvement. The researchers further analyze types of innovation in relation to firms' size and industry. As expected, Table 4.7 shows that larger firms invest more in R&D and innovate more along the four innovation measures. Interestingly, small firms carry out process innovation relatively more than medium- and large-sized firms. In addition, Table 4.8 provides a pairwise correlation among R&D and the four innovation measures.

TABLE 4.7

PERCENTAGE OF FIRMS WITH R&D INVESTMENT AND DIFFERENT TYPES OF INNOVATION

	R&D Investment	Types of Innovation			
		Product	Process	Marketing	Organizational
Percentage of Firms	0.241	0.376	0.245	0.537	0.649
Small	0.290	0.340	0.366	0.348	0.299
Medium	0.322	0.302	0.276	0.297	0.304
Large	0.387	0.359	0.359	0.355	0.397

Source: Author's calculation.

TABLE 4.8

PAIRWISE CORRELATION MATRIX OF R&D AND INNOVATION VARIABLES

Correlation	R&D Investment	Product Innovation	Process Innovation	Marketing Innovation	Organizational Innovation
R&D investment	1				
Product innovation	0.232	1			
Process innovation	0.182	0.300	1		
Marketing innovation	0.272	0.331	0.240	1	
Organizational innovation	0.244	0.307	0.237	0.362	1

Source: Author's calculation.

The decision to undertake R&D or to be innovative also varies across industries. Table 4.9 looks into whether there is a higher number of firms that invest in R&D or innovate in the government's targeted sectors, specifically in the 10 S-curve industries. The highest percentage of firms that undertake R&D investment comes from electrical machinery, instruments, and minerals, which are in line with the government's promoted industries, namely, smart electronics, next-generation automotive, and robotics, respectively. As for the four measures of innovation, the researchers observe that different sets of industry exhibit the highest percentage of firms carrying out each innovation activity. The highest number of firms with product innovations is chemicals, electrical machinery, and food whereas the highest percentage of firms with process innovations is motor vehicles, basic metals, and plastic. Firms in minerals, food, and chemicals are more likely to conduct marketing innovation while those in plastics, motor vehicles, and chemicals carry out more organizational innovation. Different types of innovation are prioritized differently in each industry, possibly suggesting different strategies aimed to promote productivity improvement.

TABLE 4.9

PERCENTAGE OF FIRMS UNDERTAKING R&D INVESTMENT AND DIFFERENT TYPES OF INNOVATION BY INDUSTRY

Industry	No. of Firms	Percentage of Firms with				
		R&D Investment	Product Innovation	Process Innovation	Marketing Innovation	Organizational Innovation
Basic metals	225	0.241	0.329	0.316	0.507	0.613
Chemicals	738	0.160	0.419	0.213	0.566	0.660
Electrical machinery	326	0.313	0.405	0.252	0.485	0.647
Food	865	0.242	0.386	0.228	0.569	0.656
Instruments	38	0.273	0.263	0.211	0.500	0.658
Minerals	163	0.263	0.380	0.233	0.601	0.626
Miscellaneous	278	0.239	0.317	0.222	0.491	0.623
Motor vehicles	218	0.179	0.358	0.321	0.518	0.679
Nonelectrical	196	0.211	0.342	0.225	0.439	0.587
Paper	223	0.153	0.332	0.238	0.511	0.659
Plastic	226	0.170	0.385	0.314	0.553	0.788
Textiles	257	0.248	0.354	0.262	0.545	0.560
Total/ Average	3,753	0.214	0.375	0.245	0.537	0.649

Source: Author's calculation.

TABLE 4.10

PERCENTAGE OF FIRMS BY EXPORT STATUS, R&D INVESTMENT, AND INNOVATION

	Non-exporters	Exporters
R&D investment	0.140	0.327
Product innovation	0.289	0.447
Process innovation	0.218	0.268
Marketing innovation	0.457	0.604
Organizational innovation	0.539	0.742

Source: Author's calculation.

Next, the relationship between firm's export status, R&D, and innovation in Table 4.10 is analyzed. It clearly shows that there is a higher number of firms that export and invest in R&D or innovate compared to non-exporters, and that the percentage of firms that export and innovate is the highest for "organizational innovation". To evaluate the effectiveness of government incentive schemes aiming to promote industrial R&D and innovation, the paper explores how Thai manufacturers and firms respond and participate in different government projects. A survey questionnaire is used to ask "whether a firm

TABLE 4.11

SUMMARY OF SUPPORT MEASURES TO PROMOTE R&D AND INNOVATION BY DIFFERENT THAI GOVERNMENT AGENCIES

No.	Policy Name	Agency	Objectives	Services	Type (financial vs nonfinancial)	Targeted	Results
1	Innovation and Technology Assistance Program (ITAP)	NSTDA	ITAP acts as the much-needed R&D manager for Thai SMEs by supporting the knowledge and technology transfer process so that it is possible for SMEs to utilize R&D activities to come up with innovative new products, new processes, and new services.	*Main services:* 1. Technical problem analysis and technology development guideline by expert (free of charge). 2. Tailor-designed technology consultancy project for private firms: • Provide experts that match the companies' need • Offer project management and assessment • Offer 50% financial support of the project budget (not over THB400,000 and not over two projects/year/ company) *Other services:* • Technical training and seminars • Technology acquisition • Techno-business matching • Linkage to other industrial service organizations	Both financial and nonfinancial (Provide financial assistance of project cost to SMEs up to 50% (limit to THB400,000/ project)	SMEs (with registration fund less than THB200 million)	Since 2001, ITAP has organized more than 13,000 preliminary consultancy services with primary technical experts and has supported more than 9,200 projects that delivered the appropriate technology solutions for the SMEs. In 2018, ITAP delivered more than 1,600 technology solutions which account for the estimated value of THB3,000 million in economic and social impact of Thailand.
2	300% Tax Exemption for R&D Expenses	NSTDA	NSTDA acts as a certifying body for research, development, and innovation projects submitted for tax privileges by firms since 2002. Thai government allow firms to base their tax reduction on three times the cost of their R&D expenditures. The maximum tax reduction allowed for each company depends on the company's income.	NSTDA will evaluate candidate firms by applying the defined definitions of basic research, applied research, and product development testing used by the Revenue Department. Currently, NSTDA offer a RDC Online Service to evaluate and certify R&D projects and monitor and check the result online. The system is designed with high security and protects information confidentiality.	Financial support		

No.	Policy Name	Agency	Objectives	Services	Type (financial vs nonfinancial)	Targeted	Results
3	Company Directed Technology Development Program (CD)	NSTDA	CD aims to provide "low interest loan" to production industries in the private sector that want to start R&D activities on their products, improve their production process, establish their laboratories, do reverse engineering, and commercialize their research.	CD provides up to 75% of total value of the project, at the maximum THB30 million for a duration of up to seven years.	Financial support	• Genetic Engineering and Bio-technology • Metal and Materials • Electronics and Technology • Other disciplines that can lead to S&T advancement	
4	Characterization and Testing Service Center (NCTC)	NSTDA	NCTC is a one-stop service center for testing services, including physical property characterization, biological property characterization, and chemical analysis. The center is equipped with a wide spectrum of analytical imaging devices, X-ray instruments, GC/MS and LC/MS instruments, and several other specialized machines with a network formed with 20 testing labs throughout the country.	• Physical characterization property laboratory (Microscopy lab, X-ray lab, sample preparation lab, material properties lab, spectroscopy lab) • Chemical analysis laboratory (Chromatograph and mass spectrometry lab, elemental analysis lab, sample preparation lab) • Biological characterization property laboratory (Enzyme activity test, protein analysis, biomolecular analysis) • Microbiology laboratory (Microbial testing, antibacterial activity, mutagenicity, disinfectant testing, personal protective equipment (PPE))	Nonfinancial	Industry coverage consists of: • Pulp & paper • Textile • Ceramic • Building materials • Automotive • Electronics • Paint and chemical • Plastic and metal • Cosmetic • Health products • Medical devices • Agricultural products • Food and feed • Petrochemical and polymer • Biotechnology	
5	Research Gap Fund (RGF)	NSTDA	RGF is a year-by-year project that provides financial support for SMEs to access public universities' research projects in order to create new products or businesses. The fund helps SMEs reduce their risks on licensing research projects and supports the expenditure on product design, product prototyping development, market feasibility study, required testing and certification, and business plan development.	The fund is provided through license-owning research institutes and supports up to 75% of qualified expenditures where the maximum amount depends on each round of funding announcement.	Financial support	SMEs	

