Pathways to National Innovation System

Insights and Lessons from Selected Member Economies

Asian Productivity Organization

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FOREWORD

The establishment of effective national innovation systems has become increasingly crucial as innovation takes center stage in driving economic growth and development. With its power to revolutionize industries, transform business models, and unlock new opportunities across sectors, innovation is recognized globally as a catalyst for enhancing productivity, competitiveness, and social progress. Nurturing and sustaining innovation require tailored approaches through the development of robust national innovation systems.

The Asia-Pacific region has made significant strides in improving national innovation systems. With the common objective of increasing economic growth and maintaining competitiveness on a global scale, diverse measures have been adopted to establish innovation-friendly ecosystems. Although the specific initiatives may differ, there are notable commonalities in successful innovation systems.

The APO conducted research to examine national innovation systems in the selected member economies India, Pakistan, the Philippines, Turkiye, and Vietnam, analyze policy measures and actions, and identify commonalities in successful systems for developing economies. The multiple steps taken and heterogeneity of approaches were highlighted. This publication demonstrates the significance of innovation systems in economic performance.

The efforts of the team of experts who conducted the research and wrote this publication are very much appreciated. The APO hopes that *Pathways to National Innovation Systems: Insights and Lessons from Selected Member Economies* contributes to the ongoing dialogue and inspires innovative approaches leading to sustainable economic growth and the development of robust national innovation systems.

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Tokyo

OVERVIEW OF NATIONAL INNOVATION SYSTEM FOR DEVELOPING COUNTRIES

BACKGROUND

National innovation system (NIS) is characterized by complicated feedback mechanisms and interactive relations involving science, technology, learning, production, policy, and demand that are shaped by the law, regulation, social, cultural norms, and technical standards. Specifically, innovation could be understood as an end product that depends upon all these factors working in tandem with each other, constituting the nucleus of "systems of innovation". These systems are influenced by dynamic structure of institutions, organizations, and social factors. Therefore, the complexity and novelty of innovation are seen in several ways. It is equally evident that with the inception of "national innovation system" in the late 1980s (Edquist, 1997; Freeman, 1987; Lundvall, 1992), relative improvements were achieved in understanding the process of developing, learning, and diffusion of innovation as well as gaining greater lucidity in measuring it efficiently. However, given the complexity of the concept, the learning of this field is still evolving. In the national system of innovation results, the "non-optimality" (Edquist, 1997) in open-ending and path-dependent process results in analyzing the empirics in relative terms.

A growing body of literature shows that the systems of innovation are examined at various units of analysis. It includes country-specific studies, comparisons of NIS in different countries, and with the advent of globalisation of knowledge creation and sharing, the sectoral and technological systems of innovation.

The Asian continent is home to several countries that have made remarkable progress in building and enhancing their national innovation systems. These systems are designed to foster innovation, promote technological advancements, and drive economic growth. Overall, Asian countries have made commendable efforts in developing their national innovation systems. These systems serve as catalysts for economic growth, job creation, and technological advancement. However, challenges remain in areas, such as entrepreneurial culture, access to funding, protection of intellectual property rights, and international collaboration. Continued investments, policy reforms, and strategic initiatives can further enhance the innovation ecosystems in these countries and ensure their sustained progress.

While each country has its unique approach and challenges, this publication highlights a general review of the national innovation systems in five APO economies - India, Pakistan, the Philippines, Turkiye, and Vietnam.

A BRIEF LITERATURE REVIEW

Literature on assessments of developing the NIS is vast and scales across both developed and emerging economies. Selected literature that forms the basis for this study is briefly reviewed in this section.

A study by Wong (2009) compares the NIS of Singapore and Malaysia, focusing on their strategies, policies, and institutional frameworks. It provides insights into the factors that have contributed to

Singapore's success in innovation and highlights the challenges faced by Malaysia. In another study by Singh, Wong, and Ho (2015), it examines the role of universities in fostering NIS in PR China and other east Asian countries and reported a critical role played by institutions of higher learning in building NIS. Wong (2011) in "Academic Entrepreneurship in Asia: The Role and Impact of Universities in National Innovation Systems" clearly highlighted the role of universities in developing NIS and their innovation capabilities. Additionlly, certain studies within this publication deal with this theme explicitly.

In another research by Wong (2003) examines the evolution of Singapore's NIS and its implications in public policy. It discusses Singapore's policy initiatives, government support, and the role of research institutions and enterprises in driving innovation. The study also explores how multinationals can effectively navigate the innovation landscape.

The study by Park, Hong, and Leydesdorff (2005) compared the knowledge-based innovation systems in the economies of the ROK and the Netherlands using Triple Helix indicators. They report a significantly important role for knowledge-based innovations in building NIS in both the ROK and Netherlands. In the context of the ROK, which emphasizes the collaboration between government, industry, and academia, the paper discusses the role of key institutions, policies, and initiatives in fostering innovation and provides insights into the strengths and weaknesses of the ROK's innovation ecosystem.

An exhaustive study by Mehta (2018) on "India's National Innovation System: An Empirical Analysis" identifies key challenges and opportunities. It discusses the role of government policies, institutions, and the business environment in promoting innovation. The paper also examines the role of intellectual property rights, access to funding, and human capital in India's innovation ecosystem.

An overview of Japan's national innovation system that highlights its strengths and challenges is provided by Nelson (1993). It explores the role of government policies, research institutions, and industry-academia collaboration in Japan's innovation landscape. The study also discusses the need for Japan to foster a more entrepreneurial culture and increase collaboration with global innovation networks. Nelson (1996) discusses the ROC's NIS and examines its historical development, institutional framework, and policy initiatives. It also examines the ROC's focus on high-tech industries, government support for R&D, and the role of small and medium-sized enterprises (SMEs) in driving innovation. The study also highlights the challenges faced by the ROC in maintaining its competitive advantage.

These studies offer valuable insights into the NIS of Asian countries, examining their strategies, policies, institutional frameworks, and challenges. They provide a comprehensive understanding of the factors that contribute to the success and limitations of these systems and offer recommendations for further improvement and development.

PUBLIC POLICY SUPPORT

Governments in many countries support entrepreneurs, start-ups, and SMEs in innovation as these small players come up with innovative goals for business, solutions to social problems, and ground-breaking productivity ideas. On the other hand, there are also governments that offer no support for them. This affects a nation's future, productivity, and competitiveness. Also, there are stark differences in the way innovation system is pursued in various countries, such as fostering R&D expenditure, strengthening skills and know-hows, encouraging patent (both process and product) registrations, and supporting technological spillover.

Some countries promote foreign direct investments (FDI) to facilitate technology transfer and diffusion. Further, there are innovative "solutions" and "socially" impactful interventions that are also recognized

and rewarded by national governments to support innovativeness. It is, therefore, vital to identify commonalities in policies to support NIS across the industries/sectors and countries.

Asian countries have implemented various initiatives to improve their NIS and foster innovation. While the specific initiatives vary by country, the commonalities to enhance their innovation ecosystems are:

- **Increasing investment in R&D:** Governments have allocated significant resources to boost R&D funding both through public investment and by incentivizing private sector participation. This includes increasing budgetary allocations, establishing dedicated R&D funds, and providing tax incentives for R&D activities

- **Strengthening industry-academia collaboration:** Asian countries have focused on promoting collaboration between industry and academia to bridge the gap between research and commercialization. This involves establishing research parks, technology transfer centers, and innovation clusters to facilitate knowledge exchange and collaboration

- **Developing supportive policy frameworks:** Governments have implemented policies and regulations that support innovation, such as intellectual property rights protection, streamlined business regulations, and pro-innovation policies. They have also introduced initiatives to attract FDI and encourage technology transfers

- **Encouraging entrepreneurship and start-ups:** Governments have launched programs and initiatives to foster an entrepreneurial culture and support the growth of start-ups. This includes setting up incubators, accelerators, and entrepreneurship training programs as well as providing access to financing, mentorship, and networking opportunities

- **Promoting international collaboration:** Asian countries have actively sought to collaborate with international partners to facilitate knowledge sharing, technology transfer, and access to global markets. This involves participating in international research programs, establishing research collaborations with foreign institutions, and attracting foreign talent

- **Enhancing education and skill development:** Countries have prioritized investments in education and skill development to cultivate a skilled workforce capable of driving innovation. This includes reforms in science, technology, engineering, and mathematics (STEM) education, vocational training programs, and initiatives to attract and retain talent

- **Creating innovation clusters and ecosystems:** Governments have established innovation clusters and ecosystems that bring together research institutions, industry players, start-ups, and supporting infrastructure. These clusters foster collaboration, knowledge exchange, and networking to create a vibrant innovation ecosystem

- **Supporting emerging technologies:** Focus is directed to supporting emerging technologies, such as artificial intelligence (AI), biotechnology, clean energy, and advanced manufacturing. This involves allocating funding, establishing specialized research centers, and providing regulatory support to promote the development and adoption of these technologies

- **Strengthening intellectual property rights (IPR) protection:** Robust IPR frameworks are essential for fostering innovation. Governments have taken steps to strengthen IPR protection by enacting laws, streamlining patent processes, and establishing specialized courts to handle intellectual property disputes

- **Improving access to financing:** Governments have recognized the importance of access to financing for innovation-driven enterprises. They have introduced measures to improve access to venture capital, angel investors, and other funding sources, including setting up dedicated funds and creating favorable tax incentives for investors

These steps taken by Asian countries demonstrate their commitment to enhance their NIS and create an environment conducive to innovation and economic growth. By combining these efforts with continuous evaluation and adaptation, these countries aim to position themselves as global leaders in innovation.

OBJECTIVE

The objective of this study is to identify commonalities in successful NIS for developing countries and to make policy recommendations in building a robust NIS. Select APO members have been identified to review their efforts in building NIS.

SCOPE AND METHODOLOGY

Scope

Identification of successful NIS that can serve as benchmarking standards for developing economies.

Methodology

Desk research, data and information collection, and analysis using most appropriate techniques (parametric and/or non-parametric analysis), policy response formulation (including policy impact analysis where applicable), and drafting a report for publication.

ANALYTICAL FRAMEWORK

The individual APO member reports mostly follow similar framework of analysis to ensure uniformity in reporting. Many countries in the world adopt a knowledge-based approach for building innovation capabilities. Specifically, this approach suggests integration of different knowledge areas during the adoption and implementation of the new idea. Knowledge is considered to be the most strategically significant resource of agricultural facilities, firms, research institutions/organization, and government. Technical innovations, using this knowledge, include products, processes, and technologies used to produce products or render services related to the basic work activity of an organization. Technical innovations occur in the technical core and follow a "bottom-up" approach or process of assimilation. Products and process innovations are distinguished based on the different areas and activities that each of them affect within the firm or organization. Product innovations are outputs or services that are introduced for the benefit of customers or clients while process innovations are tools, devices, and knowledge in throughput technology that mediate between inputs and outputs.

Product innovations are expected to occur with greater frequency in the early stage of a product's life cycle while process innovations occur later. Researchers also differentiate between radical and incremental innovations, which is based on the degree of change an innovation causes to the structure and processes of an organization. Radical innovations produce fundamental change in the activities of an organization and produce clear departures from the existing practices, whereas incremental

innovations call for marginal departure from existing products or processes and reinforce the existing capabilities of firms/organizations. These typologies help in understanding the complexity of the innovation process and also the knowledge associated with an innovation. Incremental changes that are brought about in the knowledge base of an economy define the level of their NIS.

Every APO member expert covered:

i) Aspects of innovation that is recognised in their policy documents that include classification of activities leading to innovation. As mentioned above, innovation itself is classified into produces, processes, radical, and incremental. It is important to cover all aspects in the report.

ii) Policy measures undertaken to support building innovation capabilities, like setting up of higher education institutions, facilitating collaboration between industry and academic, establishing national research laboratories, etc.

iii) Measures to enhance skills and fostering skill development as a national agenda.

iv) Critical review of the literature which have undertaken impact assessment of the innovation policies.

v) Analysis of the data relating to innovation activities, covering all above-mentioned aspects.

The documentation of the source of information and methodology used, preferably standard statistical tools for examining trends, association of attributes, and correlations and regressions (for testing cause and effect relationship) in the study has to be clearly spelt out. To what extent are the findings comparable or unique to the specific economy and/or sector(s) also needs to be highlighted. It is better to use historical time series data, especially during the last 30 years when most Asian economies switched over the pathways of globalisation (linking their economies with the economies of the rest of the world). This is also the period when a greater global capital movements was witnessed, which also facilitated technological paradigm shifts in many firms/sectors in Asian countries. The role of foreign capital in building NIS is also required to make the report comprehensive.

A SNAPSHOT OF THE CHAPTERS

This publication features five APO member-specific studies carried out for India, Pakistan, Philippines, Turkiye, and Vietnam. All the studies have set a common objective of doing a review of policies and actions toward building NIS in their respective economies. The review provided by them is exhaustive and the analysis of data to draw conclusions and lessons for future policy measures are also clearly presented in each of these chapters. The major takeaway from these studies are explained in the following paragraphs.

India

The National Innovation Policy in India has evolved over time to create an innovation-driven economy. The policy measures attempt to encourage R&D, promote entrepreneurship and innovation, and create an enabling environment for the growth of innovation ecosystems across various sectors in the economy. The steps taken include a range of initiatives, such as setting up innovation clusters, creating innovation funds, encouraging public-private partnerships, and promoting innovation in key sectors, namely healthcare, energy, and agriculture. For example, in the case of agriculture, the government created extension services to handhold the farmers to diffuse knowledge from the laboratory and field trials. The policy also strived to create a supportive environment for start-ups and entrepreneurs

through measures, such as simplifying regulations, providing access to finance, and improving infrastructure.

From the analysis presented in this report, India has made significant progress in creating a vibrant innovation ecosystem with a growing number of start-ups and a thriving technology sector. In recent years, the government has launched several initiatives, such as Start-up India, Digital India, and Make in India, which have helped to create a supportive environment for innovation and entrepreneurship. However, the total R&D expenditure continues to be abysmally low, at less than 1% of the GDP. India has set an ambitious target of becoming a USD5 trillion economy by 2025 and achieving this goal will require a continued focus on innovation and entrepreneurship with a particular emphasis on developing new technologies and business models that can address its most pressing challenges, such as climate change, healthcare, and education. All this would mean a great leap forward in R&D expenditure and efforts.

Several multinational corporations (MNCs) have set up R&D units in India to use the high quality, scientifically, and technically skilled manpower. The study recommends that there is a need for greater public-private partnerships, increased investment in infrastructure, and improved access to finance for start-ups and small businesses.

This chapter also present a case study of one higher education technical institution in India. It describes at length the steps taken in fostering an innovation culture among the academia. There are several other institutions which also report similar efforts, collaborations, and success stories. Maybe it requires a cost benefit analysis of the investment and outcomes that would help build a robust innovation system in the higher education institutions in India and other developing countries.

Pakistan

The study on NIS in Pakistan reveals that the country focuses on the establishment of R&D institutions and an R&D fund to finance the innovation activities at both micro and macro levels. With strong policy support, Pakistan could establish incubation centers for technology and industrial development, attracting the best talent from the market. This includes the small programs of innovation and entrepreneurship at schools, colleges, universities, or even cross-country levels.

Efforts have been made to ensure stable macroeconomic and other policy conditions to underpin the entrepreneurial business environment. The policies were formulated to be inclusive by taking into account the concerns raised by the SMEs during the regulatory process and move to establish one-stop centers for regulatory information and transactions and promote the use of e-government tools.

The study highlights the requirement to:

- Promote an entrepreneurial society and entrepreneurial culture, particularly through education and training
- Integrate entrepreneurship at all levels of the formal education system and ensure access to information, skills, and expertise relating to entrepreneurship via “lifelong learning” programs for the adult population
- Promote the diffusion of training programs by stimulating the private market’s supply of such services and providing hands-on focused courses
- Decentralized decision making that is urgently needed to promote entrepreneurship

- Imbibe an evaluation culture to ensure that programs are systematically monitored and assessed for their performance in achieving objectives and for their cost-effectiveness

The chapter concludes by demanding a need for building a strong and reliable statistical base to enable cross-country comparative analysis and policy-relevant longitudinal studies. Undoubtedly, an internationally comparable set of indicators should be developed for monitoring the level of entrepreneurial activity with it being highly relevant to Pakistan and other countries.

Philippines

The Philippines study highlights the importance of utilizing existing and available technology for building NIS in their economy. For example, stakeholders, such as schools, universities, and businesses, have used existing resources, not initially intended for COVID-19 response, to create products and services specifically tailored to address the COVID-19 problems. They promote innovative culture by ensuring that the education system inculcate creativity in children. The approach is strongly supported by the Philippine Development Plan strategy in continuing reforms in the education curriculum (NEDA 2017), wherein the science and technology curriculum is enhanced to "foster innovation and creative imagination."

A number of solutions presented in this chapter are based on the effective use of digital technology, especially during the COVID-19 pandemic. There is clear evidence of a slow-down in the spread of COVID-19 virus when people started using digital technology for payments. Building digital technology has also helped to promote data-driven policymaking.

The study highlights how the pharmaceutical innovations and governance regulations display was strengthened and established a good partnership. The Philippines is moving toward a better knowledge management system to ensure that they learn and improve their response to global pandemics. The study also highlights the need to document and maintain the tools that have been explored and utilized during the outbreak.

Turkiye

Since the 1950s, Turkiye has become a founding member of many European institutions, constantly associated with the European system from the early years of the EU's formation. A number of policy measures have been undertaken for various technological development, which is used as the basis of innovation policies. The study highlights that in the first two decades of the 21st century, Turkiye, which continued its export-oriented growth preference, made its structural reforms in the EU membership process and emerged as a model compatible with the EU at the institutional level. The government not only accepted the definition of innovation that is followed in the OECD Oslo Manual in 2005, but developed its entire innovation system with the perspective of the OECD and the EU. In this framework, encouraging the private sector in innovation, public initiative in critical issues, and sectoral innovation efforts have been developed. At this stage, many innovation-related strategies and mechanisms have increased institutions' capacities and contributed to the development of an innovation ecosystem, which is emphasized.

Following 2018, the main target of the strategies is the creation of high technology and high value-added products, which benefited the defense industry the most. The support and incentives of institutions, such as TUBITAK and KOSGEB, have also increased and concentrated on these areas. However, Turkiye, which has continuously expanded its R&D expenditures to GDP ratio in the last five years, is still below the OECD and EU averages with a rate of 1.13% in 2021. Despite this, Turkiye, which has been improving the Global Innovation Index ranking in recent years, has risen to the 37th place in 2022. The impact of the policies implemented after 2018 is becoming more evident both on the innovation results and global ranking.

The study highlights that development of human capital is another factor contributing to growth. It is also noteworthy that the increase in the number of patents positively affects labor productivity. Studies conducted at the company level also reveal that innovation effectively enters new markets and holds on to rich ones. Further, this study shows a strong correlation between the ratio of R&D expenditures in GDP growth and the labor productivity, specifically within the manufacturing industry, and more broadly, across all industries. The study, therefore, concludes that Turkiye's preferred policies aiming at high technology and high value-added production are realistic.

Vietnam

The chapter on Vietnam highlights that there are seven megatrends which drive the development of Vietnam's future digital economy and forms the basis for their NIS.

- **Megatrend one:** Emerging digital technologies, such as block chain, AI, big data analytics, and the IoT can leapfrog industry infrastructure upgrades, simplify supply chains and logistics, and help businesses operate more efficiently

- **Megatrend two:** International integration is pursued by opening Vietnam to new export markets, knowledge and skills transfer, and greater levels of foreign investment can promote the growth of its economy and NIS, and more specifically, its digital system

- **Megatrend three:** The study correctly identifies that there is a greater need for cybersecurity and privacy as more businesses and consumers engage in the digital economy. Critical systems, such as finance and government, are increasingly digitalized

- **Megatrend four:** There is a need to build reliable digital and energy infrastructure, especially for the power intensive technologies, such as IoT or AI. New telecommunications networks are also needed to ensure broadband is available to carry the large amounts of digital data needed for new applications

- **Megatrend five:** With a rapidly urbanized and aging nation, smart cities provide opportunities to use infrastructure and resources more efficiently as well as reduce waste, pollution, and traffic congestion

- **Megatrend six:** The increasing demand for the services sector as well as digital products and services mean there is a need to invest further in Vietnam's higher education, digital skills, entrepreneurial skills, and innovation ecosystem. The trend to move away from secure, structured, and long-term work is also driving the use of labor and product platforms for income generation and creative avenues for industrial transitions in labor markets

- **Megatrend seven:** The need to understand changing consumer behaviour as the Asian middle class emerges and orients to higher-value goods and services, including those from the digital economy. At the same time, higher digital adoption among consumers increases the influence of digital tribes and influencers both on suppliers and consumer behaviour. Currently, this is what is driving the NIS in Vietnam

The study argues that building and developing innovation ecosystems in industries, agriculture, and services associated with domestic and global value chains is the need of the hour in Vietnam. The state agencies have to play an important role to create a favourable institutional environment, policies, linkages between enterprises, production organizations, research institutes, universities, and supporting organizations to promote research, application, and innovation activities.

The study also states the importance of building and developing a system of innovation centers, including the National Innovation Center, regional and industry innovation centers, and innovative start-up support centers, to develop and integrate with high-tech zones, residential areas, financial centers, venture capital funds, universities, and research institutes will better build the NIS. It also calls for a strong and open innovation platform and open innovation networks to attract all domestic and foreign resources to invest in new technologies, new products, and forming new businesses needs. This study also puts forth a distinct recommendation to enhance collaboration, communication, and promotion activities as well as to strengthen the connectivity of innovation networks both domestically and internationally. Additionally, it emphasizes the importance of establishing a link between innovation centers and R&D centers at home and abroad.

SUMMARY

There is a clear indication from all the studies that innovation systems matter because an economy's success depends on its NIS working effectively. As innovative capacity sustains productivity, building an efficient NIS is a prerequisite for productivity growth. Understanding how a NIS operates is essential to know its key strengths and weaknesses and its performance over time as well as the measures needed to enhance a country's overall innovation performance.

CHAPTER 1

INDIA

INTRODUCTION

India is committed to grow its economy and has worked diligently to expand its innovative footprint globally through various initiatives, such as tinkering labs and incubation centers to promote innovation and create employment opportunities. Indian innovation is always a public debate and, more often than before, part of business forums and media announcements. However, the term "innovation" has multiple meanings and is often used in a narrow context of short-term relevance. In India, there is also "Alternate" or "Jugaad", a common term that refers to temporary solution or innovation under constraint that is used to overcome serious issues, and thus is wrongly evaluated as an innovation initiative[1].

Innovation is a priority in India. The country celebrated the "Decade of Innovation 2010–20" that focused on capacity building in Science, Technology, and Innovation (STI) with the goal to increase total research & development (R&D) spending to 2% of its GDP by 2020. The innovation commitment is reflected in the "Make in India" initiative, aimed to boost domestic production. Meanwhile, India's 12th Five-Year Plan (2012–17) looks into promoting growth for inclusive development while the National Innovation Fund supports grassroots innovators and the Inclusive Innovation Fund (IIF) aims to raise capital to help businesses develop innovative solutions for the "500 million people under together"[2].

TABLE 1.1

FRAMEWORK FOR HEIS NATIONAL INNOVATION

A	HEIs Strategies and Governance for Promoting Innovation and Entrepreneurship	B1	Incentivizing Students for Entrepreneurship and Start-up Pursuits
A1	Creating Innovation Pipeline and Pathways for Entrepreneurs	B3	Incentivizing Faculty and Staff for Entrepreneurship and Start-up Pursuits
A2	Building Organizational Capacity, HR, and Incentives to Support and Promote Innovative and Entrepreneurial Activities	C	Incubation and Preincubation Support and Facility Creation in HEIs
A3	Collaboration, Cocreation, Business Relationship, and Knowledge Exchange within Campus and among the Ecosystem Enablers Coexist at Regional and National Levels	D	IP Ownership Rights for Technologies Development and Transfer in HEIs
B	Norms for Faculty- and Students-driven Innovations and Start-ups	E	Pedagogy and Learning Interventions for Innovation and Entrepreneurship Development
		F	Entrepreneurial Performance Impact Assessment

Source: National Innovation and Startup Policy (https://nisp.mic.gov.in).

1 Rajan (2012), Shaping the National Innovation System: The Indian Perspective (accessed on 1 Nov 2022).

2 OECD (2014) India Policy Brief (accessed on 21 October 2022).

The guiding framework for Higher Education Institutions (HEIs) was established by the National Innovation and Entrepreneurship Policy, which emphasized various essential and practical aspects of fostering and supporting innovation, technology commercialization, and entrepreneurship within an academic structure, as represented in Table 1.1.

Enhancing and Fostering Skill Development

Skill development is essential to bridge the gap between supply and demand for skilled labor, creating frameworks for professional and technical training, upskilling and acquiring new skills, and fostering innovative thinking. The government established the Ministry of Skill Development and Entrepreneurship to support skill development (Appendix I).

LITERATURE REVIEW FOR NATIONAL INNOVATION SYSTEM IN INDIA

The concept of the National Innovation System (NIS) has been widely discussed and documented in the academic literature on innovation. Christopher Freeman and Bengt-ke Lundvall collaborated in the late 1980s and coined the term "National System of Innovation". India's NIS has gone through several stages of development over the years. Here is a brief chronological overview[3, 4, 5] :

- **Pre-independence period (1850–1947)**

  During this period, India's innovation system was largely underdeveloped with limited investment in science and technology. However, there were few notable initiatives, such as the establishment of the Indian Association for the Cultivation of Science in 1876 and the Indian Science Congress Association in 1914.

- **Post-independence period (1947–1970s)**

  After independence, India focused on building its scientific and technological capabilities to support economic growth and development. This led to the establishment of several scientific research institutes, including the Council of Scientific and Industrial Research (CSIR) in 1942, the Indian Council of Agricultural Research (ICAR) in 1947, and the Department of Atomic Energy (DAE) in 1948.

- **Technological self-reliance (1970s–1980s)**

  In the 1970s, India began to focus on technological self-reliance with an emphasis on developing indigenous technologies and reducing dependence on foreign technology. This led to the establishment of several institutions, including the Indian Space Research Organization (ISRO) in 1969 and the Department of Electronics (DOE) in 1970.

- **Liberalization and globalization (1990s–2000s)**

  In the 1990s, India began to liberalize its economy and open to foreign investment and technology. This led to the establishment of several new institutions, including the Department of Science and

3 Rao (1998), India: Science and Technology from Ancient Time to Today.

4 Ministry of Culture (2023) (accessed on 22 March 2023).

5 Krishna, V.V. India @ 75: Science, technology and innovation policies for development. Science, Technology and Society 2021: 27(1); 113–146.

Technology (DST) in 1988 and the Technology Development Board (TDB) in 1996. The government also established several policies and programs to promote innovation and entrepreneurship, such as the National Technology Development and Promotion Program (NTDPP) in 1993 and the National Innovation Foundation (NIF) in 2000.

- **Innovation-led growth (2010s–present)**

  In recent years, India has placed greater emphasis on innovation-led growth and launched several initiatives, such as the National Innovation Council (NIC) in 2010 and the Atal Innovation Mission (AIM) in 2016. The government also established several funds to support innovation and entrepreneurship, including the Technology Development Fund (TDF) and the Innovation in Science Pursuit for Inspired Research (INSPIRE) program.

In the 1980s, India witnessed a shift in economic policies that emphasized on liberalization and globalization. The innovation landscape changed and researchers started examining the NIS in India. Some of the prominent research articles in 1980–2020 period are:

- "National Innovation System in India: A Synthesis" published in 1986. The paper argues that India's innovation system is underdeveloped due to factors, such as inadequate infrastructure, lack of venture capital, and a rigid educational system (Palat R.K., 1986)

- "Science and Technology Policy in India: Evolution, Current Status and Future Prospects" published in 1990. The article provides a historical overview of science and technology policy in India and assesses its effectiveness. It concludes that while some progress has been made, there is a need for more targeted investments and a greater focus on commercialization (Bhargava B.S., 1980)

- "Innovation in Indian Industry: An Exploration" published in 1994. An analysis of the innovation capabilities of Indian firms and finds that they are weak due to factors, such as low investment in R&D, lack of collaboration between industry and academia, and insufficient government support (Mohan R., 1994)

- "Innovation in the Indian Software Industry" is a study examining the factors that have contributed to the success of the Indian software industry, including the availability of skilled labor, a favourable policy environment, and the ability to serve global markets (Arora A., 1998)

- "Innovation Systems in Developing Countries: The Case of India" by K.J. Joseph and Dinesh Abrol, published in 2000. A comprehensive analysis of the Indian innovation system is provided, including its strengths and weaknesses. It highlights the need for greater collaboration between academia, industry, and government as well as increased investment in R&D and technology transfer (Joseph K.J., 2000)

- "National Innovation System in India: Challenges and Opportunities" examines the development of the NIS in India, focusing on its strengths, weaknesses, and the challenges it faces. The authors argue that the Indian innovation system needs to be more decentralized with a greater emphasis on local innovation and entrepreneurship (Joseph K.J., 2004)

- "National Innovation System in India: Structure and Trends" provides an overview of India's NIS, highlighting its key features and current trends. The authors argue that the Indian innovation system needs to be more closely aligned with the needs of industry and society, and call for greater investment in R&D (Basant R., 2007)

- "Mapping the Indian National Innovation System: Evidence from Patent Analysis" uses patent data to analyse the NIS in India, focusing on the role of universities, research institutes, and industry. The authors find that the Indian innovation system is still heavily dominated by government research institutions and that there is a need for greater collaboration between academia and industry (Krishnan R.T., 2011)

- "The Indian National Innovation System: A Network Analysis" uses network analysis to study the NIS in India, focusing on the relationships between different stakeholders in the system. The authors find that there are a few key actors in the Indian innovation system that play a central role in connecting different parts of the system and call for greater collaboration and networking among them (Dhall A., 2014)

- "The Evolution of India's National Innovation System" provides an overview that focuses on the evolution of India's NIS over time. The author argues that the Indian innovation system has undergone significant changes in recent years with a greater emphasis on innovation-driven entrepreneurship and a shift toward a more decentralized innovation ecosystem (Ramani S.V., 2017)

- "National Innovation Systems in Developing Countries: The Case of India" puts forward a critical analysis of the NIS in India, focusing on its strengths and weaknesses. The authors argue that while the Indian innovation system has made significant progress in recent years, there are still several challenges that need to be addressed, including inadequate funding for R&D and a lack of effective policies to support innovation (Raman R., 2020)

To boost the innovation ecosystem, the Indian government has created various policies for innovation. Eleven policies have been implemented with emphasis to promote innovation by involving every stakeholder - six of the 11 policies are relevant for schools, nine are related to colleges/HEIs, and seven are for Industries/MSME that are relevant for participation. A detailed description has been shared in Appendix II.

India has released five policies on STI since its independence. They are[6]:

- **The Scientific Policy Resolution, 1958** - Aimed to lay the foundation of scientific temper and develop scientific enterprises around basic research, applied research, and industrial development. This policy also emphasized on self-reliance and social welfare

- **The Technology Policy Statement, 1983** - Focused on acquiring and developing indigenous technologies for national security, economic growth, and social justice. It also stressed on international cooperation and technology transfer

- **The Science and Technology Policy, 2003** - Aimed to increase investment in R&D to 2% of GDP by 2010. The policy also highlighted the role of STI in addressing societal challenges, such as health, education, environment, and energy

- **The Science, Technology, and Innovation Policy, 2013** - Envisioned India as one of the top five global scientific powers by 2020. This policy also advocated for creating an enabling environment for innovation through public-private partnerships, intellectual property rights (IPR) protection, and inclusive participation

6 IAS4Sure (https://www.ias4sure.com/wikiias/gs3/st-policies-in-india-upsc-gs3/).

- **The Draft Science Technology Innovation Policy (STIP), 2020** - This policy is currently under public consultation. It proposes to make India a global leader in STI by fostering a culture of innovation and entrepreneurship. It also aims to align STI with national priorities, such as sustainable development goals, digital transformation, and self-reliance[7]

Due to these policies, India published 135,788 peer-reviewed science and engineering journal articles and conference papers in 2018. This accounted for 5.31% of all global publications in scientific articles. India ranked third in the world after PR China (20.67%) and the United States of America (USA) (16.54%) in terms of research output. The report was based on data from Scopus, a database of abstracts and citations for scholarly literature. This shows that India has become a major contributor to global scientific knowledge and innovation[8]. Recognizing the importance of innovation in driving economic growth and development, the government implemented various policies and programs to foster a strong NIS in the country. In 2010, the National Innovation Council (NIC) was launched with the task of formulating policies and initiatives to promote innovation and entrepreneurship across various sectors of the economy. The NIC works closely with various stakeholders, including industry, academia, and civil society organizations, to identify barriers to innovation and develop solutions to address them.

The government has also established several institutions to support the NIS, including the Department of Science and Technology, the Council of Scientific and Industrial Research, and the Indian Institutes of Technology (IIT). These institutions provide funding for R&D, support for technology transfer and commercialization, and training and capacity building for researchers and entrepreneurs.

In recent years, the government has also launched several initiatives to promote innovation and entrepreneurship, including the Atal Innovation Mission, the Start-up India program, and the Smart Cities Mission. These initiatives provide funding and support for start-ups, facilitate collaboration between industry and academia, and promote the adoption of new technologies in various sectors of the economy. Overall, the government of India is committed to strengthening the NIS and promoting innovation and entrepreneurship in the country through various policies, programs, and initiatives. The government aims to create a conducive ecosystem for innovation and entrepreneurship that can drive sustainable economic growth and development in the years to come[9].

As for the corporates and private companies, their opinions and experiences on the NIS may vary based on a variety of factors, such as the differing sectors they operate in, size of company, and nature of business. However, in general, Indian private companies and corporates recognize the potential benefits of the NIS in driving innovation and growth in the country. Some companies have actively participated in the NIS by partnering with academic institutions and research organizations to develop new technologies and products. For instance, companies like Tata Consultancy Services (TCS), Infosys, and Wipro have established R&D centers in collaboration with leading Indian universities and institutes. Other companies have also been involved in funding and supporting start-ups and entrepreneurial ventures through initiatives, such as incubators and accelerators. India's innovation poses many opportunities and challenges, and understanding them is essential.

7 Abraham (2021), The Two Faces of India's New Science and Tech Policy. (https://science.thewire.in/the-sciences/india-national-research-foundation-draft-stip-2020-science-and-technology-policy-review/).

8 US National Science Foundation (NSF), 2018 (https://www.indiatoday.in/science/story/india-worlds-third-largest-producer-scientific-articles-china-us-1629445-2019-12-18).

9 National Science & Technology Management Information System (https://dst.gov.in/scientific-programmes/scientific-engineering-research/national-science-technology-management-information-system-nstmis).

FACTORS INFLUENCING INNOVATION

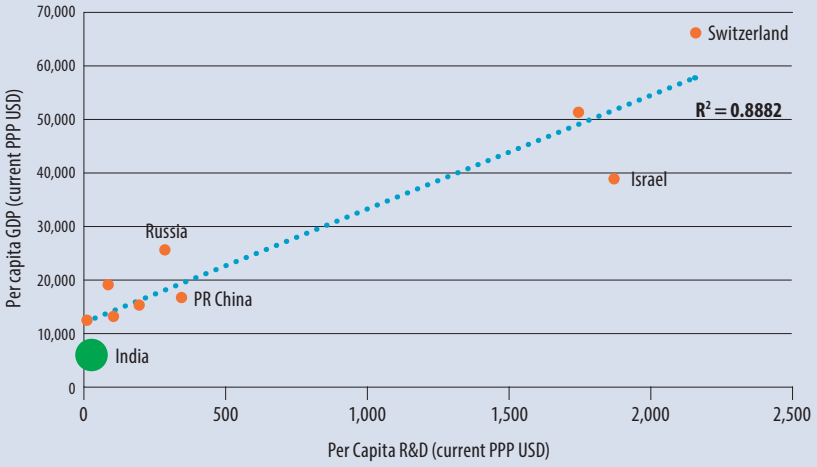
Various factors influence innovation and a comprehensive view is taken on R&D, company size, job market, and demographic bonuses.

R&D

The positive relationship between R&D per capita and GDP per capita shows the tendency of countries with high R&D spending per capita have higher GDP per capita (Figure 1.1).

FIGURE 1.1

CORRELATION BETWEEN PER CAPITA R&D EXPENDITURE AND PER CAPITA GDP



Source: India Innovation Index.

Company Size

While India has a large manufacturing industry with small companies (less than 50 employees) and large companies (more than 500 employees), it faces the "missing middle" problem. This creates a large productivity gap as large firms have higher productivity than small firms.

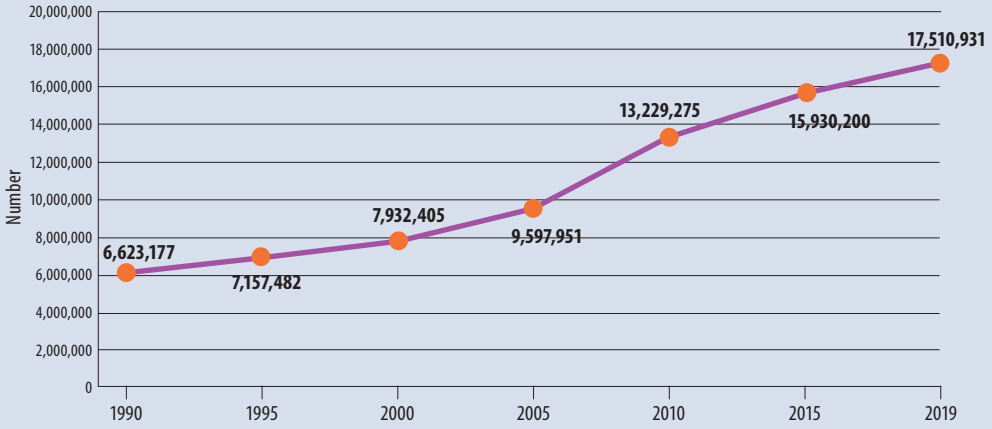
Labor Market

India's workforce is highly competitive in the hard work marketplace, making it difficult to adopt new and progressive technology. However, innovation has the power to create new jobs, as evidence show that innovation is a positive factor in the long term (Mehta S., 2016; Sinha A.K., et al., 2019).