No.	Policy Name	Agency	Objectives	Services	Type (financial vs nonfinancial)	Targeted	Results
6	Technology Licensing Office (TLO)	NSTDA	TLO is responsible for NSTDA IP policy development, NSTDA IP filing, and management.	TLO determines and negotiates fair value for licensing NSTDA research project to the industry. TLO is a contact point for accessing NSTDA IP for licensing.	Nonfinancial		
7	Thailand Tech Show	NSTDA	A program that provides SMEs with easy access to IPs owned by public research and academic institutes, offers a license of an IP to interested SMEs at a flat-rate fee of THB30,000 per IP and a royalty payment of 2% of net sales. In addition to the attractive fee, the licensing process has also been streamlined to facilitate the exploitation of local inventions.	One price technology vs Negotiable price technology.	Nonfinancial	• Agriculture fishery • Machinery equipment • Cosmetic • Medical • Food and beverages • Electronics • Learning tools • Jewelry	A total of 1,136 technologies.
8	Business Incubation Center (BIC)	NSTDA	BIC offers integrated and comprehensive support to new-tech business entrepreneurs. The center provides mentorship, business acumen workshops, connection to researchers, investors, funding, and market, along with intensive project evaluation to help promising technopreneurs bring their ideas to products that can enter the market for traction and scale.	BIC consists of Young Technopreneur Development Program, Incubation Program, and Food Accelerator Program. BIC serves its clients effectively by tapping into varieties of NSTDA expertise in terms of new technology, state-of-the-art innovation, equipped infrastructure, funding resources or joint-venture prospects, plus on-going training and business consulting services including operational techniques, business development, legal and marketing functions, organization, and human resource management.			
9	Startup Voucher	NSTDA	Startup Voucher is a scheme designed to assist start-ups to expand their markets. It provides funding support for start-ups to participate in marketing campaign, online and offline marketing, and promotional channels, including international events in order to scale-up businesses, create visibility in international markets, and initiate technological and business collaboration with international partners.	The scheme provides a voucher up to 75% of qualified expenditures at the maximum of THB800,000 per project.	Financial		

No.	Policy Name	Agency	Objectives	Services	Type (financial vs nonfinancial)	Targeted	Results
10	Thai Innovation List (INS)	NSTDA	"Thai Innovation List" containing innovations (products and services) entitled to the fast-track treatment in the government procurement process was launched in 2016 to support local enterprises engaging in the commercialization of local innovations.	Innovative products and services submitted by Firms are verified for their origination from R&D carried out in Thailand and evaluated for the quality by a committee set up by NSTDA and checked on the pricing by the Budget Bureau. The innovations passing the evaluations are published in "Thai Innovation List" by the Budget Bureau for a maximum of eight years.	Nonfinancial		A total of 541 innovations listed as of December 2021.
11	Thailand Science Park (TSP)	NSTDA	TSP, established in 2002, aims to promote innovation development and R&D activities, by building the ecosystem to support R&D linkage between government and the private sector and to stimulate the creation of new technology businesses.				Phase 1 of TSP, with 140,000 sq m of built-up space, is fully occupied by the NSTDA and its five national research centers (BIOTEC, MTEC, NECTEC, NANOTEC, and ENTEC as well as over 110 corporate tenants. This close proximity provides an opportunity for corporate tenants to gain access to highly-skilled personnel, including 2,000 full-time NSTDA researchers, of whom about 700 are PhD scientists.
12	Basic incentives + additional incentives	BOI	To promote valuable investment both domestically and overseas to enhance Thailand's competitiveness, to overcome the "middle-income trap", and to achieve sustainable growth in accordance with the sufficiency economy philosophy.	Tax incentives (exemption of corporate income tax (CIT), import duty on machinery/raw materials) and nontax incentives.		• Bio and medical industries • Advanced manufacturing industries • Basic and supporting industries • Digital • Creative industries • High-value services	

No.	Policy Name	Agency	Objectives	Services	Type (financial vs nonfinancial)	Targeted	Results
13	Measures for improvement of production efficiency	BOI	To promote investment, to improve the efficiency of energy conservation, alternative energy utilization or environmental impact mitigation, upgrading and replacing machinery, R&D or engineer design, and upgrading of production line to acquire international sustainability certification.	50% CIT exemption for three years (and 100% for supporting IR4.0 transformation) + exemption of import duty for machinery.			
14	Promotion of SMEs	BOI	To promote and strengthen Thai SMEs to international standards.	CIT exemption based on products with ceiling equivalent to 200% of investment. Criteria in granting merit-based incentives are relaxed.			
15	Investment promotion measure in southern border provinces	BOI	To boost investment in the southern border provinces and to establish model cities under the slogan "Stable, Affluent and Sustainable Triangle".	CIT exemption, exemption (deduction) of import duty on machinery (raw material), double deduction on the cost of transportation, electricity, and water supply.		• Covering five provinces (Narathiwat, Pattani, Yala, Satun, Songkhla) • Four districts (Jana, Natawee, Saba Yoi, and Taypa)	
16	Investment promotion for Special Economic Zone (SEZ)	BOI	To promote investment in SEZ and distribution of socioeconomic growth at both local and regional levels thoroughly.	Eight years CIT exemption + five years 50% CIT deduction, exemption of import duty on raw materials used in production for export, and exemption of import duty for machinery.		• 10 provinces in SEZ (Chiang Rai, Kanchanaburi, Mukdahan, Nakhon Phanom, Narathiwas, Nong Khai, Tak, Trade, Sa Kaeo, and Songkhla) • 14 targeted businesses (agricultural/ fishery, ceramics, pharmaceutics, electrical appliances/ electronics, plastic, automobile/ machinery/parts, logistics, industrial estate/industrial zone, medical devices, tourism, furniture, jewelry/ ornaments, textile/ clothing/leather, others)	

No.	Policy Name	Agency	Objectives	Services	Type (financial vs nonfinancial)	Targeted	Results
17	Investment promotion in the Eastern Economic Corridor (EEC)	BOI	To promote investment in the targeted activities in the EEC and to encourage the private sector to take part in human resource development.	CIT exemption of 5–8 years (Group A1, A2, and A3), receive additional 50% CIT deduction for two years, and activities on technology and innovation development, and enabling services receive additional one year CIT exemption.		Chachoengsao, Chonburi, and Rayong	
18	Open innovation	NIA	Area-based innovation.	Grant up to THB5 million, not exceeding 75% of project budget.	Both	• Smart SMEs and Start-ups • Bioeconomy, manufacturing and circular economy, sharing and service economy	
19	Thematic innovation	NIA	Mandatory innovation.	Grant up to THB5 million, not exceeding 75% of project budget.	Both	• High-growth innovative enterprises • Change from year to year. As for 2022: - Future food, including personalized food, alternative protein, gastronomy tourism, and immunity balance - AI, robotic, immersive and IOT (ARI TECH), including digital in healthcare, logistic, service business, and manufacturing business	
20	Social innovation	NIA	Application of new ideas of knowledge to improve the quality of life of the community and the environment, leading to sustainable positive changes for society.	Financial support, technology network, and advice on problem solving.			
21	Mind credit	NIA	To facilitate Thai entrepreneurs' access to consultant firms in 10 specialty areas with importance for innovation and development to enhance competitiveness, efficiency, and sustainability.	Grant up to THB1 million, not exceeding 75% of project budget.	Both	SMEs and Start-ups	

No.	Policy Name	Agency	Objectives	Services	Type (financial vs nonfinancial)	Targeted	Results
22	Higher Education Researcher Support Program for the Problem-Solving-Related Operations and Enhancement of Competency for Industry Sector (Talent Mobility)	STI	To facilitate and promote STI-related personnel to perform their duties in the private sector in accordance with the established policy.				
23	Food Innopolis	STI	A global food innovation hub focusing on RDI for food industry.	• Rental spaces and facilitates for RDI • One-stop service center • Market research • Business development			
24	National Research Council of Thailand (NRCT)		The major organization sponsoring funds for research and innovation of the country in the field of sciences and humanities, from research to application.	• Sponsoring national research and innovation funds • Creating databases and indexes in science, and national research innovation • Initiating, driving, and coordinating the operations of important national research and innovation projects • Establishing research strands and ethics • Promoting and transferring knowledge for application • Giving awards, honoring, or complimenting individuals or institutions for their research and innovation • Supporting and encouraging personnel development in terms of research and innovation			

No.	Policy Name	Agency	Objectives	Services	Type (financial vs nonfinancial)	Targeted	Results
25	Thailand Research Fund (TRF)		To assist in the development of researchers and research-based knowledge through making research grants and assisting with research management.	• To support grants for R&D to create knowledge, policy, innovation, and intellectual property • To foster professional researchers and develop research community • To support national research system development • To encourage the utilization of research results			

Source: Author's compilation.
Note: To look at ABBREVIATIONS for full names.
Footnote: 1. Firms with an income of less than THB50 million can deduct up to 60% of their income, firms with income of more than THB50 million but less than THB200 million can deduct no more than 9% of their income, and firms with income of more than THB200 million cannot have a deduction greater than 6% of their income.

is aware of and/or enrolled in any of the incentive schemes offered by several Thai government agencies?". Table 4.11 provides a summary of the support measures available to promote R&D and innovation by various Thai government agencies.

The paper first analyzes firms' awareness on policies by dividing various R&D and innovation promotional schemes in accordance to their most relevant government agencies, which include 13

TABLE 4.12

PERCENTAGE OF FIRMS THAT ARE AWARE AND/OR ADOPT GOVERNMENT INCENTIVE SCHEMES BY GOVERNMENT AGENCIES

Detail	Awareness	Adoption
Total number of firms: 3,655		
Percentage of firms participate in programs hosted by:	0.470	0.230
NSTDA	0.280	0.121
1. 300% tax	0.135	0.036
2. TAP	0.126	0.035
3. NCTC	0.063	0.029
BOI	0.282	0.119
1. Product-based incentives	0.180	0.070
2. Production efficiency	0.177	0.069
3. SMEs	0.136	0.054
NIA	0.125	0.034
1. Open innovation	0.070	0.013
2. Thematic innovation	0.057	0.008
3. Social innovation	0.055	0.009
STI	0.071	0.017
• Talent Mobility	0.045	0.008
Others	0.105	0.033
• National Research Council of Thailand	0.067	0.019
• Thailand Research Fund	0.067	0.009

Source: Author's calculation.

measures by NSTDA, six measures by BOI, seven measures by NIA, three measures by STI, and four other government agencies: National Research Council of Thailand (NRCT), Agricultural Research Development Agency (ARDA), Thailand Research Fund (TRF), and regional science parks. On average, 47% of surveyed firms are aware of at least one of the policy incentive schemes available and 23.5% are aware of only one single policy support out of the 33 measures listed in the questionnaire. The results in Table 4.12 show that awareness of policy incentives is the highest for programs organized by NSTDA (28%) and BOI (28%).

NSTDA's top three policy incentives that received the highest awareness are:

- 300% tax deduction for R&D (13.5%)
- Innovation and Technology Assistance Program - ITAP (12.6%)
- Characterization and Testing Service Center (NCTC) (6.3%)

As for BOI's support policy measures that firms are most aware of are:

- Product-based incentive packages (18%)
- Measure for improvement of production efficiency (17.7%)
- Measure to support investment from SMEs (13.6%)

Meanwhile, 12.5% of the firms report that they are aware of the policy projects by NIA with the highest rates on policies governing Open Innovation (6.95%), Thematic Innovation (5.7%), and Social Innovation (5.4%). As for other government agencies, 6.7% of firms report that they are aware of policy supports by NRCT and TRF.

The next important question is what are the policy adoption rates among firms that participate in different government programs. On average, 23% of firms are enrolled in at least one of the policy incentives and that most of the firms are registered for only one supportive program (16.5%). As for each

TABLE 4.13

PERCENTAGE OF FIRMS' POLICY AWARENESS AND ADOPTION BY COMPANY SIZE

Company Size	No. of Observations	Awareness	Adoption
Small	1,301	0.445	0.171
Medium	1,124	0.440	0.202
Large	1,330	0.518	0.310
Total observation	**3,755**	**1.000**	**1.000**

Source: Author's calculation.

individual program, the registered rates are the highest for the BOI projects (5%–7%) and lower enrollment for programs offered by NSTDA (3%), with only about 1% firms enrolled in most of government projects offered by NIA, STI, NRCT, or TRF.

When categorizing firms by size, it is observed that policy awareness across small-, medium-, and large-sized firms are about the same (Table 4.13). As expected, a higher percentage of large firms enroll in the available R&D and innovation promotional schemes compared to small and medium firms. In addition, exporting firms have higher awareness and adoption rates compared to non-exporters, as shown in Table 4.14.

TABLE 4.14

PERCENTAGE OF FIRMS POLICY AWARENESS AND ADOPTION BY EXPORT STATUS

Company Size	No. of Observations	Awareness	Adoption
Exporter	2,037	0.525	0.287
Non-exporter	1,718	0.404	0.161
Total observation	**3,755**	**1.000**	**1.000**

Source: Author's calculation.

The paper further delves into the awareness and adoption of R&D and innovation incentive schemes that span across industries. In terms of awareness, about 50% of the participating firms in the survey are aware of the policy incentives. Within each industry, the number of firms ranging about 40%–51% is aware of policy incentives. However, adoption rates are quite different across industries. In Table 4.15, the top three industries with the highest number of firms reported of having enrolled in government programs are Instrument (36.8%), Plastic (27.4%), and Food (26.1%). Additional analysis on each individual industry identify the policy incentives that are most adopted. As for instruments, the highest adoption rates are found for NSTDA policies, including ITAP (10.5%), R&D tax deduction 300% (7.9%), and BOI policies, including product-based (7.9%) and SMEs (7.9%). For Paper, programs offered by the BOI, including product-based (9.7%) and production efficiency (6.6%), reveal a higher number of firms' enrollment compared to Tax deduction (4.0%) and Startup Voucher (5.31) by NSTDA. Last but not least, policy adoption of firms within the food industry is the highest for the policy offered by NSTDA NCTC (3.93%) and start-up voucher (4.5%), and a slightly higher adoption rate observed for BOI promotional policies, including production efficiency (6.2%) and product based (5.4%).

It is clear that despite the high awareness of R&D and innovation policy incentives available, actual firms' enrollment remained low and differed across types of policy as well as industries. The pairwise correlation coefficient between policy awareness and policy adoption is equal to 0.57 and statistically significant at 1% level. For this reason, different industry needed to be targeted differently using different kinds of R&D and innovation policies. Possible reasons that only about 50% of firms are aware of the available policy

TABLE 4.15

PERCENTAGE OF FIRMS WITH POLICY AWARENESS AND ADOPTION BY INDUSTRY

Industry	No. of Firms	Percentage of Firms with Policy Awareness	Percentage of Firms with Policy Adoption
Metals	225	0.49	0.196
Chemicals	738	0.434	0.218
Electrical machinery	326	0.512	0.206
Food	866	0.478	0.261
Instruments	38	0.500	0.368
Minerals	163	0.417	0.215
Miscellaneous	279	0.459	0.183
Motor vehicles	218	0.500	0.248
Nonelectrical machinery	196	0.500	0.199
Paper	223	0.404	0.211
Plastic	62	0.500	0.274
Textiles	62	0.490	0.241

Source: Author's calculation.

incentives and actually participate are due to the difficulties in qualifying for the projects, including strict definition of R&D, programs' requirements, and time-consuming approval process.

Although there is a positive relationship between public-support policies and R&D investment, as shown in the equation, the estimation could suffer from the problem of endogeneity. The researchers looked for further evidence to see if there is a higher number of firms that participate in government support programs to also perform more innovation activities. Table 4.16 shows that there are more firms that did not enroll in any of the government programs nor report innovation than those that did, with the biggest percentage of firms showing "not enrolled, no innovation" for product innovation (50.8%), process innovation (61%), and marketing innovation (40%). Firms that enroll in government programs are equally likely to report product innovation (11.2%) or no product innovation (11.8%). Surprisingly, a higher fraction of firms reported positive product innovation even though they are not enrolled in any of the government programs (26.3%), compared to those that are. Similar pattern is observed for process innovation and firms' enrollment in government support programs, except a higher fraction of firms is seen to enroll in government programs but do not report process innovation (14.5%) compared to those that have successfully implemented process innovation (8.5%). It is likely that other forces, other than policy-induced incentives, are driving firms' product and process innovation.

For marketing and organizational innovations, the percentage of firms that are enrolled and report successful marketing and process innovations (16% and 19%) are larger than firms that are enrolled but show no innovation (7% and 4%). There appears to be a positive relationship between enrollment in government-supported programs and marketing and organizational innovations. Nonetheless, smaller firms show higher incidences of successful innovation with no government support compared to larger firms that are more likely to participate in government programs and report successful innovation.

TABLE 4.16

PERCENTAGE OF FIRMS WITH OR WITHOUT GOVERNMENT SUPPORT AND INNOVATION OUTCOMES BY FIRMS' SIZE

Types of Innovation (by company size)	Not Enrolled, No Innovation	Not Enrolled, with Innovation	Enrolled but No Innovation	Enrolled and with Innovation
Product	0.508	0.263	0.118	0.112
-Small	0.543	0.285	0.090	0.082
-Medium	0.513	0.285	0.109	0.093
-Large	0.468	0.222	0.153	0.157
Process	0.610	0.160	0.145	0.085
-Small	0.632	0.196	0.109	0.062
-Medium	0.638	0.160	0.137	0.065
-Large	0.565	0.125	0.186	0.124
Marketing	0.398	0.372	0.065	0.165
-Small	0.417	0.412	0.045	0.127
-Medium	0.403	0.395	0.065	0.137
-Large	0.377	0.314	0.085	0.225
Innovation	0.313	0.458	0.038	0.191
-Small	0.395	0.434	0.045	0.127
-Medium	0.294	0.504	0.047	0.155
-Large	0.248	0.442	0.025	0.285

Source: Author's calculation.