The opportunity for innovation can be placed at about 60% of India's population that fall in the age group of 15–59. However, innovation usually comes with risk factors and Indians generally tend to be risk-averse as the mindset is rife with the worry of failure and intolerance (Sharma P., et al., 2012). Due to absence of adequate support, the youth tend to migrate to other countries in search for opportunities. Figure 1.2 shows the increasing number of migration from India between 1990–2019.

FIGURE 1.2

MIGRATION FROM INDIA TO OTHER COUNTRIES BETWEEN 1990 –2019



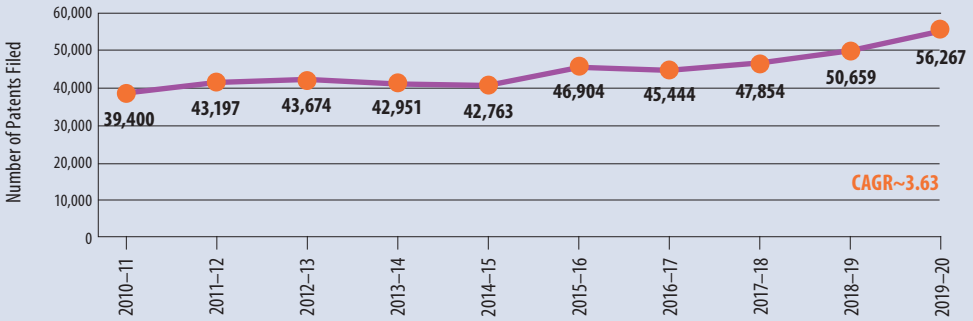
Source: India Innovation Index.

Market Demand

Research must be tailored to business requirements in order to bridge the gap between academia and industry needs. To achieve this, researchers are working with universities and data analytics institutes to gain early access to research results and influence their research agenda (Figure 1.3). This allows corporations to scale back the costs of outsourcing research and dealing with academic institutions (Radermacher A.W.G., 2013).

FIGURE 1.3

PATENTS FILED OVER THE YEARS IN INDIA



Source: India Innovation Index.

Venture Capital

Venture capital is a way to provide funds and necessary experience to run a business. But banks are reluctant to lend to start-ups due to lack of collateral and high risk of default. Microfinance provides

capital to firms, but its limited scope and amount restricts its ability to pioneer (Sonne L., 2012). Capital and personal equity flows in India have increased from INR4 billion to INR1,327 billion over the past 25 years (Nuthalapati C.S.R., 2019).

ACADEMIA-INDUSTRY INTERFACE TO BOOST INNOVATION

Academia-industry interface is a term that refers to the collaboration and interaction between academic institutions and industrial sectors for mutual benefits, such as research, innovation, education, and development. It can help boost innovation in India by facilitating knowledge transfer, technology development, skill enhancement, problem solving, and market access. Some of the initiatives that have been launched to promote academia-industry interface are:

- **Lab2Market initiative by INDIAai and National Association of Software and Service Companies (NASSCOM)**

  This initiative aims to identify and showcase AI-based research projects from academic institutions that have potential for commercialization and social impact[10]. India is also to adopt the National Education Policy which includes strengthening the role of industry in the design and implementation of curriculum, providing internships and apprenticeships, supporting research and innovation projects, establishing incubators, and mentoring start-ups[11].

- **New Generation Innovation & Entrepreneurship Development Centre (NewGen IEDC)**

  A scheme by the Department of Science & Technology (DST), it supports academic institutions to set up incubation centers for nurturing innovative ideas and entrepreneurial skills among students (Vinoth S., 2021). A detailed review of several institutional collaborations and links have been shared in Appendix III.

EVOLUTION OF INDIAN INNOVATION INDEX

To be a part of the fourth industrial revolution (IR4.0), the Indian Innovation Index has been designed by mapping it with the international Innovation Index (GII). The innovation inputs were measured through five enabler parameters and two performance parameters for output.

TABLE 1.2

FRAMEWORK COMPOSITION OF INDIA INNOVATION INDEX (III)

Dimensions	III-2019	III-2020	III-2021
Enablers	23 indicators	25 indicators	50 indicators
Performers	10 indicators	11 indicators	16 indicators

Source: India Innovation Index 2021.

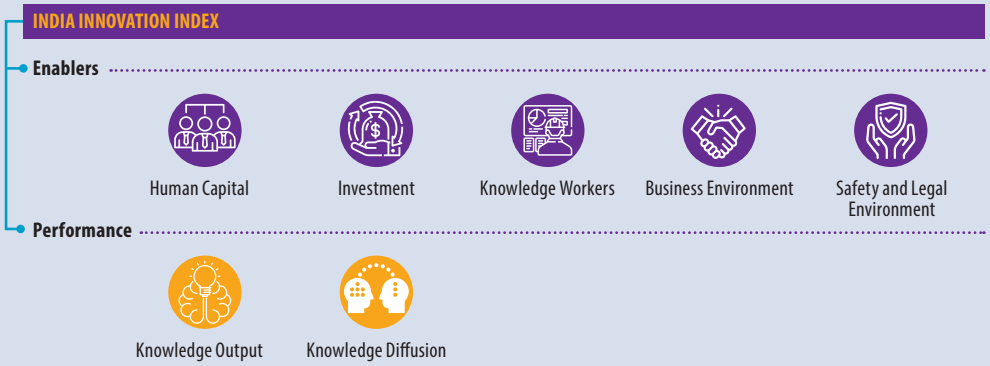
10 INDIAai (2021) (https://indiaai.gov.in/article/lab2market-initiative-launched-to-boost-industry-academia-collaboration).

11 HT (2017) (https://www.hindustantimes.com/education/india-moving-towards-innovation-through-academia-industry-partnerships/story-qqSXC3zx3G70SBdkoXDHjM.html).

All metrics within the Enabler column cover necessary features, such as promoting innovation within the State/Union territories (UTs). The indicators in the "Performance" pillar represent a nation's superiority in terms of information creation and competitiveness of economic science and economics indicators, as shown in Figure 1.4.

FIGURE 1.4

INDIA INNOVATION INDEX 2021 FRAMEWORK



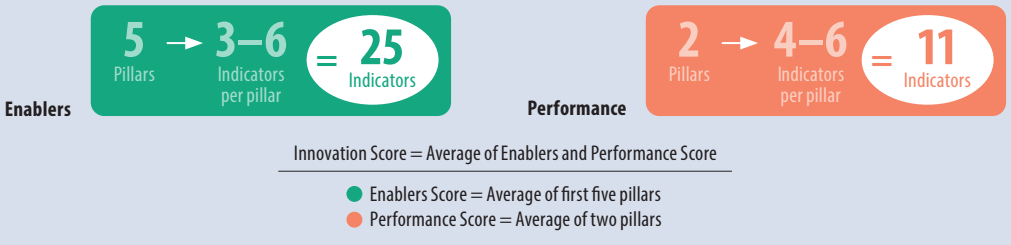
Source: India Innovation Index 2021.

The ranking of states and UTs in the India Innovation Index is predominantly determined by Enablers that encompass innovative capabilities, policies, infrastructure, markets, and capital while Performance pillars measure innovation outputs. These categories gauge the extent to which a state or UT has created a conducive environment for innovation. On the other hand, the Performance pillars assess the outcomes of the Enablers or inputs by evaluating their impact on the creation of wealth, generation of knowledge, and enhancement of competitiveness (Figure 1.4).

The India Innovation Index is dependent on the two parameters which are expanded to pillars, and further branch to a number of indicators (Figure 1.5).

FIGURE 1.5

MEASURES OF INDIA INNOVATION INDEX 2021



Source: Pruthi R. (https://www.jagranjosh.com/current-affairs/india-innovation-index-how-is-it-calculated-1611323872-1).

Evaluating the fit is a methodology for calculating the India Innovation Index among the individual indicators through the calculation of Cronbach's alpha for each pillar. Alpha provides a measure of internal consistency of a test and is presented as a number between 0 and 1. Alpha was developed in 1951 by Lee Cronbach. Figure 1.6 shows the Alpha value of individual indicators.

FIGURE 1.6

EVALUATING FIT

DIMENSION	PILLAR	ALPHA
Enabler	Human Capital	0.79
	Investment	0.70
	Knowledge Workers	0.79
	Business Environment	0.88
	Safety and Legal Environment	0.328
Performance	Knowledge Output	0.84
	Knowledge Diffusion	0.75

Source: India Innovation Index 2021.

METHODOLOGY FOR CALCULATING INDEX

Aggregation: The Principal Component Analysis (PCA) is employed for calculating weights of those indicators inside a pillar. The pillar price is calculated through this formula:

Pillars = ∑ (w_i * indicator)

The pillar score is set within the values of 0–100. The best-case and worst-case scenarios are used to achieve this:

(Xj-Worst Case)/(Best Case-Worst Case)

Xj is the raw pillar value.

Dimension Scores: The score of every dimension is considered as a straightforward average of its pillars:

$Dimension_d$ = 1/i ∑ $Pillar_c$ (I=5 or 2)

Index Scores: The dimensions of Enablers and Performance are given equal importance in all aspects of innovation. Thus for calculating the index scores, equal weightage is given to every dimension to focus on their roles:

India Innovation Index = 1/2 ∑ $Dimension_d$

Goodness of fit: Post the calculation of each pillar and index scores, the goodness of fit is evaluated using the Kaiser-Meyer-Olkin (KMO) measure. The KMO values in highlighted in Figure 1.7.

FIGURE 1.7

CALCULATION OF PILLARS BY USING KAISER-MEYER-OLKIN (KMO) MEASURE

DIMENSION	PILLAR	KMO
Enabler	Human Capital	0.58
	Investment	0.67
	Knowledge Workers	0.74
	Business Environment	0.69
	Safety and Legal Environment	0.64
Performance	Knowledge Output	0.72
	Knowledge Diffusion	0.65

Source: India Innovation Index 2021.

Human Capital

Human capital is crucial for spreading innovation, though not necessarily requiring skilled labor from the state. Improving education, research quality, and fostering an inquiry environment boosts innovation. Investing in educational institutions, R&D, and universities enhances human capacity and innovation capability. This pillar aims to measure a country's human capital based on 15 key indicators, as shown in Table 1.3.

TABLE 1.3

HUMAN CAPITAL ENABLERS

HUMAN CAPITAL	
School Education	
Schools with ICT labs	Secondary school level completion rate with respect to primary school level completion rate
Assessment in reading, mathematics, and science (Class V NAS Scores, 2015, Cycle 4)	Pupil-Teacher ratio: Primary & Secondary
Expenditure on school education as a % of Gross State Domestic Product (GSDP)	Accolades in STEM Activities/1000 Students in States; i.e.: INSPIRE Awards, NTSE Scholarship, Olympiads, any other state/national/international level awards
NER in school education	Percentage of schools having Science/ Technology Tinkering/ Innovation labs, such as Atal Tinkering Labs (ATL)
Tertiary and Higher Education	
Enrolment in engineering and technology (at undergraduate, postgraduate, and diploma level)	Colleges connected through National Mission on Higher Education Through ICT (NMEICT)
Enrolment in PhD per 100,000 of population	Enrolment in vocational education or skill development courses/100,000 of population
Higher education institutions with NAAC grade A and above	Enrolment in vocational education or skill development courses/100,000 of population
Pupil-Teacher Ratio - Higher Education	Percentage of schools having Science/ Technology Tinkering/Innovation labs, such as Atal Tinkering Labs (ATL)

Investment

Funding for education, science, and R&D is crucial in developing innovative ability. Increased public and private funding will enhance knowledge infrastructure. Access to credit and investor support facilitates doing business, leading to a strong market, easy access to credit, and FDI. This is measured by six indicators, as shown in Table 1.4.

TABLE 1.4

INVESTMENT ENABLERS

INVESTMENT
R&D
Expenditure on higher and technical education
Expenditure on Science, Technology, and Environment
Expenditure on R&D
NIRF ranking of top five universities
Market Sophistication
Venture capital deals
FDI inflows

Knowledge Workers

Skilled workers are crucial to enhance a company's innovative prowess, productivity, competitiveness, and potential. A highly qualified workforce through skills development, education, training, and hiring is necessary to evaluate business development and innovation activities. Table 1.5 highlights the six indicators used for this enabler.

TABLE 1.5

KNOWLEDGE WORKERS ENABLERS

KNOWLEDGE WORKERS
Workforce
Knowledge-intensive employment
Private R&D units in the state
NGOs involved in knowledge-intensive areas
R&D institutions funded by states/UTs
Skill development training
% of females employed with advanced degrees out of total employed

Business Environment

To foster innovation, it's crucial to establish a business ecosystem with responsible governance, protection, and incentives. This pillar evaluates each state/UTs' business environment based on ease of doing business, efficient governance, and digitization while focusing on government's support for private entrepreneurship and innovation (Table 1.6).

TABLE 1.6

BUSINESS ENVIRONMENT ENABLERS

BUSINESS ENVIRONMENT
Trade, competition, and market scale
Ease of doing business
Common facility centers
Share of manufacturing and services as a % of GSVA (gross state value added)
Gross capital formation as a % of GSDP/GVA (gross value added)
Incubator centers in the state
Cluster strength
Credit
Number of bank accounts/1,000 population
Percentage of bank accounts with Aadhar seeding
Domestic credit to the private sector, % SDP
Microfinance institutions Loan portfolio (MUDRA, etc.)
Digital Infrastructure
Internet subscribers
Total number of online services transactions/1,000 population
Number of services offered online by state government/other sources
Percentage of villages in the state with internet connectivity
Percentage of subsidies or benefits transferred through the digital platform

Safety and Legal Environment

State governments establish fair processes, regulate markets, and protect property rights through each pillar (Table 1.7). Lighter regulatory leads to higher innovative business activity.

TABLE 1.7

SAFETY AND LEGAL ENVIRONMENT ENABLERS

SAFETY AND LEGAL ENVIRONMENT
Security/Safety Environment
IT/Intellectual property-related acts (Rate of offences)
Cybercrime police stations
Rate of cognizable crime police personnel/100,000 of population
Social media monitoring cells
Legal Regulatory Environment
Pendency of court cases
Charge sheeting rate
Pendency percentage - Corruption cases investigation

Knowledge Diffusion

This pillar (Table 1.8) gauges a nation's development and competitiveness by measuring value-added components of products and services and the shift toward an innovation-driven economy. The high-tech and manufacturing exports, handicrafts, and handlooms embody the knowledge production pillars of an economy transitioning from resource-oriented to innovation-oriented.

TABLE 1.8

KNOWLEDGE DIFFUSION ENABLERS

KNOWLEDGE DIFFUSION
Knowledge Dissemination
High-tech exports as a % of total exports
ICT exports
High- and medium-high-tech manufacturing entities
Citations
Creative Goods and Services
GIs registered
Circulation by all newspapers/state population
Handicraft sales/GSDP

Knowledge Output

R&D investment boosts innovation, making products and services more competitive. Patents and trademarks protect their value while scientific publications demonstrate technological achievements (Table 1.9).

TABLE 1.9

KNOWLEDGE OUTPUT ENABLERS

KNOWLEDGE OUTPUT
Knowledge Creation
Grassroot innovations
Publications
Knowledge Impact
Start-ups in the state
New businesses - Number of companies registered during previous FY
GSDP per capita growth rate
Environment clearance of proposals/project
Intangible Assets
Patents filed from state
Industrial designs by origin
Trademark application filed

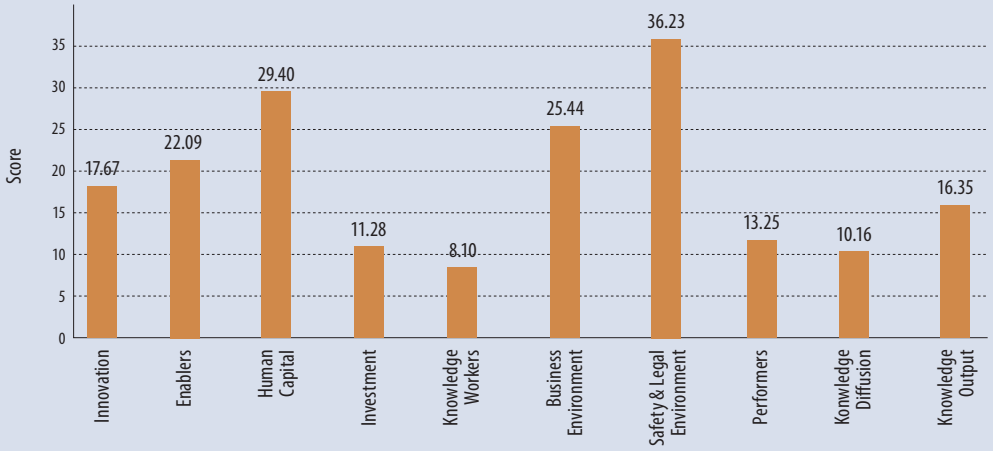
Source: India Innovation Index 2021 and Vikaspedia (2022) (https://vikaspedia.in/e-governance/national-e-governance-plan/india-innovation-index).

Uttarakhand's Performance

Using the index, it ranks the strengths and weaknesses of Uttarakhand based on relative performance and uses scorecards to show performance and comparison. The scorecard-coloured red represents performance below the peer group average while yellow indicates consistent performance with the peer group and green indicates relative strength (Figure 1.8 and Figure 1.9).

FIGURE 1.8

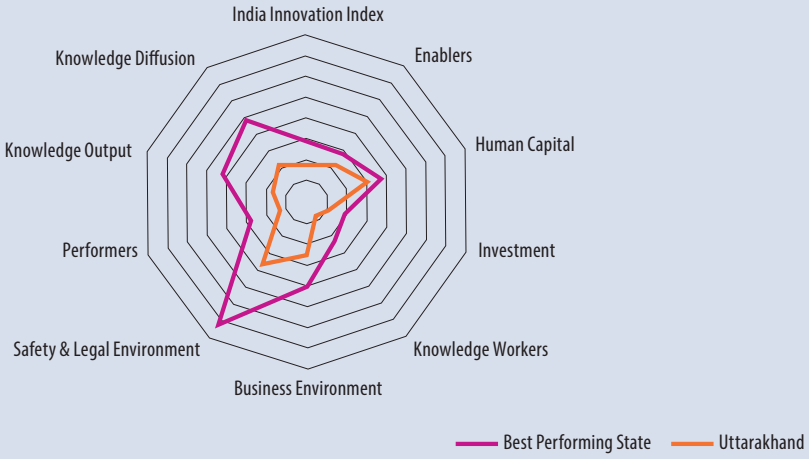
UTTARAKHAND'S INDEX SCORE



Source: India Innovation Index 2021.

FIGURE 1.9

COMPARISON BETWEEN UTTARAKHAND AND INDIA'S BEST PERFORMING STATES



Source: India Innovation Index 2021.

NIS INDIA VS. GLOBAL INNOVATION INDEX (GII)

The India Innovation Index is a reliable benchmark on the impact of measures at a subnational level. The primary edition of the index has managed to guide and support policymakers in raising native innovation ecosystems. This drive to enhance the innovative tendencies has resulted in India breaking into the top 50 nations of the GII 2021, published by the World Intellectual Property Organization (WIPO), declaring India as one of the leading innovation achievers of 2020–21 in the central and southern Asian

region. In the GII, a joint cooperative effort between the WIPO, Cornell University, and INSEAD that annually ranks the innovation performance of over 130 economies, India is ranked as the 40th innovative nation in 2022. It is a testament to the enhancements created in its innovation ecosystem. Additionally, India ranks the best among central and southern Asian countries and is a new entrant to the highest three innovation economies among the lower-middle-income cluster nations with Vietnam and Ukraine. The consistent progress is significant in comparison to the 2017 rankings when India occupied the 60th position (Table 1.10).

The world innovation landscape is shifting; PR China, Vietnam, India, and the Philippines are systematically on the rise. India's high ranks in data and technology outputs and market sophistication significantly exceed the GII rankings[12].

TABLE 1.10

INDIA'S PERFORMANCE ON THE GII

Year	GII Score	GII Rank	Total Countries
2017	35.50	60	127
2018	35.20	57	126
2019	36.58	52	129
2020	35.60	48	131
2021	36.40	46	132

Source: India Innovation Index 2021.

Gross Expenditure on R&D (GERD)

One of India's foremost statistics is seen in its gross expenditure on R&D (GERD). Figure 1.11 provides GERD for several countries that shows India ranked lowly with only USD43 per capita. To overcome this, India should be increasing its disbursement, at least, to be on par with the BRICS or ASEAN member states - Russia (USD285), Brazil (USD173), and Malaysia at (USD293).

Foreign Direct Investment (FDI) in R&D

India's science, innovation and research and development (SIRD) sector is dependent on investment from the government, infrastructure, institutions, and businesses. The government-supported IITs, IISc, TIFR, IISER, national laboratory, and central university form the backbone of R&D in the country. India's investment in R&D in 2017–18 exceeded INR11.3 million and increased to INR12.3 million in 2018–19. Total spending on R&D (GERD) has tripled in the past decade, as shown in Table 1.12. However, GERD as a percentage of GDP shows a downward trend over the same period[13].

FDI in R&D is only a small part of total FDI inflows to India. For offshore companies, India is recognized as the world's leading destination for their R&D. ICT, science and technology, and pharmaceuticals are the main benefactors in receiving FDI in R&D. Only a few studies have investigated the inflow of FDI in R&D (RDFDI) to India. The study by National Institute of Science, Technology and Development Studies (NISTADS 2011) estimates the RDFDI inflows to India and the impact of such inflows (Joseph R.K., 2019).

12 Global Innovation Index Database, WIPO, 2021 (https://www.globalinnovationindex.org/userfiles/file/reportpdf/GII-2021/GII_2021_results.pdf).

13 HT Times (https://www.hindustantimes.com/opinion/the-private-sector-can-transform-india-s-science-innovation-and-r-d-landscape-101648970964497.html).

TABLE 1.11

GERD PER CAPITA (IN CURRENT PPP USD) IN 2018

Country	GERD per Capita (USD)
Israel	2,108.20
USA	1,777.93
Germany	1,701.47
Belgium	1,438.17
United Kingdom and Northern Ireland	791.43
Italy	593.90
PR China	325.82
Malaysia	293.39
Russian Federation	284.80
Brazil	173.37
South Africa	105.69
Mexico	63.82
India	**43.41**
Indonesia	26.34

Source: India Innovation Index 2021.

The government of India has various schemes, such as financial incentives and R&D funds as well as incentivising investment in industrial R&D. The Industrial R&D Promotion Programme (IRDPP) of Department of Scientific and Industrial Research (DSIR) is the only program, under the government, to benchmark industrial R&D. It aims is promote R&D intensity in the industry, public-funded R&D institutions, and scientific and industrial research organizations (SIROs). It also provides fiscal incentives to scientific research. Under this scheme, various ministries grant R&D funds to corporate companies, public funded R&D institutions, and SIROs.

TABLE 1.12

RDFDI INFLOWS TO INDIA

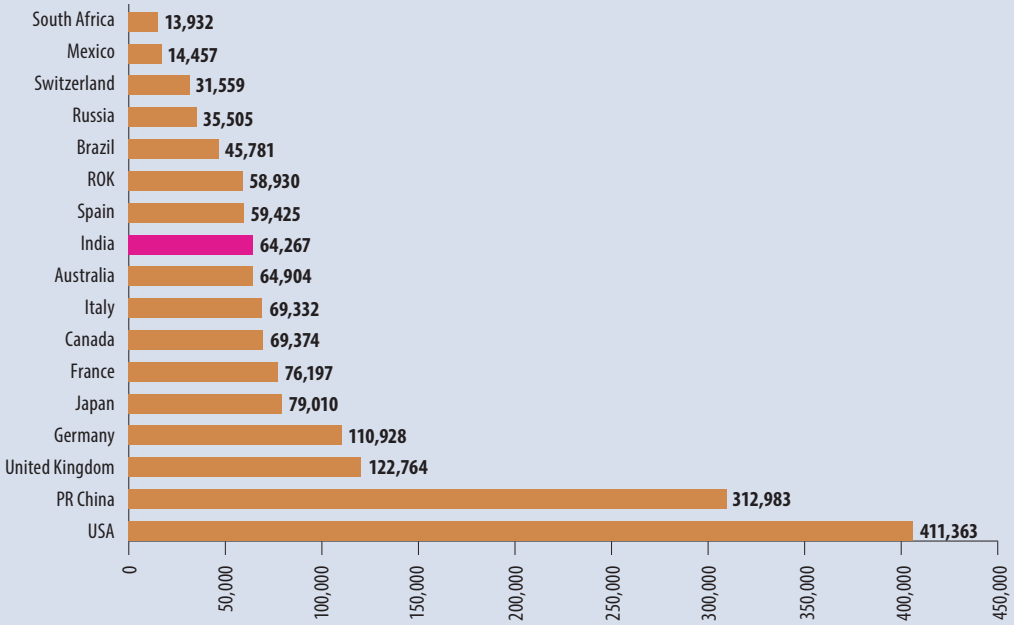
Year	FDI (INR'million)	RDFDI (INR'million)	Share of RDFDI (%)
Sept–Dec 2004	112,805.2	185.0	0.2
2005	192,706.0	1047.1	0.5
2006	503,572.1	1,304.8	0.3
2007	654,950.4	4,844.0	0.7
2008	1,351,452.2	3,986.8	0.3
2009	1,309,797.7	1,922.6	0.1
2010	960,149.4	3,764.4	0.4
2011	1,202,384.9	4,146.8	0.3
2012	1,215,914.4	2,665.6	0.2
2013	1,294,825.1	7,512.8	0.6
2014	1,753,133.7	7,852.8	0.4
2015	2,525,614.7	14,063.5	0.6
Jan–March 2016	513,112.2	1,566.3	0.3
All the above years	13,590,418.0	54,862.6	0.4

Research Publications

One of the measures to analyse the innovation capability of a country is the research outcome in terms of number of publications and citations. Figure 1.10 highlights the number of research papers printed in selected countries in 2016. Despite lower GERD, India publishes more research papers than countries, such as Russia, Brazil, and the ROK. It accounted for 4.1% of total world citations in 2016 (DST, 2019–20). This suggests that with more research opportunities, the country's R&D is active and developed.

FIGURE 1.10

NUMBER OF RESEARCH PAPERS PUBLISHED ACROSS SELECTED COUNTRIES IN 2016



Source: India Innovation Index 2021.

Research Composition

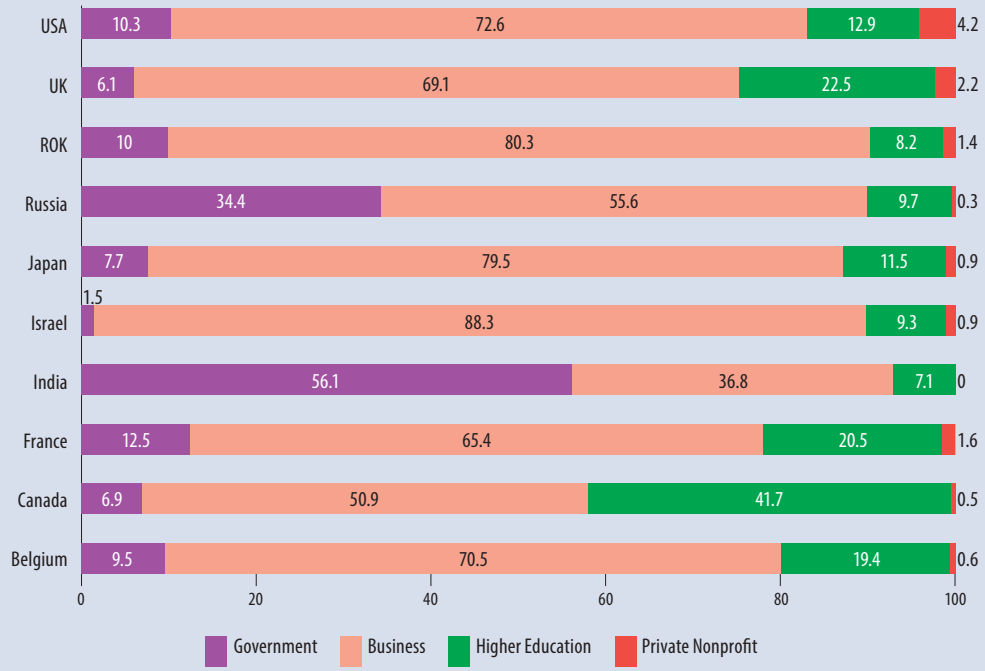
It isn't merely enough to fund R&D, but also necessary to look into its sectoral composition. Figure 1.11 shows that the Indian government spends on R&D, unlike other countries where the R&D expenditure is undertaken by business enterprises and the higher education sector. India's business sector must overtake the government and finance more R&D pursuits.

On a positive note, the number and variety of universities see a year-on-year increase, growing in four digits at a compound annual growth rate (CAGR) of around 5.3% over the past decade (Figure 1.12).

The composition also identifies the sectors or objectives of R&D expenditure. Over a third of the country's total R&D spending is on medical and defence (Figure 1.13). While these two sectors are essential, India must also focus on alternative sectors for overall growth.

FIGURE 1.11

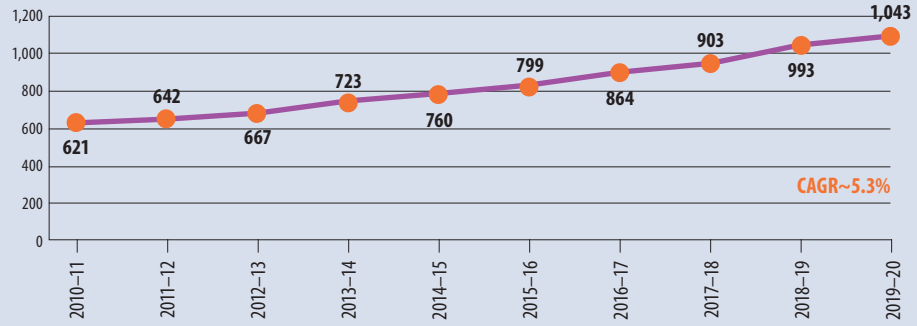
SECTORAL COMPOSITION OF R&D SPENDING



Source: India Innovation Index 2021.

FIGURE 1.12

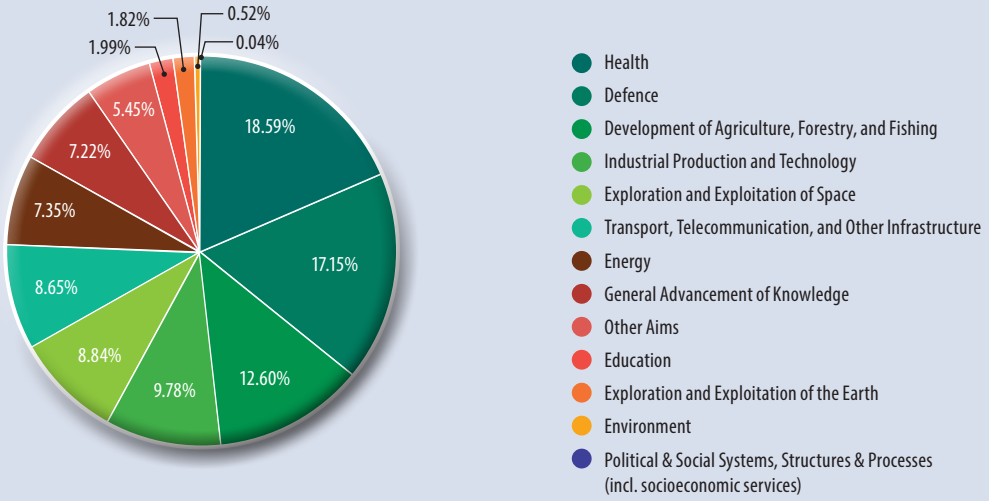
NUMBER OF UNIVERSITIES IN INDIA BETWEEN 2010–2020



Source: India Innovation Index 2021.

FIGURE 1.13

PERCENTAGE SHARE OF NATIONAL R&D EXPENDITURE BY SECTORS/OBJECTIVES IN 2017–18



Source: Research and Development (DST), Government of India.

CONCLUSION

India's National Innovation Policy has been developed with the aim of creating an innovation-driven economy by leveraging on science, technology, and innovation. The policy is aimed at encouraging R&D, promoting entrepreneurship and innovation, and creating an enabling environment for the growth of innovation ecosystems across the country.

The policy includes a range of initiatives, such as setting up innovation clusters, creating innovation funds, encouraging public-private partnerships, and promoting innovation in key sectors, including healthcare, energy, and agriculture. The policy also seeks to create a supportive environment for start-ups and entrepreneurs through measures, like simplifying regulations, providing access to finance, and improving infrastructure.

The report "India Innovation System" can be strengthened by focusing on specific important elements that encompass:

- Factors leading to better performance
- Challenges causing low performance
- Peer-to-peer learning and state-specific policies

India has already made significant progress in creating a vibrant innovation ecosystem with a growing number of start-ups and a thriving technology sector. In recent years, the government has launched several initiatives, such as Start-up India, Digital India, and Make in India, which have helped to create a supportive environment for innovation and entrepreneurship.

Looking toward the future, India has set an ambitious target of becoming a USD5 trillion economy by 2025. Achieving this goal will require a continued focus on innovation and entrepreneurship, emphasizing particularly on developing new technologies and business models that can address the country's most pressing challenges in climate change, healthcare, and education, among others.

To support the growth of the innovation ecosystem in India, the government must continue to invest in R&D, promote collaboration between academia and industry, and create an enabling environment for start-ups and entrepreneurs. At the same time, there is a need for greater public-private partnerships, increased investment in infrastructure, and improved access to finance for start-ups and small businesses.

The 5th National Science, Technology, and Innovation Policy (STIP) is a holistic and pragmatic policy dedicated to science, technology, and most importantly, innovation. The policy aims to reorient STI in terms of priorities, sectoral focus, and strategies[14]. In conclusion, India's National Innovation Policy provides a strong foundation for the growth of a vibrant innovation ecosystem. By continuing to invest in innovation and entrepreneurship, India can achieve its goal of becoming a global leader in science and technology while addressing some of the country's most pressing challenges[15].

CASE STUDY ON INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE (IIT ROORKEE)

INTRODUCTION

Indian Institute of Technology Roorkee (IIT Roorkee) is a prestigious autonomous research university in India, recognized as Asia's oldest technical college. It has gained national and international acclaim for its academic excellence. The institute holds an impressive seventh rank in the overall and sixth rank in the engineering category, according to the National Institutional Ranking Framework (NIRF) 2022. The study also considers innovation as a key parameter for assessing organizational and/or institutional productivity. In a globalized market, IIT Roorkee acknowledges the need for collaboration with industry to sustain success and meet technological innovation demands by bridging academia and industry.

This case study delves into their initiatives for teaching-learning innovation.

ABOUT IIT ROORKEE

Background

The university experienced substantial growth since its inception in 1847. On 21 September 2001, the government of India officially renamed it as the Indian Institute of Technology (IIT) Roorkee through the Institutes of Technology (Amendment) Act, 2002. Located in Uttarakhand, India, the institute emphasizes curriculum that aligns with national needs and prepares students for handling global challenges.

IIT Roorkee excels in technical education, research, and engineering, making notable contributions in developing talents in HR, research, and technology. The institute celebrated its 150th and 175th anniversaries in October 1996 and 2022, respectively. It was recognized as the seventh IIT in 2001 as an Institution of National Importance. Offering a wide range of undergraduate, graduate, and PhD programs, admissions are based on the national Joint Entrance Examination (JEE).

14 PSA, Government of India (2022) (https://www.psa.gov.in/stip).

15 Government of India (2011) National Innovation Policy (https://dst.gov.in/sites/default/files/STIP_Doc_1.4_Dec2020.pdf).

Departments and Centers

There are 11 departments, 11 centers, and five supporting units at IIT Roorkee. Centers focus on interdisciplinary research in specific technology areas while departments have a broader academic scope (Appendix IV).

EVALUATION OF ACADEMIC AND RESEARCH ACTIVITY

Institute's Academic Policy

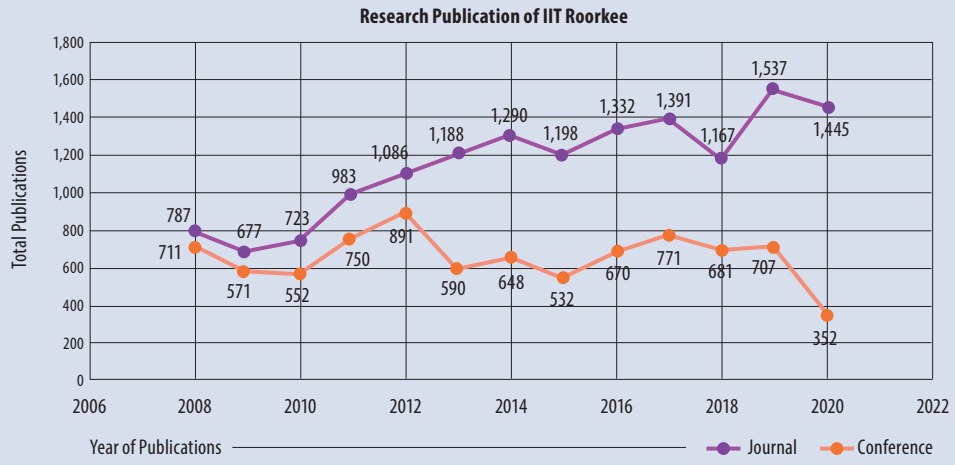
IIT Roorkee's Academic Affairs Office oversees academic administration. The institute offers diverse programs with thousands of students enrolled. It is renowned for its education, research, and global recognition as the sixth largest technical institution in India[16].

Faculty Research

The Institute boasts over 500 expert faculty members covering diverse fields of science, engineering, and technology, forming the backbone of the institution[17].

FIGURE 1.14

RESEARCH AND CONFERENCE PUBLICATIONS



Source: SCOPUS .

IIT Roorkee has produced 32,868 publications with journal articles surpassing conference articles since 2008 and emphasizing the institute's focus on journal publications (Figure 1.14). In 2020, there was a notable increase in journal articles and a decline in conference publications due to the COVID-19 pandemic[18].