CONCLUSION AND POLICY INFERENCES

Unlike previous studies that generally use a cross sectional firm-level data to study R&D, innovation, and productivity in the Thai context, this paper utilizes the panel feature of RDI Survey data on Thai manufacturing firms to estimate a dynamic structural model developed by Aw et al [5]. The paper empirically examines the bidirectional relationship between decision to invest in R&D and to participate in export markets, both having a positive effect on firms' future productivity and thereby, leading more firms to self-select into both activities and contributing to the future path of their productivity improvement. Firms that invest in R&D in the specified time period have 5.9% higher productivity level. Firms that export in the same period display an even larger productivity gain from learning by exporting at 16.5%. The results show that firms that carry out both R&D and export have 11.8% higher productivity than firms that do neither. The findings provide evidence in support of the role played by export and R&D in conjointly enhancing firms' productivity performance. This is particularly important for policymakers to foster innovation and facilitate trade openness for a successful productivity-led growth to escape the middle-income trap problem.

In terms of policy recommendations, this paper further distinguishes innovation into four types, namely, product innovation, process innovation, marketing innovation, and organizational innovation as to capture qualitative differences between the nature of innovation activities undertaken and how each respond to various R&D policy stimulus. The researchers find that the majority of firms focus mostly on organizational and marketing innovation and, to a lesser extent, on product and process innovation. In addition, despite the high awareness of R&D and innovation policy incentives available, actual firms' enrollment remained low and differed across types of policy as well as industries, possibly due to the difficulty in qualifying for the project. When linking policy adoption to innovation outcomes, there is a positive relationship between government-supported programs enrollment for marketing and organizational innovations. However, there is a higher fraction of firms that enroll in government programs but report no process innovation compared to firms with successful process innovation, suggesting that there are other forces, other than policy-induced incentives, that are driving firms' process innovation. Therefore, better policy design with insight into firms' heterogeneity in responding to government R&D promotional schemes is needed to promote successful innovation and productivity enhancement both at firm and national levels.

CHAPTER 5

VIETNAM

ABSTRACT ON VIETNAM'S FDI FOR INNOVATION AND PRODUCTIVITY GROWTH

FDI is a key driver of Vietnam's economic growth. This paper, using Vietnam's annual enterprise census and innovation survey data, aims at investigating the relationship between FDI firms and Vietnamese private firms' innovation activities and productivity. The finding shows that the presence of FDI firms has almost no correlation with innovation probabilities of local firms. At the same time, it also has statistically insignificant effect to the local firms' technological progress as well as efficiency. However, it appears to positively affect labor productivity (LP). Given the results, productivity policies should focus more on improving domestic firms' innovation capabilities in line with promoting the linkages between them and the FDI firms.

INTRODUCTION

Vietnam achieved the status of lower-middle income country in 2011 and has targeted to be a high-middle income country in 2030. The biggest concern now is to escape the middle-income trap. Recent literature reviews [1–3] had pointed to some trends that Vietnam may be heading into that direction based on the following:

- Productivity growth from sectoral reallocation and technology catch-up are eventually exhausted while rising wages make labor-intensive exports less competitive at the world markets
- Switching labor from low-productivity sectors to higher-productivity sector provides a massive but one-off rise in per capital income
- The switch in the initial phase of development is triggered by the application of imported technologies adopted in the sectors that produce labor-intensive, low-cost products. However, once the country reaches middle-income levels, the pool of rural underemployed workers drains and wages begin to rise, thereby eroding competitiveness
- Growth slowdowns coincide with the point in the growth process where it is no longer possible to boost productivity by shifting additional workers from agriculture to industry and where the gains from importing foreign technology diminish significantly

Thus recent research literature stresses that the strategy for escaping middle-income trap should be different from that of moving from low- to middle-income level.

After three decades of reforms, Vietnam has obtained critical economic achievements, such as high economic growth in association with fast poverty reduction, quick integration to the global economy, and attracting large FDI into the country. The red alert in this case is the possibilities of coping with the middle-income trap once the growth model is described as mainly based on resource expansion. Aggregate data shows that since 2020, LP has tripled and increasingly contributed to the economic growth. However, for at least the last 10 years, the productivity growth is lower than the economic growth (for example 4.88%/year compared to 6.8%/year for 2015–18).

More evidence reveals the weakness in the country's productivity improvement, particularly the position in the international ranking tables. According to the Global Competitiveness Report [4], Vietnam ranks 82 out of 140 countries for innovation indicator (33.4/100 point), the rank of other sub-indicators is also similar whereby, patent and R&D investments are also remarkably low at 89th and 76th, respectively. Further, Vietnam's ranking is 70 of 100 for labor resource, of which, high skilled labor is at 81st, higher education quality is 75th, and 90th for technology and innovation.

Fully aware of the middle-income trap as well as the situation of the country's low innovation capacity, the government of Vietnam has issued various policies to encourage innovation and technology transfer. This includes the Law on Science and Technology in 2013 and the National Technology Innovation Fund in 2011, among others. Recent studies in Vietnam, however, have pointed out the ineffectiveness of such policies due to the low and inappropriate interventions from the government as well as the low internal capability of the research institutions and domestic firms. In line with that, the government has introduced critical improvements in the business environment and investment promotion to attract FDI, particularly that with advanced technology. The expectation is that the FDI inflow will be accompanied with advanced technologies which in turn can spillover to and learned by domestic partners.

Recent theoretical and empirical studies on the spillovers of FDI [5–6]) summarize many different ways by which the presence of FDI can bring about technological benefit to local firms. First, local firms can imitate the technology and management skills from FDI firms. They can also obtain technological information through labor turnover or the workforce that previously worked for FDI firms. Other avenues include the production linkages and the urgency to overcome competitors. In short, it implies that the presence of FDI firms potentially encourage innovation and technology improvement of domestic firms.

While Vietnam has continuously received large inflow of FDI (approximately USD20 billion each year from 2018–20) and resource has become increasingly important in boosting the economic growth (contributes around 75% of total export), criticism has also been leveled on its low possibility of long-term productivity effect, particularly the effect to innovation/technologies of local firms. Given this point, this paper is designed to investigate the microevidence of FDI in boosting innovation-led productivity, focusing on local manufacturing firms. The paper's objectives are to:

- Provide the situation analysis on Vietnam's innovation, technology improvement of local firms, and the effectiveness of its policies

- Empirically test the existence of the technological/innovation effect to derive some policy implications for the government to elevate firms' innovation and productivity improvement

In addition to the introduction and conclusion, the paper also consists of two sections. The first section provides descriptions of productivity improvement, and also specifically in Vietnam, including government policy and firm performance to date. The second section focuses on the empirical estimation of the influences of FDI in determining innovation of local firms by using the dataset from annual enterprise census as well as the sciences and technology survey data in Vietnam.

THE PRODUCTIVITY OF DOMESTIC MANUFACTURING FIRMS

National Productivity Policies

The demand for productivity improvement was emphasized early, mostly in very general ways. For example, this is seen in Vietnam's socioeconomic development strategies and plans. Until the mid-1990s, Vietnam witnessed the early introduction of quality and management (ISO 9000) as well as productivity enhancement instruments, such as 5S and Kaizen. These efforts were limited in scale. In fact, it contributed little to the overall productivity improvement during this period.

A breakthrough productivity policy was introduced in 2010 as well as the national program for domestic firms to improve productivity and product quality in 2020 [7]. The program focuses on issuing national standards and productivity improvement instruments (providing guidance, support, technology introduction, etc.) to businesses. Specific objectives in this program for the period 2010–20 are:

- Increase the contribution of TFP to GDP to 35% by 2020
- Introduce 6,000 national standards
- 60,000 firms to be guided to apply technological advancement, managing system, and tools to enhance productivity and quality
- Establish a network of organizations to test the compliance of core products with national standards
- 40% of enterprises that produce core products are to execute a plan to boost productivity
- Create productivity and quality movement at all cities and provinces

Due to resource limitation and particularly, the poor coordination among central and local institutions, the first phase of this program (2011–15) was perceived to have met most of its targets, but several limitations emerged: (i) there was delay in procedure and approval of various productivity improvement projects; (ii) authorities and provinces adopted different methods which made cooperation among them difficult; (iii) did not fully attract the attention from businesses; (iv) not able to arrange a network of productivity advisers; and (v) shortage of budget resources. Up to 2020, the program was only able to directly assist about 15,000 firms[1] which is much lower than the target of 60,000 businesses.

In addition to the national program in the same period, other efforts were made by the government, as specified in the Resolution 05/NQ-TW (2016) on the reform in growth model toward enhancing growth quality and productivity, Resolution 27/NQ-CP for the government to implement the Resolution 05/NQ-TW, and Directive 07/CT-TTg on the measurement to upgrade LP. However, as mentioned in Vietnam Institute for Economic & Policy Research (VEPR) and Graduate Institute for Policy Studies (GRIPS [8][2], most policies followed the top-down approach, dispersed implementation with poor coordination, and limited resources which resulted in the limitation of the policy coverage and lack effectiveness.

Productivity at National Level

Though the direct policies for productivity improvement are limited, many indirect instruments, particularly the structural policies and business/investment environmental reform have remarkable

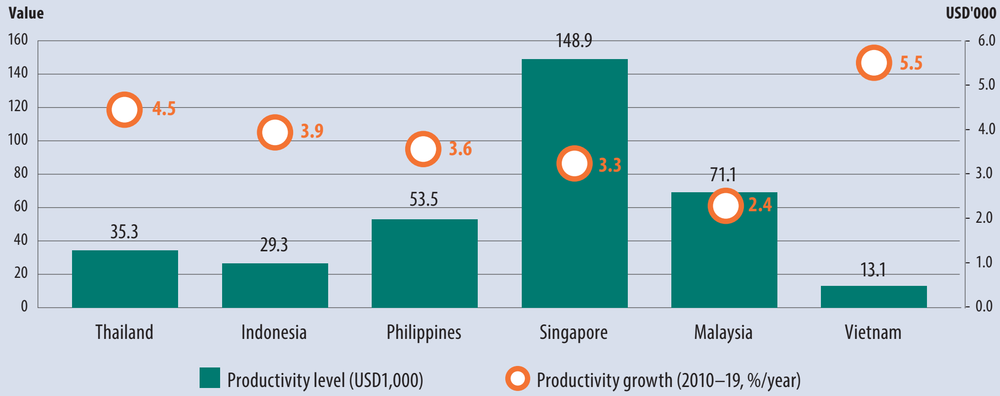
[1] https://tapchitaichinh.vn/tai-chinh-kinh-doanh/ap-dung-chuong-trinh-712-giup-nhieu-doanh-nghiep-tang-nang-suat-giam-hang-ton-kho-324790.html.

[2] https://www.grips.ac.jp/forum/pdf21/VN_Productivity_Report/[VIE]ProductivityReport.pdf.

impact to the country's productivity. In fact, Vietnam has recorded substantial improvement in productivity since 2010. The annual LP growth reached 5.88% for 2016–20, much higher than 2011–15 (4. 24%), marking the overall growth for 2010–20 to 5.06% [9]. The country becomes one of the highest in productivity growth country in the region (Figure 5.1) which helps narrow the productivity gap. For example, the gap between Vietnam and Singapore reduced from 21 times in 1990 to 11.2 times in 2019.

FIGURE 5.1

ASEAN PRODUCTIVITY COMPARISION



Source: APO Databook (2020) and Total Economy Database.

However, in terms of productivity level, Vietnam is still lagging behind its regional neighbors. As analyzed by VEPR and GRIPS [8], in 2017, Vietnam's LP for nine sectors (APO classification) was just more or less at the bottom in comparison with the regional countries. It is lowest for construction, transportation, and communication; almost the lowest (just higher than Cambodia) for agriculture, fishery and forestry, manufacturing, electricity provision, commerce, hotel, and restaurant. Vietnam's ranking is somewhere in the middle for the productivity of mining, finance, real estate, and business services.

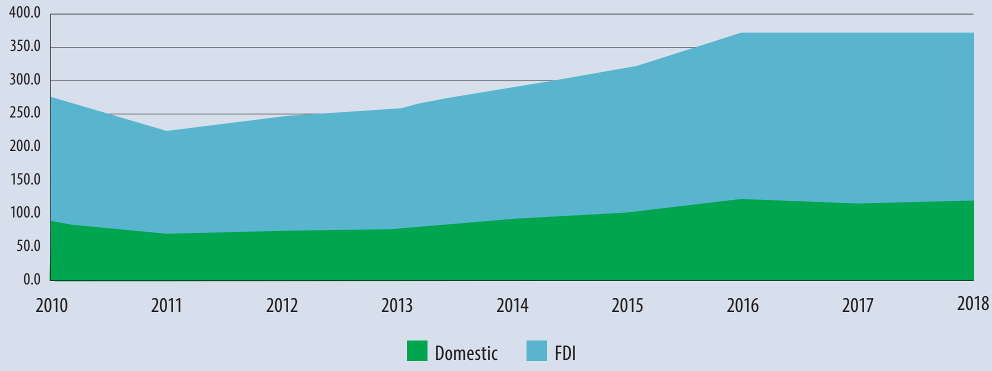
Productivity in Manufacturing Sector

Statistical data indicates that the manufacturing productivity in Vietnam is low compared to the national average, and more important to note is that it has grown worse over time. In 2010, the LP in this sector was VND39.6 million, lower than the average by 3.6%. Up to 2020 (estimated), it was about VND92 million and noticeably lower than the average by 20.8% (VND117 million). One of main reasons perhaps is the increasingly labor intensity of this sector.

Within manufacturing, FDI firms are likely to retain dominance. Although the number of FDI firms is small, they have gradually accounted for a majority of employment with an increase seen from 41% in 2010 to 57% in 2019. It is very high in some subsectors, such as electronics and leather at 91.9% and 71%, respectively. There are some labor-intensive sectors, like wooden products or food processing where local businesses share a larger proportion. However, the presence of FDI firms has increased. Calculations from enterprise census suggest that FDI firms' LP in manufacturing is much higher than local firms. In 2010, it was recorded at VND188.5 million, about 2.18 times higher than the local counterpart and the gap between them is increasing (Figure 5.2). Given the facts, there are reasons to believe that there would be significant productivity impact on local businesses and their performance.

FIGURE 5.2

LP IN MANUFACTURING (VND MILLION)



Source: Author calculated from enterprise census.

Firms' Innovation Performance in the Manufacturing Sector

A survey conducted by Vietnam's Ministry of Science and Technology in 2014–16 provides the overall picture and pointers for the productivity performance in manufacturing[3]. In general, more than 61% of firms in the sample have carried out some form of innovation, either in products, production process, management, or marketing (Table 5.1). In addition, there are more firms in technical innovation than nontechnical one. In other words, the focus is more on new or modified products and production processes as opposed to seeking new management or marketing methods. The ratio of innovation is highest in the form of production process at 40%, followed by management and product innovation. Meanwhile, marketing as a business function has the lowest innovation. The observation is businesses often only take one type of technical or nontechnical innovation. Less than one-third of the firms in the survey executed both types of innovations and the correlation between the two is only 0.39. These results imply that Vietnam's manufacturing firms often do not have an overall or master plan for innovations. Innovation may be of one type that is caused by some drivers, such as requirement of the markets or advantageous conditions rather than a master plan for long-term productivity improvement.

The above findings are also consistent with a survey conducted by the World Bank where it reveals that although there are a relatively high proportion of businesses having innovation, most of the innovation is simple. For instance, though the innovation is referred as "new production" is high, in fact 49% of such new product is just new to the firm, 41.5% is new for domestic market, and only 9.2% is new in the international market. Most of the innovations are embedded into machineries and equipment purchased, followed by training. The ratio of firms purchase patent license is just about 12.1%.

The survey also points out that FDI firms have the lowest ratio of innovations. As presented in Table 5.1, about 60% of the FDI firms are involved in innovation activities that are substantially lower than state-owned or local private firms (65.14% and 77.6%, correspondingly). This figure is possibly explained by

[3] The OECD's Oslo Manual [10] is followed to define innovation activities of firms. Accordingly, an innovation is "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)". Under this definition, innovation does not need 'new to the world' or creation of nonexisting product or process. It only needs "new to the firm". Firms can achieve "new to the firm" in some ways, such as self-development or just copy or transferred from others. It covers both technical and nontechnical activities of firms. The technical innovation relates to product and production. Meanwhile, nontechnical innovation refers to activities other than production of firm, such as management or marketing. This distinction is indeed based on conceptual coverage of innovations in the OECD's Oslo Manual and the Global Innovation Index [11].

the fact that the FDI firms in Vietnam mainly operate in labor-intensive sector and simple activities of assembling. A considerable proportion of them operate as a factory for their parent firms from abroad which carry out the most R&D or innovation activities. This ratio of FDI firms implies a limited spillover effect to local firms. Meanwhile, a remarkable proportion of state-owned enterprises (SOE) have at least one type of innovation. These may be explained by several factors, such as larger size firm, easier access to resources, including that for innovation; mainly involved in some capital-intensive sectors.

TABLE 5.1

PROPORTION OF FIRMS HAVING INNOVATION ACTIVITIES (%)

Types of Innovation	Overall	Product	Process	Management	Marketing
By ownership					
State owned	77.62	51.14	57.15	61.08	52.74
Domestic private	65.14	32.03	38.54	41.34	29.57
FDI	60.81	30.18	42.34	36.76	22.37
By level of technology (NACE [4])					
High	68.72	45.81	46.83	44.51	28.39
Medium-high	68.69	43.00	43.93	45.57	36.03
Medium-low	62.21	32.66	40.61	36.50	30.13
Low	63.67	27.98	38.86	40.82	24.9
Total	**64.15**	**32.03**	**40.37**	**40.42**	**27.9**

Source: Authors' calculation with data from the Innovation Survey.