16 About IITR. (https://iitr.ac.in/Academics/Home.html).

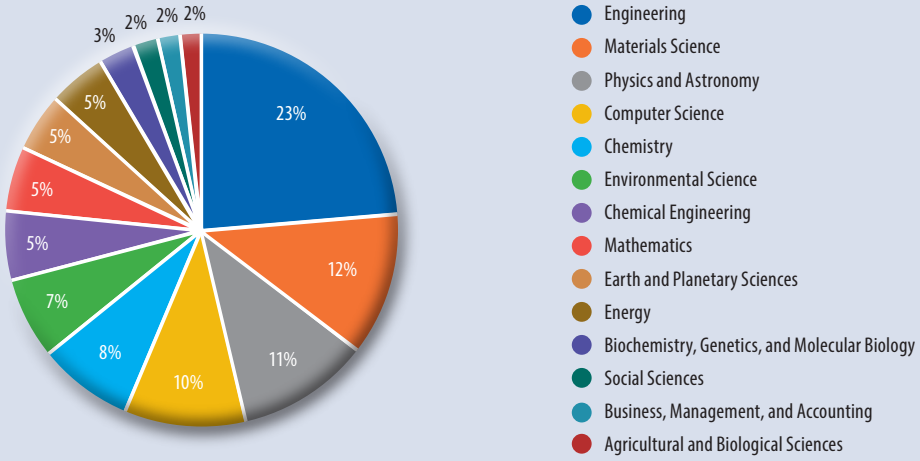
17 Various IIT Roorkee Annual Reports from 2012 to 2021 (https://www.iitr.ac.in/Institute/Annual_Reports_Of_IIT_Roorkee.html).

18 Scopus Database for IIT Roorkee Publication (https://www.scopus.com/affil/profile.uri?afid=60031818).

FIGURE 1.15

PUBLICATION ACROSS DISCIPLINES

IIT Roorkee Publication Areas



Source: SCOPUS.

According to the Scopus data, 15 departments at IIT Roorkee contribute to research outcomes, with Engineering and Material Science being the largest contributors at 35%. Physics and Astronomy, Computer Science, and Chemistry and Environmental Science also make significant contributions. Other departments contribute smaller percentages while Biotechnology, Genetics, Molecular Biology, Social Sciences, Business, Management, Accounting, and Agricultural and Biological Sciences collectively contribute 9% (Figure 1.15).

Doctoral Research Programs[19]

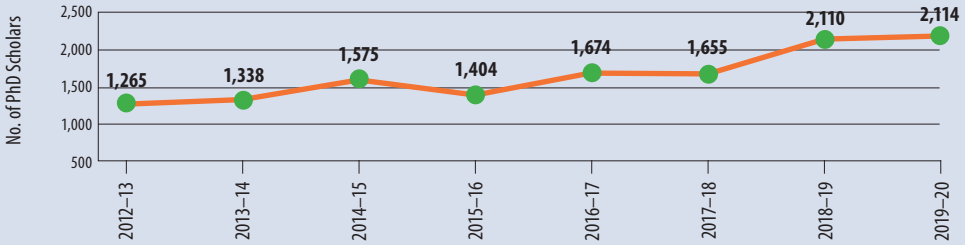
The available data shows that the enrolment of PhD scholars increased from 1,265 in 2012 to 2,214 in 2019–2020 (Figure 1.16), charting a significant 67% growth over eight years.

IIT Roorkee started with three PhD thesis publications from 1957–59, but research outcomes grew substantially over the years, peaking in the 2000–09 (Figure 1.17). The institute has maintained a consistent upward trend in thesis publications from 1957–2009.

[19] Various IIT Roorkee Annual Reports from 2012 to 2021 (https://www.iitr.ac.in/Institute/Annual_Reports_Of_IIT_Roorkee.html).

FIGURE 1.16

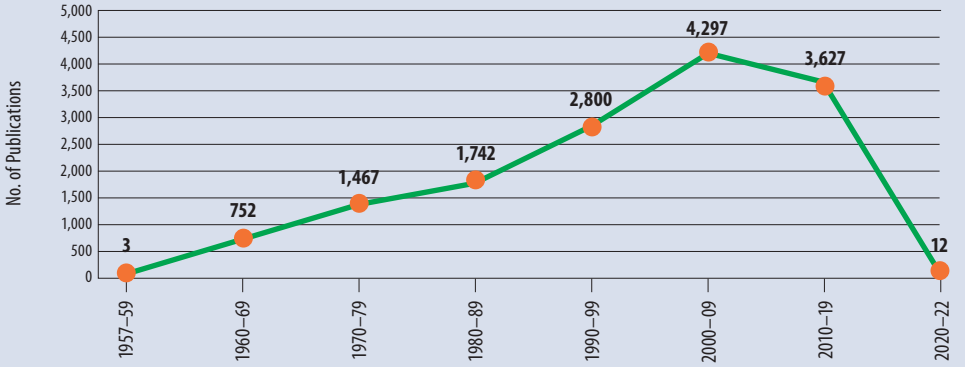
PHD SCHOLARS AT IIT ROORKEE



Source: IIT Roorkee Annual Report 2021.

FIGURE 1.17

THESIS PUBLICATIONS AT IIT ROORKEE



Source: IIT Roorkee Annual Report 2021.

Collaboration with External Parties[20]

To excel in academic programs, research, consulting, and industry collaboration, interaction with government organizations, funding agencies, alumni, and industry is vital. Figure 1.18 displays the sponsored projects for eight years with a CAGR of 7.98%.

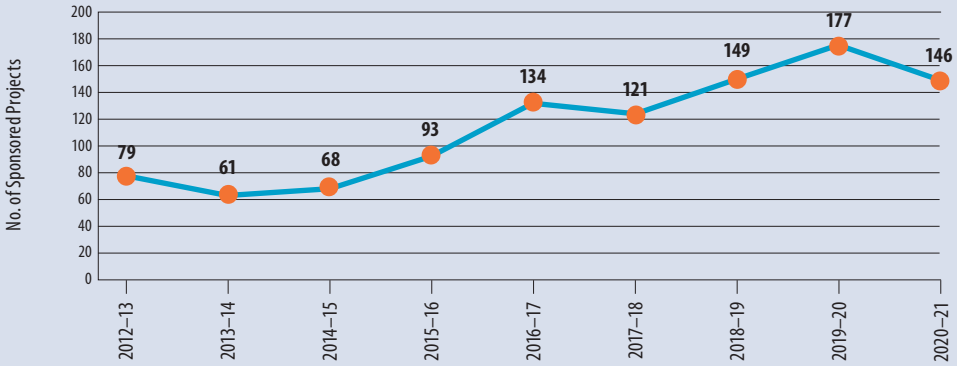
The institute encourages industry-funded undergraduate programs to enhance industry involvement in engineering education, where students undertake sponsor-related projects.

The institute has undertaken 6,471 consultancy projects from 2012–13 to 2020–21, averaging 719 projects per year (Figure 1.19).

[20] Various IIT Roorkee Annual Reports from 2012 to 2021 (https://www.iitr.ac.in/Institute/Annual_Reports_Of_IIT_Roorkee.html).

FIGURE 1.18

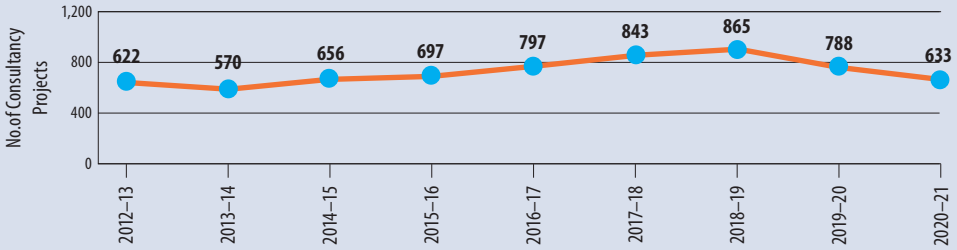
SPONSORED PROJECTS AT IIT ROORKEE



Source: IIT Roorkee Annual Report 2021.

FIGURE 1.19

CONSULTANCY PROJECTS



Source: IIT Roorkee Annual Report 2021.

Organization for Technology Transfer and Intellectual Property (IP)

The IPR unit actively manages IP strategies, including patent filing, copyright registration, design patent filing, and technology transfer. Workshops and expert talks promote focused research and learning incentives for Derwent innovation software.

Figure 1.20 and Figure 1.21 display the institute's patent filings from 2006 to 2015, showing a flat growth with an average of approximately four patents filed per year. Since 2016, there has been an upward trend, except for a decline in 2020 due to the COVID-19 pandemic. The departments of Mechanical and Industrial Engineering (MIE), Metallurgy and Material Engineering (MME), Biotechnology, Chemical, and Electronics and Communication (ECE) are the major contributors to patent filings.

FIGURE 1.20

PATENTS FILED BY THE INSTITUTE

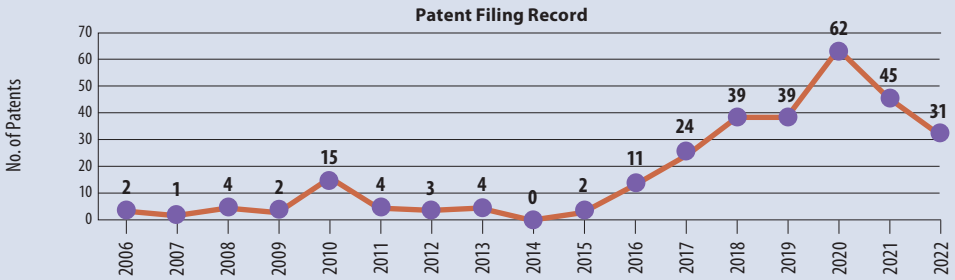
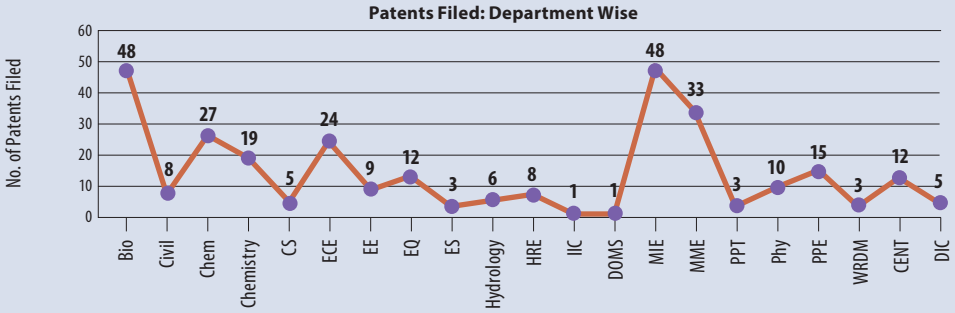


FIGURE 1.21

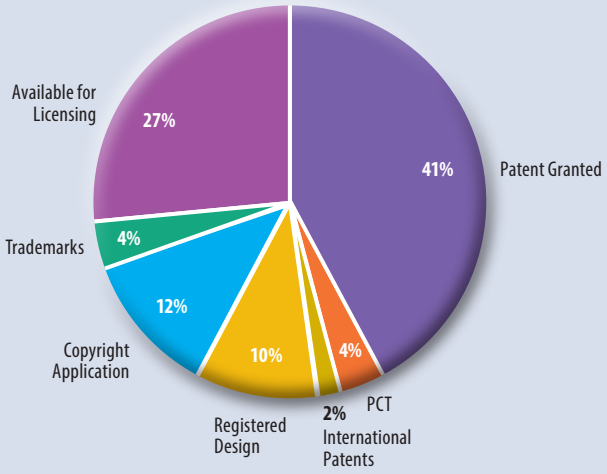
PATENTS FILED BY DEPARTMENTS



Note: Refer to the list of Abbreviations and Acronyms.

FIGURE 1.22

TECHNOLOGY & IP COMPENDIUM



System of Technology Transfer and IP Compendium

IIT Roorkee focuses on teaching, research, and knowledge transfer through mechanisms that facilitate technology transfer to industry, fostering partnerships and joint ventures for mutual benefit and further advancements.

Technology transfer and IP compendium serve as indicators of knowledge diffusion, contributing to productivity. The study found the factors and percentages as: patents granted accounted (41%), available for licensing (27%), copyright applications (12%), registered designs (10%), trademarks (4%), international patents (2%), and PCT (4%).

INSTITUTIONAL ACHIEVEMENT AND RANKING DEVELOPMENT

National Ranking[21]

The National Institutional Ranking Framework (NIRF) was accepted by the Ministry of Education on 29 September 2015. IIT Roorkee has been evaluated by NIRF on the following parameters and growth, highlighted in Table 1.13.

TABLE 1.13

PARAMETERS OF NIRF RANKING

TLR	Teaching, Learning, & Resources (TLR)	• Student Strength including Doctoral students (SS) • Faculty-student ratio with emphasis on permanent faculty (FSR) • Combined metric for Faculty with PhD (or equivalent) and Experience (FQE) • Financial Resources and their Utilization (FRU)
RPC	Research and Professional Practice (RP)	• Combined metric for Publications (PU) • Combined metric for Quality of Publications (QP) • IPR and Patents: Published and Granted (IPR) • Footprint of Projects and Professional Practice (FPPP)
GO	Graduation Outcomes (GO)	• Metric for University Examinations (GUE) • Metric for Number of PhD Students Graduated (GPHD)
OI	Outreach and Inclusivity (OI)	• Percentage of Students from Other States/Countries (Region Diversity RD) • Percentage of Women (Women Diversity/WD) • Economically and Socially Challenged Students (ESCS) • Facilities for Physically Challenged Students (PCS) • Perception (PR) Ranking
PR	Peer Perception	• Academic Peers and Employers (PR)

As per Figure 1.23, in the TLR parameters and GO, the institute has improved whereas in the parameters of RPC, OI, and PR have decreased, resulting in the overall fall in the two rankings from 2016 to 2022 (Table 1.14).

[21] Various NIRF Reports from 2016 to 2022 (https://www.nirfindia.org/home).

FIGURE 1.23

NIRF RANKING PARAMETERS

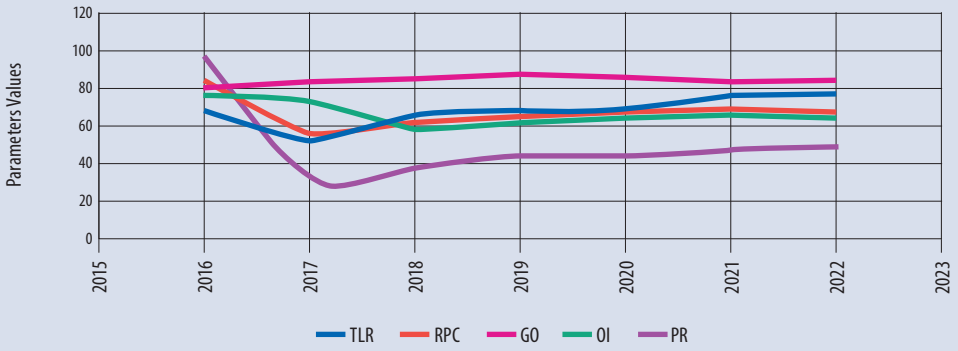


TABLE 1.14

PARAMETER-WISE RANKING OF THE INSTITUTE

Years	TLR	RPC	GO	OI	PR	India Ranking
2016	67.83	83.5	81.61	76.59	96	5
2017	52.24	56.6	83.38	72.7	32.38	9
2018	65.88	61.59	85.29	58.65	37.56	8
2019	67.32	65.08	87.14	61.64	43.66	8
2020	68.29	67	85.21	64.29	44.17	9
2021	76.68	68.37	83.16	65.31	47.28	7
2022	77.22	67.03	84.42	64.36	48.84	7

Global Ranking[22]

In the SCImago Institutions Rankings (SIR) 2022, IIT Roorkee has been evaluated on Overall Rank, Research Rank, Innovation Rank, and Societal Rank (Table 1.15).

22 SCIMAGOIR Website Ranking (https://www.nirfindia.org/home).

TABLE 1.15

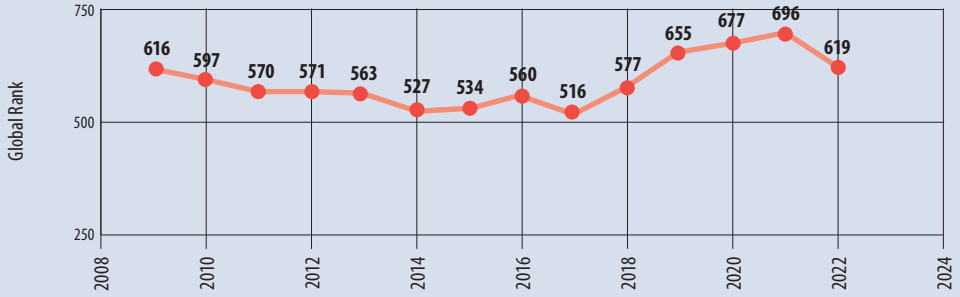
RANKING BY SUBJECT AREAS/CATEGORIES OF IIT ROORKEE IN COMPARISON TO THE WORLD REGION[23]

Area	World Ranking	Asiatic Region Ranking	BRIICS Ranking	India Ranking
Agricultural and Biological Sciences+	692	444	390	87
Arts and Humanities	586	144	141	15
Biochemistry, Genetics, and Molecular Biology	871	501	428	87
Business, Management, and Accounting	264	60	49	4
Chemistry	692	418	360	53
Computer Science	484	186	129	12
Earth and Planetary Sciences+	415	226	221	10
Economics, Econometrics, and Finance	516	184	168	15
Energy	465	282	229	26
Engineering+	396	192	144	8
Environmental Science	459	287	252	27
Mathematics	518	217	168	22
Medicine+	815	450	376	66
Pharmacology, Toxicology, and Pharmaceutics	675	342	286	37
Physics and Astronomy	554	282	216	14
Social Sciences+	607	154	131	3

Source: SCImago (2022).

FIGURE 1.24

INSTITUTE'S GLOBAL RANKING

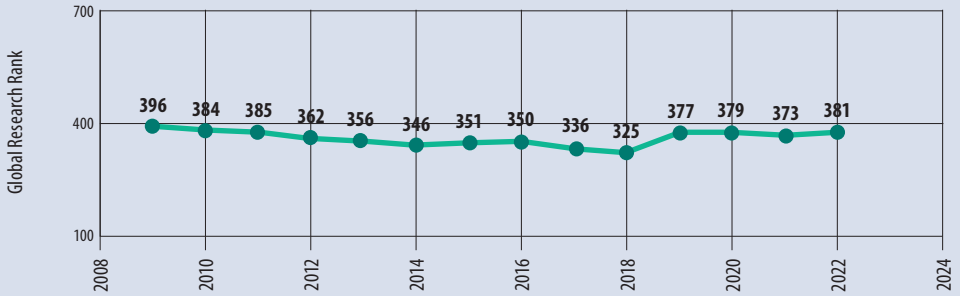


As shown in Figure 1.24, the global ranking of the institute reached the peak in 2021.

[23] SCI Rank of Indian Institute of Technology, Roorkee (https://www.scimagoir.com/institution.php?idp=10302).

FIGURE 1.25

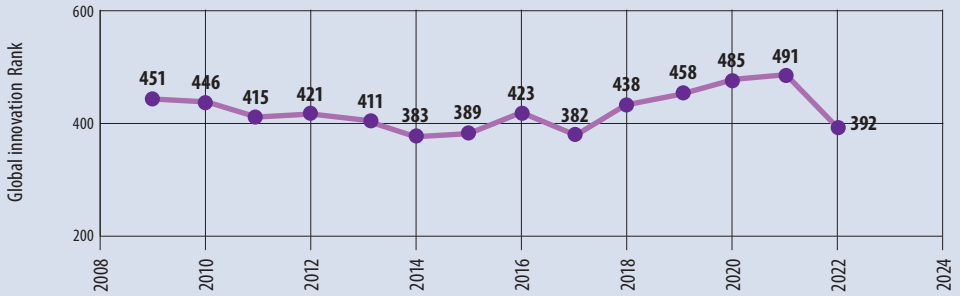
RESEARCH RANKING OF IIT ROORKEE



The institute's global research rank remained in the top 400 since 2008, improving from 396 to 325 in 2018, but then dropped by 44 positions.

FIGURE 1.26

INNOVATION RANKING OF THE INSTITUTE



The institute's innovation ranking improved by 59 positions from 2008 to 2022, positively impacting organizational productivity (Figure 1.26). Further, the accumulated results after years of operations can be referred in Appendix V.

APPENDIX I

1. List of departments engaged in promoting Skill and Innovation in India

- Directorate General of Training (DGT)
- National Skill Development Agency (NSDA)
- National Council for Vocational Education and Training (NCVET)
- National Skill Development Corporation (NSDC)

- National Skill Development Fund (NSDF)
- 38 Sector Skill Councils (SSCs)
- 33 National Skill Training Institutes (NSTIs/NSTI(w))
- 15,000 Industrial Training Institutes (ITIs) under DGT and 187 training partners registered with NSDC

Some of the measures taken by the government are mentioned below:

Education sector[24]

- New Education Policy 2020
- SWAYAM
- Qualification of Teachers
- RTE (Right to Education) Act
- National Achievement Survey (NAS)
- Program for International Students Assessment (PISA)
- Sarva Shiksha Abhiyan

Technical education

- National Scheme of Apprenticeship Training
- National Programme for Technology Enhanced Learning (NPTEL)
- Indian National Digital Library in Engineering, Science & Technology (INDEST-AICTE) Consortium
- Technology Development Missions (TDM)
- Direct Admission of Students Abroad

Research & innovation[25]

- UCHCHATAR AVISHKAR YOJANA
- IMPacting Research INnovation and Technology (IMPRINT)

24 Vikaspedia (https://vikaspedia.in/education/policies-and-schemes/schemes-for-elementary-secondary-higher-education).

25 Ministry of Education (https://www.education.gov.in/en/technical-education-13).

M/o MSME and its organisations[26]

- Prime Minister's Employment Generation Programme (PMEGP)
- Credit Guarantee Trust Fund for Micro & Small Enterprises (CGTMSE)
- Entrepreneurship and Skill Development Programme (ESDP) Scheme
- Micro & Small Enterprises Cluster Development Programme (MSE - CDP)
- Assistance to Training Institutions (ATI) Scheme
- A Scheme for Promoting Innovation, Rural Industry & Entrepreneurship (ASPIRE)
- Tool Rooms and Technical Institutions - A Component of Infrastructure Development & Capacity Building scheme
- ZED Certification Scheme
- MSME - Innovative (Incubation, IPR, and Design)
- DIGITAL MSME

APPENDIX II

TABLE 1.16

LIST OF GOVERNMENT POLICIES BOOSTING ECOSYSTEM FOR INNOVATION IN THE COUNTRY

S. No.	Policy Name	Eligibility	Beneficiaries (Level)	Agenda and Activities
1.	National Innovation and Entrepreneurship Promotion Guidelines for Schools[27]	School students and teachers	Foundational Stage (in two parts, that is, 3 years of Anganwadi/pre-school + 2 years in primary school in Grades 1–2; both together covering ages 3–8), Preparatory Stage (Grades 3–5, covering ages 8–11), Middle Stage (Grades 6–8, covering ages 11–14), and Secondary Stage (Grades 9–12 in two phases, i.e., 9 and 10 in the first and 11 and 12 in the second, covering ages between 14–18).	• Changing thinking, awareness, and training • Infrastructure and mentoring to drive innovation • Encourage and motivate teachers • Education innovation • Community-school-community partnership • Start-ups led by school entrepreneurs
2.	National Innovation and Startup Policy 2019 for students and faculty[28]	Enrolled in any undergraduate, postgraduate, and PhD course	College students and faculties in HEIs	• The 2019 National Innovation and Entrepreneurship Policy for students and faculties of higher education institutions (HEIs) will enable institutes to actively engage students, faculty, and staff in related activities, to innovation and entrepreneurship. This framework will also help the Ministry of Education standardize HEIs in terms of IP management, technology licensing, and institutional entrepreneurship policy, thus enabling the creation of a healthy ecosystem. Entrepreneurship and innovation are strong in all higher education institutions

26 Invest India (https://static.investindia.gov.in/s3fs-public/2022-10/Scheme%20Booklet%202022-23.pdf).

27 National Innovation and Entrepreneurship Promotion Policy for Schools.pdf (https://static.mygov.in/rest/s3fs-public mygov_16508646911052162O1.pdf).

28 Innovation & Startup_policy_2019.pdf (https://mic.gov.in/assets/doc/startup_policy_2019.pdf).

S. No.	Policy Name	Eligibility	Beneficiaries (Level)	Agenda and Activities
3.	Guideline for Developing Student Innovation & Start-up Ecosystem in University/ Engineering Campuses[29]	AICTE-approved institutes	College students in HEIs	• Student Innovation & Start-up Centre/Club - Institutionalization of top-stage method and implementation unit • Codification/gauging present innovation and start-up efforts in university • Awareness and outreach to all stakeholders • Infrastructure to guide Student Innovation & Start-ups • HR to execute TEQIP mandate on Innovation & Start-Ups on Institute stage • Setting milestones • Creating innovation pipeline/funnel at institute stage • Creating method for institute stage on Innovation & Start-up Ecosystem Development • Design of Innovation & Student Start-up Support System (DiS4) • Benchmarking and satisfactory exercise deployment • Resource mobilization for Supporting Innovation & Start-up efforts • Leveraging TEQIP sources • Institutionalization and sustainability of tasks • Efforts to higher Innovation, Creativity & Entrepreneurship (ICE) index • Incentive layout for stakeholders in innovation procedure • Activity and innovation procedure layout at institute stage • Pedagogic and educational interventions to acquire Student Innovation & Start-up dreams • Leverage present infrastructure, useful resource, and knowledge for mandated efforts to guide pupil innovation & start-ups • Inculcating innovation and pupil start-ups, a key pastime of institute method • Capacity constructing of stakeholders • Inclusion, get right-of-entry and low-priced method to gain most pupil innovators • Collaboration & Co-introduction Strategy for every institute for selling innovation • Leveraging technological systems to combine all efforts associated with innovation & entrepreneurship • Codification, documentation, and dissemination of Student Innovation & Start-up efforts at institute stage
4.	National Skill Development Mission[30]	Any Indian resident	Graduates, ITIs, degree holders, technicians, common people	• Create an end-to-end implementation framework for skills development, which provide lifelong learning opportunities. This includes integrating skills into school curricula, providing quality short- and long-term vocational training opportunities, providing high-paying employment and ensuring career growth, meet the needs of the students
5.	Student Start-up and Innovation Policy[31]	Any student and faculty/teachers	Schools, institutes, and universities	• The Gujarat Government's Student Entrepreneurship and Innovation Policy aims to create an integrated university innovation ecosystem across the state to support young students' ideas and innovations and provide an environment conducive to optimal use for their creative task

[29] Guideline to TEQIP III Institutes for Creating Student Innovation & Start-up Support Ecosystem.pdf (https://drive.google.com/file/d/127aaNN9xos53CVPBzepxKlcgkCTWkUQ_/view).

[30] National Skill Development Mission.pdf (https://msde.gov.in/sites/default/files/2019-09/National%20Skill%20Development%20Mission.pdf).

[31] Student Start-up and Innovation Policy_2017_colleges_17.pdf (http://www.ssipgujarat.in/datafiles/SSIP_2.0_Education_Department_Gujarat.pdf).

S. No.	Policy Name	Eligibility	Beneficiaries (Level)	Agenda and Activities
6.	National IPR Policy[32]	Any Indian resident	Students of schools, HEIs, start-ups, MSMEs, Indian farmers, rural artisans, etc.	Promote a dynamic, vibrant, and balanced IP system in India to: • Promote creativity and innovation, thereby fostering entrepreneurship and enhancing socioeconomic and cultural development • Focus on improving access to health care, food security, and environmental protection, among other areas of social, economic, and technological importance
7.	National Design Policy[33]	Any Indian resident	Small scale and cottage industries and crafts, automobile and transportation, jewelry, leather, soft goods, electronics/IT hardware products, toys & games	The National Design Policy Vision envisions the following: • Prepare a platform for innovative design development, design promotion, and partnerships across multiple sectors, states, and regions to integrate design with traditional and technological resources
8.	National Innovation Foundation - India[34]	Any Indian resident	Start-ups, MSMEs, common people	• NIF locates, supports, and creates grassroots innovations developed by local individuals and communities in any field of technology, supporting human existence without any assistance from the official sector. It also strives to ensure that these innovations are spread widely through commercial and/or non-commercial channels, creating material or immaterial incentives for them and other players in the value chain
9.	National Policy for Skill Development and Entrepreneurship[35]	Any Indian resident	HEIs, start-ups, MSMEs, common people	• Creating demand for skills across the country; edit and align skills with required skills; linking the supply of qualified HR with industry needs; certification and assessment to global and national standards • Foster an ecosystem in which productive entrepreneurship and innovation germinate, sustain, and grow, leading to the creation of a more vibrant start-up economy and more formal paid jobs
10.	Science, Technology, and Innovation Policy (STIP)[36]	Any Indian resident	Schools, HEIs, MSMEs, start-ups, common people, NGOs, civic society people, MNCs	• This policy aims to bring about profound change through short-, medium-, and long-term mission mode projects by creating a nurturing ecosystem that fosters research and innovation from the side
11.	Scientific Social Responsibility (SSR) Guidelines[37]	Any Indian resident	Students, school/college teachers, local bodies, communities, women's groups, farmers, self-help groups, self-employed, informal sector enterprises, MSMEs, start-ups, NGOs; anganwadi workers, biodiversity management committees (BMCs); etc.	• Harnessing the potential of the nation's scientific community to voluntarily strengthen the links between science and society, and bring the S&T ecosystem to life. The main aim is to bridge the gap between science and society, science and science, society and science, bring trust, partnership, and responsibility to science, and achieve social goals more quickly

32 National-IPR-Policy2016-14October2020.pdf (https://dpiit.gov.in/policies-rules-and-acts/policies/national-ipr-policy#:~:text=The%20National%20IPR%20Policy%20is,)%2C%20concerned%20statutes%20and%20agencies.).

33 NationalDesignPolicy_english.pdf (https://dpiit.gov.in/sites/default/files/NationalDesignPolicy_english.pdf).

34 NIF ANNUAL-REPORT-2020-21.pdf (https://nif.org.in/dwn_files/ANNUAL-REPORT-2020-21.pdf).

35 National Policy on Skill Development and Entrepreneurship Final.pdf (https://www.msde.gov.in/sites/default/files/2019-09/National%20Policy%20on%20Skill%20Development%20and%20Entreprenurship%20Final.pdf).

36 Science, Technology, Innovation Policy (STIP)_Doc_1.4_Dec2020.pdf (https://dst.gov.in/sites/default/files/STIP_Doc_1.4_Dec2020.pdf).

37 Scientific Social Responsibility (SSR) Guidelines (https://static.psa.gov.in/psa-prod/publication/SSR%20Guidelines%202022%20Book_0.pdf).

APPENDIX III

Academia-Industry Interface to Boost Innovation

Academia-industry relationships can be described as mutual agreements between academic institutions and businesses to achieve specific mutually overarching goals.

Recent Initiatives Taken by Stakeholders

- **Government of India**

  The Scheme for Promotion of Academic and Research Collaboration (SPARC) is an initiative of the Ministry of Education to improve the research ecosystem of Indian universities by facilitating academic and research collaboration, including research between Indian institutions and leading institutions in the world. The government approved the program in August 2018 for a total amount of INR4.18 billion for implementation by 31 March 2020. IIT Kharagpur is the national coordinating body.

  AICTE launched the National Employment Enhancement Improvement Mission (NEEM). NEEM focuses on practical training for graduates and dropouts in all fields to enhance their employability. This initiative is expected to improve collaboration between universities and industry, which will lead to better employability.

- **Academic institutions and industry**

  Industry-university cooperation is the first step towards improvement and innovation. This partnership is fundamental to ensuring industry relevance in academic research. To meet the challenges associated with competitiveness, companies often look to industry partners as well as academic contributors for innovation.

TABLE 1.17

INDUSTRY-UNIVERSITY COLLABORATION

Institute	Industry	Purpose
Indian Institute of Science (IISc), Bengaluru	Wipro	Development of AI, IoT, machine learning, visual computing
IIT Kharagpur	Wipro	Focus on AI research applied to areas, such as healthcare, education, retail, climate change, and cybersecurity
IIT Guwahati	Samsung	Opening of Digital Academy at IIT Guwahati. The academy aims to train more than 300 of its employees in cutting-edge technologies, such as AI, machine learning, and IoT over the next three years, by 2023. In addition to IIT Guwahati, Samsung India has established innovation hubs at IIT Hyderabad, IIT Kanpur, IIT Delhi, IIT Kharagpur, and IIT Roorkee.
IIT Madras	Sterlite Technologies ESPNcricinfo Confederation of Indian Industry (CII)	R&D on 5G To release a device known as Superstats Support and promote green and innovative start-ups nationwide
IIT Hyderabad	National Research Institute for Earth Science and Disaster Resilience (Japan)	Undertake research in areas, such as earthquake engineering with focus on numerical simulation
IIT Kanpur	Mahindra Group, Tech Mahindra	Conduct joint research in the field of cybersecurity
IIT Delhi	Indian Space Research Organisation (ISRO)	Conduct joint research to contribute to the study of space technology
IIT Roorkee	APL Apollo Tubes Limited (APL Apollo) Microsoft	Provide a platform for research and training facilities for IIT Roorkee students and APL Apollo personnel Boost quantum computer learning by teaching about quantum computers for the whole semester
IIT Bombay	Tata Motors	Development of an electric racing car named "EVoK". Tata Motors Electric Vehicle Business Unit (EVBU)

Source: AIM (https://analyticsindiamag.com/top-industry-academia-collaborations-in-2019/).

Innovation Through Public-Private Partnership (PPP)

The economic prosperity of a country depends on its scientific and technical capabilities. To succeed within these parameters, it is imperative that academia and industry establish close relationships and overcome each other's limitations. Table 1.18 depicts the various public and private organizations that have initiated industry-academia schemes/projects in India.

TABLE 1.18

INDUSTRY-ACADEMIA PROGRAMS/SCHEMES OF PUBLIC AND PRIVATE SECTORS[38]

Public Sector				Private Sector	
Funding Agencies	**Education Sector**	**Banks**	**International Agencies**	**Industry Associations**	**Banks**
DST	MoE	SIDBI	UNIDO-INDIA	FICCI	ICICI Bank
TIFAC	UGC	SBI	IFC-INDIA	CII	Yes Bank
GITA	AICTE	NABARD		NASSCOM	
DSIR		IDBI		Other industrial associations	
NRDC		Syndicate Bank			
CSIR					
CTPL					
BIRAC					
ICAR					
ICME					
DRDO					
DIPP					
DAE					
MeitY					
MoEFCC					
ISRO					

Academia Industry Model (AIM)

Academic institutions are reservoirs of wisdom that industries want to use for their ongoing and future R&D activities. It has been observed that the industry is eager to partner with academic institutions that have made admirable achievements in the areas of patents, technology, and entrepreneurship. Within these institutions, industry has contributed financially to the establishment of centers of excellence, research/test laboratories, industry committees, and fellowships. The industry also assigns much research work to scientists.

Industry-academia partnerships have become vital and relevant as they bring scientific innovation to existing systems to advance and compete globally. It is therefore imperative that industry and academia work together to conduct targeted research that can lead to innovative products/technology/processes.

Cases of academia-industry collaboration in AIM are as follows:

Centers of Excellence	
Public Sector: Higher Education Institute (HEI) **Private Sector:** International Business Machines Corporation (IBM), India	Higher Education Institute (HEI) International Business Machines Corporation (IBM) has established nearly 120 software centers of excellence in educational institutions across India. These centers of excellence are known as IBM Software Centres of Excellence. (Source: https://www.ibm.com/in-en/marketing/careereducation/our_partners.html)

Research Laboratories	
Public Sector: Higher Education Institute (HEI) **Private Sector:** Industries	Higher Education Institute (HEI)

[38] DST-Centre for Policy Research (https://cpr.puchd.ac.in/wp-content/uploads/2020/07/2015-16-all.pdf).

Various industries have established specialized laboratories/units in academic institutions, where industry staff and academics (lecturers and researchers) work together to implement industry-oriented research activities (Table 1.22)[39].

TABLE 1.19

INDUSTRIAL SETUP IN HIGHER EDUCATION INSTITUTIONS

Industrial Setup	Academic Institution
• Xilinx FPGA Laboratory • The Tata Infotech Laboratory • Intel Microelectronics Laboratory • Laboratory for Intelligent Internet Research • Tata Consultancy Services Laboratory for VLSI Design and Device Characterization • Texas Instruments Digital Signal Processing (TI-DSP) Laboratory • Wadhwani Electronics Laboratory • Cummins Engine Research Laboratory • Applied Materials Nano Manufacturing Laboratory • VLSI Design Consortium	IIT Bombay
• Intel set up a planet lab in Electronics and Communication Department • Cisco set up equipment for a Telephony and Security Lab in E&C Dept	IIT Roorkee
• Bharti School of Telecommunication Technology and Management	IIT Delhi
• General Motors-IIT Kharagpur Collaborative Research Laboratory on Electronics, Controls, and Software	IIT Kharagpur
• Autodesk, Microsoft, and Intel have established Centres of Excellence and sponsored research laboratories on campus	IIT Madras
• Ricoh Company - Centre for Design and Innovation at the institute	IIT Gandhinagar
• Analog Teaching Lab and C2000 Micro Controller Lab setup by Cranes Software International Limited	Bombay College of Pharmacy, Mumbai

R&D in India

The R&D process requires equal participation of three key players.

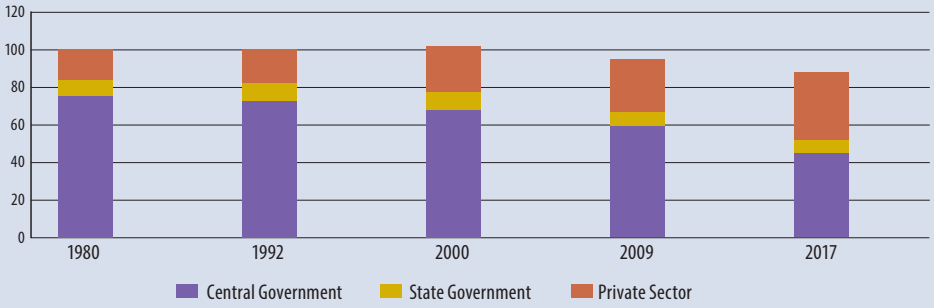
Central government State government	• Higher education institutions • Independent government-funded research labs • Incubation centers
Academia	• Public-sector companies • Private-sector companies
Industry	• Public-sector companies • Private-sector companies

[39] Bhardwaj (2017) (https://www.researchgate.net/publication/354463718_Industry-Academia-RD-Ecosystem-in-India).