Table 5.1 also points out the correlation of the firm's technological level and the possibilities of innovation. Firms in high and medium-high technology group tend to have higher proportions of innovation. It is the same for all types of innovation.

PRODUCTIVITY EFFECTS OF FDI ON LOCAL FIRMS

Estimation Strategy

Unlike the literature in spillovers effects of FDI which traditionally use the single econometric model to test the presence of FDI effect on productivity (either LP or TFP) or the sales growth of the local firm, the researchers in this paper delve further with two steps. First, by testing the presence of FDI and check if it has effect to the firm's innovation. It is widely believed that innovation is one of the long-term determinants of a firm's technological progress which is also one component of productivity. Second is to test the impact to the firm's technical efficiency which is determined by both the internal attempts to improve productivity and the external factors that make a firm more efficient with a given technology. This approach allows the exploration of more insights of productivity effect.

First step: A binominal logit model is specified on which firm innovation is estimated against the presence of FDI and the controlled variable that includes the details of the firms, sector, and regional. The dependent binominal variable is the event of having innovation activities or otherwise, either the innovation in products, process, management, or marketing (the model of each individual type of innovation is also estimated). The presence of FDI firms is measured as the proportion of employment

[4] According to this classification, manufacturing industries are classified into four groups based on level of technology sophistication, namely as high technology, high- and low-medium technologies and low technologies.

in FDI firms in 3-digit sector level. Firm size is employed to proxy of details where firms are classified by different categories, such as less than 100 employees, 100–300 employees, and more than 300 employees. In addition, the variables export and import are all dummies, reflecting on whether the firms have international trade activities or otherwise. Firms in the sample are also classified by the level of technology of industries. As such, four levels have been used, including high technology, medium-high, medium-low, and low technology. As a measure of control for geographical factors, regional dummies were incorporated.

Second step: The effect of FDI is examined on the technical efficiency of local firms. The technical efficiency is a critical component of productivity in addition to the technological progress and scale efficiency. Literatures on this issue argue that for a given technology, different firms may obtain different output for the same input used. Besides the scale effect, the rest is explained by the different efficient levels which relate to the firm's internal and external factors (e.g., management structure, regulations). The detailed discussion of technical efficiency can be referred from Kumbhakar [12] and Battese et al. [13]. So, in this step, the technical efficiency of the firms is estimated against the presence of FDI and other control variables explained for the efficiency. To measure technical efficiency of the firms in the sample, stochastic frontier procedure is used with the association of translog production function which has the form

$$lny_{it} = \beta 0 + \beta_t t + 0.5\beta_{tt} t^2 + \beta_k lnk_t + \beta_l lnl_t + 0.5\beta_{kk} (lnk_{it})^2 + 0.5\beta_{ll} (lnl_{it})^2$$

$$+ \beta_{kl} lnk_{it} lnl_{it} + \beta_{tk} tlnk_{it} + \beta_{tl} tlnl_{it} - v_{it} + \varepsilon_{it}$$

of which value added (*y*) of the firm (*i*) is estimated against time (*t*), labor (*l*), and fixed asset (*k*) proxied for the stock capital. Technical efficiency change (TEC) is estimated from $TE_{it} = exp\ (e^{-v_{it}})$.

Having computing the technical efficiency change, this term is used as dependent variable in the estimation equation of: $TEC_{it} = f\ (FDI_{jl}, S_{it}, X)$; where S_{it} and X are vectors of firms and sectoral specifics. The model, then, is estimated for all domestic firms and for subsample by groups of firms. Also examined is some additional issues relating to productivity, such as the impact of FDI to technological progress and to LP which may play as the robustness for this research.

The Data

The data used in this paper is combined from two surveys. The first survey is called "Firms Innovation Survey" conducted by the Ministry of Sciences and Technology (MOST). The survey is specialized for innovation activities of manufacturing firms for the period 2014–16 with a sample size of around 8,000 firms, including both FDI and local firms in manufacturing. The data also captures information on a firm's details, such as revenue, asset, employment, etc. It is noted that, though the survey is conducted for 2014–16, it is not a panel data. The interviewed information for each observation is for the whole period. Details on this survey can be referred from Ho and Pham [14].

The innovation database was then merged with the second survey - the enterprise census database conducted by the Vietnam's General Statistic Office which looks into firms' identity. As highlighted, the shortcoming of the innovation data is that it is period data rather than annual data. It forces the researchers to resort to an intermediate measure of taking periodical average firm data from the annual enterprise census. As such, the annual data of each manufacturing firm between the period 2014–16 is taken as an average for the whole period. After merging with innovation data and removing firms with less than five workers and FDI firms from the sample, the final dataset was left with about 3,800 local manufacturing firms. This combined dataset is used for estimating the influence of FDI presence (calculated as labor share of FDI firms in 3-digit sector used from enterprise census data) on firm innovation (the first step is mentioned in the previous section).

To estimate the productivity spillovers, the researchers mainly employed the annual enterprise census which is combined to form a panel data. For accessibility reason, only the dataset for 2014–19 was used. The dataset captures basic information of the firms, including the firms' details (sector, location, ownership) and the business performance (sale, investment, employment, fixed asset). After removing all missing data and firms with less than five employees, there were more than 30,000 local businesses in manufacturing. The statistics description for the dataset is presented in Table 5.2.

TABLE 5.2

STATISTICAL DESCRIPTION OF VARIABLES

		Mean	Std. Dev.	Min	Max
lnY	Output (value added)	8.869	2.415	-2.112	17.871
lnL	Total labor (end of the year)	4.689	1.625	1.609	11.757
lnK	Total asset (book value)	8.163	3.258	-2.757	18.425
Export	Export participation, dummy	0.515	0.678	0.000	1.000
Import	Import participation, dummy	0.397	0.457	0.000	1.000
Herfindahl index	Sum of squared of firm's labor share	0.145	0.086	0.000	0.015
FDI	Employment share of FDI in 3-digit sector	0.654	0.368	0.000	0.987

Source: Author's calculation.

RESULTS AND DISCUSSION

FDI and Innovation of Domestic Firms

The results for the first step are presented in Table 5.3. It explains the determinants of innovation in the overall manufacturing firms in the first column. Subsequent columns present the estimation results for individual types of innovation, including the innovation of new products, new production process, new management methods, and new marketing methods. The results suggest that larger firms appear to have a higher tendency to innovate compared to small businesses as the category on firm sizes is positive and statistically significant (the base is firms having less than 100 employees). For instance, given other constants, firms with 100–300 employees have a higher probability of innovation at about 0.22% compared to those with less than 100 employees. In fact, there is an empirical ambiguity on the relationship between firm size and innovation. It is noted that, in practice, some expressed that smaller firms may have several advantages in terms of quick decision-making, willingness to take risks, and flexibility in responding to new market opportunities. Therefore, medium and small firms may have a bigger tendency to innovate. However, others argue that larger firms have advantages that are linked to scale and availability of specialist resources which create better conditions for innovation [15–16]. The findings in this paper support for the latter and suggests the relative strengths of large businesses in Vietnam.

The result also points out that export and import emerge to be substantially correlated with a firm's innovation. The coefficients of both variables - export and import - are positive in this paper's estimations, confirming the international market experience and innovation tendency. That effect may come from product imitation, international competition, and "learning by exporting". This finding is consistent with Neuman et al.'s [17] learnings of SMEs in Vietnam. It is also not surprising that a plethora of qualitative evidences in Vietnam suggests the related positive relation, such as the introduction of new agro-processing products and involving new marketing methods[5].

TABLE 5.3

LOGIT MODELS FOR INNOVATION

	Overall (1)	Product (2)	Process (3)	Management (4)	Marketing (5)
100–300	0.228** (2.47)	0.344*** (3.73)	0.470*** (5.26)	0.157* (1.73)	0.0842 (0.88)
>301	0.602*** (4.86)	0.516*** (4.53)	0.947*** (8.29)	0.508*** (4.51)	0.488*** (4.22)
Export	0.130 (1.29)	0.0797 (0.80)	0.0985 (1.01)	0.243** (2.49)	0.192* (1.87)
Import	0.319*** (3.20)	0.265*** (2.72)	0.306*** (3.19)	0.293*** (3.07)	0.282*** (2.79)
Herfindahl	0.008 (0.31)	0.0683*** (2.58)	0.0735*** (2.86)	-0.069*** (-2.75)	-0.101*** (-3.84)
FDI	-0.350 (1.60)	-0.374 (-1.07)	-0.288 (-1.38)	0.153 (0.75)	0.744* (1.76)
SOE	0.339 (1.56)	0.369** (2.02)	0.239 (1.27)	0.741*** (3.89)	0.748*** (4.07)
High-tech	0.634*** (2.79)	0.945*** (4.81)	0.125 (0.63)	0.353* (1.80)	0.411** (2.03)
Medium-high	0.539*** (4.27)	0.833*** (7.26)	0.223* (1.94)	0.451*** (3.96)	0.674*** (5.69)
Medium-low	0.160** (2.00)	0.190** (2.28)	0.128 (1.61)	0.112 (1.40)	0.189** (2.24)
Regional dummies	Yes	Yes	Yes	Yes	Yes
Constant	0.0606 (0.54)	-1.243*** (-10.66)	-0.938*** (-8.46)	-1.076*** (-9.82)	-1.150*** (-9.90)
No. of Obs.	3841	3841	3841	3841	3841
Prob > F	0.000	0.000	0.000	0.000	0.000

Source: Author' estimation with data from the Enterprise Census and the Innovation Survey.