Each of these stakeholders has made extensive efforts over the past decade to enhance R&D cooperation, efficiency, and effectiveness in India, including the establishment of research centers, policies, and initiatives. Since independence, the central government has invested the most in India, but has since declined while the private sector has grown. Indian companies eventually look to R&D for product innovation as the primary target for reinvestment. India is an exception in this regard. While in most countries, R&D expenditure is undertaken by business enterprises and the higher education sector, but in India, the government spends the most on R&D[40].

FIGURE 1.27

R&D EXPENDITURE SHARE OF STAKEHOLDERS



Share of Central Government, State Government and Private Sector in India's research and development expenditure (MoneyControl News, 2022)

Source: Chetty (2022) (https://www.projectguru.in/an-overview-of-research-and-development-in-india/).

TABLE 1.20

STAKEHOLDERS' EFFORT[41]

Industry	• Industry accounts for 36.7% of India's total R&D spending • Major R&D expenditure is devoted to automotive, pharmaceutical, and semiconductor research • Costs increased by only 0.32% in 2020 during the COVID-19 pandemic • Over the next 10 years, spending is expected to focus on cybersecurity, cloud computing, AI, and 5G
Government	• The Indian government mandate broadens the scope of CSR spending to include R&D • Initiatives to stimulate spending on R&D include the creation of consulting organizations (NRFs), laboratories (Atal Tinkering Labs), and collaborative organizations (IITs, IISc, etc.) • The government introduced the patent umbrella in the Finance Bill (2016), which levies a 10% tax on the royalties of patents registered in India • Create the Manthan website to foster industry-university partnerships for R&D projects
Academia	• The most significant move by academia in recent years has been the formation of R&D clusters and research parks comprising leading STEM educational institutions in Tier 1 and Tier 2 cities • Committee University funding has required each academic institution to establish a R&D center to facilitate networking and collaboration for interdisciplinary and multidisciplinary research • Public universities are the main facilitators of the "Skills India" mission, which aims to provide quality education, training, and research, and make effective use of human resources

40 MoneyControl News, 2022.

41 Chetty (2022) (https://www.projectguru.in/an-overview-of-research-and-development-in-india/).

The R&D industry in India is managed by the DSIR, under the Ministry of Science and Technology. Organizations that are part of DSIR include the Council for Scientific and Industrial Research (CSIR), the Center for Consulting Development (CDC), Central Electronics Limited (CEL), the National Research Development Corporation (NRDC), and the Asia-Pacific Centre for Technology Transfer (APCTT). Mechanisms such as technology transfer have been introduced to accelerate R&D in all industry segments and increase operational efficiency, product development, competitive advantage, and technological advancement.

The Department of Industrial Promotion and Policy (DIPP) provides a framework to reduce IPR processing time to encourage innovation and entrepreneurship in the country. The organization, Accelerating the Growth of New Initiatives of India (AGNIi), supports the ongoing efforts to foster the innovation ecosystem by connecting industry innovators, individuals, and base to the market and help commercialize their innovative solutions. The Biotechnology Industry Research Support Council (BIRAC) supports young, high-risk participants from academia, start-ups, or incubators with interesting ideas in their infancy or early/planning stages. The government think tank NITI Aayog, and the Competitiveness Institute have released the India Innovation Index 2020[42] which reports the top three states that foster the most vibrant innovation environment are Karnataka, Maharashtra, and Tamil Nadu[43].

CSR Activities

CSR is how companies deal with large groups of stakeholders. CSR, breaking away from the age-old fields of charity and philanthropy, has now reached a new brand of corporate response and action to issues and needs. Society requires sustainability to go further in the new era of collective work in the future considering sustainable business strategies for good governance and for the development of society and people[44]. Table 1.21 shows the CSR expenditure public-sector undertakings (PSUS) and non-PSUS in specific years.

TABLE 1.21

CSR EXPENDITURE BY PSUS AND NON-PSUS IN 2014–15 AND 2018–19[45]

	2014–15		2015–16		2016–17		2017–18		2018–19	
Nature of Company	No. of Companies	Total Amount Spent (in INR'billion)	No. of Companies	Total Amount Spent (in INR'billion)	No. of Companies	Total Amount Spent (in INR'billion)	No. of Companies	Total Amount Spent (in INR'billion)	No. of Companies	Total Amount Spent (in INR'billion)
PSU	493	2.817	532	4.215	546	3.296	527	2.553	609	3.836
Non-PSUs	16,055	7.249	17,758	10.303	18,993	11.034	20,870	11.067	24,293	14.818
Total	16,548	10.066	18,290	14.517	19,539	14,330	21,397	13,621	24,902	18,653
	Average Spending		Average Spending		Average Spending		Average Spending		Average Spending	
PSUs	5.714		7.922		6.037		4.845		6.298	
Non- PSUs	0.452		0.580		0.581		0.530		0.610	
Total	0.608		0.794		0.733		0.637		0.749	

42 India Innovation Index 2020 (https://www.thehinducentre.com/resources/article33624644.ece/binary/IndiaInnovationReport2020Book_compressed.pdf?

43 Vedachalam N. (https://www.orfonline.org/research/indias-innovation-ecosystem-mapping-the-trends/).

44 Tandon N., Kaur S. The role of corporate social responsibility in India. Research Journal of Commerce & Behavioural Science-RJCBS 2017; 6: 29–34.

45 Annual Reports, Ministry of Corporate Affairs. (2020–21). (https://www.mca.gov.in/bin/dms/getdocument?mds=OoAPyiJse9QRULR80SKCTw%253D%253D&type=open).

The role of CSR in promoting innovation and entrepreneurship in India has emerged significantly in terms of creating entrepreneurs in micro and small businesses. The government has recognized the importance of entrepreneurship as a tangible alternative to traditional wage labor in the new economy and its role in promoting economic growth. As a result, the Indian government has issued many special guidelines to especially help female entrepreneurs. Table 1.23 shows the top 10 CSR activities in the education sector[46].

TABLE 1.22

CSR IN EDUCATION FY 2019–20

CSR Project Name	Name of Company	Location of Project	Total Expenditure on the Project (INR million)	Prescribed CSR in the FY 2019–20 (INR million)
Promoting education	National Mineral Development Corporation	Chhattisgarh (Bastar, Dantewada, Sukma, Kondagaon, Narayanpur, Bijapur, Kanker), Karnataka (Ballari), Madhya Pradesh (Panna), Telangana	803.4	1,178.1
Satya Bharti School Program	Bharti Infratel Limited	Rajasthan (Jodhpur), Punjab (Amritsar, Ludhiana, Sangrur), Haryana (Kaithal, Mahendragarh, Jhajjhar, Kurukshetra, Rewari), West Bengal (Murshidabad), Tamil Nadu (Sivaganga), Uttar Pradesh (Farukkhabad, Shahjahanpur)	477	681.9
Nanhi Kali	Mahindra and Mahindra Limited	Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Tamil Nadu, Uttar Pradesh, West Bengal	164.5	1,065.6
Project Agastya	Hindustan Petroleum Corporation Limited	Pan India	117.4	1,821.3
Education with special focus on the girl child	Titan Company Limited	Tamil Nadu, Uttar Pradesh, Uttarakhand, West Bengal, Karnataka	110.8	307.5
Vidyadhanam	Tata Motors Limited	Pan India	93.6	Nil
Promoting education	Vodafone Idea Limited	Uttarakhand, Uttar Pradesh, Madhya Pradesh, Rajasthan, Chhattisgarh	88.3	Nil
The School Project	Thermax Limited	Maharashtra	69.6	74.6
Improve quality of education	Cyient Limited	Andhra Pradesh, Telangana, Karnataka, Uttar Pradesh	55.8	82
Project OIL Super 30	Oil India Limited	Arunachal Pradesh, Assam, Rajasthan	51.2	556.7

The history of CSR goes back to 1892 when the JN Tata Endowment Foundation was established. Principles of safety, welfare, respect for human rights, and inclusive growth were laid down for Indian companies. Under the Companies Act, large Indian companies are now required to have a CSR board, committee, policy, project, reporting, and information[47].

46 CSRBOX (2020) (https://csrbox.org/India_CSR_news_Top-10-Education-CSR-Projects-in-India-in-FY-2019-20_934).

47 India CSR Outlook Report (ICOR) 2022 (https://csrbox.org/media/CSRBOX-India-CSR-Outlook-Report-2022_Full-version.pdf).

TABLE 1.23

CSR FUND DISTRIBUTION IN EDUCATION & SKILL SECTOR FY 2021–22

Education & Skill Sector Projects	Number of Projects Implemented	Actual CSR Spent (in INR billion)
Education Projects	1,706	2.448
Skill Development	340	0.749
Total	2,046	3.197

APPENDIX IV

The following is the list of departments/centers functioning at the IIT Roorkee and academic programs offered.

TABLE 1.24

LIST OF DEPARTMENTS AND CENTERS

DEPARTMENTS[48]	CENTERS[49]
Architecture & Planning	Centre of Excellence in Disaster Mitigation & Management (CoEDMM)
Biosciences and Bioengineering	Centre for Photonics and Quantum Communication Technology
Chemical Engineering	Centre for Transportation Systems (CTRANS)
Civil Engineering	Centre for Nanotechnology
Electrical Engineering	Continuing Education Centre (CEC)
Electronics & Communication Engineering	E-Learning Centre
Computer Science and Engineering	Greater Noida Extension Centre IITR
Mechanical & Industrial Engineering	Institute Computer Centre (ICC)
Mehta Family School for Data Science and Artificial Intelligence	Institute Instrumentation Centre (IIC)
Metallurgical & Materials Engineering	Mahatma Gandhi Central Library
Physics	Rethink! The Tinkering Lab

TABLE 1.25

SUPPORTING UNITS OF IIT ROORKEE

Other Supporting Units of IIT Roorkee
iHUB Divyasampark TIH - under NM-ICPS mission, Government of India
Intellectual Property Right (IPR) Cell
Water for Welfare: An Uttarakhand Government Initiative
TIEDS Business Incubator
Space Technology Cell

48 Departments of IITR (https://iitr.ac.in/Departments/index.html).

49 Centres IITR (https://iitr.ac.in/Centres/index.html).

APPENDIX V

ACCUMULATED RESULTS AFTER YEARS OF OPERATIONS[50]

i) Faculty Development Programs (FDPs) in emerging technologies

Institute has undertaken/plan to undertake the FDPs on the emerging technologies such as:

- Natural Language Processing
- IOT & Applications (Smart Systems)
- Data Science for All
- Machine Learning for Computer Vision
- Numerical & Engineering computation, optimization for physicists, scientists, and engineers using open-source-SCILAB
- Android & Programming Applications
- Designing with FPGA (Intel)
- Research Methodology

The execution of FDPs has been seen as knowledge diffusion and seen as a parameter to gauge productivity of the institution.

ii) International relations

IITR has executed MoUs/agreements with more than 100 international institutes/universities representing 33 countries around the world. Agreements for Student Exchange and Internships programs have been signed with top-ranking universities, including KTH (Sweden), TUM (Germany), University of Tokyo (Japan), ANU (Australia), and NTU (Singapore). Joint/dual degree programs are conducted with some of the premiere global universities, such as University of Alberta (Canada), University of Strasbourg (France), and AIT (Thailand).

Exchange of students and faculty, relationships with other universities, both within and outside India has been seen as knowledge exchange and diffusion by IIT Roorkee. This has been seen as one of the criteria in assessing productivity.

iii) International networks

The institute has forged international networks with the following:

- DST Africa initiative
- Shastri Indo-Canadian Institute (SICI)

[50] IIT Roorkee (https://ir.iitr.ac.in/pdf/Information_Brochure2022.pdf).

- IC-IMPACTS
- HERITAGE NETWORK
- United States-India Educational Foundation
- Japan Society for the Promotion of Science

The institute has signed more than 100 MoUs with international universities and/or institutes in the last five years. Also, the institute has been represented in more than 60 countries through international students. International networks are important to promote knowledge exchange and knowledge transfer. Strong international networks also promote productivity.

iv) SPARK Fellowships

IIT Roorkee organizes institute-funded SPARK fellowships for internships with a weekly stipend of INR2,500/week and project-funded internships in 2022[51].

v) Internship and scholarship programs

The institute has pursued internship and scholarship programmes at foreign institutes for its college students under agreements including:

- Future Research Talent (FRT) Awards, Australia
- NTU-INDIA Connect Scholarship, Singapore
- DUO-India Fellowship Programme
- Ecole Polytechnique University Scholarship, France
- Combined Study and Practice Stays for Engineers from Developing Countries (KOSPIE), Germany
- Raman-Charpak Scholarships, France
- Mitacs Globalink Research Internships, Canada
- QUAD Fellowship program
- Eiffel Scholarship Program of Excellence, France
- ThinkSwiss Scholarship, Switzerland
- Shastri Indo-Canadian Institute, Canada
- Commonwealth Split-site page Scholarships, UK

[51] IIT Roorkee SPARK (https://spark.iitr.ac.in).

- DAAD Working Internships in Science and Engineering (WISE), Germany
- Newton-Bhabha PhD Placement Scholarships, UK
- Research Internship Programme at Yale University, USA
- International Youth Exchange Programme (IYEP)

CHAPTER 2

PAKISTAN

INNOVATION IN PAKISTAN

Pakistan is moving toward Industry 4.0 vision through incremental innovation. Incremental innovation, also known as continuous improvement, consists of improving a product or service in its market. It is less "spectacular" and immediate than other types of innovation, yet incremental innovation is effective when addressing transformation issues within the company or change processes. Industry 1.0 to Industry 4.0 is an example of incremental innovation.

Another innovation in Pakistan is the adjacent innovation, where technology acquisition is obtained from developed countries. Adjacent technology is existing capabilities (like technology or knowledge) to appeal to a new audience or enter a new market. This provides a competitive advantage to the original product or service that allows it to be differentiated in the market.

Justification for Innovation

Several factors come into play to justify the reasons and importance of innovation.

- **Market failure** - Innovation is difficult to create, with monetizing it being even more difficult. In today's knowledge-based economy, unintended knowledge spillover is increasingly strengthening market failure. For example, pharmaceutical firms invest billions of dollars in developing new drugs; however, generic drugs are often introduced easily. Thus governments use various methods to protect innovators' economic rents through policies, such as patent protection and intellectual property (IP) rights

- **System failure** - Technology is developed depending on previous patterns or paths (e.g., R&D strategies and institutions) when successful results have been made in the past. Firms and governments tend to stick to existing technology development strategies or policies due to sunk cost. After all, in a situation of high uncertainty, finding something new from an existing system of relatively high stability is difficult because firms do not know the best way to solve the problems it faces

- **Capability failure** - The innovation system of developed countries is indirectly applicable to developing countries, although the strategy for building the system is needed because developing countries often lack the capability to adopt the developed countries' innovation system

Table 2.1 highlights the activities that lead to innovation.

TABLE 2.1

THREE TYPES OF LAGS THAT JUSTIFIES INNOVATION

Classification	Market Failure	System Failure	Capability Failure
Focus	Market institution	Interaction among actors	Actors (firms)
Source	Knowledge as public good	Cognition failure from tacit knowledge	Historically given; No learning opportunity
Example problem	Suboptimal R&D	Lower R&D effects	No R&D
Solutions	R&D subsidies	Reducing cognitive distance	Access to knowledge and help in learning
Relevance	Developing and advanced countries	Developing and advanced countries	More unique to developing countries

Source: Adapted from Lee (2013).

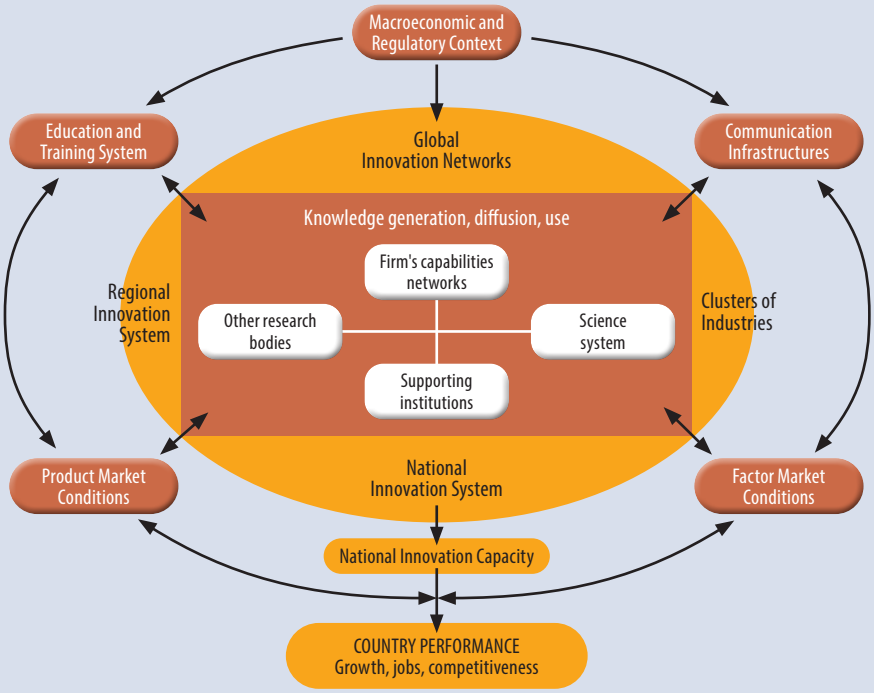
NATIONAL INNOVATION SYSTEM (NIS)

The concept of a NIS was proposed in the 1990s by economists, such as Freeman (1995), Lundvall (1992), and Nelson (1993). These and other economists attempted to explain the relationship between a nation's investment in S&T and its economic development.

NIS can be defined as "the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge and are either located within or rooted inside the borders of a nation state." (Lundvall, 1992).

FIGURE 2.1

NATIONAL INNOVATION SYSTEM



Source: The OECD National Innovation Systems Model-Source: OECD (1999).

By contrast to an innovation system in general, NIS is made up of primary actors whose relationships and interactions foster innovation within a nation.

A well-functioning NIS includes not only institutions and industry related to infrastructure, education, training, and R&D activities, but also government legislations, standard setting institutions, industry structure, and factors that facilitate international technology transfer and its absorption as well as the interaction among all these institutions.

NIS plays a crucial role in countries' efforts to catch up with technological advances (UNCTAD, 2005). Different educational institutions and systems, legislation, and frameworks for technological activities and policies have a significant impact on a country's technological performances and in turn, influence their economic performance.

However, NIS in developing countries, such as Pakistan, are uncoordinated and fragmented thus constitute a major problem in building the country's indigenous technological capabilities (ITC).

Some of the common problems of NIS in many developing countries, including Pakistan, are (UNCTAD, 2005):

- A lack of networks of S&T institutions, such as universities, research institutes, and standards institutions
- Isolation of these institutions from the productive sectors of the economy
- Inadequate level of coordination between the main areas of public policy - fiscal and monetary, foreign investment, intellectual property, competition, trade, agricultural and industrial development, environment, health, etc. that may be interrelated with investment in S&T development
- Insufficient coordination between S&T policies at the national, regional, and community levels
- Lack of consultation with and participation of all main actors - government agencies, business, academia, S&T institutions, consumers, labor, and civic groups - in the formulation and implementation of S&T and innovation policies

Current State of Innovation in Pakistan

Pakistan is a developing country with an unstructured and unfragmented NIS. However, significant effort is put in to encourage innovation in the country. Pakistan is developing and implementing many innovation policies and projects to bring the innovation outcomes at sustainable levels. A recent development is the draft of National Science Technology and Innovation Policy 2021 that was developed with the objective to promote innovation-based strategies in Pakistan.

Pakistan uses the following indicators to benchmark the status of innovation and R&D capabilities (either strongly or poorly):

- R&D expenditure
- Patent statistics
- Research papers/journals
- R&D personnel

- Areas of focus of R&D
- Technical and tertiary education

The innovation performance is usually measured with the chronological data analysis against the following broad Innovation Inputs and Outputs:

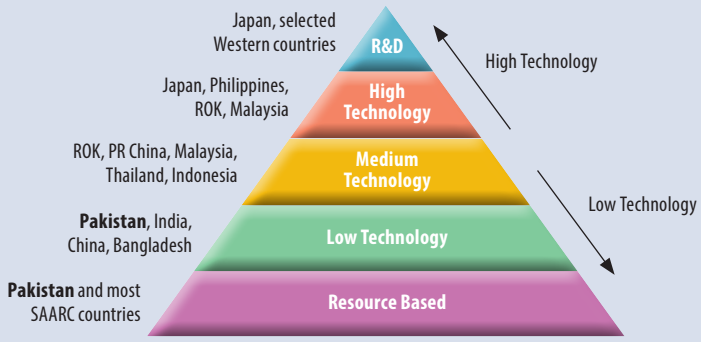
- Pakistan Innovation Index
- R&D expenditure
- IT exports
- High-tech exports
- Patents applications

Pakistan vs. Other Countries in Innovation and Indigenous Technological Capabilities (ITC)

Innovation brings technological capabilities in countries. Countries that invest in R&D develops its ITC faster than others. Figure 2.2 depicts the best relationship of innovation and ITC of selected countries.

FIGURE 2.2

INNOVATION COMPARISON BETWEEN DEVELOPING AND DEVELOPED COUNTRIES



Source: National Innovation System and the Need for an Upgradation Policy for Innovative and R&D Capabilities in Pakistan: M. N. Khattak, M. Baseer, M. Bajwa; 2009.

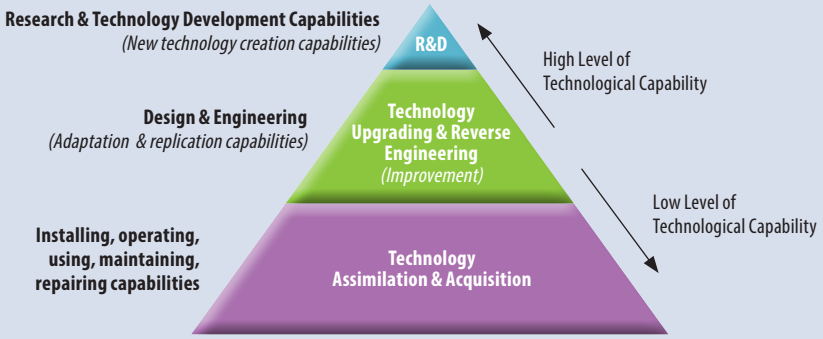
For Pakistan to move toward the apex of the pyramid toward R&D and innovation, it is necessary for it to develop its ITC. This is only possible if Pakistan develops its capabilities to move toward the apex of the following ITC pyramid, as in Figure 2.3 (Intarakamnerd, Chairatana, Tangchitpiboon, 1992).

In order for Pakistan to reach the apex of both its ITC and technological status pyramids (Figure 2.3) toward R&D, it is crucial for it to develop its innovative capabilities. However, given the existing market imperfections, a shift in paradigm is not possible without government interventions for technology deepening, particularly innovation. Thus the development of ITC for innovation at both the national

and firm levels necessitates a workable policy framework to be in place. Development of R&D and innovation capabilities would also enable Pakistan to become a producer of specific cutting-edge technologies in key areas. Moreover, it is important to note that such interventions for research and innovation would also directly contribute toward the strengthening of a national innovation system.

FIGURE 2.3

INDIGENOUS TECHNOLOGICAL PYRAMID (ITC)



Source: National Innovation System and the Need for an Upgradation Policy for Innovative and R&D Capabilities in Pakistan: M. N. Khattak, M. Baseer, M. Bajwa; 2009.

Classification of Activities Leading to Innovation in Pakistan

Table 2.2 distinguishes between instruments focusing on the supply of or the demand for innovation. Fifteen major innovation policy instruments are included in the table. Many of these instruments relate to more than one goal and vice versa. The first two focus on the creation of new knowledge and innovation through financial support to R&D and innovation are applied in a number of countries and with a huge variety of designs. At least three instruments (3–5) focus on the support of capabilities and skills to generate and commercialize innovation while taking into account the constant need for learning in innovation systems. The next three policy instruments support various forms of interaction and learning, including cluster support, which is the way for development for policymakers.

While the instruments considered so far may be seen as focusing mostly on the supply of innovations, the role of demand for innovation is receiving more attention at national and regional levels. Consistent with this, there are three types of policy instruments (10–12) which focus on influencing demand for innovation in one way or another.

Regulation and standardization influence both supply and demand conditions and incentives while a final instrument, technological foresight, is an approach for policy makers and stakeholders to understand future technological trajectories and develop policies to support and benefit from such trends. Over time, a rather diverse set of innovation policy instruments have emerged, reflecting different theoretical rationales and political priorities. Attention is now turned to what is known about the impacts of these instruments.

TABLE 2.2

ACTIVITIES LEADING TO INNOVATION

Sr. No.	Innovation Policy Instrument	Supply of Innovation	Demand for Innovation
1	Fiscal incentives for R&D		
2	Direct support to firm R&D and innovation		
3	Policies for training and skills		
4	Entrepreneurship policy		
5	Technical services and advice		
6	Cluster policy		
7	Policies to support collaboration		
8	Innovation network policies		
9	Private demand for innovation		
10	Public procurement policies		
11	Precommercial procurement		
12	Innovation inducement prizes		
13	Standards		
14	Regulations		
15	Technology foresight		

Development of "Green Economies" which means the policy instruments will bring innovation in the country

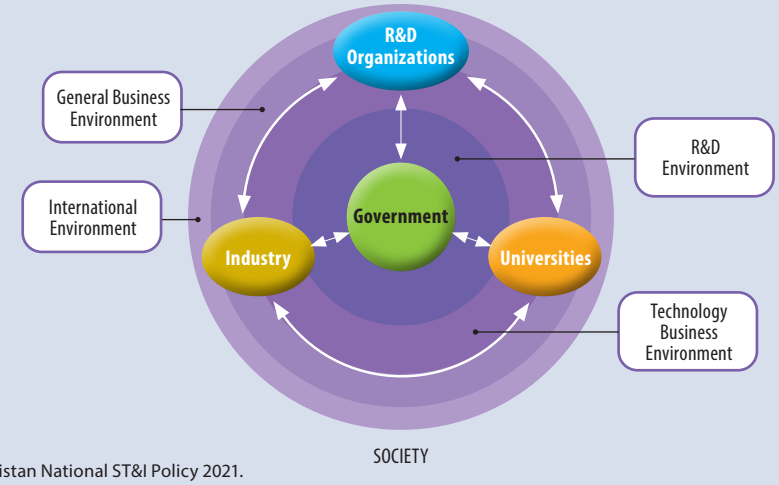
Demand for innovation which means the policy instruments is dependent on the innovation in the country

Current NIS Practices

For Pakistan, innovation is not a new phrase. Efforts to stimulate innovations in Pakistan dates back to 1953 with the establishment of the Pakistan Council of Scientific and Industrial Research. Similarly, Pakistan Agriculture Research Council and the National Agriculture Research Centre were established to give innovative solutions to the agricultural issues in the country (Higher Education Commission of Pakistan, 2010).

FIGURE 2.4

NATIONAL INNOVATION SYSTEM OF PAKISTAN



Source: Pakistan National ST&I Policy 2021.

On policy, the federal government sanctioned the first draft of the Science and Technology Policy in 1984. The second draft of ST&I policies were subsequently presented in 2012 and 2021.

i) R&D organizations

There are 65 R&D organizations in the country with more than 250 suborganizations. All these organizations are in the public sector and mainly conduct applied research. At the federal level, there are 30 R&D organizations, comprising 90 suborganizations, working under 11 federal ministries. Some of these R&D organizations have extended organizational structures. For example, Pakistan Atomic Energy Commission (PAEC) has five major suborganizations under its administrative control while Pakistan Agricultural Research Council (PARC) consists of 16 suborganizations and research stations. One of these suborganizations, National Agriculture Research Center (NARC), consists of another 16 R&D institutes.

Federal R&D organizations perform R&D activities in different fields covering almost all major areas of S&T, ranging from agriculture to space technology. Major federal R&D organizations are semiautonomous bodies with their own board of governors, and the heads of these organizations are responsible for the execution of R&D activities in their respective organizations. However, practical autonomy of these organizations may vary, depending on their administrative ministry and actual legal framework/Act.

There is also a disparity in the salary structures and fringe benefits among the organizations working under different ministries. At present, R&D organizations working under the Ministry of Science and Technology have the least favorable salary structure compared to the organizations under different ministries. The salary and incentive structures differ widely among organizations operating under different ministries as well as between R&D organizations and universities. This obvious disparity has emerged as a demotivating factor for scientists employed in disadvantageous organizations. Moreover, numerous organizations are grappling with a shortage of manpower, with some operating at less than 50% of their approved staffing levels. The situation is further compounded by the failure of administrative ministries to timely appoint heads of organizations. There is always a lag time between two successive heads; sometimes the lag time drags longer than the tenure of the head.

ii) Universities

There are 229 Higher Education Commission (HEC)-recognized universities and degree-awarding institutions in the country. Universities exist both in the public and private sectors and undertake basic as well as applied research. A major volume of R&D activities, however, is undertaken by the public-sector universities (140) as compared to private-sector universities (89). There are also 110 research institutes and 54 research cum educational institutes under the administrative control of universities. Most are "general" universities, undertaking educational and R&D activities in multiple disciplines. However, there are also some 'mono discipline' universities, focusing predominantly on one discipline, such as agriculture, medical, or engineering and technology.

Since the establishment of the HEC in 2002, the number of universities in Pakistan has increased manifold, from 34 in 2000 to 229 in 2021. Total enrollment at the university level has also increased and reached 1.87 million in 2018. However, the overall participation rate in the tertiary level education remains extremely low at only 9% in 2018, compared with 29% in neighboring India and 21% in Bangladesh. As per UNESCO Institute of Statistics, the number of outbound Pakistani tertiary level students was 58,821 in 2018, showing more than 88% growth in the last decade. This may be, at least partially, attributed to the shortcomings in the national higher education system. However, some international students from Muslim-majority developing countries, such as Somalia, Sudan,

Yemen, and, most notably, neighboring Afghanistan, pursue studies in Pakistan, where they can access education of higher quality than that at home.

Despite the enhanced capacity of the national universities, indicated by the significant increase in the production of PhDs, which has risen from only 202 per year in 2001 to 1,325 per year in 2014, Pakistan universities still have a long way to go to compete with the world's top universities. As per QS World University Rankings 2021, there are no Pakistani university in the top 100 universities of the world, and only three Pakistani universities are included in the top 500 universities of the world. National University of Sciences and Technology (NUST) in Islamabad, ranked 355th in the world, is the highest ranked university in Pakistan.

iii) Industry

The Pakistan Statistical Bureau's Census of 2015–16 reported there are 42,262 manufacturing industrial units in Pakistan, comprising 37,347 small, 3,598 medium, and 1,317 large units. The industrial sector share in the national GDP is less than 20% with the textile industry being the largest manufacturing industry in Pakistan and the eighth largest textile products exporter in Asia. Cotton, textile production, and apparel manufacturing account for 65% of the merchandise exports and almost 40% of employed labor force.

Food and beverage processing industry is the second largest industry at 27% of the value-added production and 16% of employment in the manufacturing sector. Other major industries include cement, fertilizer, edible oil, sugar, steel, tobacco, chemicals, and machinery. In general, family-owned business mindset prevails in the industry with very little motivation for innovation. Hence, the industry mainly remains non-innovative and operates at the lower level of technology. There is lack of automation in the production systems and lack of awareness for the need of R&D. The industry attributes these deficiencies toward various factors, including limited access to finances, the unavailability of 'industry-ready' university graduates, lack of well-trained technicians who meet industry requirements, and at times, overregulation.

Although, operating at the lower level of technology, the industry overlooks the potential benefits of collaborating with local universities or R&D organizations to upgrade its technology or develop new products. This may be attributed to the fact that Pakistani firms generally develop very few new products, especially high-tech or high-quality products, or they do not consider the universities to be reliable partners.

iv) Government

The government provides an encouraging environment for the other three actors of the NIS function. The NIS environment consists of multiple layers, which can be described as:

- **R&D environment** - Its elements directly impact the capacity and performance of the main actors of the NIS. STI policy, R&D funding mechanisms, R&D infrastructure, higher education policy, R&D incentives for industry, and IP policy and laws are some examples

- **Technology business environment** - The second layer of the NIS environment consists of technological elements, such as the innovation incentives for the industry, start-up policy, venture capital market, technical standards, technology regulations, technology business infrastructure, technology education, and training system

- **General business environment** - It influences the performance of the NIS through its impact on the final outcome of the ecosystem. General business environment is affected by, among

others, industrial policy, ease of doing business, monetary policy, energy policy and infrastructure, commerce and trade policy, financial market, labor market, communication and transport infrastructure, and education system

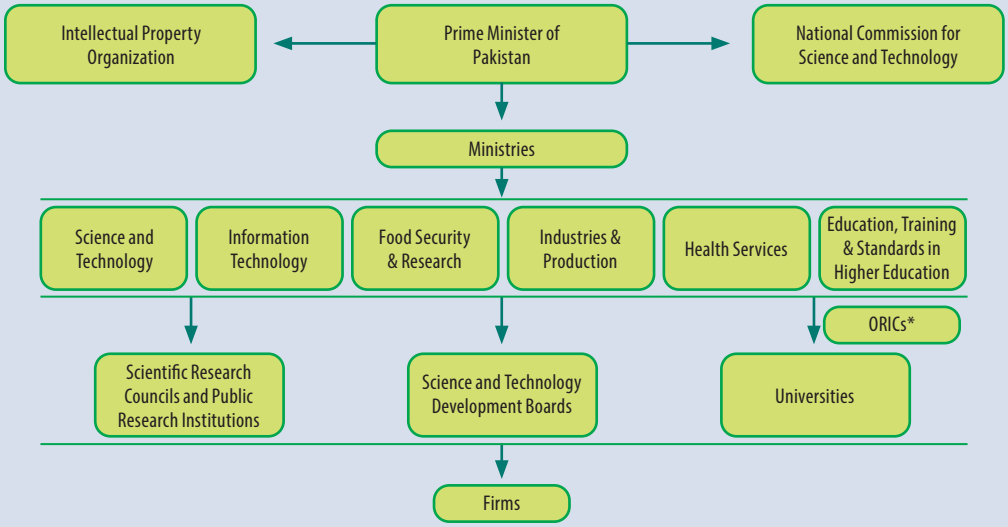
- **International environment** - This also influences the NIS with factors, such as international competition, globalization, international obligations/agreements, international trade, etc.

Pakistan's NIS Players

Pakistan's NIS consists of different institutes and market players. First, the institutional pattern, institutional functions, and institutional interactions are discussed.

FIGURE 2.5

INSTITUTIONAL PATTERN



Source: Analysing National Innovation System of Pakistan; ISSN 2225-0565 (Online) Vol.4, No.4, 2014.

Institutional Pattern

The remarkable point in the innovation pattern of Pakistan is the establishment of organizations, such as:

- Committee on Scientific and Technological Cooperation (COMSTECH)
- Center for Applied Microbiology (CAMB)
- National Commission for Science and Technology (NCST)
- Quaid-e-Azam University
- National University of Science and Technology
- Technology Upgradation and Skill Development Company (TUSDEC)

- Small and Medium Enterprise Development Company (SMEDA)
- Innovation Fund Pakistan
- Higher Education Commission of Pakistan

The most recent development is the announcement of the National Science Technology and Innovation Policy 2021.

Institutional Functions

i) **Policy formulation** - The National Council of Science and Technology is the government's top level policy maker that encompasses the innovation system in Pakistan. However, S&T policy planning and making have been an area of heightened neglect. A recent policy document issued by the Ministry of Science and Technology admits that the process of policy making for S&T has been delayed for many years. The first policy was sanctioned in 1984. In 1993, an action plan for Technology Policy and Technology Development was formulated. The ongoing Science, Technology and Innovation Policy was unveiled in 2012 and renewed in 2021 (Government of Pakistan 2021).

ii) **R&D activities** - R&D activities are mainly conducted in Pakistan's public research institutions and universities. Public R&D establishments fall under different ministries of provincial and federal governments. The areas of public research institutions range from agricultural sciences, engineering and technology, medical sciences, energy, biotechnology to water resources. Most of the research activities in Pakistan are concentrated in agriculture science with 44 research organizations operating in this particular sector while only 19 S&T organizations focus on engineering and technology. The number is smaller on medical science with just five research organizations (Pakistan Council of Science and Technology 2009). Despite the higher number of research organizations in agriculture, Pakistan has yet to realize food self-sufficiency and appears to be far from the goal.

iii) **R&D funding** - Funding for innovation systems are received mainly from the government. Firms, the third tier of innovation, play a meagre role in R&D funding. According to the latest available statistics compiled by the Pakistan Council of Science and Technology, the country's R&D gross expenditure stands at 0.59% of the GDP. The share of government funding in gross domestic expenditure is as high as 83%. The other sources of funds for R&D include higher education (10%), business sector (3%), private nonprofit (2%), funding from abroad (1%), and 1% respective share in the overall funding. An examination into the R&D expenditure reveals that the major recipient of R&D funding is agricultural sciences, followed by industrial research, defense, health, engineering, and technology (Pakistan Council of Science and Technology 2009).

iv) **HR development** - There are 26,129 researchers in Pakistan which counts to only 162 individuals per million of population, a number far below many developing countries. Of the total number, 17,147 are employed in higher education institutions and 8,982 are working in R&D organizations. A significant number of the scientists work in the domain of natural sciences, followed by engineering and technology, medical sciences, agricultural sciences, social sciences, humanities, and other fields. An oddity to the country's HR in the fields of innovation system is the lack of higher qualification.

v) **Technology transfer** - There is no common mechanism to bridge technology breakthroughs between R&D institutions and the commercial sector. R&D institutions are responsible to market their innovation to the industry. Pakistan Council of Scientific and Industrial Research (PCSIR),

TUSDEC, SMEDA, and Engineering Development Board (EDB) are tasked with conducting industrial research. On the other hand, the National Agriculture Research Council (NARC) and universities have independently established linkages with the industry to bridge the gap in technology transfer.

vi) **Technological entrepreneurship** – An economy needs efficient capitalists and technology parks to promote technological entrepreneurship. Venture capitalists provide seed capital to aspiring entrepreneurs while technology parks provide a platform in commercializing academic innovations. In Pakistan, venture capital firms have been operating for the last two decades while the idea of S&T Parks is at the very initial stages. A recent survey on the economy of Pakistan reported that only 18%–20% of the final requirements of IT companies are fulfilled by financial institutions and venture capitalists.

Institutions' Interactions

i) **R&D collaboration** - Inventions that do not meet market rigor may not contribute toward the prosperity of the country. In Pakistan, public-sector research institutions and universities conduct their research without linkage with the private sector, resulting in firms' disinclination to set up research agenda with public-sector research organizations. This approach makes innovations less competitive. The lack of linkage between research performers further leads to the selection of research projects based on interests of individual researchers rather than the demands of business community.

ii) **Technology diffusion** - For proper technology diffusion, R&D collaboration is vital among the actors of innovation system. A higher rate of innovation adoption means a higher rate of diffusion, which can only be assured through effective collaboration. In Pakistan, most firms are non-R&D based which impedes the diffusion of technology. The attitude toward technology adoption also varies from big to small firms; bigger firms are more orientated toward technology adoption. Firms with higher sale turnover also adopt technology at a faster pace.

Innovation policy (2012, 2021) outlines the measures for effective and faster technology diffusion at national and institutional levels. They include:

- Capacity building for technology transfer
- Enhancing absorptive capacity of firms
- Industry-university collaboration

Pakistan at the Global Innovation Index (GII)

Pakistan ranks 99th among the 132 economies featured in the GII 2021.

TABLE 2.3

RANKINGS OF PAKISTAN IN 2019–21

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

Source: Global Innovation Index Report 2021.

Table 2.4 shows the country's ranking between 2019–21, noting that data availability and changes to the GII model framework influence year-on-year comparisons of the rankings. The statistical confidence interval for the ranking of Pakistan in the GII 2021 is between ranks 90 and 101.

Pakistan performs better in innovation outputs than innovation inputs in 2021. While the innovation inputs was at 117 in the same year, it was higher in 2020 though lower in 2019. As for innovation outputs, Pakistan ranks 77th, which is higher than both 2020 and 2019. When benchmarked against 34 lower middle-income group economies, Pakistan is on the 17th rung while ranks seventh among the 10 economies in central and southern Asia.

Pakistan performs above the lower middle-income group average in four pillars - Institutions, Business sophistication, Knowledge and technology outputs, and Creative outputs. It also performs above the regional average in the same pillars among the central and southern Asian countries.

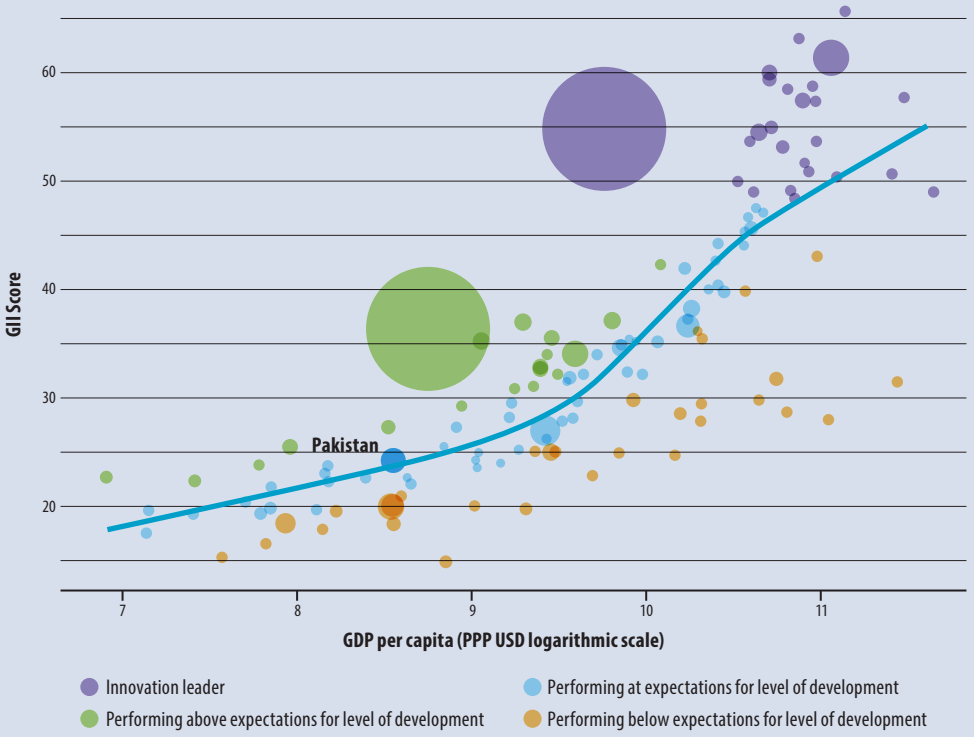
FIGURE 2.6

PAKISTAN'S SEVEN GII PILLAR SCORES

Source: Global Innovation Index Report 2021.

FIGURE 2.7

PAKISTAN'S INNOVATION PERFORMANCE



Source: Global Innovation Index Report 2021.

Pakistan's Innovation System's Strength and Weaknesses

TABLE 2.4

STRENGTHS AND WEAKNESSES

Strengths			Weaknesses		
Code	Indicator name	Rank	Code	Indicator name	Rank
2.3.4	QS university ranking, top 3	43	2.1	Education	121
4.2.1	Ease of protecting minority investors	27	2.1.3	School life expectancy, years	117
4.3.3	Domestic market scale, bn PPP USD	22	2.2.1	Tertiary enrolment, % gross	117
5.2.1	University-industry R&D collaboration	42	3.2	General infrastructure	125
5.3.2	High-tech imports, % total trade	29	3.2.2	Logistics performance	112
6.1.4	Scientific and technical articles/bn PPP USD GDP	49	3.2.3	Gross capital formation, % GDP	113
6.1.5	Citable documents H-index	50	4.1	Credit	123
6.2.3	Software spending, % GDP	33	4.2.3	Venture capital investors, deals/bn PPP USD GDP	88
6.3.4	ICT services exports, % total trade	36	6.2.2	New businesses/th pop. 15–64	117
7.3.4	Mobile app creation/bn PPP USD GDP	19	7.2	Creative goods and services	126

Strengths			Weaknesses		
Code	Indicator name	Rank	Code	Indicator name	Rank
			7.2.2	National feature films/mn pop. 15–69	107
			7.2.3	Entertainment and media market/th pop. 15–69	62
			7.3.3	Wikipedia edits/mn pop. 15–69	123
			-	Innovation policies	-
			-	Political stability	-
			-	Marketing mechanisms	-

Source: Global Innovation Index Report 2021.

Factors Impacting Continued Success in Innovation and Challenges in Pakistan

i) Education and workforce

Pakistan has low participation of women in the workforce, despite high levels of participation in education. This is partly driven by culture and unfavorable working conditions. The participation of women in STEM (science, technology, engineering, and mathematics) education is low as per expectation.

Technical and vocational education has a critical role to play in getting employees to run the industry. They lay the foundation for skill development, which is critical for economic growth and social development of the country. With the increase of adoption of advanced manufacturing technologies, the problem is bound to become more severe if adequate structural changes are not put in place. Not only will there be a lack of manpower with the desired skillsets but employers will have to make high capital investment in reskilling and upskilling their existing workforce to suit their requirements.

To cope with this demand, skill development centers must be established to develop industrial workforce with high levels of scientific and technological talents for the growth of industries.

ii) Leadership in technology and business innovation to create a knowledge-based economy

Knowledge-based economy (KBE) is one that has an economic and institutional regime that stimulates acquisition, creation, dissemination, and use of knowledge and information to improve its growth and welfare as well as effective systems of education and skills, ICT, R&D, and innovation.

To measure and monitor progress of economies as knowledge-based economies, the World Bank developed the Knowledge Economy Index (KEI), using a four-pillar framework:

- Education and skilled workforce
- NIS
- Networks and ICT
- Policy and regulatory environment

Pakistan also ranks low in the Global Competitiveness Index (GCI), ranking at 111 in technology readiness and 128 in labor market efficiency out of 137 countries, according to the World Economic

Forum - Global Competitiveness Report 2017–18. The country is facing sluggish growth rates in output and exports, mainly due to technical inefficiencies, low levels of applied R&D, and limited investment that result in lower productivity and uncompetitive Pakistani products.

Low skill levels in the labor force is also a major constraint in achieving economic growth and eliminating poverty in Pakistan. Currently, the world trade is dominated by high- and medium-tech manufacturing exports (58%) to meet customer demand while Pakistan's manufacturing exports are crowded with low-end products that account for more than 74% of total exports.

Keeping in view Pakistani's low ranking in KEI and GCI, the government established "Task Force on Technology Driven Knowledge Economy" to be the key forum to stimulate knowledge-based industrial development through technology innovation, dissemination, and commercialization.

iii) Room for innovation in SMEs

Encouraging innovation in small- and medium-sized enterprises (SMEs) remains at the heart of policy initiatives in stimulating economic development at the local, regional, national, and European levels (Jones and Tilley, 2003).

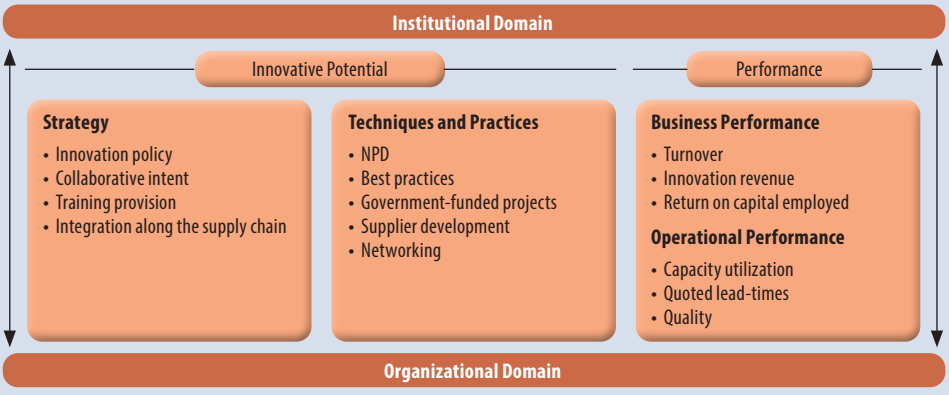
Innovation is a key determinant of productivity and long-term growth. Supporting innovation in established SMEs can foster inclusive growth by reducing productivity gaps and wage gaps between SMEs and large companies.

On average, SMEs are less innovative than large enterprises. However, some small enterprises are highly innovative and can reach productivity levels above those of large companies. Companies which develop and use their internal strategic resources effectively (e.g., managerial and workforce skills, ICT, R&D, etc.) and collaborate with external partners in the innovation system have better innovation performance.

Governments can support SMEs innovation by creating a sound business environment, helping SMEs to develop and use their internal strategic resources effectively, and building an innovation system that is effective in research commercialization and inclusive of all SMEs.

FIGURE 2.8

INNOVATION POTENTIAL AND PERFORMANCE



Source: Understanding innovation in small and medium-sized enterprises: A process manifest: T. Edwards, R. Delbridge, M. Munday; October 2005.

iv) R&D funding

R&D funding will directly finance the acquisition of targeted technologies, paraphernalia, and skillsets in facilitating the upgradation process to a higher technical stage. Such technical jumps will eventually tip over to reduce the technology gap and move wider on the techno-spectrum.

Direct grants, on a 70:30 sharing basis with the beneficiaries, will be provided for the procurement of targeted technologies, machinery, and techno guarantees. The techno/innovation grants would be subjected to strict performance indicators based on assimilation of targeted technologies and channelizing the enhanced potential toward export growth and import substitution.

For the commencement of innovation activities that lead to fruitful results, the following activities can be undertaken:

- A fund management unit (FMU) can be formed to extract the results of an innovation program
- Technical experts/consultants can be engaged to design detail modalities of the program, for e.g., selection criteria, mode of financing that result in a standard lending program/scheme. The mode of engagement will be dependent on the timeframe of their assignment
- For financial management of the fund, services of a commercial bank/financial institution could be hired
- A technical evaluation committee comprising of technology innovation/skill experts, along with members from the academic institutions, can be formed to evaluate the submitted proposal on the predefined criteria. The team will review the application and recommend it for acceptance, when/if appropriate
- Recommended cases from the technical committee will be forwarded to the partner financial institution which will evaluate/verify the beneficiary details on financial perspective
- Beneficiaries that meet all the desired criteria/requirements will be granted with the funds. FMU will be responsible for effective monitoring and evaluation of funds utilization
- Beneficiaries are required to submit a formal application, together with the engagement description/proposal and supporting documentation, to the FMU

v) Entrepreneurship and start-ups with technology diffusion

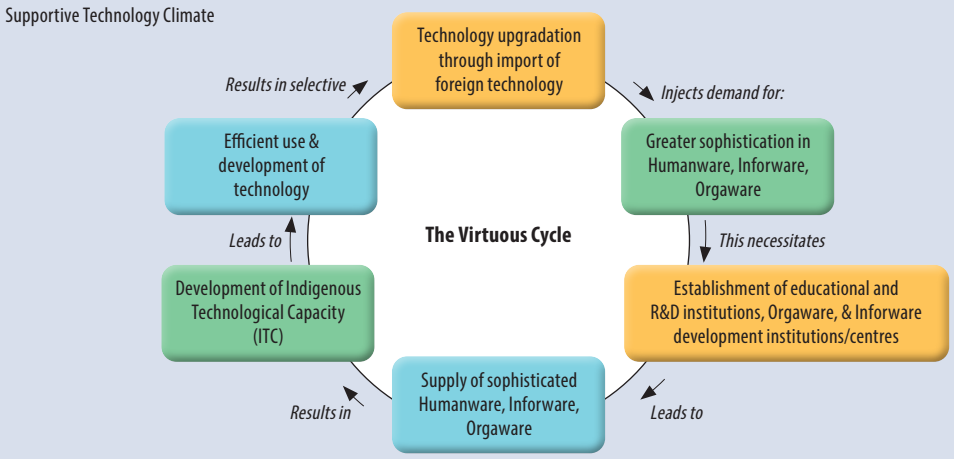
Technology upgradation/diffusion refers to the rapid induction and assimilation of technology, which causes quantum improvements of an existing technology. The induction of technology improvements can expedite the process of value-addition, in addition to enhancing the productivity of an industrial sector. The upgradation of technology through the import of foreign technology injects and facilitates a virtuous cycle in terms of the accumulation of humanware and infoware. The mechanism behind this virtuous cycle is illustrated in Figure 2.9.

Recognizing the importance of technology for industrial development, various countries developed and adopted different models to bring in the latest technology. One of the best technology promotion model is the Investment and Technology Promotion Offices (ITPO), developed by UNIDO in various countries all over the world. The ITPO promotes investment and technology through the concept of integrated economies for information and sharing of best

practices, delegate programs for exchange of experts, capacity building, and subregional cooperation for sustainable industrial development. These countries include PR China (Beijing and Shanghai), France, Greece, Japan, Poland, Slovakia, ROK, the Russian Federation, Bahrain, Italy (Bologna and Milan), Belgium (Walloon region), and Brazil (Recife, State of Pernambuco).

FIGURE 2.9

THE VIRTUOUS CYCLE - TECHNOLOGY CLIMATE



Source: TUSDEC.

ITPOs bring industrial investment and latest technology to countries most in need of a promotional helping hand. It opens up new opportunities for investors and technology suppliers to link up with potential partners in developing countries and countries with economies in transition. Few countries have also established Investment Promotion Units (IPUs) to provide support to their industries for international competitiveness.

The ITPO models of PR China, Japan, and the ROK are supported by relevant government ministries and chambers. Based on the effective implementation of technology development models, these countries achieved industrial competitiveness, productivity, integration into global value chain, improved exports, and employment generation.

vi) Knowledge diffusion from universities and research institutes

Diffusion of technology and knowledge is a prominent feature found in technologically advanced countries that emphasizes on technological change, innovation, and growth. Much attention has been given to the role of universities. Although there is a considerable variety across industries, many studies provide pieces of evidence for the strategic importance of the link between university and industry in modern economies. The key empirical indicators of the growing relationships between universities and firms are:

- Industrial funding of university research and partnering projects
- Patenting by universities

- Start-up companies from universities
- Joint authorship of articles from university and industry research
- Counts of patents or innovations, market to book value, and stock returns are common variables used for measuring the impact of academic knowledge on firms' performance
- University-industry linkages

vii) Societal adaptation to change over time

For developing countries like Pakistan, which is still dependent on technology acquisition, it is essential to embrace the innovation out of these social norms in order to adapt with "go with the flow" approach.

Socializing and diffusing innovative practices and the lessons associated with them, help inspire and equip individuals with knowledge and ideas on ways to innovate in their own contexts. It helps to celebrate innovative ideas and activities, and demonstrate that innovation is welcomed, even when it is not directed or actively sought. More needs to be done to foster and cultivate feedback loops/engagement with citizens to better understand the areas that require change or address dissatisfaction with current practices.

Reviewed Literature and Documents/Policies

Before drafting this preliminary report, a comprehensive overview of the country's industrial sector and in-depth analysis of the impacts of relevant national and international policies, and regulatory and institutional reforms by different countries are undertaken to date. This review helps to identify and analyze the development and innovation-related opportunities and challenges in each of the priority service sectors. This desk study includes, but not limited, to:

- Research papers/journals/periodicals
- Innovation Policy Asia
- Japan Innovation Policy
- Innovation Policy, ROK
- Innovation Policy India
- NIS/Innovation of PR China
- ECO Vision 2025
- STPF, Pakistan
- Draft S&T Policy 2012/2021, Pakistan
- NIS of Pakistan - Research
- Barriers of NIS in Pakistan

This study has constituted the starting point and basis for the drafting of the innovation document for Pakistan. Most of the innovation policies and ST&I documents reveal two broad factors - technology and R&D.

Data Analysis for Innovation Measures in Pakistan

Pakistan's innovation performance is usually measured with chronological data analysis against broad innovation inputs and outputs. They are:

- Pakistan Innovation Index
- R&D expenditure
- IT exports
- High-tech exports
- Patents applications

Pakistan Innovation Index

The GII capture elements of the national economy that enable innovative activities.

Definition: The GII includes two subindices: innovation input and innovation output. The first subindex is based on five pillars: institutions, human capital and research, infrastructure, market sophistication, and business sophistication. The second subindex is based on two pillars: knowledge and technology outputs and creative outputs. Each pillar is divided into subpillars and each subpillar is composed of individual indicators.

FIGURE 2.10

PAKISTAN'S INNOVATION INDEX

Pakistan Innovations Index	(0-100)
Latest value:	24.4
Reference:	2014–21
Measure:	Points

Source: Cornell University, INSEAD, and the WIPO.

R&D Expenditure

The expenditure for R&D on the charts includes both private and public spending on R&D.

Definition: Gross domestic expenditures on R&D, expressed as a percentage of GDP. They include both capital and current expenditures in the four main sectors: business enterprise, government, higher education, and private nonprofit. R&D covers basic research, applied research, and experimental development.

FIGURE 2.11

PAKISTAN'S R&D EXPENDITURE

R&D Expenditure: Percentage of GDP
Latest value: 0.2
Reference: 2005–19
Measure: Percentage

Source: UN.

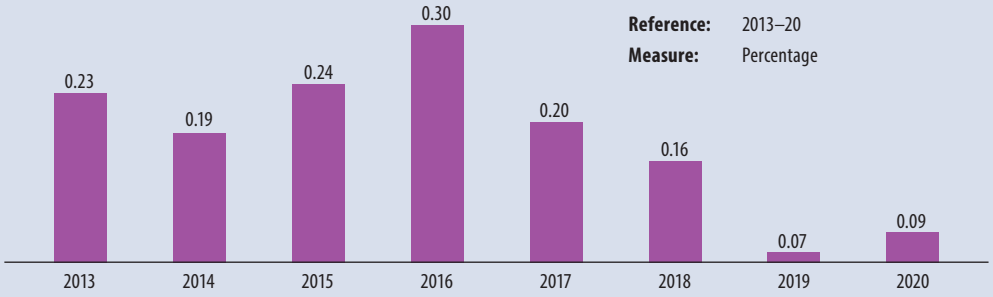
IT Exports

Definition: ICT exports include computers and peripheral equipment, communication equipment, consumer electronic equipment, electronic components, and other information and technology goods (miscellaneous).

FIGURE 2.12

PAKISTAN'S IT EXPORTS

IT Exports: Percentage of total goods exports
Latest value: 0.09
Reference: 2013–20
Measure: Percentage



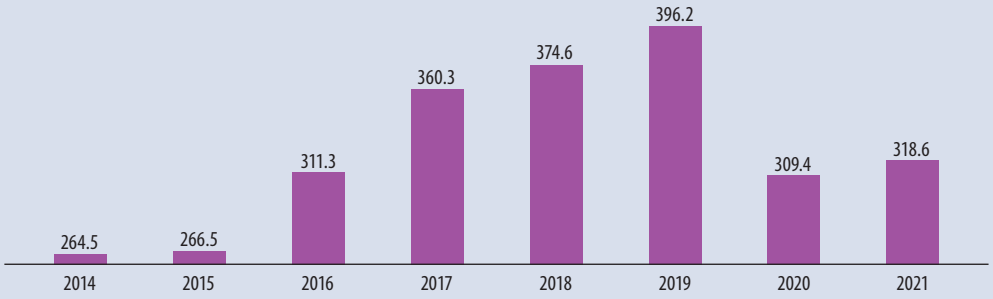
Source: UN.

High-tech Exports

Definition: High-tech exports are products with high R&D intensity, such as aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery. Data are in USD (current at time of writing).

FIGURE 2.13

PAKISTAN'S HIGH-TECH EXPORTS



Pakistan:	High-tech Exports
Latest value:	318.59
Reference:	2014–21
Measure:	USD in million

Source: UN.

High-tech is also shown in Figure 2.14 as a percentage of manufactured exports.

FIGURE 2.14

PAKISTAN'S HIGH-TECH EXPORTS, PERCENTAGE OF MANUFACTURED EXPORTS

Pakistan:	High-tech exports, Percentage of manufactured exports
Latest value:	1.89
Reference:	2013–20
Measure:	Percentage

Source: UN.

Patent Applications

Definition: Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention, a product or process, that provides a new way of doing something or offers a new technical solution to a problem. A patent provides protection for the invention to the owner of the patent for a limited period, generally 20 years.

FIGURE 2.15

PAKISTAN'S NUMBER OF PATENT APPLICATIONS

Pakistan:	Patent application by residents
Latest value:	338
Reference:	2013–20
Measure:	Number

Source: WIPO.

Initiatives for Innovation in Pakistan

Innovation Pakistan

Areas of Interest: Health care, agriculture, IT, clean water, water storage plans, children growth stunting, increasing school enrolment, and reduction of poverty.

Functions of Innovation Pakistan are to:

- Explore new and innovative ideas, involving no cost or at low cost, to improve lives of common citizens
- Formulate plans/solutions for improvement in service delivery system of all government agencies and departments
- Assess social and economic impact of the proposed interventions
- Evaluate possibility of ideas that contribute toward social drivers of economy in increasing employment and entrepreneurial opportunities
- Pilot innovative solutions through voluntary organizations or social sector responsibility stream
- Encourage R&D activities by linking academia with industry and public sector

- Strengthen proposals with clear implementation mechanism, including outlining responsibilities and tentative timelines

- Align objectives of proposed interventions with the social, developmental, and economic goals of the government

Achievements

- Establishment of Hatch 8 - Hatch 8 is a nurturing space for great minds and brilliant ideas. The preincubation program offered at the National Science and Technology Park (NSTP) is a six-month cohort program offered to selected start-ups, twice a year

- Establishment of Cube 8 - Cube 8 is the foundation of strong and successful start-ups. Incubation program offered at the NSTP is a 24-month running program and is designed to provide each start-up with the right balance and time to establish a strong base

- Establishment of Excelerate - Excelerate is a program for late-stage start-ups that have built something impressive. The start-ups are connected to dedicated coaches, late-stage investors, and even acquirers. This is a four-month cohort program offered to selected start-ups, twice a year

Pakistan Innovation Foundation (PIF)

PIF is a private sector-driven and not-for-profit organization that promote innovation across the Pakistani society, particularly the country's corporate sector. It delivers through a three-pronged strategy in:

- Awareness building

- Reward and recognition

- Research and advocacy

Achievements

- Launched Karachi Civic Innovation Lab (KCIL) which aims to institutionalize innovation to become a way of thinking for a diverse group of Karachi's stakeholders

- Conducted Pakistan Innovation Forum from 2014 to 2017

- Established Creativity, Science, and Innovation (CSI) Labs for robotics and STEM Skills to youth

- Executed idea of Development Innovation Lab locally in collaboration with Singapore

- Developed a high number of initiatives and activities for innovation, including Tecnovation for girls, PIF labs, women transport challenge, etc.

Vision 2030 - Ministry of Planning, Development and Reform (MoPD&R)

The ministry is embracing Industry 4.0 with new innovation techniques. The aim is to create "developed, industrialized, just, and prosperous Pakistan through rapid and sustainable development, in a resource constrained economy by deploying knowledge inputs".

MoPD&R works on increasing the share of the manufacturing industry sector of GDP from 13% to 30% by employing the latest technologies, including ICT and cutting edge technologies.

Achievements

- Establishment of Industrial Design and Automation Centers (IDACs) in Lahore, Karachi, and Sialkot to support the Industry 4.0 mission
- Establishment of additive manufacturing and designing software in Multan, Peshawar, and Quetta
- Acquisition of modern machinery for the support of different industrial sectors, including construction, textile, light engineering
- Training quantum of enormous number on innovative skilled trades
- New innovative project for footwear cluster development through CAD/CAM and CNC machining
- State-of-the-art engineering support centers in Hyderabad, Lasbela, and Peshawar for the engineering industry through different engineering services

National Science and Technology Park (NSTP)

Innovate Pakistan is a platform launched by NSTP with the ultimate aim of emerging as the innovation powerhouse to drive growth and create economic activity in the country.

The platform is designed to synergize researchers, creators, investors, implementers, and end users of technologies to transform innovative ideas into successful products and services while promulgating a culture of entrepreneurship by inspiring and nurturing businesses and entrepreneurs to develop and realize their true potential.

Innovate Pakistan has the following key elements:

- Platform for collaboration
- Platform for digitization
- Innovation center
- IP service
- Business consultancy center
- Financial hub

Achievements

- High-tech Special Economic Zone (SEZ) - Establishing a high-tech economic zone with its status approved in October 2020. It comprises eight thematic sectors, 104 high-tech companies, 41 anchor tenants and SMEs, 64 start-ups, and 10 MNCs from 7 countries

- NSTP pilot - The newest addition to the National University of Science and Technology's (NUST) growing portfolio, the pilot is an innovative project that will be home to a vibrant and high-tech entrepreneurial and business community of over 100 enterprises, from entrepreneurial start-ups to global multinationals. It features 110,000 square feet of office space, ample parking, state-of-the-art IT, and easy access to NUST's R&D ecosystem

Technology-driven Knowledge-based Economy Task Force

The task force was developed by the government in 2019 to focus on the economic and institutional regime that stimulates acquisition, creation, dissemination, and use of knowledge and information to improve economic growth and welfare as well as effective systems of education and skills, ICT, R&D, and innovation.

The task force is driven with for the following objectives:

- Knowledge-based industrial development through technology innovation, dissemination, and commercialization
- Promote cutting-edge research in academia and industry
- Intensify cooperation among the stakeholders, including government, private sector, and academia
- Take steps to build human capital in critically important areas
- Take all measures necessary in ensuring education, science, technology, and innovation can be effectively employed to develop a strong, inclusive, and sustainable knowledge economy

The task force recommends the innovative projects to Public Sector Development Program (PSDP) that focuses on built knowledge-based economy.

Achievements

National Strategic Programme for Acquisition of Industrial Technology (NSPAIT) received PKR3.207 billion to kickstart Pakistan's innovation agenda. NSPAIT is one of the key initiatives of knowledge-based economy under the purview of TUSDEC. It includes acquisition of modern innovative technologies, R&D, and testing laboratories to facilitate major industrial clusters in Pakistan. The program entails 10 major interventions in three broad industrial sectors, which are construction, engineering, and textile. The program is implemented across different cities to bridge the gap between technology and innovation.

National Science, Technology and Innovation Policy 2021 - Draft

The main focus of the policy is on ST&I planning and management structure, HR development, indigenous technology development, technology transfer and creation of absorptive capacity, and international cooperation as well as identify R&D thrust areas.

ST&I 2021 policy focuses on the following major objectives:

- Enhancing the role of STI in the societal development
- Adopting 21st century approach to STI governance and management

- Invigorating human capital for driving innovation
- Transforming knowledge into product
- Enhancing technology-based innovation and entrepreneurship
- Focusing on emerging and frontier technologies
- Revitalizing science diplomacy
- Ensuring policy implementation

Ignite National Technology Fund (Ignite)

Ignite (formerly National ICT R&D Fund) is a nonprofit company owned by the government and administered by the Ministry of Information Technology and Telecommunication. It provides grants to start-ups and innovative projects that utilize the fourth industrial wave technology to solve local problems and target global opportunities in health, education, energy, agriculture, telecom, finance, and other verticals.

Some of its features include:

- Established a network of incubators across Pakistan to support start-ups and engage them with investors and corporations. Ignite has established National Incubation Centers (NICs) at five major cities across Pakistan
- Launched Digiskills program to prepare one million people for future technologies
- Seek to inform professionals, media, students, corporations, and policy makers about the challenges and threats posed by the new economy and the importance of innovation with outreach activities
- Introduced the flagship HRD initiative in the Prime Minister's National ICT Scholarship Program
- Implemented a range of projects in innovation technologies and ideas

Achievements:

- Launch of SEED Fund that saw a total of 60 technical proposals worth PKR1.7 billion from academia, industry, and start-ups. The proposal acceptance rate was at 19% and the SEED fund focused on the fourth industrial wave technology and provided a funding of PKR192 million
- Orbit: Bringing Augmented Reality to Classrooms, where its objective is to introduce augmented reality (AR) into classrooms and make the teaching and learning process three-dimensional, sparking creativity in children, and improving their understanding. During Orbit's pilot, one-third reduction in teaching time was observed and 80% of the students in class showed an improvement in grades
- Pakistan's first portable kidney dialysis kit
- Automating international remittances and customer records with blockchain
- Software-defined radios for 5G networks

- Servup, a comprehensive digital marketplace solution
- Online shopping for eastern wear using image search
- Bakhabar Kissan, which is revolutionizing Pakistan's agricultural landscape
- National innovation incubators that are located in Lahore, Islamabad, Peshawar, Karachi, and Quetta

Other Projects

- **National Skills Strategy (NSS)** - A key policy document prepared by the National Vocational and Technical Training Commission (NAVTTC) to revamp Pakistan's TVET sector to make a just, prosperous, and industrialized country by year 2030
- **Draft Industrial Technology Acquisition Policy (ITAP)** - TUSDEC developed the "Draft Industrial Technology Acquisition Policy" to benchmark, acquire, assimilate, and improve the technology used in various industrial sectors across all major clusters of Pakistan
- **Smart Cities** - A government initiative to link development in cities with IoT to cater to security needs
- **Electronic government initiative** - An electronic platform for government registries and document acquisitions
- **China-Pakistan Economic Corridor (CPEC)** – China President Xi Jinping in his speech in 2017 stated that "we should pursue innovation driven development and intensify co-operation in frontier areas, such as digital economy, artificial intelligence (AI), nanotechnology and quantum computing, and advance the development of big data, cloud computing and smart cities so as to turn them into a digital silk road of the 21st century"
- **Innovator Seed Fund (ISF)** - An initiative under HEDP that aims at engaging entrepreneurs and upcoming aspirants who want to convert their business ideas into action

Highlights of Achievements

Based on good initiatives, Pakistan has achieved encouraging outcomes with various initiatives:

- Hatch 8 - An innovation incubator
- Cube 8 - State-of-the-art innovation incubator
- Excelerate - A program for late-stage start-ups that have built something impressive. Conducted Pakistan Innovation Forum from 2014 to 2017
- Creativity, Science, and Innovation (CSI) Labs - Innovative labs for robotics and STEM Skills to youth
- Development Innovation Lab - Innovation in collaboration with Singapore in Pakistan
- Tecnovation for girls
- PIF labs

- Women transport challenge
- NSPAIT - Knowledge-based economy initiative
- IDACs - State-of-the-art centers supporting Industry 4.0 vision in Lahore, Karachi, and Sialkot
- Centre for Additive Manufacturing and Designing Software in Multan, Peshawar, and Quetta
- Technology acquisition of modern machinery - Support to different industrial sectors, including construction, textile, and light engineering
- HR skilled education programs - Trainings on innovative trades, NAVTTC, PSDF, BBSYDP, NRSP, NPGP, GIZ, UNDP, etc.
- Footwear cluster development through CAD/CAM and CNC machining - State-of-the-art services in footwear designing and manufacturing
- State-of-the-art engineering support centers in Hyderabad, Lasbela, and Peshawar, supporting engineering industry through different engineering services
- High-tech Special Economic Zone (SEZ)
- NSTP pilot - newest addition to NUST's growing portfolio
- SEED Fund - Supporting innovative ideas for youth and fresh start-ups
- Orbit - Bringing augmented reality to classrooms
- Pakistan's first portable kidney dialysis kit
- Automating international remittances and customer records with blockchain
- Software-defined radios for 5G Networks
- Servup - a comprehensive digital marketplace solution
- Online shopping for eastern wear using image search
- Bakhabar Kissan - revolutionizing Pakistan's agricultural landscape
- National innovation incubators in Lahore, Islamabad, Peshawar, Karachi, and Quetta

Barriers in Pakistan's NIS

The major barriers that are identified in Pakistan's NIS can be concluded as follows:

- Lack of understanding of universities' real purpose
- Slow adaptation of universities' new roles

- Producing more job seekers
- Only balancing the research budget
- Increasing quantity, not quality of doctorate students
- Inadaptability of fresh PhD graduates
- Lack of multidisciplinary knowledge
- Misconception about "agriculture-based knowledge economy"
- Pakistan as a knowledge-based economy
- Pakistan as an agriculture-based economy
- Lack of understanding of the innovation concept
- Lack of trust among actors
- Bureaucracy
- Lack of funds
- Outdated innovation that affects performance of faculty, students, and management of HEIs and language barrier
- Slow intellectual property rights' process

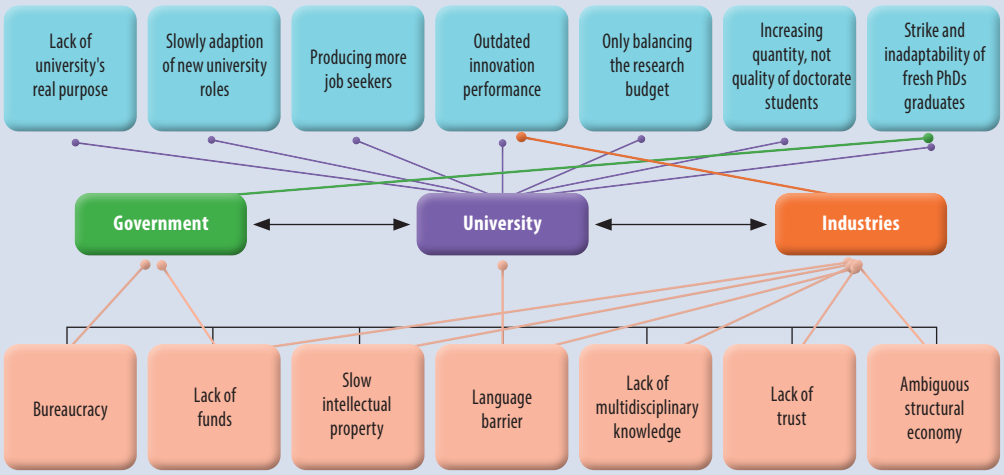
Figure 2.16 further illustrates the barriers to Pakistan's NIS.

There are also common problems of NIS in developing countries, including Pakistan, that include:

- Lack of networks in S&T institutions, such as universities, research institutes, and standards institutions
- Isolation of these institutions from the productive sectors of the economy
- Inadequate level of coordination between the main areas of public policy, such as fiscal and monetary, foreign investment, intellectual property, competition, trade, agricultural and industrial development, environment, health, etc., that may be interrelated with investment in S&T development
- Insufficient coordination between S&T policies at the national, regional, and community levels
- Lack of consultation with and participation of all main actors, government agencies, business, academia, S&T institutions, consumers, labor, and civic groups, in the formulation and implementation of S&T and innovation policies

FIGURE 2.16

INTERRELATIONS AMONG BARRIERS TO PAKISTAN'S NIS



Source: Barriers of NIS in Pakistan: Volume 15, Issue 4, 2021.