Note: t statistics in parentheses; * p<0.10, ** p<0.05, *** p<0.010.

For the variable FDI presence, the estimation in Table 5.3 indicates in the overall column that it doesn't likely lead to innovation of local firms as the coefficient of this variable is not statistically significant. It even shows a negative sign. The only positive and statistical evidence is for the case of innovation in new marketing methods. Potential reasons for the "almost no significant links" between the presence of FDI firms and innovation of local firms are perhaps due to the FDI firms themselves, poor absorptive capability of local firms, poor linkages between FDI and local firms, and the effects of negative competition. As pointed out in the literature by Nguyen et al. [18], FDI firms in Vietnam does not bring many innovation activities, but they focus on product assembly which takes advantage of cheap labor in the country. Such situation hinders innovation or R&D spillovers through imitation or learning by doing, etc. Secondly, local firms have critically low capacity for innovation. As mentioned by Ho and Pham [14], though a high number of firms reported their innovation, most of the innovations involved simple modification, either in product or process, rather than investment, R&D, or inventing new

[5] Some [19] may argue on the mutual correlation of this because firms that innovate may have more capability to export or import. However, the cross-section data does not allow the researchers to examine the relation, suggesting the possible endogeneity and raising caution when interpreting this result (see [19] for discussion of this issue).

products. The almost zero absence of association between the presence of FDI and innovation activities of local firms may also confirm a weak link between the two factors. Indeed, when key FDI firms, such as Samsung, Canon, LG, and those similar decide to invest, they often attract their traditional suppliers to invest in Vietnam as well. Therefore, it is hard for Vietnam's firms to get involved in providing inputs to the foreign firms.

Competition may result in both increase and decrease of innovation in firms. The presence of FDI firms in the domestic market results in local businesses having a smaller market share. Therefore, it reduces returns to innovation and local firms may reduce their innovation activities which may cancel out the positive effects of the presence of FDI firms.

FDI, Technical Progress, and Technical Efficiency Change

In this section, the researchers investigate the relation between FDI inflow and technological progress and technical efficiency change of local firms. As mentioned in the previous section, the data for this is abstracted from enterprise census survey for 2016–19. Two-step procedures were applied. In the first step, production function (translog form) was estimated in order to predict technological progress and technical efficiency change. In the second step, the panel econometric model was constructed to examine the influences of FDI to TFP component changes. The results for the first step are provided upon request. Table 5.4 presents the results in the second step.

TABLE 5.4

INNOVATION EFFECTS ON TECHNICAL PROGRESS AND TECHNICAL EFFICIENCY CHANGES

	Technical Efficiency	Technological Progress	Labor Productivity
FDI(lag1)	0.007 (-1.49)	-0.00433 (-1.31)	0.233* (-1.76)
100–299 workers	0.0255*** (-9.18)	0.0115*** (187.05)	0.245*** (-9.26)
300 and above workers	0.0331*** (-10.66)	0.0201*** (219.85)	0.310*** (-9.35)
Export	0.000646* (1.76)	0.000226*** (22.96)	0.134*** (11.82)
Herfindahl	-0.000367 (-0.28)	0.0005*** (13.85)	0.0123* (1.99)
SOE	0.0365*** (7.42)	0.00177*** (12.72)	0.574*** (20.77)
Capital intensity	0.0039*** (4.86)	0.0050*** (246.81)	0.228*** (25.61)
High-tech	0.0165** (-2.41)	-0.0016 (-0.89)	0.484*** (-11.1)
Medium-high	0.00566 (-1.39)	-0.00203 (-0.19)	0.392*** (-15.87)
Medium-low	0.00416 (-1.5)	0.00785 (-1.05)	0.201*** (-9.98)
Regional dummies	Included	Included	Included
Time dummies	Included	Included	Included
Constant	0.641*** (-115.45)	-0.0470*** (-299.40)	2.902*** (-84.99)
Hausman test (P-value)	0.1216	0.4135	0.0986
No. of Obs.	31840	31840	31840

Source: Author' estimation with data from the Enterprise Census and the Innovation Survey.

Note: * p<0.10, ** p<0.05, *** p<0.010.

The first column of Table 5.4 presents the results for three estimations. It also features the results of the estimation with independent variable on the technical efficiency change of local firms. The second column presents the impact of FDI inflow to technological progress. For comparison with a research literature on productivity spillover, an estimation of the LP of local firms is estimated against the presence of FDI. The results are presented in the last column. It is noted that a research literature usually argues about the endogeneity of the FDI variable in those estimations. As such, FDI is assumed to intentionally flow into the sectors of those that already have higher productivity and causing the simultaneity or mutual correlation between the dependent (productivity) and independent variable (FDI) that lead to a possible biased estimation. However, for Vietnam, this may not be the case as the FDI largely flows into sectors that are highly labor intensive or manufacturing assembly which do not have high productivity. If the endogeneity existed, it may not be substantial. To reduce this, the researchers also used the lag (t-1) of the variable FDI in all three estimations as an instrument.

Overall, the results point out that firms with high capital intensity tend to have higher technical change and technology progress, resulting in higher productivity. However, the contribution of this factor is likely smaller than other factors. On firm size, it indicates that firms that operate in larger scale are likely to have higher technical efficiency and technological progress as the size variables are positive and statistically significant at 1%, implying the higher productivity improvement in comparison with base group (less than 100 workers).

Similar with the previous section, the international market experiences, proxied by export of firms, contribute to their productivity change. However, it is larger for LP than for efficiency or technological progress. It is understandable due to the fact that export will bring with them the scale effect in addition to the effect to technology improvement. For different technological level groups, the estimation results indicate that firms with higher level of technology have higher LP as well as TFP change, except technological progress. The coefficients for those dummies' variable (with the base variable is low-tech) is negative. However, it is not significant.

The coefficients of the interest variable - the presence of FDI in the 3-digit sectors - is not statistically significant, regardless for the equation of technical efficiency change or technology progress but positive for the case of the LP. This finding is, to some extent, consistent with the findings in other research literature. Though theoretical arguments on the productivity spillovers of FDI point out the possible positive effect of FDI as the result of the technological and other factors (know-how imitation, competition pressure, labor turnover, etc.), empirically, it is mixed and shows no clear evidence (see Görg H. and Greenaway [20] and Afewerk and Bergeijk [21] for the updated meta-analysis).

The reasons for the mixed evidences are due to the conditions of which the spillovers will be realized. For instance, the spillovers depend on the absorptive capability of local firms, reflected by their recent innovation capability, such as human resource for R&D and technical experts, the capability of firm owners, the availability of capital resources, etc. If absorptive capability is too low then the presence of FDI firms in the sector will not result in the productivity change of local firms. There are also other conditions. For example, the technological gap between FDI and local firms. If it is too far or too close then there are also fewer tendencies of spillovers [22] and also if the conditions for positive spillovers are not satisfied conclusively. The result will lead to local firms to suffer from negative effects, such as the brain drain, competition in output, and input markets that erode their productivity.

For the case of Vietnam in this research, the evidence of positive productivity spillovers is also unclear and the coefficients obtained is statistically insignificant though it has positive sign. Previous studies for Vietnam [18] points out the positive effect for the data of 2004, however, it uses cross-sectional data which may be subject to biased estimation. Later studies can be found from the work by Le and Rechard [23] who find positive impacts but no evidence of vertical spillovers (the effect from upstream or downstream FDI) and valid for the data before 2010. However, Nguyen et al. [24], using the data for 2007–15, pointed out the negative effect to productivity of local firms from both horizontal and vertical

FDI. In fact, the results of the productivity spillovers are mixed and sometimes confusing. This could be due to using different period of data or different proxies for firms' productivity that was provided quickly and changed the manufacturing pattern in the country.

Given the decomposition of LP in productivity literature in Salinas-Jiménez [25], the LP growth can be decomposed to TFP change and capital accumulation. The former term, in turn, can be separated to technical efficiency change and technological progress. As the estimation results suggest the positive and significant impact of FDI to LP, but not to TFP components, it may imply that the presence of FDI can affect mostly to the growth of capital accumulation of local firms rather than TFP change. Statistics point out that in the research period, the investment of the private sector in Vietnam increased substantially. The share of domestic private investment in total investment went up from 36.1% in 2010 to 43.27% in 2018. There are various reasons explained for this, including the improvement of business environment and FDI inflow which create bright economic growth perspective[6].