Incentives for Innovation in Pakistan

Incentives for Patent Filing

i) Higher Education Commission (HEC), Islamabad

- Free evaluation of invention to explore the patentability of the invention
- Payment of patent application and patent attorney's fee

ii) Pakistan Council of Scientific and Industrial Research (PCSIR)

- Free technical facilitation on patent search and legal consultancy to ensure protection
- Full payment of fee of 100 local application filings and five foreign application filings

iii) Pakistan Science Foundation (PSF) and Pakistan Scientific & Technological Information Center (PASTIC), Islamabad

- Award for inventions and innovations
- Patent search service
- Supply of copies of patents
- Facilitation in filing of patent applications

iv) Center for Innovation and Entrepreneurship (CIE) at NUST

- Technical advice on facilitation of patent, trademark, and copyright filing
- Promotion of R&D
- Patent helplines for guidance of researchers' community

v) Intellectual Property Organization of Pakistan (IPO Pakistan)

- Outreach program for linking and leveraging internal and external constituencies
- Patent helplines for guidance of researchers, inventors, and innovators

vi) Small & Medium Enterprise Development Authority (SMEDA), Lahore

- Free service at patent helpline

Other Incentives on ICT

Various incentives are being granted to the sector including:

- Establishment of 15 software technology parks
- Zero income tax on IT and IT-enabled services export
- Zero income tax on Pakistan Software Export Board-registered IT start-ups
- Tax holidays for venture capital firms till 2024

DigiSkills Incentives in Pakistan (IT sector)

- An extension of the tax holiday on IT exports till 2025 (which would have otherwise expired in 2019)
- 5% cash rewards on exports
- A reduction in the federal sales tax (GST) on IT and ITes
- Building of SEZs for the tech sector and commercial loans for tech companies at preferential rates

Fiscal Incentives, Monetary Incentives, and Ecosystem

TABLE 2.5

INCENTIVES FOR PAKISTAN

*Fiscal Incentives	Monetary Incentives	Ecosystem
• Exemption from property tax • Exemption from all taxes under the Income Tax Ordinance, 2001 • Exemption from Federal Sales Tax under the Sales Tax Act, 1990 • Exemption from tax on Import of Capital Goods **Exemptions are valid for the period of 10 years from the date of issuance of license.* **Incentives as provided under the Special Technology Zones Authority Act, 2021.*	• Eligible for special forex currency account • Fully repatriable investment, profits and dividends • All legitimate payments abroad allowed without any limitation • Ease of opening and maintaining Forex accounts	• Human capital development • Job creation • R&D • Accelerated economic growth

Special Technology Zones Authority (STZA)

STZA will build Special Technology Zones (STZs) all over Pakistan and offer special incentives to get investors, builders, and technology companies to work with the government. This will help both local and international companies in the STZs through a single point of contact. Further, the authority plans to build knowledge ecosystems that will be able to take advantage of Pakistan's tech potential and put the country on the path to an entrepreneurial, innovative, and tech-driven future for shared prosperity and growth for all.

Focus Innovation Sectors in Pakistan

TABLE 2.6

SECTORAL INCENTIVES FOR PAKISTAN

Sector	Innovation
ICT	• Development of Digital Pakistan Policy • Export favored through reduction in taxes • Industry 4.0 vision • Development of tech SEZs • Establish a framework for setting-up incubation centers in provincial capitals and major secondary cities • Mobile wallet channels • Internet banking • Promote the use of technology in education, health, agriculture, and other key socioeconomic sectors • Enabling an environment where payment service providers (PSP) and payment service operators (PSO) can operate and establish an effective e-commerce setup • Development of IT Zones and Software Technology Parks • Open digitization for shared services, including cloud technologies, to achieve synergies and economies of scale • Support standardization efforts, maximize reusability, create synergies, and deliver cost effectiveness • Ensuring female adults and children have equal access to ICT to reduce inequalities and support gender equality. Initiate specific ICT for girls' programs by imparting quality trainings • Promote domestic software market and utilize the Pakistani diaspora in the global markets

Sector	Innovation
Energy	• Establishment of renewable power generation plants in Pakistan - solar, wind, biogas • Standardization of equipment • Testing laboratory for standardization of products • e-Energy systems • Net metering • Energy audit programs • Implementing AI mechanisms in energy • Synchronization of different power generating mechanisms with ICT technologies • Smart grid
Digital Skills	• Programs to train youth on Digiskills • Freelancing/entrepreneurship • Amazon, Daraz, and other e-commerce trainings • Social media marketing • Establishment of learning management system (LMS) • National Technology Fund for technology learning
Customer Facilitation	• e-Banking • Prime Minister Citizen portal • Different payment mechanisms • Online currency • Establishment of sale/purchase portals • Mobile facilitation of services • One-window operation • e-Services at the National Database and Registration Authority (NADRA), passport, birth certificate, death certificate, and visa services in Pakistan • e-Challan • Fees deposit online mechanism • Online bank account opening • Bakhabar Kisaan - One-stop solution for farmers • Automating international remittances and customer records with blockchain
Shopping & Retail	• Innovative applications, like Foodpanda, Cheetay, and similar, for hassle-free food ordering • Installation of bar code readers • Smart store automation with AI • Online shopping for eastern wear using image search • Online shopping facilitation through customer chat boxes and other methods • Advanced freight methods for faster shipping • Order tracking, cash on delivery (COD)
Manufacturing	• Technology-driven, knowledge-based economy • Development of programs, like NSPAIT, for construction, light engineering, and textile sectors • Establishment of Industrial Design and Automation Centers (IDAC) • Feasibility studies for electronics manufacturing facility in Pakistan • Industry 4.0 Vision • 3D-Printing/3D scanning
Education	• ICT programs • Digiskills learnings programs • Incubation centers and accelerators • Universities-industry collaborations • R&D centers at universities • Skill development programs in cutting-edge technologies • e-Learning platforms • LMS portals • Digitized learning methods for classroom teaching • 3D printing

Sector	Innovation
Tourism	• Technological innovations in hotels • Online ticket booking (Bus, train, flight) • Orange line train, Metro bus • Social media marketing and publicity of tourism spots • Using VR technology, especially for foreign tourists • Digital awareness • Encourage public transport • Car rides (Uber, Careem, In-drive) • Building eco-friendly resorts

Pakistan's Innovation Measures during the COVID-19 Pandemic

i) Ehsaas Ration Donation Coordination Platform

A key innovation is the Ehsaas Ration Donation Coordination Platform, a portal that aims to connect food donors and philanthropists to communities most in need of help. The platform extends digital services at scale and access to them is priority.

ii) Tech-driven innovation

UNDP assisted Pakistan's federal and provincial governments to strengthen response efforts, support economic recovery, conduct rapid diagnostics, and improve service delivery in the country by using behavioral and systems change, some driven by technology and others by policy and institutional measures to extend reach.

iii) Pakistan National Human Development Report (NHDR)

Innovation has been identified to help other aspects of inequality too. UNDP's NHDR on Inequality (2020), brings forward new Child and Youth development indices with the aim to add new ways of tackling inequality with further policy and institutional innovations in Pakistan. This can in turn work to insulate these groups from the damage wreaked by COVID-19 and help with faster recovery.

iv) Development of Online Platforms

During the COVID-19 pandemic, innovation methods have been developed, including online platforms, for shopping, trade, traveling, and others. Following are the innovations evolved during the pandemic in Pakistan:

- Use of technology in education, health, agriculture, and other key socioeconomic sectors
- e-Banking portal
- Mobile facilitation of services
- e-services at NADRA, passport, birth certificate, death certificate, and visa services in Pakistan
- e-Challan
- Fees deposit online mechanism

- Online bank account opening
- Innovative applications, like Foodpanda and Cheetay, for hassle-free food ordering
- Online shopping for eastern wear using image search
- Advanced freight methods for faster shipping
- Order tracking, COD
- e-Learning platforms
- LMS portals
- Online ticket booking (Bus, train, flight)
- Car rides (Uber, Careem, Indrive)

CASE STUDY - THEMATIC DEEP DIVE: THE INCREASED USE OF TECHNOLOGY FOR LEARNING IN PAKISTAN DURING THE COVID-19 PANDEMIC

The COVID-19 pandemic has demonstrated how government and the private education technology (EdTech) sector can combine their efforts and innovate quickly. Evidence suggests that the education response to COVID-19 has been purposeful and reactive. Communicating a long-term vision could reduce systemwide uncertainty and anxieties on several issues, such as class progression and examinations. Attention also needs to focus particularly on addressing, among other things, important language challenges, to see if the availability in more local languages would increase reach and impact.

The EdTech response to COVID-19 in Pakistan has raised some key issues that, if addressed, would significantly enhance the reach and quality of the learning response.

i) **A national/provincial coordination of the EdTech approach and content** - The devolved education powers make it difficult, but not impossible, to have a coordinated approach to EdTech. Lack of a coordinated approach means a lack of alignment, accountability, and governance. Lesson sharing across provinces could drive equitable improvement.

ii) **National coordination would also lead to a common approach to ensuring the most marginalized are not left out** - There are several EdTech companies that focus on specific marginalized groups in Pakistan. But without a coherent overarching framework and continuity plan, marginalized groups risk being isolated and are dependent on ad hoc levels of interest and investment.

iii) **The rapid curation of content and products resulted in standalone good quality products** - However, as one government official put it, there were many "small pockets of innovation which came out of the response, such as the use of YouTube channels, WhatsApp, etc, but they were not cohesive efforts". Private companies also recognized this disconnect in saying "the problem is without the interactivity, assessment and teacher participation, the product is not able to maintain itself".

iv) **Learning should be driving EdTech, not the other way around** - While the national curriculum framework does include the integration of ICT in teaching and learning, it is not clear how this is implemented provincially as there does not appear to be a framework that supports continuity in the digital approach. This has resulted in EdTech companies approaching the government to use their product. While this has been extremely useful during the initial COVID-19 response, there is now the need for those responsible for curriculum and training to drive discussions with EdTech partners, based on the need of schools and learners on which solution would be most appropriate to drive learning outcomes. While there are many very useful start-ups and EdTech companies in Pakistan, they often can't or don't, and perhaps shouldn't take their products to scale. Their solutions will need to be taken forward in partnership with the government, so that scalability is factored into design from its inception, and the government has appropriate regulatory oversight of the work of such partners in achieving the crucial public good of education for all.

v) **Insufficient involvement of students, teachers, and parents** - Little training appears to have been offered to teachers and parents in engaging with the new content and platforms, and the digital readiness of students and teachers to take up online content has not been fully assessed and supported. It appears the capacity to use devices and access the Internet has been largely taken for granted, where in many communities, especially the poorest and most disadvantaged, individuals may never have had the opportunity to interact with a smartphone, a tablet, or a computer. Further, people who are illiterate and uneducated, live completely outside of modernity, technology, and the digital world. Providing such populations with internet access and devices simply will not be enough, and capacity development efforts will need to start at the very beginning and incorporated in planning and costing. In addition, even for teachers and parents with some familiarity with digital functions and content, they nonetheless need support in their key roles, or risk lack of understanding and frustration.

MEASURES TO ENHANCE SKILLS AND SKILL DEVELOPMENT AS NATIONAL AGENDA

As a developing country, Pakistan has taken the following measures to enhance skills and skill development as national agenda:

- Establishment of National R&D and testing laboratories
- Skills mapping and industrial-academia collaboration for skill development courses
- National technology and skill development plans
- Facilitating entrepreneurship and knowledge diffusion
- ST&I and education policy
- Establishment of skill development/on-job training centers in industrial and cutting-edge technologies
- Implementation of knowledge-economy initiatives
- Development of skill development strategy
- Implementation of regulatory/institutional mechanisms
- Innovation platforms and competitions

- National innovation fund
- Establishment of R&D organizations, such as Pakistan Innovation Foundation, IGNITE, and Innovation Pakistan

Table 2.7 highlights Pakistan's enhancing innovation in reaching its objective to measure up in Industry 4.0.

TABLE 2.7

PAKISTAN'S ENHANCING INNOVATION

Islamic Republic of Pakistan
• ST&I policy 2021
• Knowledge-economy transformation
• Enhancing role of STI in the societal development
• Incentives for green economic development
• Invigorating human capital for driving innovation
• Transforming knowledge into product technology-based innovation & entrepreneurship
• Competition and innovative skill development
• Industry 4.0
• Ensuring policy implementation
• Joint ventures - industry and academia collaboration
• Tax incentives for policy beneficiaries
• Policy oversight implementation mechanism

Commonalities between Pakistan and Other APO Members

After extensive analysis of various policy documents of APO members (developed and developing), most of the innovation policies and ST&I documents reveal two broad factors - technology and R&D.

However, the following commonalities are identified in successful NIS for APO members:

- S&T plans and policies
- Investment in R&D
- Fostering skill development as national agenda
- Establishment of high-tech industries
- Collaboration between industry and academia
- Effective institutional and regulatory framework
- Enhancing strategic international alliances
- Strengthening education and training systems

CONCLUSIONS AND RECOMMENDATIONS

Based on Pakistan's recent developments of innovations and after reviewing the evolution of other APO members, the following are the conclusions and recommendations to move forward in developing the NIS.

i) Establishment of R&D institutions and sufficient R&D fund to finance the innovation activities at micro and macro levels.

ii) Establishing incubation centers for technology and industrial development, and attracting the best talents from market. This may include the small programs of innovation and entrepreneurship at schools, colleges, universities, or even cross-country levels.

iii) Development of innovation agencies/mechanisms to regulate the innovation activities. This could be the existing government institutions, in collaboration with the private sector, academia, and SMEs.

iv) Ensure stable macroeconomic and framework conditions to underpin the entrepreneurial business environment. Policy design in areas, such as competition, regulatory framework, tax system, labor markets, financial markets, and bankruptcy laws should take into account of the way these areas impinge on SMEs and innovation in knowledge-based economies.

v) Ensure the reduction and simplification of administrative regulations and costs which fall disproportionately on SMEs. Take account of SMEs' views during the regulatory process; require regulatory agencies to prepare Small Business Impact Statements; establish one-stop shops for regulatory information and transactions; and promote the use of e-government tools.

vi) Promote an entrepreneurial society and entrepreneurial culture, in particular, through education and training. Integrate entrepreneurship at all levels of the formal education system and ensure access to information, skills, and expertise relating to entrepreneurship via "lifelong learning" programs for the adult population. Promote the diffusion of training programs by stimulating the private market's supply of such services and providing hands-on focused courses.

vii) Integrate the local development dimension into the promotion of entrepreneurship. The roles of subnational authorities in the promotion of entrepreneurship are of paramount importance and should be defined and coordinated with central governments, as appropriate for the country.

viii) Ensure that programs in support of SMEs and entrepreneurship are realistic in terms of cost and are designed to deliver measurable results. An evaluation culture should be developed to ensure that programs are systematically monitored and assessed for their performance in achieving objectives and for their cost-effectiveness.

ix) Strengthen the factual and analytical basis for policymaking so that policy makers can take decisions in an informed manner based on empirical evidence. A strengthened statistical base will permit cross-country comparative analysis and policy-relevant longitudinal studies. An internationally comparable set of indicators should be developed for monitoring the level of entrepreneurial activity and the entrepreneurial environment in each country.

CHAPTER 3

PHILIPPINES

INTRODUCTION

On 11 March 2020, the World Health Organization (WHO) declared the COVID-19 outbreak as a global pandemic. To stop the disease from spreading further, the Philippine government raised the COVID-19 alert system to the maximum Code Red Sublevel 2 on 12 March 2020, as recommended by the Inter-Agency Task Force on the Emerging Infectious Diseases (IATF-EID) (Philippine Information Agency 2020). This declaration imposed stringent social distancing measures in the National Capital Region (NCR) for 30 days, including the suspension of classes, public offices, and mass gatherings as well as the adoption of flexible work arrangements in the private sector and community quarantine protocols in selected affected areas. Domestic air, land, and sea travel to and from NCR were suspended 48 hours after the issuance of the declaration although public transport systems remained operational. On 16 March 2020, the Philippine government declared an "enhanced" community quarantine, which extended the scope of the initial declaration from NCR to the entirety of Luzon Island (Luna 2020) until 12 April and this was extended further to the end of April (CNN Philippines 2020). By 29 March 2020, the WHO reported a total of 361,457 confirmed cases and 21,430 deaths across 60 countries and territories with 57.8% and 65.3% of these confirmed cases and deaths, respectively, recorded in the previous six days[1]. A series of community quarantines with reimpositions and liftings occurred from 2020 to 2021.

The COVID-19 pandemic sent shockwaves throughout the world. The WEF recognized that the public was coping with not one, but two pandemics: the first being viral and the other being financial anxiety resulting from economies having been forced to a standstill (Lacina 2020). The ADB (2020a) reported that global losses could possibly range from USD2.0 trillion to USD4.1 trillion, or roughly 2.3%–4.8% of global GDP due to the pandemic. Several organizations also suggested that progress in the fight against poverty could be reversed. According to a study of the United Nations University's World Institute for Development Economics, half a billion people in developing countries were pushed into extreme poverty (i.e., having income less than USD1.90 per person per day in 2011 purchasing power parity prices) setting back the clock of progress by up to 30 years (UNU-WIDER 2020). According to the ILO (2020), there will be between 9–35 million new working poor (at the higher World Bank poverty line of USD3.20 per day) in developing countries in 2020. Most will live in middle-income developing countries. A paper from International Food Policy Research Institute (IFPRI) by Vos et al. (2020) estimated that a global GDP slowdown of one percentage point would increase poverty (at the lower World Bank poverty line of USD1.90 per day) by between 14 million (1.6%) to 22 million people (3.0%).

Faced with this challenge, the Philippines relied on its current National Innovation System (NIS) to come up with new products, projects, and programs to address the challenges brought about by the adaptations to COVID-19, such as the community quarantines (lockdowns) and increase in the use of medical supplies (face masks). Despite some weaknesses, the NIS has fostered health, education, production, and mobility innovations; all of which addressed key societal problems at that time. This paper presents these innovations vis-à-vis the state of the NIS that have fostered their development.

[1] The WHO provides weekly surveillance reports on the COVID-19 pandemic, see: http://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/weekly-surveillance-report

Objectives of the Study

This paper aims to describe the NIS of the Philippines based on global and national indicators of innovation as well as policies related to innovation as documented in Philippine development plans and official documents. The paper also looks at the cases of COVID-19-related innovations that sprouted due to the pandemic and influenced by the NIS. The interaction of the policy environment and innovation activities may provide lessons on cultivating innovation activities.

Significance of the Study

Innovation is an important driver for sustaining growth and development. It is also a means of finding enduring solutions to socioeconomic and environmental challenges. Innovation is embedded in the SDGs to which countries have committed in 2015 to achieve by 2030. SDG 9 targets to "build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation" (UN 2015).

Aside from international commitment to foster innovation, external shocks also push the need to innovate. The health and economic impact strained from the COVID-19 pandemic limited resources in economies across the world. Governments, together with the private sector, in several countries and territories have resorted to innovative ways of creatively utilizing and mobilizing scarce resources. These innovations, broadly defined as a new idea or method, can be seen occurring in a number of sectors, encompassing education, entertainment, governance (finance and logistics), health, and manufacturing.

As innovations have helped sustain the activity of companies during COVID-19, it is important to review the innovation experience during this period. In addition, Google, Temasek, and Bain (2022) noted how companies innovated their processes during COVID-19 lockdowns in order to continue operations. For instance, the incidence of e-commerce and the use of digital platforms have increased at the height of the COVID-19 lockdowns. Even the government adopted process innovations in order to efficiently perform their functions despite the restrictions on mobility. There have been documented innovations from companies that were spurred by COVID-19.

As this study is an enumeration of innovations brought about by the COVID-19 response, it supports the Philippine Innovation Act by recognizing the contribution of innovation to the Philippines' COVID-19 response. It also supports the National Economic and Development Authority's (NEDA) plans[2] by identifying specific innovations that can be institutionalized and select lessons that can be learned for the Philippines' new normal.

Limitations of the Study

This study is an attempt to produce specific cases that would highlight key lessons from the innovation experience of the Philippines. It is not a comprehensive inventory of all the innovations made by the different stakeholders in the ecosystem. This paper also relies on limited research and development (R&D) and innovation indicators as data has not been collected regularly.

The impact to innovation activities that is attributable to the relevant government policies is an empirical question that still requires investigation. There are existing policies in place even before the outbreak of the pandemic that may have supported the innovations due to COVID-19. For instance, the Philippine Innovation Act, or Republic Act (RA) 11293, aims to promote a culture of strategic planning and

[2] NEDA has publicly announced that the Philippine government has begun to identify and ready policies to adjust the country's economy to the "new normal." (https://pia.gov.ph/news/articles/1038148).

[3] RA 11293 (https://www.officialgazette.gov.ph/downloads/2019/04apr/20190417-RA-11293-RRD.pdf).

innovation in the country through improving innovation governance and adopting long-term goals. The Act recognizes the richness of the country's resources and culture and the ways these can be harnessed to further innovation and entrepreneurship. Among others, it seeks to explore, promote, and protect the potential for innovation of traditional knowledge, traditional cultural expressions, and genetic resources.

The rest of this chapter is organized as follows: the section that presents innovation landscape of the Philippines while the subsequent section identifies the Philippines' innovations in relation to their response to the COVID-19. These include health innovations, productivity, governance, and mobility, among others. Lessons learned and recommendations from these innovations concludes the study.

INNOVATION LANDSCAPE IN THE PHILIPPINES

Philippine NIS

For the Philippines, the official definition of innovation is covered by the Philippine Innovation Act (PIA). According to the PIA, innovation "refers to the creation of new ideas that results in the development of new or improved policies, products, processes, or services which are then spread or transferred across the market." The PIA distinguishes various types of innovation, such as innovative goods and services, marketing innovation, and organizational innovation. The law also recognizes the need for innovation to be inclusive. Inclusive innovation refers to the "creation of new ideas that results in the development of new products, processes and services, that help improve the welfare of lower-income and marginalized groups." While PIA provides a detailed definition of innovation, it is also important to look at the state of the society within which the innovations are created and disseminated.

According to Fukugawa (2021), innovation covers new products, processes, and practices created in a society and disseminated within the society. This definition has three important implications for this study. First, it presents that innovation is not merely a technical process driven solely by scientific advancement but also a social process that depends on the receptiveness of users to the new technologies and practices. Another factor is the responsiveness of knowledge providers to social needs. Such recognition has important implications for innovation activity.

Second, the novelty element associated with innovation defined here does not necessarily mean the innovation must be new to the world. A technology that is entry-level in one society can be regarded as an innovation in another society where the technology has yet to be introduced as long as it brings new solutions to existing problems in the society.

Third, the introduction of state-of-the-art technology without considering social needs and absorptive capacity is not merely ineffective but could also be detrimental to social welfare. Ample anecdotal evidence demonstrates that the introduction of entry-level technologies could have an immense impact on living standards in developing countries. Typical examples include vaccination against diphtheria, pertussis, and tetanus; the supply of clean water; and improvement in sanitation (World Bank, 2010).

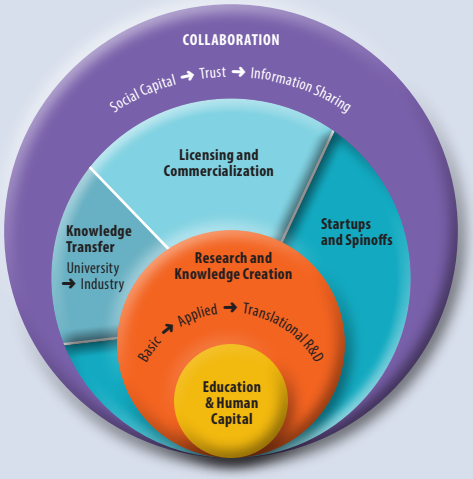
Fukugawa's definition is important for the discussion of this paper as a number of the COVID-19 innovations are not necessarily state-of-the-art but were able to respond to certain needs at the time. The impact to the society is highlighted in the case studies.

State of Philippine Innovation Environment

In presenting the innovation ecosystem of the country, this paper builds on the RTI International framework (Figure 3.1) that shows an innovation ecosystem having interrelated relationships. The following are the fundamental elements found in the framework: education and human capital development, research and knowledge creation, knowledge and technology transfer between the academe and industry, entrepreneurial environment that enables start-ups and spinoffs, and an environment for collaboration (USAID STRIDE 2020).

FIGURE 3.1

RTI INNOVATION FRAMEWORK



Source: Department of Trade and Industry (DTI) (2018).

Based on the RTI framework, several observations were identified.

- **Quality education system and a strong base of human capital** is important to facilitate research and knowledge creation (RTI 2017, as cited in DTI 2018)

- **New knowledge created must then be transferred into commercial applications.** This can be done through direct service agreements where universities provide assistance to commercial clients, commercialization through licensing of intellectual properties (IPs), and spinoffs and start-ups transitioning IPs to small firms

- **The interplay among different actors in the ecosystem need to take place in an atmosphere of collaboration**, wherein social capital, trust, and information sharing exist. Silicon Valley and northern Italy are prime examples of ecosystems with collaborative environment, wherein shared goals and meritocratic and cooperative norms of conduct combine to generate social capital (USAID STRIDE 2014)

This study will highlight these three aspects of the innovation ecosystem.

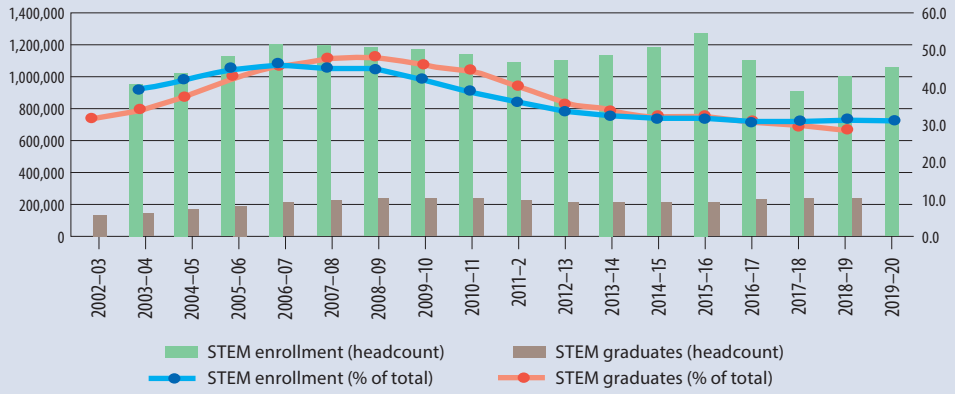
i) Quality education and strong human capital base

Development of education and human capital, particularly in science, technology, engineering, and mathematics (STEM) disciplines, is crucial in strengthening the country's innovation ecosystem.

Looking at Figure 3.2, the overall interest in STEM disciplines in the country appears inconsistent, as the total number of STEM enrollees has fluctuated since the 2000s. The percentage share of STEM in the total number of enrollees has also exhibited a decreasing trend since the late 2000s. Relative to enrollees, STEM graduates have been substantially lesser over the past two decades, albeit having a slightly increasing trend. The percentage share of STEM in the total number of graduates has also been diminishing since the late 2000s. On the positive side, the number of STEM enrollees since 2017–18 has shown a recovery.

FIGURE 3.2

PHILIPPINES' STEM ENROLLMENT AND GRADUATES

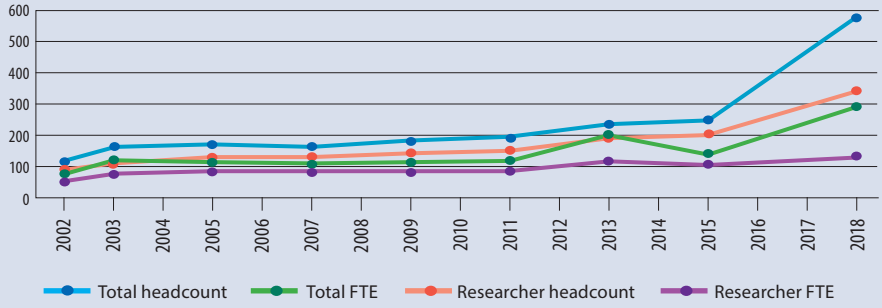


Source: Commission on Higher Education (CHED).
Note: STEM disciplines were based on the classification of Albert et al. (2020).

Philippine R&D personnel indicators showed slow improvements since early 2000s but full-time equivalent (FTE) measures indicate the need for more personnel focused on R&D. R&D personnel (per million inhabitants) in the Philippines had little improvements in early 2000s, but markedly increased in the 2015–18 period (Figure 3.3). While a significant number of researchers suggests

FIGURE 3.3

R&D PERSONNEL (PER MILLION INHABITANTS) IN 2002–18



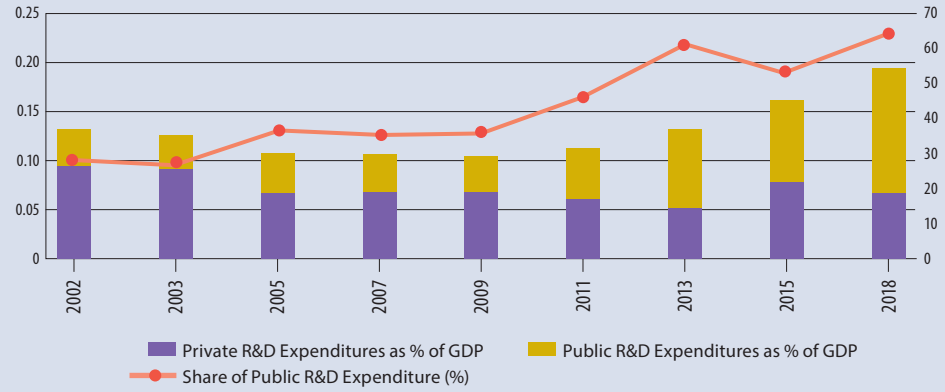
Source: 2018 Research and Development Survey Report, Department of Science and Technology (DOST).
Note: FTE - Full-time equivalent.

that R&D personnel are primarily tasked to conduct research activities, the FTE[4] figures reveal that many R&D workers in the country perform tasks other than R&D, such as administrative work. The increase in the gap between the headcount and FTE figures during the 2015–18 suggests that R&D workers have not been focused on conducting R&D activities. This is more alarming among researchers, as the FTE in 2018 (132) was less than half than the researcher headcount (336).

R&D spending in the Philippines has gradually improved during the previous decade. Despite the dip in the percentage share of R&D expenditures to GDP during the 2000s, it exhibited a greater recovery in the succeeding decade, peaking at 0.19% in 2018 (Figure 3.4). However, as mentioned, the country's R&D expenditures are still well below the 1% recommendation set by UNESCO. It is also important to note that the share of the public sector in R&D expenditures increased during the last two decades. The trend was more noticeable during the 2010s, as the share grew from 35.7% in 2009 to 64.5% in 2018. The increasing share of public R&D expenditures might reflect the government's proactive efforts to strengthen the country's innovation ecosystem in recent years[5].

FIGURE 3.4

R&D EXPENDITURES IN 2002–18



Source: 2018 Research and Development Survey Report, DOST.
Note: Phillipines GDP.

ii) New knowledge must be transferred to commercial applications

Intellectual property rights (IPR) activities, such as filings and registrations, are indicators of translating knowledge into innovative products and services. Figure 3.5 shows that patent applications in the Philippines have steadily increased since the 2010s. From 3,122 in 2012, total patent filings rose to 4,598 in 2021. Meanwhile, patent grants in the country have fluctuated during the period; with the exception of 2016 (4,095) and 2018 (3,543), the total grants for each year were less than 2,500. Nonresidents have comprised the bulk of total patent applications, with percentage shares greater than 80%; consequently, they have dominated the patent grants in the country. The significant presence of nonresidents in patent activities could be crucial in facilitating innovative activities in the country, as nonresident patents have been perceived to be a channel of knowledge and technology transfers for developing countries (Hu, et al., 2016).

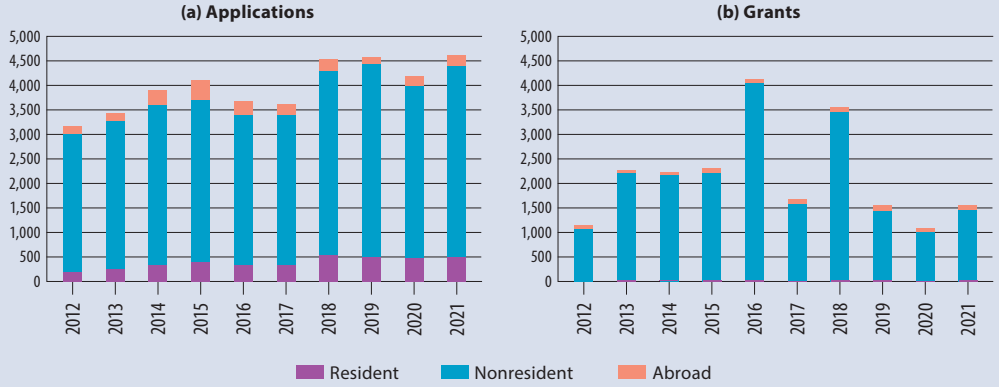
4 FTE of R&D personnel is based on the ratio of working hours allotted to R&D activities divided by the total number of working hours (OECD 2015).

5 The 2016–2022 midterm update of the Philippine development plan has targeted to increase R&D expenditure as a proportion of GDP to 0.5% by 2022 from the 2016 baseline figure of 0.16%. It is projected that the 0.5% target will be achieved by 2025 (NEDA 2022).

It is interesting to observe that, despite being marginal, the percentage share of resident applications has slowly increased since the previous decade. From 5.2% in 2012, the share of local filings increased to around 11% during the latter part of the decade. This trend could be a positive sign in relation to the country's pursuit for technological catch-up. During the ROK's catch-up phase in the mid-1980s to mid-1990s, domestic patent filings increased substantially (despite having a smaller share), mainly due to local firms manifesting improvements in their respective technological capabilities (Lee 2009). By the start of the 1990s, patent filings in the ROK were already dominated by local firms. This pattern was also observed in the respective catch-up phases of Japan, the ROC, and PR China (Lee 2009). Thus it would be crucial to sustain and accelerate the growing share of domestic patent filings in the country.

FIGURE 3.5

PHILIPPINES' PATENT APPLICATIONS AND GRANTS IN 2012–21



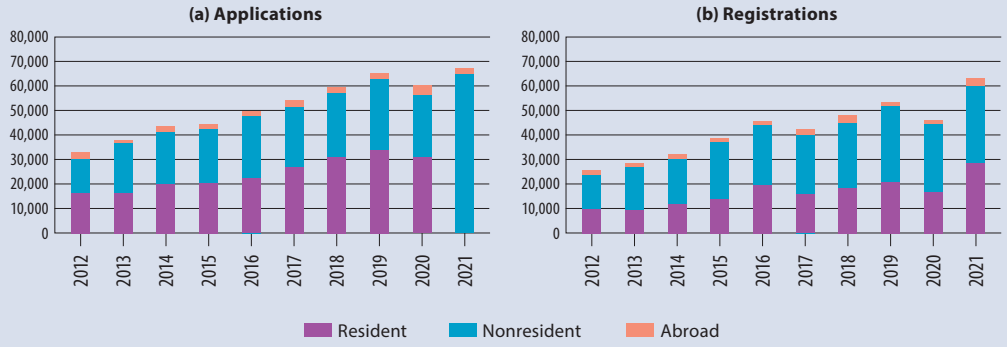
Source: World Intellectual Property Organization (WIPO).

While patents have been the IPR form most commonly associated with innovation, trademarks suggest an alternative path toward firms' technological development (Kang, et al., 2020). Gangjee (2021) posited that trademarks could indirectly facilitate firm innovation through the feedback cycle, establishing a strong brand that could result in significant returns on investments in innovation activities. Trademarks could also indirectly protect non-patentable innovations, such as service and marketing innovations. Thus it would be worthwhile to assess trademark activities (as well as other IPR forms) in relation to the country's innovation landscape.

Trademark activities seem to be more prominent in the country than patents, as trademark applications and registrations exhibit greater numbers than patent applications and grants. Trademark filings in the Philippines have steadily increased since the 2010s, from 33,365 in 2012 to 67,549 in 2021. Compared to patent filings, domestic filings accounted for much higher shares in trademark applications. Residents have actually covered more than half of total trademark applications since 2018. Trademark registrations have also shown gradual increases since 2012. Throughout the 2010s, registration of foreign trademarks constituted more than half of total registrations in the country (Figure 3.6).

FIGURE 3.6

TRADEMARK APPLICATIONS AND REGISTRATIONS IN THE PHILIPPINES IN 2012–2021



Source: WIPO.

iii) Interplay among different actors

Collaboration and linkages among actors have increased but needs to be sustained. Based on the Global Innovation Index (GII) indicators on innovation linkages, the Philippines was able to improve linkages among stakeholders, but they are not sustained as dips in the indicators are observed immediately after years of strong performance. University-industry linkages, for instance, steadily increased from 2013–16, but this dropped significantly in 2017 with scores almost returning to 2013 levels. The score has steadily increased to 57.5 in 2020, but this dropped again significantly the following year.

TABLE 3.1

INDICATORS OF INNOVATION LINKAGES IN 2013–22

	Innovation Linkages	University-industry R&D Collaboration (Score 0-100)	State of Cluster Development and Depth (Score 0-100)	GERD Financed by Abroad, (% GDP)	Joint Venture/ Strategic Alliance Deals (bn PPP USD GDP)	Patent Families/ bn PPP USD GDP
2013	21.4	40.9	50.4	6.4	22.7	1.4
2014	26.2	43	50.5	5.2	25.7	3.2
2015	25.4	46.6	50.5	5	15.7	4.3
2016	23.7	46.6	49.6	2.4	14.9	0.7
2017	21.2	41.4	45.7	3.1	9.1	0.6
2018	21.9	42.1	46.6	3.5	10.7	0.4
2019	22.6	57.5	50	3.5	15.8	0.4
2020	21.3	57.5	48.1	0.5	18.0	0.3
2021	17.1	43.7	42.3	0.4	11.9	0.4
2022	20.5	44.4	46.6	0.5	10.4	0.5

Source: Global Innovation Indicators from 2013–22.

Fluctuating patterns can also be observed for other indicators related to linkages (Table 3.1), such as state of cluster development and depth, gross expenditure on R&D (GERD) financed by abroad, and joint venture/strategic alliance deals. Such patterns reveal the capacity of the country to build linkages

among stakeholders, such as the private sector and universities, including international partners. However, there needs to be a stronger effort to maintain these relationships to sustain the positive trajectory of the indicators.

The country has also exhibited strong performance in ICT-related indicators of innovation. ICT score for the country has been growing steadily, increasing to 68.9 from an initial score of 28.6 in 2013. ICT access and use are also increasing with use increasing much faster than access. This may reveal the need for a stronger and more targeted government infrastructure program to help increase ICT access. Meanwhile, ICT and businesses have been fluctuating with the score declining from its 2013 figure of 63.6 to 60.3 in 2016. On a positive note, the indicator has rebounded to 68.9 in 2019 which is an indication of more ICT-related businesses being created in recent years (Table 3.2).

TABLE 3.2

ICT-RELATED INDICATORS OF INNOVATION

Indicator	Subindicator Type	2013	2014	2015	2016	2017	2018	2019	2020
Information and communication technologies (ICTs)	Score (0–100)	28.6	29.9	42.7	46.1	50.6	52.9	68.5	68.9
ICT access	Index	3.3	3.4	4.3	4.4	4.7	4.9	4.7	4.9
ICT use	Index	1.0	1.5	2.3	3.5	2.9	3.7	4.5	4.5
ICTs and business model creation	Score (0–100)	63.6	63.3	60.5	60.3	60.9	60.8	68.9	–
ICTs and organizational model creation	Score (0–100)	–	63.7	60.3	57.1	54.8	53.6	61.7	61.7

Source: GII, 2013–20.

Benchmarking Philippine Innovation Performance

Since 2017, the Philippines has slowly improved its position as an emerging innovation hub. According to GII, the country's rank improved from 73rd in 2017 to 50th in 2020.

In terms of the GII main pillars, the country performed well (relative to its overall ranking) in business sophistication (39th), knowledge and technology outputs (41st), and creative outputs (58th). In contrast, institutions (90th), human capital and research (86th), infrastructure (81st), and market sophistication (78th) were noted as the weaker areas in the country's innovation ecosystem. Among the subpillars, the country was among the global leaders in terms of trade diversification, knowledge absorption, and knowledge diffusion. Meanwhile, its rankings in regulatory environment, education, and credit were among the lowest in the world.

Despite its drop in these rankings, the Philippines is still noted as a potential driver of transformation in the global landscape. For the fourth straight year, the country was included in the GII innovation achievers - economies that perform above expectation based on their respective levels of development.

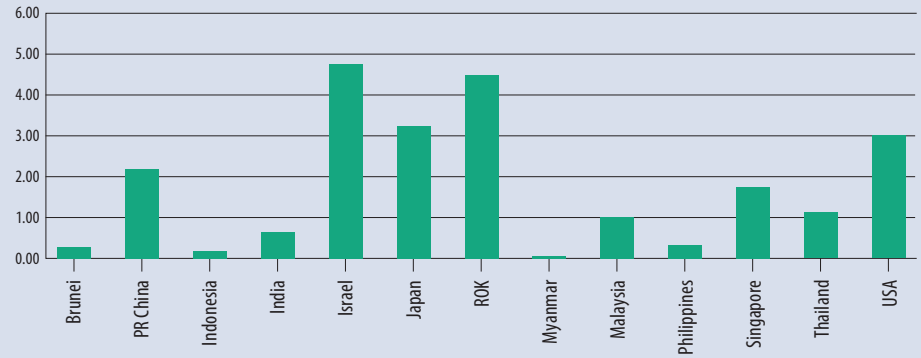
While its improvement in GII rankings indicates significant progress in the Philippine innovation landscape, the country has not intensified its engagement in R&D. Figure 3.7 shows R&D expenditures as percentage of GDP in 2018. The country's percentage of 0.32% is well below the UNESCO's recommendation of 1%. Moreover, the Philippines lags behind its regional neighbors, as they were able to exceed the 1% threshold.

The Philippines is also yet to create a critical mass of human capital in R&D. In 2018, the country R&D personnel stood at 173.6 (per million people). This is noticeably lower than the figures exhibited by

some of its ASEAN neighbors. For instance, Thailand had 1,758.1 researchers per million people, which is more than 10 times the number of the Philippines. Meanwhile, the ROK and Singapore have been at the forefront of producing R&D personnel. The 7,980.4 (per million people) R&D researchers produced by the ROK was the highest in the world while Singapore was in the top five producers (Figure 3.8).

FIGURE 3.7

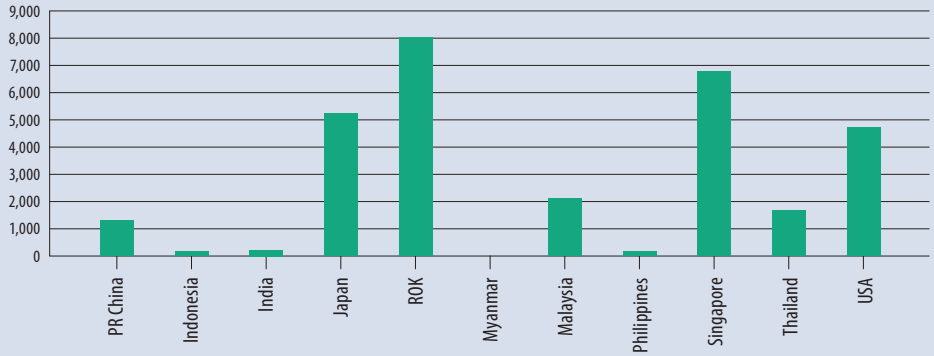
R&D EXPENDITURE (% OF GDP) IN SELECTED COUNTRIES IN 2018



Source: World Development Indicators, World Bank.

FIGURE 3.8

RESEARCHERS IN R&D (PER MILLION PEOPLE) IN SELECTED COUNTRIES IN 2018



Source: World Development Indicators, World Bank.

This was the state of innovation activity occurring in the Philippines when the COVID-19 pandemic broke out. The innovation policies that may have contributed to the innovative activities that happened as part of COVID-19 response are explored next.

Philippine Innovation Policies

Innovation policy during the Aquino II Administration (2010–16), defined under the Philippine Development Plan (PDP) 2011–16, aims to achieve globally competitive and innovative industries and

sectors (NEDA). The PDP 2011–16 identified four strategies to improve local industries by leveraging on existing technologies and developing R&D capacity:

- Broadening the access of small-scale entrepreneurs to modern, cost-effective, and appropriate technologies
- Enabling local industries to innovate by providing publicly funded, state-of-the-art facilities to be used in design, prototyping, and product development
- Leveraging ICT as means of providing more economic opportunities
- Strengthening networks to foster cooperation and information exchange among Filipino scientists and engineers to support social and technological innovations at the community level (NEDA, n.d.)

Aligning with the policies in the PDP 2011–16, the DOST developed the Harmonized National R&D 2013–2020. The DOST also updated the National Science and Technology Plan 2002–20 to strengthen the long-term plan.

Leveraging the use of science and technology also included innovation policies geared toward poverty reduction and empowerment of the poor and the vulnerable, rapid, inclusive and sustained economic growth, and integrity of the environment and climate change adaptation and mitigation. Aligning with the strategies put forward, government facilities were developed to support local industries (DOST, 2014):

- Advanced Device and Materials Testing Laboratory for semiconductor and electronics industry
- Die and Mold Solutions Center for the metals industry
- Electron Beam Irradiation Facility at the Philippine Nuclear Research Institute for the needs of industries in the spices and dehydrated foods, cosmetics, packaging, and medical devices sectors

Under the Duterte administration (2016–22), Science, Technology and Innovation (STI) was seen as a pillar for strategic growth, a high-trust and resilient society, and a globally competitive knowledge economy. The PDP 2017–22 utilizes a two-pronged approach: (i) promote and accelerate the use of technology and innovation in all production sectors; and (ii) boost innovation by improving the capacity to generate knowledge and strengthen collaborations across the STI ecosystem (NEDA, 2017).

The Duterte administration has also been aggressive in creating an enabling environment for STI by strengthening the regulatory framework through landmark laws and blueprints:

- Innovative Startup Act (Republic Act 11337) aims to strengthen, promote, and develop an innovative and entrepreneurial ecosystem and culture in the Philippines. Further, it focuses on providing benefits and removing constraints in order to encourage the establishment and operation of innovative new enterprises and businesses crucial to their growth and expansion. The Philippine Startup Development Program (PSDP) will be at the center of the law's implementation, together with the other benefits, such as Startup Venture Fund (SVF), Grants-in-aid, subsidies, Startup BOSS (start-up business one-stop shop), and Startup Investment Development Plan (DTI, n.d.)
- The Philippine Innovation Act (Republic Act 11293) intends to guide the country's innovation goals and is expected to make the policy environment in the country conducive for more STI efforts. The PIA creates the National Innovation Council (NIC) which is to be chaired by the president of the Republic of the Philippines and which shall steer the whole-of-government coordination and

collaboration in innovation governance. Likewise, the law also creates the National Innovation Agenda Strategy Document (NIASD) which shall set the direction of the country's innovation goals, priorities, and strategies (DTI, n.d.)

- The DTI unveiled its Inclusive Innovation Industrial Strategy (i3S) which aims to grow innovative and globally competitive manufacturing, agriculture, and services industries while strengthening their linkages in the global value chain to achieve an inclusive and sustainable growth that generates more opportunities for employment and entrepreneurship in the country. i3S is based on six strategic actions aimed at pursuing coordination with other government agencies, industry, and academe: (i) embrace Industry 4.0; (ii) promote the development of more innovative MSMEs and start-ups; (iii) integrate the production system; (iv) improve infrastructure by streamlining and automating regulatory processes; (v) upskill/reskill the workforce; and (vi) support innovation and entrepreneurship ecosystem through collaboration (DTI, n.d.)

- Launched in 2021, the eCommerce Philippines 2022 Roadmap highlights the need for financial support for innovators to expand and gain more traction. The Roadmap also advocates for the immediate utilization of the Philippine Innovative Startup Fund and facilitates the creation of the venture capital fund of the National Development Corporation (NDC) and other government financial institutions (DTI 2021)

- Artificial Intelligence Roadmap of the DTI describes the implementation, infrastructure, and investments needed to cover the four important dimensions for AI readiness, namely: (i) digitization and infrastructure; (ii) R&D; (iii) workforce development; and (iv) regulation. The above dimensions are then supported by seven measurable strategic imperatives and 42 strategic tasks. Central to the roadmap is the creation of a National Center for AI Research (NCAIR) that houses full-time scientists and research engineers, serving as nexus to AI competitiveness of the country. The roadmap also identifies R&D projects in agriculture, manufacturing, and services (DTI)

- Memorandum Order No. 61 which approves the 2022 Strategic Investment Priority Plan which highlights R&D activities; technical manufacturing and innovative products and services; and the establishment of innovation support activities

Aligned with the Duterte administration's thrust to leverage on STI, the Department of Science and Technology has implemented four programs:

- Collaborative Research and Development to Leverage Philippine Economy (CRADLE) aims to promote innovation and technology development of local enterprises and ultimately, support the growth of the Philippine Innovation ecosystem. The academe and/or R&D institutions in partnership with a Filipino company, undertakes R&D to improve the company's products, processes, and services to become more competitive in their respective industries (S4CP 2021)

- Niche Centers in the Regions for R&D Program (NICER) aims to capacitate Higher Education Institutions (HEIs) in the Philippine regions to undertake research by providing grants to improve its science and technology infrastructure

- R&D Leadership Program (RDLead) intends to engage experts to enhance the research capacities of HEIs and/or R&D Institutions

- The Business Innovation through Science and Technology (BIST) for Industry Program aims to facilitate the acquisition of local companies of vital technologies by financing the procurement of high-tech equipment and machinery, technology licenses, and/or patent rights

The current administration of President Ferdinand Marcos Jr. has signified support for investing in science and technology to boost the country's disaster risk reduction and management efforts (PNA, 2022). In line with this, the Department of Science and Technology has outlined six priority R&D areas for disaster and risk reduction management: natural and health hazards, water, energy, environment, and society, including infrastructure. Earlier this year, the National Economic Development Authority has approved the Harmonized National Research and Development Agenda 2022–28 which outlines the plan for technology adoption in the country.

COVID-19 INNOVATIONS AND THE NIS

The assessment of United States Agency for International Development—Science, Technology, Research and Innovation for Development (USAID STRIDE) (2020) of the Philippine innovation ecosystem revealed that many innovation stakeholders noted the improvements in the country's innovation during the latter part of the 2010s, which were mainly attributed to proactive government interventions. The improvements focused on industry-academe alignment and industry's increased openness to collaborate with the academe on human capital development and R&D activities. Notable developments were observed across all ecosystem elements, namely, human capital and education, research and knowledge creation, knowledge transfer, start-ups and spinoffs, and collaboration.

The findings of the study noted that the government has initiated programs, such as the Balik Scientist Act, to bring back Filipino scientists while the academe has started to work with the private sector on curriculum development. Coinciding with the growing interest in research, industry and academe have started to establish strong connections; the government, on the other hand, has made its programs and facilities available in the regions. Knowledge transfer has also been improving as government and the academe have initiated efforts to raise awareness of IPRs, with the government establishing Intellectual Property Offices (IPOs) and Knowledge and Technology Transfer Offices (KTTOs) in the country. In terms of start-ups and spinoffs, interest in entrepreneurship has noticeably increased in the country, although science and technology spinoffs are still rare, and start-ups are still constrained by regulatory barriers. Collaboration in the innovation ecosystem has improved, especially government-academe and industry-academe linkages. However, no significant improvements were observed on government-industry collaboration, and CHED has been noted to possess weak linkages with the rest of the innovation ecosystem.

The establishment of the Regional Inclusive Innovation Center (RIIC) has been one of the most crucial initiatives in strengthening the innovation ecosystem in the country. Through the collaboration of DTI, CHED, DICT (Department of Information and Communications Technology), DOST, and the USAID STRIDE, RIICs were established to create a network of innovation stakeholders and facilitate collaborative efforts among these agents, in order to stimulate innovation and research commercialization as well as generate new products, services, and business models.

As of 2019, five RIICs have been established, including Region III (Bulacan), Region V (Legazpi), Region VII (Cebu), Region X (Cagayan de Oro), and Region XI (Davao). Additional RIICS were established in Zamboanga (Region IX), Batangas (Region IVB), Tuguegarao (Region II), Iligan (Region X), and Leyte (Region VIII). A case study of the Region X and Region XI RIICs noted that the RIICs have been instrumental in establishing the regions' respective innovation ecosystems. For Region X, the Optimizing Regional Opportunities for Business Excellence Through Science Technology, and Innovation (OROBEST) RIIC established linkages among the regional innovation actors. Notable developments achieved through OROBEST include providing grants to innovation funding proposals and agility in developing new joint programs in response to emerging issues. On the other hand, the Region XI RIIC, the Innovation through Science, Technology, and Risk-resilient based Initiatives toward Knowledge Economy Davao (iSTRIKE Davao), has enabled collaboration through highly structured industry engagements, which helped raise awareness on innovation, and facilitate the assimilation of technologies among stakeholders.

Collaborations among innovation actors have also resulted in more strategic and targeted interventions, such as responding to the needs of MSMEs in scaling up their businesses (USAID STRIDE 2022).

It is with this policy environment under which the innovations adopted for COVID-19 were implemented. The cases of the innovations presented in the following paragraphs were selected because of the lessons that they can reveal on the innovation in the sector and how the innovation ecosystem has influenced them.

Health Innovations

Innovations Related to E-health and Electronic Prescriptions Reveal the Interplay between ICT-Use and Innovation Regulation

The high ICT-use of the country coupled with the high awareness and the strong need for health services have fostered the growth of telemedicine and e-health services. Supporting these innovations were the timely policies released by the health authorities that allowed the use of digital prescriptions and health certificates.

With health services in the country concentrating on combating the COVID-19 pandemic, supply of health services in the country needed to be supplemented. Other medical cases have suffered due to the limited availability of doctors and medical professionals, and the need to maintain social distancing. Also, a number of patients were apprehensive of going to hospitals for a minor check-up in the fear of being exposed to the virus. An innovative solution to this problem has been the promotion of telemedicine or e-health technologies. For example, KonsultaMD, Medifi.com, SeriousMD, and Doxy.me.

E-health provides another option to patients than physically being present in hospital-based consultations. It also reduces the number of people going to emergency rooms, allowing hospitals to concentrate on providing the necessary health services for COVID-19 patients and Persons under Investigation (PUIs). In some ways, e-health also provides additional benefits over and above traditional hospital-based consultations, such as the availability of accessing consultations 24/7 at the convenience and safety of one's own home. E-health also reduces the risk of getting infected as there is no direct physical contact with medical practitioners and patients.

In addition to e-health, the Food and Drug Authority (FDA) of the Philippines has issued FDA Circular No. 2020-007[6] that provides the guidelines for the use of electronic means for issuing prescriptions for drugs for the benefit of individuals vulnerable[7] to COVID-19. This circular requires drugstores, pharmacies, and other similar outlets to recognize the validity and effectivity of electronic prescriptions issued by licensed physicians. Further, the circular is valid only while the enhanced community quarantine is imposed and lifted upon the termination of the community quarantine.

Partners in Innovation: DOST-Supported COVID-19 Innovations

The existing linkages and strong collaboration among HEIs with high R&D capabilities gave way to DOST-supported COVID-19 innovations. The Department of Science and Technology - Philippine Council for Health Research and Development (DOST-PCHRD) has backed research and innovation supporting the Philippine response to the COVID-19 (Macan 2020). These include the locally developed detection kit, spearheaded by Dr. Raul Destura of the University of the Philippines National Institutes of Health

6 FDA Circular No. 2020-007, or the Guidelines in the implementation of the use of electronic means of prescription for drugs for the benefit of individuals vulnerable to COVID-19 (https://www.fda.gov.ph/wp-content/uploads/2020/03/FDA-Circular-No.-2020-007.pdf).

7 Individuals vulnerable to COVID-19 have been defined by the MC as senior citizens or persons with disability with chronic illness, or those with immunocompromised conditions who need to take prescription medicines and maintenance drugs.

(UP-NIH) and the research study on the efficacy of lauric acid and its derivatives against the SARS-CoV-2[8], which is in partnership with Ateneo de Manila University (AdMU).

The locally-developed GenAmplifyTM COVID-19 rRT-PCR Detection Kit is manufactured by Manila HealthTek, Inc, which is a spin-off company from University of the Philippines (Macan 2020). The detection kit aims to detect the SARS-CoV-2 with high specificity and efficiency through a one-step multiplex real-time polymerase chain reaction (PCR) platform. It can accommodate up to 120,000 tests with results being available in about two hours. A key advantage of this kit is that it costs significantly lower than imported detection kits. The Philippine FDA also recently issued a certificate of product registration for the said technology on 3 April 2020 after conducting field trials with gene sequencing from 1–10 March 2020.

To support the search for possible treatments to the virus, AdMU conducted the "in-vitro study on the efficacy of lauric acid and its derivatives against SARS-CoV-2." The project tested whether certain coconut oil components can diminish or prevent the effectivity of SARS-CoV-2, the causative virus of COVID-19. The project focuses first on the determination of the anti-viral properties of the compounds with results in further studies (Macan 2020).

In addition, two clinical trials leveraging existing natural resources abundant in the country were supported by the Philippine Council for Health Research and Development (PCHRD). These involve the use of Lagundi and Tawatawa. The clinical trial was conducted on the efficacy and safety of Lagundi (Vitex negundo) tablets/syrup (NIRPROMP formulation) with standard treatment compared to placebo with standard treatment in patients with mild COVID disease without comorbidities. This was spearheaded by Dr. Cecilia Maramba from the University of the Philippines National Institutes of Health (UP NIH). Through the clinical trial, the project team found the standard dose (600mg) of Lagundi to be as safe and efficacious as high-dose (1.2g) Lagundi. After the intervention, patients reported relief of symptoms, especially for anosmia (loss of sense of smell) and overall relief of discomfort due to other symptoms. There was no significant difference in adverse event grade and incidence between the intervention group (group who received Lagundi) and control (group who did not receive Lagundi). The research team concluded that Lagundi can be safely used for the symptomatic treatment of mild COVID-19 (PCHRD 2021).

Meanwhile, the clinical trial on the efficacy and safety of Tawatawa (Euphorbia hirta L.) extract as an adjunctive treatment for mild to moderate COVID-19 patients was spearheaded by Dr. Philip Ian Padilla from the University of the Philippines Visayas. The project aimed to determine the efficacy of standardized aqueous Euphorbia hirta L. (tawa-tawa) spray dried extract (SDE), previously developed with the support of DOST-PCHRD Tuklas Lunas® Program, as adjunctive treatment for mild to moderate cases of COVID-19. The team has completed the recruitment of patients, particularly those aged 19–55 years old without comorbidities and suspected or confirmed to have mild to moderate COVID-19. In general, COVID-19 symptoms started to disappear between days 3–5. After this period, respondents exhibited no symptoms. Patients reported an increase in appetite, better bowel movement and urination, and alleviation of cough, after the intake of "tawa-tawa" (a common plant in Philippines). Currently, the team is conducting extensive statistical analysis. Depending on the outcome of the study, the FDA registration status of the products can be reevaluated. Furthermore, the concerned agencies may issue policy recommendations on the use of these products for COVID management or treatment (PCHRD 2021).

[8] According to the WHO, SARS-CoV-2 refers to the virus severe acute respiratory syndrome coronavirus 2 whereas COVID-19 refers to the coronavirus disease that the virus causes. The WHO explains that viruses are named based on their genetic structure to facilitate the development of diagnostic tests, vaccines, and medicines while diseases are named differently to enable discussion on disease prevention, spread, transmissibility, severity, and treatment, (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it).

Governance Innovations

Use of CBMS Data for Social Amelioration and Relief Programs Reveal the Value of Investing in Data

The Community-Based Monitoring Systems (CBMS) is a data collection system designed to methodically process and integrate local government data for monitoring both micro impacts of macroeconomic shocks and multidimensional poverty (Diokno-Sicat, et al., 2020). The CBMS is a useful tool in bridging data gaps on poverty at the local level and can be used to identify eligible beneficiaries for social amelioration programs targeting the poor.

In light of the COVID-19 crisis response operations, Local Government Units (LGUs) in the Philippines with existing CBMS-Accelerated Poverty Profiling (APP) databases can process and use the data for identifying beneficiaries of relief operations. The CBMS established in the LGUs can generate the necessary disaggregated data inputs for planning and implementation at the local level of policies and programs by local governments as well as that of the national government to help cushion the impact of the crisis.

The LGU-CBMS databases can be used to quantify, identify, and conduct mapping of income and food poor households and families. It can also be used for generating list, location, and verification of poor on vulnerable households and families with at least one or a combination of, but not limited to, the following characteristics in barangays, cities, municipalities, or provinces for the implementation of social amelioration and other related safety net programs.

Research and Big Data Analysis Makes the Case for Public-private Collaboration

The De La Salle University (DLSU) is pursuing big data analytics and transportation network analysis to support traffic management during the COVID-19 pandemic. The simulation results showed relative intensities of incoming traffic to Metropolitan Manila at various entry points, which is useful to those managing the checkpoints, such as the Philippine National Police and the Armed Forces of the Philippines, in the periphery of Metropolitan Manila (Nazario 2020).

AdMU developed with DOH and DOST-PCHRD, the Feasibility Analysis of Syndromic Surveillance using Spatio-Temporal Epidemiological Modeler (FASSSTER) for early detection of diseases using data from the Philippine Integrated Disease Surveillance and Response (PIDSR) system, electronic medical records, and short message service (SMS)-based reports of primary care facilities (Macan 2020). FASSSTER is used to create predictive models and to visualize possible scenarios of outbreaks of dengue, typhoid fever, and measles at specified time periods, and an enhanced version can be used for the COVID-19 pandemic surveillance and response, which will help support planning and decision-making processes in the DOH, LGUs, and healthcare facilities.

The Research Institute for Tropical Medicine (RITM) launched a study on the clinical characteristics and transmission patterns on COVID-19 in confirmed cases and their contacts in the Philippines, which seeks to determine the transmission patterns of COVID-19 to help prevent its spread and thus support DOH in crafting policies for the containment and prevention of this pandemic (Macan 2020).

Mobility Innovations: Future Will Be Digital

With the imposition of the enhanced community quarantine in Luzon Island, the mobility of consumers have been limited and this has posed some problems to consumption and purchasing of basic needs. LGUs have limited the opportunities to go out and purchase food to specific schedules. Households located in far-flung areas have no means of going to marketplaces because of the lack of public transport services. To address these problems, mobility innovations have sprouted. These would include

e-commerce, e-payments and transport innovations. These cases reveal that innovation in the future will become digitally driven.

E-commerce

In the Philippines, not only is there contactless delivery being practiced by GrabFood and Foodpanda (Manalang 2020), there is also a number of services that are literally brought to the Filipino people's doorstep. Online grocery services, such as MetroMart and Lazmart, have proliferated (Nuestro 2020). Likewise, both Mayors of Pasig City and Valenzuela City successfully launched a mobile "palengke" that not only reduces the volume of people in markets, it also brings banking services to the Filipino doorstep (GMA News 2020a; 2020b).

According to Google, Temasek, and Baine (2021), 39% of digital merchants believe they would not have survived the pandemic if not for digital platforms. Digital merchants now use an average of two digital platforms, but profitability remains a top concern. Digital financial services saw very rapid growth in 2021, not only from e-wallets but also from the national payment rail.

Of the digital merchants surveyed, 97% now accept digital payments while 67% have adopted digital lending solutions. Many are also embracing digital tools to engage with their customers, with 68% expecting to increase usage of digital marketing tools in the next five years.

E-Payments and Special Banking Services Mix Innovations with Old Strategies

The e-payment system is a crucial tool that should be maximized as the government is exploring ways to reach the highly vulnerable sectors of society, especially during the enhanced community quarantine. It provides a number of solutions to the problems brought about by limitations on mass gatherings and mobility restrictions. Thus contactless cash transfers should be enabled to minimize mass gatherings and long queues at disbursement centers. Moreover, coursing relief cash grants through the e-payment system would help ease the logistical cost and requirements of government relief programs, thus freeing up resources for other pressing needs.

In operationalizing this, the Philippine government across national and local levels have partnered with fintech players, such as GCash and PayMaya, to enable fund transfers to targeted beneficiaries in their respective jurisdictions. The national government, primarily through the Department of Interior and Local Government (DILG), can take stock of which cities and municipalities have already existing partnerships with current fintech players, and perhaps, use these as patterns for developing protocols. Some examples are the cities of Makati and Valenzuela, which has partnered with GCash and PayMaya, respectively (Globe 2019; Marasigan 2020). Both fintech players have a similar setup with these local governments:

- Eligible beneficiaries of the local government are identified
- Identified beneficiaries are each given a prepaid card, which may be activated through SMS in any type of mobile phone or a mobile money application available on feature phones and smartphones to setup a mobile money account
- E-cash transfers can then be made to these beneficiaries' mobile money accounts

Select banks were also innovative, particularly the Philippine National Bank in their "Bank on Wheels" and UnionBank with their "Banking on Wheels," which both refers to a banking kiosk fitted to a van (Business Mirror 2020; The Manila Times 2020).

Drone-assisted Services

Drones mounted with AI-powered thermal scanners are set to be produced to easily scan and pinpoint people with high body temperature. These drones are among the technologies unveiled by the DOST-Philippine Council for Industry, Energy, and Emerging Technology Research and Development (PCIEERD), developed by Filipino innovators to fight the spread of COVID-19 (Casilao 2020).

Figure 3.9 shows a sample of the six drones targeted to be produced in partnership with DWARM Technologies, the Far Eastern University - Institute of Technology Innovation Center, UPSCALE Innovation Hub, Orbital Exploration (OrbitX) Technologies, and PLDT innohub. These drones provide real-time data transmission and are equipped with global positioning systems and a two-kilometer range for communication.

This technology will shorten the queuing of people and minimize contact between individuals at checkpoints. Initially, six units will be produced for testing and deployment in selected LGUs.

FIGURE 3.9

SAMPLE OF A DRONE DEVELOPED FOR THE COVID-19 PANDEMIC RESPONSE

Source: Casilao (2020).

Production Innovations Display the Importance of R&D in HEIs

Manufacturing of Health Supplies

In order to address the shortage of PPEs and other medical supplies, Xavier University and the Polytechnic University of the Philippines helped produce rubbing alcohol for health workers and for students and teachers, respectively (Asido 2020; Dublado 2020). The DOST Philippine Textile Research Institute (PTRI) worked on the production of 500,000 reusable and washable face masks of up to 50 times.

Elsewhere in the Philippines, fashion designers helped produce face masks and protective gears (Barcia 2020) with one instance where former Vice-President Robredo partnered with designer Mich Dulce (CNN Philippines 2020c). The designers used the approved pattern made by Joey Socco using Tafetta Silver Back Lining, which is a water repellent fabric suitable for personal protective equipment (PPEs).

3D Manufacturing

3D printer owners and fabrication facilities also joined in the effort to address the shortage of medical supplies, particularly where groups, such as 3D Printing for a Cause, manufactured improvised face shields and masks, and fabrication labs, such as Batangas State University's LIKHA FabLab and Jose Rizal Memorial State University's FabLab, assembled complete PPE units (Angara 2020).

The Advanced Manufacturing Center (AMCEN) and the Additive Manufacturing Research Laboratory (AMREL) of the Bataan Peninsula State University (BPSU) meanwhile produced 3D-printed face shields for health workers (Nazario 2020).

LESSONS LEARNED

The discussions in the previous section have shown that various stakeholders in the country have initiated innovative contributions to support the fight against the COVID-19 pandemic. There are a number of lessons to be learned from these innovative solutions and this chapter identifies the following:

i) Innovations need not be completely new. The experience of the Philippines for certain types of innovation displays the importance of utilizing existing and available technology.

ii) Innovative responses to the challenges highlighted the importance of having a culture of innovation and critical thinking. The new challenges faced by the country have forced various sectors to look for creative and innovative solutions. Many of the stakeholders (schools, universities, businesses) have used existing resources not initially intended for COVID-19 response to create products and services specifically tailored to address COVID-19 problems.

iii) There is a need to maintain an innovative culture by ensuring that the education system promotes innovation and creativity in children. This recommendation strongly supports the PDP strategy of continuing reforms in the education curriculum (NEDA 2017) wherein the science and technology curriculum is enhanced to "foster innovation and creative imagination." It is further recommended, however, that it is not only the science and technology curriculum which should be revisited but all areas of education as well.

iv) Innovative solutions to the problems caused by the pandemic cannot be forced to comply with archaic laws that have never considered the emergence of new technologies and global pandemics. Thus it is important for the government to be proactive and flexible in releasing regulations/ guidance on the use of these innovations. This is the lesson learned regarding the use of digital innovations on health and digital payments.

v) A number of the solutions presented in this chapter have been made possible because of the presence of digital technology and related technologies under the fourth industrial revolution (IR4.0). There is a need to maximize the use of digital technology in solving the problems resulting from the COVID-19 pandemic. For instance, by using digital technology, banks are able to contribute to slowing the spread of COVID-19 (Benseley, et al., 2020). Also, using digital technology can promote data-driven policymaking.

vi) Collaboration is important. The pharmaceutical innovations and governance regulations display the importance of strengthening partnership with the private sector. Some of the pharmaceutical trials were done as partnership of research institutions together with the PCHRD, which is a research arm of the Department of Science and Technology.

vii) Facilitate the transfer of technology and information. One of the research projects supported by the PCHRD is the use of the Lagundi as a possible treatment for mild cases of COVID-19. The NIRPROMP formulation is a product of the successful technology transfer of the research on Lagundi to other stakeholders who were able to commercialize and promote the use of the product (Quimba, et al., 2020).

viii) Knowledge management is important in ensuring that the Philippines learns and improves its response to global pandemics. There is a need to document and maintain the tools that have been explored and utilized during the outbreak. Critical regulations and policies that were imposed during this period may be revisited in times of disaster.

CHAPTER 4

TURKIYE

TURKIYE'S INNOVATION POLICY PATH

Turkiye was slow to make any significant progress in the face of global innovative economic developments that emerged at the beginning of the 20th century. The young Republic of Turkiye, born from a crumbling empire, had to put forward policies to develop and gain competence, especially in the industrial sense.

In the 1950s, Turkiye implemented its first liberal economic policies. Following World War II, Turkiye became a member of NATO in 1952 and OECD in 1961, after the formation of the new alliance system. When the foundations of the EU were laid, Turkiye established close relations with the European Economic Community and started its membership process. Throughout the Republic period, Turkiye has maintained strong connections with the European system, owing to its historical past. The nation has not only been influenced by Western institutional and economic developments, but has also played a founding and active role in most of its institutional developments. This development path has enabled Turkiye to develop its national innovation system (NIS), in line with OECD policy recommendations.

Science and technology policies are formulated based on Turkiye's Development Plans and are accepted and used as the basis for follow-up innovation policies implemented in the Republic. The First Five-Year Development Plan (1963–67) outlined that basic research activities should be given importance in terms of science and technology policies, and research should be conducted by institutions of higher education. In this context, the most fundamental development in science and technology policies of the period was the establishment of the Scientific and Technical Research Council of Turkiye (TUBITAK) in 1963. In addition, the "Pilot Teams Project (1962)" carried out by the OECD Scientific Research Committee with Turkiye's participation, represented an important step toward measuring the impact of scientific research and technology on welfare.

It is essential to explore the relationship between the innovation system development and science and technology policies in Turkiye with macroeconomic policies. Economic policies at various stages from the first years of the Republic to the present and the science and technology policies and developments of these periods are briefly summarized.

1923–50 - First years of the Republic

The Republic took the basic industrialization steps and strived to move from an agricultural economy to an industrial economy.

- There is no specific science and technology policy
- A period in which proficiency in the field of the industry was tried to be achieved, and university reforms were made

1950–60 - First steps of liberal economy

This period sees the first steps of the Republic's transition to a liberal economy with encouragement to the private sector.

- With the transition to the liberal period, the private sector flourished in the economy
- Industrialization studies were attempted by the private sector
- Science and technology policies are not in the political agenda

1960–80 - Emergence of basic institutions

Basic institutions were established with a developmental perspective during this phase.

- Economic policies are carried out in line with the development plans of the State Planning Organization
- TUBITAK is established in 1963
- The Pilot Teams Project is carried out in 1962
- In the 3rd Development Plan, the emphasis is placed on the domestic technology production
- Technology Policy is included for the first time in the Fourth Development Plan

1980–2002 - Liberalization and export-oriented economy model

After 1980, the most significant economic paradigm shift is observed. Transitioning to an export-oriented liberal economic model, Turkiye has put forward its first policies in the fields of science, technology, research and development (R&D), and innovation.

- Turkish Science Policy - The 1983–2003 document is the first document to establish a science and technology policy
- In 1983, the Science and Technology High Council (BTYK) is established
- Turkish Science Policy: 1993–2003 document is approved
- Technology Development Zones Law is enacted
- In 1990, the implementation of the innovation survey is initiated
- Community Innovation Survey studies are conducted for the first time
- Turkiye's Science and Technology Policy document is published

2002 to current

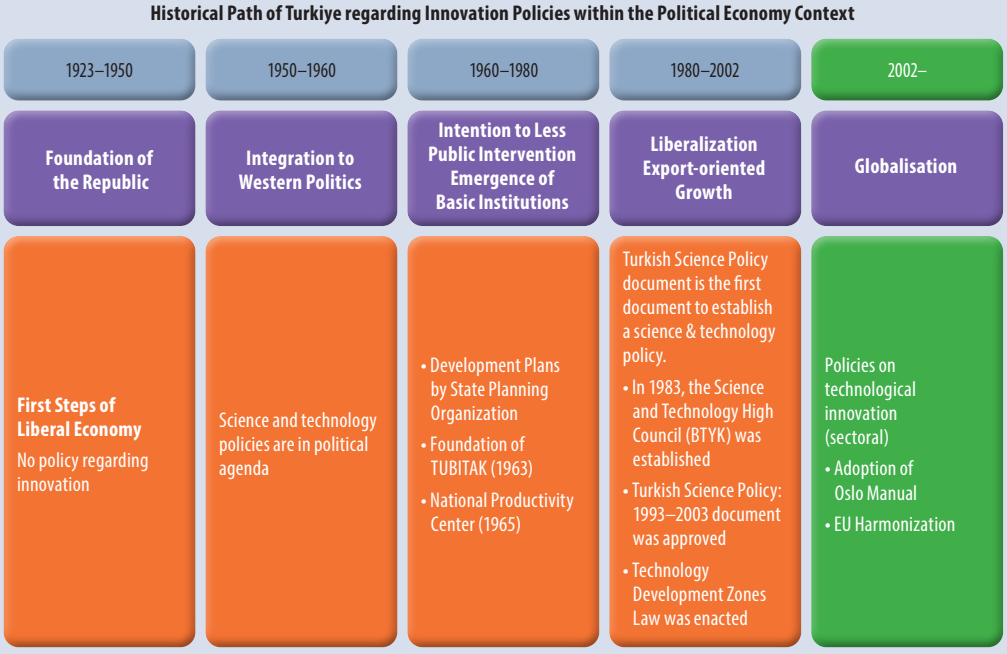
Turkiye has rapidly adapted to the global economy since 2002. In the period that started with the opportunities brought by the membership negotiations with the EU, Turkiye has made significant progress in innovation and R&D due to rapid economic growth and increasing foreign trade.

- Focused on policies aimed at producing technological innovation in sectors
- In 2004, Turkiye's Research Area (TARAL) is defined
- In 2005, evaluations on Turkiye is carried out in the European Innovation Scorecard
- The International Science, Technology and Innovation Strategy for 2007–10 is published
- Concept and types of innovation is defined for the first time in the National Innovation Strategy (2008–10) document. Innovation activities are shown among the focal points. The Oslo Manual has been adopted as a reference document
- The National Science, Technology and Innovation Strategy (UBTYS) 2011–16 document is announced
- Vision 2023 Strategy Document is published in 2004
- The Tenth Development Plan (2014–18) and Eleventh Development Plan (2019–23) presented a holistic political framework for the NIS

Figure 4.1 summarizes Turkiye's innovation policies timeline within the political economy context.

FIGURE 4.1

TURKIYE'S INNOVATION POLICIES TIMELINE



Various studies, as mentioned earlier, have shown a building block for innovation-related issues. When the science and technology policy documents are examined to grasp the innovation process of Turkiye, the main goal is to create a NIS within the network, including national and international aspects.

Keystone Policy Documents of Turkiye's NIS

Vision 2023 - National Science and Technology Policies 2003–2023 Strategy Document

This document represents Turkiye's first groundbreaking study in the field of R&D, technology, and innovation after 2002, providing a comprehensive vision for the country until 2023, the 100th anniversary of the Republic. The vision outlined in this document is for Turkiye that excels in science, technology, and innovation with a focus on transforming these competencies into tangible economic and social benefits through the creation of new products and services, new production and distribution methods, and new systems. To achieve this vision, the strategy outlined in the document emphasizes the importance of prioritizing strategic technology areas and establishing "cooperation networks" within these areas. The goal of Vision 2023 Strategy is to:

- Increase R&D activities
- Develop cooperation networks in focus strategy areas
- Integrate science, technology, and innovation policies in systemic integrity with other policies of the country, such as education, tax, industry and investment policies
- Create the Turkish Research Area (TARAL) that can be consolidated with the European Research Area (ERA)

TARAL is an institutional framework that outlines effective governance of R&D and innovation activities among the public, private sector, and universities in Turkiye. Within this governance structure, TUBITAK plays a pivotal role in ensuring that the necessary resources, expertise, and funding are readily available for the targeted group. The integration of TARAL and ERA has significantly bolstered Turkiye's research and innovation capabilities, facilitating the exchange of researchers and promoting research collaborations with the EU.