The nonsignificance of the FDI variable in the technological progress equation also confirms the results in the previous section relating to the impact of FDI to innovation of local firms. As such, FDI is likely not resulting in the local firm innovation, either in new product, new process, or new management (except new marketing). All four forms of innovations significantly link to technical progress. This finding is also not something new for Vietnam nor in spillover literature. For Vietnam, Tran [26] used the dataset for 2000–05 and pointed out that the presence of FDI has negative effect on technological progress of local firms. Similarly, Suyanto and Salim [27], for the case of Indonesia, found that technological progress is the dominant contributor in the TFP growth and FDI has very diverse effect to efficiency and technological progress. As such, there are positive spillovers on efficiency change but negative spillovers on technological progress in the food-processing industry. This contrasted with their findings for the electrical machinery industry. Explanation for the nonsignificance or even negative effect takes a step back in the technology level of local firms when compared to FDI firms. This simply means that local firms are not benefitting from FDI's technologies. It also relates to the isolation of FDI firms in Vietnam where most of the FDI firms operate separately for export and they have poor linkages with local firms while simultaneously compete with them on input, such as land and labor.

However, the nonsignificance of this variable in the equation technical efficiency is surprising and unexpected. It is noted that the technical efficiency is reflected in the relative efficiency distance between firm performance and the frontier (the most efficient firm in the sector). Given the increasing inflow of FDI (total FDI disbursement from US10.46 billion in 2012 to USD19.98 billion in 2019 and registered FDI from USD21.9 billion in 2012 to USD38.02 billion in 2019), this inflow is expected to facilitate the local firms' efficiency from the positive competition effect. In this case, competition itself can be considered as a motivation for reducing X-inefficiency, or coming from technical support or guidance from FDI firms (in cases of involving supply relation), or from the skilled acquisition effect, particularly for managerial staffs. Such impact channels seem not to be the case or erased by negative effect. The explanation for this may be the isolation of FDI and local firms in the economy, as previously mentioned, and also from the adverse effect of lacking skilled workers due to the attraction to FDI firms.

CONCLUSION AND POLICY IMPLICATIONS

Fully aware on the importance of productivity in the long-term growth to escape the middle-income trap, the Vietnamese government has issued various policy instruments as a stimulus to productivity improvement and innovation of local firms. However, most of them use the top-down approach, have scattered implementation with poor coordination, and limited resources which result in limitation of

[6] However, given the poor performance of the production linkages between FDI and local firms in Vietnam and slow improvement of that links, the impact of FDI to the capital accumulation of local firms should be further investigated.

policy coverage and effectiveness. Meanwhile, the Vietnamese government attempts to attract more FDI with the expectation that the capital flow will come with higher technology and productivity, and cascade some spillover effect to local firms.

Vietnam has witnessed substantial improvement in productivity since 2010 and is on the road in becoming one of the highest productivity growth countries in the region and narrowing the productivity gap. However, the country's productivity is still rather far from the target of convergence with other regional countries. Within Vietnam, statistic data indicates that manufacturing productivity is rather low compared to the national average and appears to decline further over time. For that context, this paper is employing a combination of two datasets of Vietnamese firms to investigate the correlation between the presence of FDI firms on innovations and productivity in local firms.

Results show that Vietnamese firms are involved in various forms of innovation. About two-thirds of the sample firms that participated in the survey conveyed that they have implemented innovations in at least one innovation form for new or modified product, production process, management, or marketing methods. However, only about 10% conducted innovations in all four forms (within three years), supporting the argument that Vietnamese firms do not often have a master plan for innovation. In addition, most of the implemented innovation relate to simple modifications and not part of firm-wide strategy. The presence of FDI firms is found to have almost no effect on innovation among the local firms. It can be deduced that they have poor innovation capabilities and the existence of significant technological gap between FDI and local firms results in decreasing innovations in the domestic sector. It also indicates that larger firms and firms with higher technology are more likely to innovate.

The result emphasizes the vital importance of government policies to facilitate growth in the sector. According to the Ministry of Planning and Investment [28] while the number of firms grow rapidly (7.6%/ year for 2017–19), the average firm size has dropped significantly[7]. Though the government emphasizes the importance of start-ups, facilitating the establishment, simplifying firm registration procedures, etc. to elevate innovation, policies to facilitate local firms to survive and thrive should also be boosted, particularly on resource accessibility, reducing the intermediate cost to help increase income, and savings to invest in innovation.

In addition, supporting firms to improve the capability of innovation is also necessary. As highlighted earlier, only a small number of local firms have master plans for innovation while the rest carry out simple modifications. Poor human resource for R&D and innovation is a critical reason for this. As such, government support in connecting firms to research institution and/or facilitating them to improve their human resource for R&D and innovation is especially important.

Policies to facilitate the link between FDI and local firms should also be emphasized. A poor linkage between the two is a critical reason for nonsignificance evidence of either innovation or productivity spillovers of FDI. This situation has yet to change and highlighted widely in previous research literature for Vietnam. The improvement of this linkage should be from both sides. For FDI inflow, it is necessary to have a proper selection procedure to screen FDI investments and more priority should be given to FDI firms that have potential or committed to establish production ties with local firms. From the domestic side, improving the technologies of local firms is precondition to obtaining the linkages. Further science and technology facilitation from the government is necessary, particularly in supporting firms to access technology funds to improve their productivity.

To date, the government of Vietnam already has many policies on both FDI and local firms. However, fragmentation, complication, and resource misallocation are three major disadvantages of the current

[7] For 2016 and 2018, reduced from 22.18 to 20.17 worker, the corresponding figures for manufacturing is 44.03 and 41.15.

policies. The resource misallocation is depicted by the fact that priorities are given to R&D rather than non-R&D, such as technology adoption activities [29]. Therefore, it is necessary to give priority of resource to non-R&D innovation, such as technology transfer and adoption in general. Particularly, the policy improvement should aim at consolidations and simplifications of procedures, e.g., a concrete guide for technology transfer or involvements of local firms in production chains for new FDI projects that can help Vietnam gain more from FDI firms.

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ABBREVIATIONS

ADB	Asian Development Bank
APO	Asian Productivity Organization
ARDA	Agricultural Research Development Agency
ASI	Annual Survey of Industries
BIC	Business Incubation Center
BIOTEC	National Center for Genetic Engineering and Biotechnology
BOI	Board of Investment
CD	Company Directed Technology Development Program
CIS	Community innovation survey
CIT	Corporate income tax
DSIR	Department of Science and Industrial Research
DST	Department of Science and Technology
EEC	Eastern Economic Corridor
ENTEC	National Energy Technology Center
EVs	Electric vehicles
F&B	Food and beverage
FDI	Foreign direct investment
GCC	Gulf Cooperation Council
GERD	Gross domestic expenditure on R&D
GII	Global Innovation Index
GMM	Generalized method of moments
GNI	Gross national income
GRIPS	Graduate Institute for Policy Studies
ICT	Information and communication technologies
i.i.d.	Independent and identically distributed
ILO	International Labour Organization
IMF	International Monetary Fund
IP	Intellectual property
IPR	Intellectual property rights
IR4.0	Fourth industrial revolution
LP	Labor productivity
LSM	Large-scale manufacturing
MIT	Middle-income trap
MNC	Multinational corporation
MOST	Ministry of Sciences and Technology
MTEC	National Metal and Materials Technology Center
NANOTEC	National Nanotechnology Center
NECTEC	National Electronics and Computer Technology Center
NIA	National Innovation Agency
NIS	National Innovation System
NPO	National Productivity Organization
NRCT	National Research Council of Thailand

NSPAIT	National Strategic Programme for Acquisition of Industrial Technology
NSTDA	National Science and Technology Development Agency
NXPO	Office of National Higher Education Science Research and Policy Council
O&G	Oil and gas
OBM	Original brand manufacturer
OECD	Organization for Economic Cooperation and Development
OEM	Original equipment manufacturer
OLS	Ordinary least square
PIP	Public Investment Programme
PQI	Productivity, quality, and innovation
PSE	Public-sector enterprise
R&D	Research and development
RDI	Research, development, and innovation
REACH	Registration, Evaluation, Authorization, & Restriction of Chemical Substances
RGF	Research Gap Fund
ROC	Republic of China
S&T	Science and technology
SEZ	Special Economic Zones
SMEDA	Small, Medium Enterprises Development Authority
SMEs	Small and medium enterprises
SNP	Sustainable National Productivity
SOE	State-owned enteprises
ST&I	Science, technology, and innovation
STI	National Science Technology and Innovation Policy Office
STIPs	Science, technology, and innovation policies
STIP2013	Science and Technology and Innovation Policy Statement 2013
STP2003	Science and Technology Policy Statement 2003
TFP	Total factor productivity
TLO	Technology Licensing Office
TSP	Thailand Science Park
TVET	Technical and Vocation Education and Training
VEPR	Vietnam Institute for Economic & Policy Research
UMIC	Upper middle-income country
WDI	World Development Indicators
WEF	World Economic Forum
WIPO	World Intellectual Property Organization

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