Tenth and Eleventh Development Plans

Development Plans in Turkiye, as the top policy document, outlines the basic public policies in five-year periods. The Tenth Development Plan (2014–18) determined the objectives of public policies under four main headings with the theme "Innovative Production, Stable High Growth".

Among the goals and prominent measures included in the Plan are:

- All economic policies should be designed on the axis of innovation
- Develop R&D, Innovation, and Entrepreneurship ecosystem
- Encourage innovation for high added value and technology
- Transition to a knowledge-based economy
- Transforming the economy into an innovative structure with reduced import dependency

The macro target of the plan is to increase the ratio of R&D expenditures to GDP to 1.8%.

The Eleventh Development Plan (2019–23), entitled "Competitive Production and Productivity", defined targets and measures in R&D and Innovation. The report stated that Turkiye has limited capabilities compared to developed countries in terms of technology development and productive use of these technologies, especially innovative technologies. To keep up with the technological transformation, Turkiye needs to ramp up its competitiveness by enlarging its qualified HR in priority sectors and areas, increase the spread of technology to enterprises, improve companies' organizational and innovation capabilities, and putting in place effective mechanisms for financing R&D and innovation.

It is evident that there is a structural change in this plan from a policy perspective. All priority sectors, such as chemistry, pharmaceuticals and medical devices, machinery and electrical equipment, automotive, electronics, rail system vehicles, are among the medium-high and high technology sectors. Moreover, the development of these sectors will also increase the demand for R&D. This framework aims to focus on critical technologies by implementing a robust R&D and innovation approach in priority sectors. While there was a sector-based policy perspective in the past, this plan puts forward a technology-oriented innovation effort.

2023 Industry and Technology Strategy

The "National Technology Move" vision is structured to implement policies that will enhance Turkiye's global competitiveness and ensure its economic and technological independence. Its first successful implementation is in the defence industry, which has increased the technology production capability of domestic suppliers, reduced costs, and revealed product development capacity in advanced technologies, such as unmanned aerial vehicles, missiles, radar systems, and satellites. The gains from these projects and self-developing domestic suppliers will set an example for other sectors. Strong national planning and coordination have played a significant role in the domestic production of critical technologies, increasing domestic product use from 20% to 68% in the defence industry. To meet the needs for cost-effective and competitive solutions in other sectors, governance mechanisms at the national level will also be established in civil sectors, processes led by the private sector will be designed, and sectoral roadmaps will be prepared.

National Technology Move and its Impact on Society

One of the essential components of the National Technology Move policy framework is to involve all segments of society in the development processes of national and original technological products. It aims to enable young people to actively participate in national technology development-oriented projects and competitions at a very early age and make society the subject of this process. As shown in the following parts of the study, actions taken in line with this goal have created high awareness in society.

Turkiye's Adoption of the Oslo Manual Definition

The BTYK meeting in 2005 became a milestone for R&D and innovation studies, which started to gain more traction on the political agenda after 2002. The following decision was announced at this meeting:

> *2005/7. Acceptance of OECD's Frascati, Oslo and Canberra Guidelines as References in R&D Activities*
>
> In the light of all these studies and within the framework of harmonization with the European Union acquis, Frascati, Oslo and Canberra guides are used as a reference for the collection of R&D statistics in all public institutions and organizations, the determination of the subjects within the scope of R&D and R&D support and other related issues, and the use of the guides by the society. It has been

decided to appoint TUBITAK to carry out dissemination studies for the adoption of it by the relevant segments.

With the announcement, the NIS in Turkiye was developed according to OECD guideline, and OECD research became a reference for the following period.

In the third edition of Oslo Manual, innovation is defined as (OECD/EUROSTAT, 2005: 46):

*"An **innovation** is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations."*

According to the Oslo Manual, innovation and R&D activities are divided into four categories - product innovation, process innovation, market innovation, and organizational innovation (OECD/EUROSTAT, 2005).

- **Product innovation** can be defined as the introduction of a new or significantly improved good or service with respect to its existing properties or intended uses. The main factor in the emergence of product innovation is the need to benefit from new technologies, gain competitive advantage, and meet the changing needs of consumers

- **Process innovation** is implementing a new or significantly improved production or delivery method. This innovation includes significant changes in techniques, equipment, and/or software. The underlying purpose is the desire to increase competitiveness by reducing production or distribution costs

- **Marketing innovation** is a new marketing method involving significant changes in product design or packaging, product positioning, product promotion, or pricing. This innovation aims to meet customer expectations and respond more quickly to increase the company's total sales volume, take place in new markets, or position the company's existing products in the markets with new methods

- **Organizational innovation** is the application of a new organizational method in the business practices, workplace organization, or external relations of companies. Organizational innovations are preferred to reduce various cost elements, such as administrative or transaction costs of the companies, to increase the organizational satisfaction of the employed and thus to increase the productivity of the workers, to facilitate access to external information, or to improve the performance of the company by reducing the costs of the materials used in the company

With the adoption of the OECD's definition of innovation, every activity that meets the OECD criteria is considered innovation, regardless of the other classification of innovation in the literature (TUBITAK, 2018).

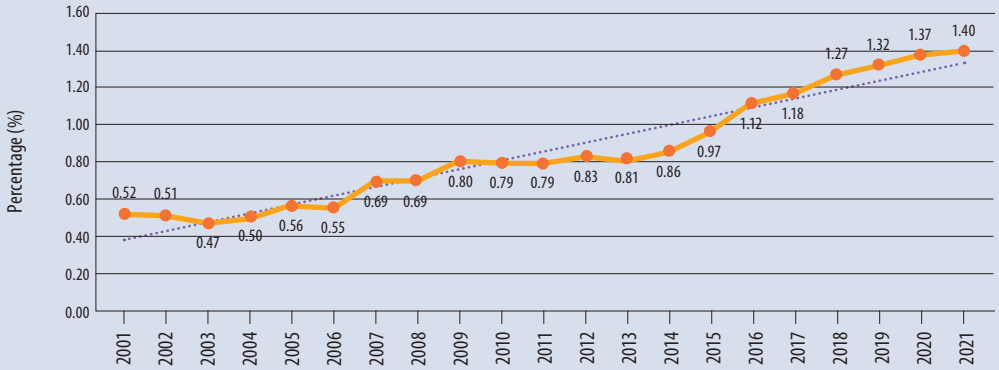
Basic Statistics on R&D and Innovation

In Turkiye, based on the Oslo Manual definition in 2005, basic statistics on R&D and innovation are produced in line with OECD and EU. Hence, due to the same data methodology, Turkiye's statistics are comparable to those of EU and OECD.

Figure 4.2 shows the share of R&D expenditures in GDP in Turkiye from 2001–2021. According to the most recent (revised) data in 2021 (Turkstat, 2023), this figure reached the highest level in history at 1.40%. According to the trend model created by linear regression, it can be said that this figure tends to increase by 4.8% every year.

FIGURE 4.2

TURKIYE'S SHARE OF R&D EXPENDITURES IN GDP IN 2001–21



Although Turkiye has increased this statistical value over the years, it still lags behind the OECD and EU averages. The share of R&D expenditures in GDP can be seen in Figure 4.3, which includes OECD countries that have data for 2020 (OECD, 2022).

RELATIONSHIP OF PRODUCTIVITY AND INNOVATION IN TURKIYE

In the political context, it is widely recognised that innovation increases productivity, and this issue is frequently on the agenda of the global economy. Many policy documents refer to the issue and policies are developed based on the existence of the relationship at the levels of firms and economies. However, compared to the qualitative research, the number of quantitative studies on Turkiye is relatively limited. A more comprehensive study is needed to understand the relationship between productivity and innovation. However, within the scope of this study, recent prominent studies in the literature were investigated, and a brief statistical analysis is shown at the end of this section.

Literature Review on Turkiye's NIS

In this segment, the macro-level studies include two areas: (i) the relationship of R&D and innovation activities with economic growth; and (ii) micro-level studies that examine the performance of innovation in firms' exports, new markets, etc., using company data.

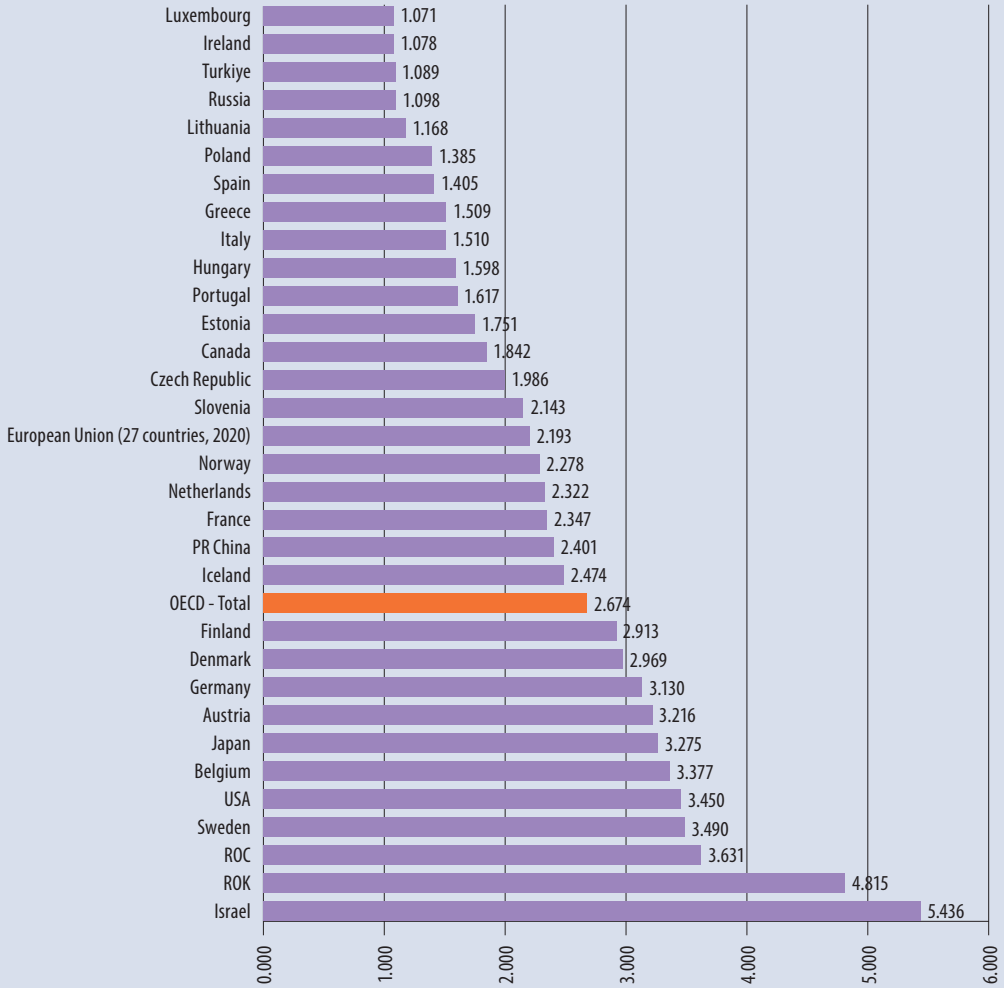
Studies at Macro Level

Eygu and Coskun (2020) conducted a time series analysis on Turkish economy from 1995–2018 to examine the relationship between human capital, innovation, and economic growth. They found that human capital and innovation do not have a short-term effect on economic growth but have a positive effect in the long term. Using the Granger causality analysis revealed a one-way causality relationship from human capital to innovation.

FIGURE 4.3

SHARE OF R&D EXPENDITURES IN GDP IN OECD MEMBER STATES

Gross Domestic Spending on R&D, Total % of GDP, 2020



Source: OECD, 2022.

Karaca's (2018) study employed the CDM model to explore the link between productivity, innovation, and research in the manufacturing sector in Turkiye. The study utilized data on the number of patents per employee, turnover per staff employed in the R&D unit, and value-added per employee from 2009 and 2015. The panel data model showed that an increase in the number of patents leads to a rise in innovative sales, which in turn, increases in labor productivity.

A study by Korkmaz (2010) investigated the relationship between R&D activities and economic growth in the Turkish economy from 1990 to 2008. Results found cointegration between R&D expenditures and economic growth. Additionally, the Granger causality test showed that R&D expenditures have a short-term impact on GDP. Overall, the study concluded that R&D expenditures positively affect GDP both in the short term and long term.

Studies at Micro Level

Lo Turco and Maggioni (2015) examined the impact of product and process innovation on market entry in the Turkish industry. The researchers discovered that product innovation has an impact on entering new markets and companies with higher innovation capability have greater export possibilities. Further, process innovations enable companies to enter wealthier markets. These findings support Turkiye's intensified policies after 2018 that aimed to develop exports of high technology and high added value.

Karabulut's (2015) study focused on the effect of different types of innovation, as defined by the OECD, on firm performance. The study involving 197 manufacturing companies found that product innovation, process innovation, organizational innovation, and marketing innovation have positive effects on various aspects of firm performance, including financial performance, customer performance, internal business process performance, and learning and growth performance.

Fındık and Beyhan (2015) aimed to understand the impact of collaborations on firm innovation performance. They noted that although some previous studies support that firms' external collaborations improve their innovation capabilities, the knowledge of the impact of collaborations on firm innovation performance is still limited. In 2009, they utilized the innovation survey conducted by the Turkish Statistical Institute to measure companies' innovation activities between 2006 and 2008. The factor analysis results revealed two main effects of innovation: product-oriented and process-oriented impacts. In particular, there is a positive relationship between external cooperation and the product-oriented impacts of innovation. Companies that collaborate externally in innovation observe better products and market developments. External collaboration also improved companies' production processes.

Summary of the Literature Review

The reviewed literature in Turkiye highlights the relationships between innovation, productivity, and other economic factors. Human capital and R&D expenditures have positive effects on innovation and economic growth in the long term. The number of patents is associated with increased labor productivity. Additionally, product innovation facilitates new market entry while marketing innovation positively impacts various aspects of firm performance, including financial, customer, and overall business performance.

However, there is a need for more macro-level studies on the productivity-innovation relationship specific to Turkiye. Therefore, this study aims to look into the relationship between productivity and innovation in the industrial sector using simple statistical methods and the most recent available data in Turkiye.

Examination of the Relationship between Productivity and Innovation in Turkiye

Methodology

In this examination, the correlation analysis is used to explore the relationship between productivity and the ratio of R&D expenditures to GDP, which represents innovation data. The analysis focuses on total industrial sector (unit labor cost and value-added per person employed) and specific

sectors (value-added per person employed). Due to the limited availability of detailed data, this analysis provides a macro perspective and does not include any causality assumptions.

For the analysis, the most recent available data for Turkiye (2009–21) is used to examine the relationship between productivity and the ratio of R&D expenditures to GDP (Turkstat, 2022). The productivity data represents annual labor productivity (indexed as 2010=100) for relevant economic activities, which is published as official statistics (MoIT, 2022b). The selected sections include Total Industry, J-Information and communication, M-Professional, scientific and technical activities, and C-Manufacturing sections, according to the NACE Rev. 2 classification.

Statistical tests are conducted to determine the correlations between the ratio of R&D expenditures to GDP (selected data that represent innovation performance) and productivity data. Tables 4.1 and 4.2 present the relevant statistics and correlation analysis results.

TABLE 4.1

LABOR PRODUCTIVITY DATA OF SELECTED ECONOMIC ACTIVITIES AND SHARE OF R&D EXPENDITURES IN GDP

	Productivity Data (according to NACE Rev.2 Classification)					R&D Data
	Total Industry	Total Industry	J-Information and Communication	M-Professional, Scientific, and Technical Activities	C-Manufacturing	Share of R&D Expenditures in GDP
Year	Unit Labor Cost	Value-added per Person Employed	Value-added per Person Employed	Value-added per Person Employed	Value-added per Person Employed	
2009	92.02	102.04	111.20	102.11	101.80	0.80
2010	100.00	100.00	100.00	100.00	100.00	0.79
2011	103.38	103.99	101.17	101.69	105.54	0.79
2012	118.73	99.28	98.81	96.86	95.64	0.83
2013	122.55	106.70	100.85	98.31	106.62	0.81
2014	136.52	105.64	100.29	99.41	105.48	0.86
2015	141.98	113.10	96.74	100.92	118.29	0.88
2016	159.84	120.86	102.01	101.46	130.25	0.94
2017	166.92	125.90	106.06	101.78	135.45	0.95
2018	181.63	133.58	109.21	98.16	140.17	1.03
2019	220.08	136.99	115.34	100.94	128.72	1.06
2020	221.16	140.09	132.47	103.77	142.91	1.09

TABLE 4.2

CORRELATION OF PRODUCTIVITY AND SHARE OF R&D EXPENDITURES IN GDP

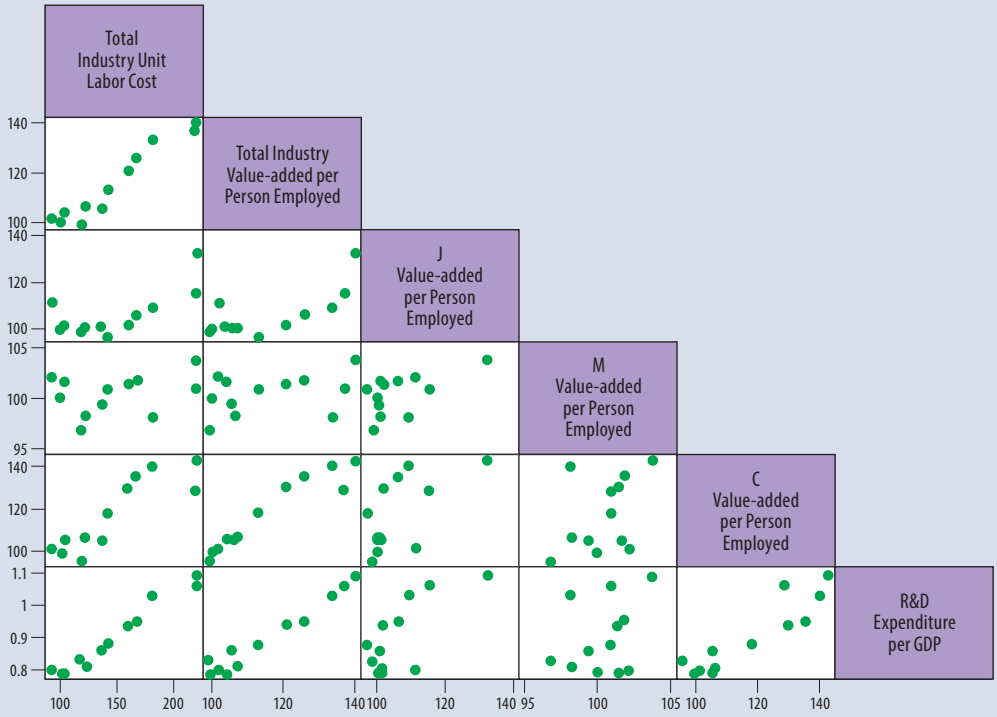
	Total Industry		J-Information and Communication	M-Professional, Scientific, and Technical Activities	C-Manufacturing
	Unit Labor Cost	Value-added per Person Employed	Value-added per Person Employed	Value-added per Person Employed	Value-added per Person Employed
Correalation coefficient for share of R&D expenditures in GDP	0.981277	0.979408	0.734443	0.313075	0.91238
p-value	0	0	0.0065	0.3218	0

Results

According to the correlation analysis made to uncover the relationship between the proportion of R&D in GDP and labor productivity (Table 4.2), it is observed that the unit labor cost of the total industry, value-added per person employed of the total industry, and manufacturing industry exhibit statistically significant and highly positively correlations with the share of R&D expenditures in GDP (0.981, 0.980, and 0.912, respectively). Further, according to NACE Rev. 2, economic activity section J, which includes information and communication activities, is found to be statistically significant and highly positively correlated. However, in section M-Professional, scientific, and technical activities do not demonstrate a significant correlation with R&D share data. Figure 4.4, based on Table 4.1, presents a scatter plot depicting the analyzed data.

FIGURE 4.4

SCATTER PLOT OF LABOR PRODUCTIVITY AND SHARE OF R&D IN GDP IN 2009–20



In addition to illustrating the relationships between the productivity levels of the selected sectors, Figure 4.4 also highlights the correlations between Turkiye's innovation performance and the productivity levels of the sectors at the bottom.

The scatter plots at the bottom further demonstrate the relationship between the unit labor cost and labor productivity of the total industry and the labor productivity of the manufacturing industry, which align with the findings of the correlation analysis.

ACTORS AND INSTITUTIONS OF THE NIS IN TURKIYE

When examining the innovation and R&D policy steps briefly mentioned in the first segment, it becomes evident that Turkiye had a need and/or problem-oriented approach to innovation efforts until the 2000s. In terms of policy design, institutions and policy instruments were not yet at the desired level of scope and competence during this period. Furthermore, the frequency of BTYK meetings, which serves as the highest decision-making body in science, technology, and innovation, indicates that the full extent of political will had not been fully demonstrated.

Developments between 2000 and 2018

Starting from 2000, there was an increase in political will, and institutions, mechanisms, policy tools, and coordination began to take shape within the framework of strategies. The first significant step in this regard was the announcement of Vision 2023 Project in 2001. This project was crucial as the initial comprehensive initiative that promoted technology foresight, measures for HR, and strengthening research infrastructures and interagency cooperation.

From 2002 onwards, with the change of governing party, strategy documents with short-term goals that were primarily focused on addressing needs, were published to enhance innovation capacity in various fields. A brief overview of the period between 2002 and 2018 reveals that new actors were included in the NIS, the government expanded financial opportunities and tools, cooperation among actors increased, and the steps taken started yielding sustainable and lasting results. The following list presents the strategy documents published during this period:

- Vision 2023
- National Science, Technology and Innovation Strategy 2011–2016
- 10th Development Plan 2014–2018
- 11th Development Plan 2019–2023
- The New Industrial Revolution: Smart Production Systems Technology Roadmap
- Turkiye Public-University-Industry Cooperation Strategy and Action Plan 2015–2018
- Turkiye Biotechnology Strategy Document and Action Plan 2015–2018
- Turkiye Entrepreneurship Strategy and Action Plan 2015–2018
- National Cyber Security Strategy and Action Plan 2016–2019
- Turkiye Software Strategy and Action Plan 2017–2019
- National Broadband Strategy and Action Plan 2017–2020
- 2023 Digital Turkiye Roadmap

- Information Society Strategy and Action Plan 2015–2018
- Action Plan/National Employment Strategy 2017–2019
- Roadmap Document for The Protection of Critical Infrastructures 2014–2023
- Turkiye Industrial Strategy Document 2015–2018
- Turkiye Textile, Apparel and Leather Products Sectors Strategy Document and Action Plan 2015–2018
- National Geographical Indication Strategy Document and Action Plan 2015–2018
- National Intellectual Rights Strategy Document and Action Plan 2015–2018
- National Metrology Strategy and Action Plan 2015–2018
- Productivity Strategy and Action Plan 2015–2018
- Science and Technology Human Resources Strategy 2011–2016
- SME Strategy and Action Plan 2015–2018
- Technology Prioritization Study 2019

It is worth noting that most of the strategy documents in the list had a horizon until 2018. As their names suggest, most of these documents published between 2000–18, primarily emphasized sector-specific characteristics. This period can be defined as the institutionalization and establishment of the innovation ecosystem within Turkiye's NIS. Institutions and actors, responsible for strategies, developed their essential functions related to the sectors during this period and are now prepared for new strategies on thematic areas.

Period After 2018

Following the elections in 2018, Turkiye transitioned from a parliamentary system to a presidential system. Under the new government system, executive power was restructured, and the BTYK, which previously served as the highest decision-making body for innovation policies, underwent a reorganization and was renamed the Council of Presidency Science Technology and Innovation Policies (CoSTIP), now part of the Presidency.

This newly established Council consists of representatives from the public and private sectors and NGO representatives. Although it operated as an advisory board, it plays a decisive role in policy-making and determines the policy priorities for other public institutions.

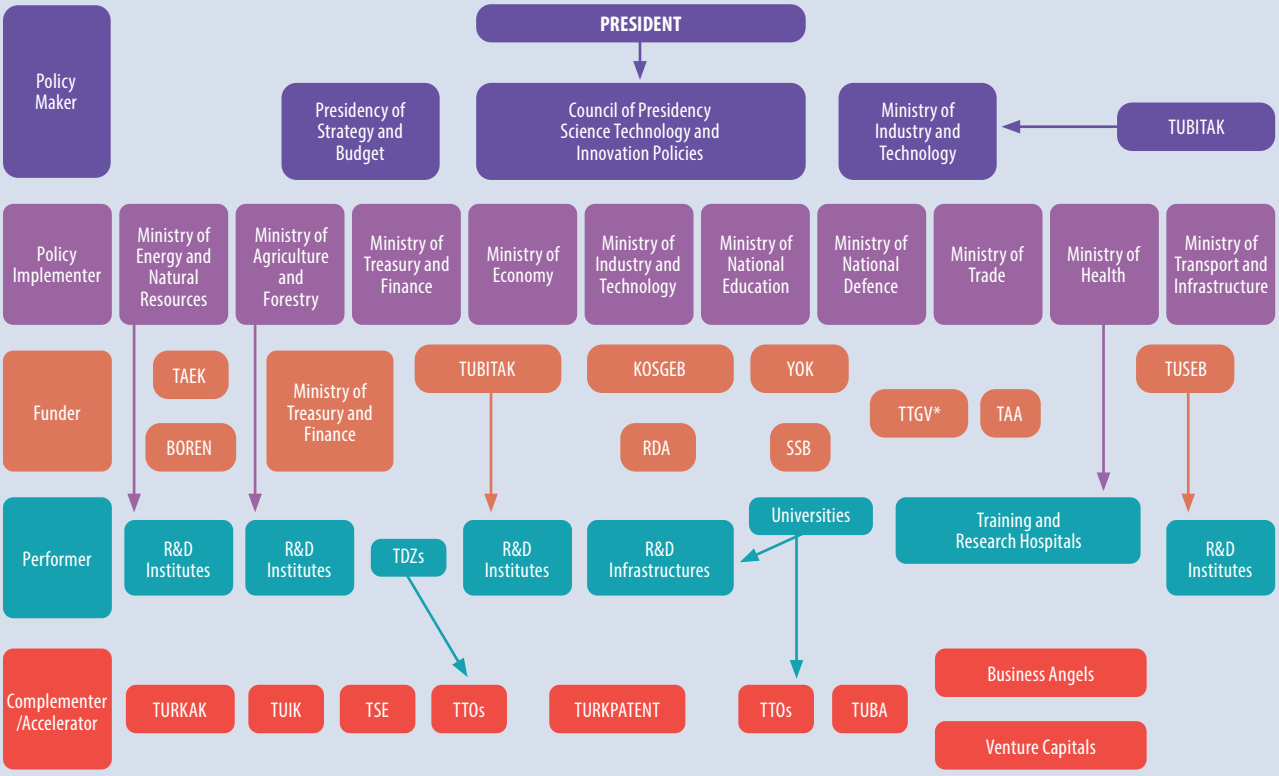
Within this new structure, three key actors stand out: (i) TUBITAK, which has been at the forefront of science, technology, and innovation studies since 1963; (ii) Presidency of Strategy and Budget (SBB), which serves as a decision-making institution that determines the budget and investment

needs of the public sector; and (iii) Ministry of Industry and Technology (MoIT), responsible for implementing innovation policies within the government and overseeing numerous affiliated organizations.

The following infographic (TTGV, 2020:33) provides an overview of the actors tasked with duties and responsibilities in science, technology, and innovation policies in Turkiye after 2018.

FIGURE 4.5

TURKIYE'S NIS ACTORS



BTYK	Supreme Council of Science Technology and Innovation
CoSTIP	Council of Science Technology and Innovation Policies
KOSGEB	Small and Medium-Sized Enterprises Development Organization
MoAF	Ministry of Agriculture and Forestry
MoCT	Ministry of Customs and Trade
MoD	Ministry of Development
MoENR	Ministry of Energy and Natural Resources
MoF	Ministry of Finance
MoFA	Ministry of Foreign Affairs
MoFAL	Ministry of Food Agriculture and Livestock
MoH	Ministry of Health
MoIT	Ministry of Industry and Technology
MoND	Ministry of National Defence
MoNE	Ministry of National Education
MoSIT	Ministry of Science, Industry and Technology
MoT	Ministry of Trade
MoTF	Ministry of Treasury and Finance
MoTI	Ministry of Transport and Infrastructure
MoTr	Ministry of Transport
PM	Prime Minister
RDA	Regional Development Agencies
SBB	Presidency of Strategy and Budget
SSM	Undersecretariat of Defence Industries
TPE	Turkish Patent Institute
TSE	Turkish Standards Institute
TUBA	Turkish Academy of Sciences
TUBITAK	Scientific and Technological Research Council of Turkey
TUIK	Turkish Statistics Agency
TURKAK	Turkish Accreditation Agency
TURKPATENT	Turkish Patent and Trademark Office
TUSEB	Health Institutes of Turkey
UoT	Undersecretariat of Treasury
YOK	Higher Education Council

Source: TTGV, 2020: 33-34.

Essential NIS Actors in Turkiye

CoSTIP

The council was established in 2018 and comprises five permanent members from business, academia, and government. The members are elected by the President from the public, private, and NGO sectors. The council provides policy recommendations to public institutions and monitors the policy implementation. Additionally, working groups within the council contribute to the policy design by working in related fields.

MoIT

The most crucial actor in Turkiye's innovation ecosystem is MoIT. With the change in the government system in 2018, the ministry acquired new functions and duties and plays a role in policy design and implementation. The General Directorates within the ministry perform various functions, such as support programs, R&D and design centers, technoparks, techno-enterprise and techno-investment, research infrastructures, and Technology-oriented Industrial Move Program. Moreover, MoIT, with its affiliates - TUBITAK, Small and Medium-Sized Enterprises Development Organization (KOSGEB), TURKPATENT, and TSE - coordinates the government's relations with industry and researchers, making it a vital player within the NIS.

Presidency of Strategy and Budget (SBB)

SBB has been operating as the central planning body of the Turkish public administration since 1965. Its main functions include preparing development plans, medium-term government programs, and identifying and allocating public investments. By providing public funding for the NIS, SBB ensures the relevance of innovation policies to national macro policies.

TUBITAK

TUBITAK has been leading R&D and innovation studies of Turkiye since its establishment. A critical policy maker until 2018, TUBITAK's role shifted to coordination to focus on basic research and innovation issues. It continues to play a crucial role in carrying out joint projects with EU members and other countries and gaining know-how.

TUBITAK is vital in implementing policies and providing support, incentives, scholarships, and entrepreneurship opportunities to the scientific community. It carries out research and technology development functions needed by the public and private sectors through its research institutions Marmara Research Centre (MAM), Information and Information Security Advanced Technologies Research Centre (BILGEM), Defense Industry Research and Development Institute (SAGE), Space Technologies Research Institute (UZAY), National Metrology Institute (UME), Rail Transport Technologies Institute (RUTE), and Basic Sciences Research Institute (TBAE).

KOSGEB

The establishment of KOSGEB dates back to the 1970s. Initially tasked to focus on the development of SMEs in the manufacturing industry, KOSGEB expanded its scope to include nonmanufacturing

sectors as well as realizing the potential of SMEs in job and added value creations. It aims to develop programs that enhance SMEs' technology development and innovation capacities. KOSGEB is one of the most important implementing institutions in innovation, R&D, incubation, laboratory services, entrepreneurship ecosystem, and financial support.

Critical NIS Performers in Turkiye

Technology Development Zones (TDZ)

TDZs are special campuses consisting of start-ups, firms, and R&D labs of large-scale firms that are modeled after well-known technoparks around the world. These zones provide special incentives and support mechanisms, mainly within the university campuses, where entrepreneurship and innovation are intertwined.

TDZs are established under Law No. 4691 in 2001 that contribute to: (i) production; (ii) commercialization of technological information; (iii) raising product quality and standards; (iv) developing innovations; (v) ensuring SMEs' adoption of new and advanced technologies; and (vi) creating job opportunities for researchers and foreign capital. They also aim to increase industry competitiveness by attracting foreign investments.

As of October 2022, 81 of the 96 TDZs are operating while infrastructure works for the remaining 15 are underway. The TDZs are home to 8,378 companies, of which 2,085 are incubators and 1,767 have academic partnerships. Out of the total 86,910 employees, 72,291 are working as R&D staff, and 1,185 are in design. Since their establishment, the TDZs have completed 48,268 projects and generated exports worth USD7.7 billion with almost 50% of the companies operating in the software industry. TDZs have also seen a significant number of intellectual and industrial property registrations with 1,567 national and international patents registered and 3,203 ongoing applications (MoIT, 2022a).

Technology Transfer Offices (TTOs)

TTOs facilitate efficient and rapid commercialization of academic research. These offices operate within universities, connecting researchers to entrepreneurs, investors, and industrialists. They also provide consultancy on patent issues, commercialization, funding opportunities, and others, contributing to the transfer of knowledge and technologies from academia to the industrial/entrepreneurship sector. It also contributes to the governance of the innovation ecosystem within the universities. TTOs are also part of TUBITAK's support mechanism.

Technology Centers (TEKMERs)

TEKMERs are important intermediaries in Turkiye's NIS, following their establishment under the KOSGEB in the 1990s. Initially focused on creating and supporting technology-based SMEs and academic start-ups, especially by supporting R&D and innovation and industrial application activities through university-industry cooperation, TEKMERs now prioritize crucial areas, particularly on fintech and industrial software development, to meet the demand of the business world. These centers provide services for preincubation, incubation, business development in post-incubation, access to financial resources, management, consultancy, mentoring, and participation in networks. The TEKMER Support Program also supports companies on operational matters, such as office

furniture and hardware, machinery/equipment and software expenses, salaries, training, consultancy, organization, and promotional budgets. There are 17 TEKMERs operating as incorporated companies in Turkiye.

TALENT AND SKILLS DEVELOPMENT IN TURKIYE'S INNOVATION AGENDA

The Industry and Technology Strategy 2023 proposes comprehensive measures related to the policy areas of its future vision on fostering talent and skills development. These can be defined under three headings:

- Competitions within the body of Aerospace and Technology Festival (TEKNOFEST) and Experiment Technology Workshops (DENEYAP), which are held in order to disseminate the vision of the National Technology Move to all segments of the society and to instill awareness of technology production, especially digital technologies and software development among young people

- Specialized scientific programs of TUBITAK

- In the education system; collaboration with the R&D centers of science high schools and enhancing the curriculum and learning systems of technical high schools; and Science Olympics organized by TUBITAK

MoIT Programs on Talent and Skills Development

TEKNOFEST

TEKNOFEST, organized by the Turkish Technology Team Foundation (T3 Foundation) and the MoIT, is Turkiye's first and only aerospace and technology festival, and supported by institutions that play a crucial role in Turkiye's technological development.

With the vision of the National Technology Move, TEKNOFEST aims to raise awareness of technology and science throughout society and increase Turkiye's HR training in science and engineering. It organizes the largest award-winning technology competitions in Turkiye's history, encompassing many pioneering areas, such as biotechnology innovation, smart transportation, vertical landing rocket design, environmental and energy technologies, electric vehicle, hyperloop and helicopter design, and chip design. Financial support is also provided to participants in the competitions, which are open to students from all age groups, researchers, and private–sector entrepreneurs. This approach aims to foster a culture of technology and innovation among young individuals and cultivate Turkiye's human capital.

Experiment Technology Workshops (DENEYAP)

The primary objective of Experiment Technology Workshops is to nurture young individuals with high technology production competence to form the human infrastructure of the National Technology Move's vision and long-term development perspectives. The educational model of Experiment Technology Workshops is designed to equip students in two age groups with skills,

such as entrepreneurship, creative thinking, critical thinking, solving complex problems, effective communication, and teamwork. During experiments, young people at the beginning of secondary and high school age receive 36 months of free training on 11 topics, including Design and Production, Robotics and Coding, Electronic Programming and Internet of Things, Nanotechnology and Materials Science, Aviation, and Space Technologies. In this three-year period, they acquire fundamental technology competencies, deepen their specialization in areas of interest, and develop the ability to undertake projects (Deneyap Turkiye, 2022).

42 Software Schools

Bilisim Vadisi Technology Development Zone has initiated a software training program as part of the Open Source Platform project conducted in collaboration with TUBITAK. By implementing the 42 Software Schools based on the French Ekol 42 Software Schools model in 2021, the aim is to increase the number of software developers and transform Turkiye into a software and technology-exporting country. The 42 Software Schools focus on software learning through a "peer learning" model and gamified learning infrastructure. Students are encouraged to work on software projects in teams, fostering their passion for software development. At least 40% of the students enrolled in these schools, which are open to anyone over the age of 18, come from non-software backgrounds or have not received software training throughout their education life. With approximately three years of education at the software school, students also complete a compulsory three-month internship at the end of the first year. 42 Software Schools have become important in achieving the target of 500,000 software developers, as set as in the 2023 Industry and Technology Strategy (Bilisim Vadisi, 2022).

Support from TUBITAK in Talent and Skill Development

TUBITAK, with its long-standing history and tradition, contributes to the policy agenda and serves as a significant accelerator and practitioner. TUBITAK organizes national and international science Olympics, not only for high school students in basic sciences and software branches, but also provides qualified training programs to prepare students for international competitions. This approach has led Turkiye to achieve remarkable success in the Olympics for many years.

TUBITAK has also established Science High Schools and provided substantial support to them. These specialized high schools have been operating for nearly 40 years, offering rigorous science education in the high school level. They have a wide range of laboratories, physical facilities, and boarding education options. TUBITAK plans to lead more Science High Schools by implementing more specialized programs through the research campus.

Another exciting initiative is the Outstanding Researchers Programme, which encourages Turkish scientists' return from abroad, and the Industrial Doctorate Program, which focuses on fields needed by the industry sector.

A SUCCESSFUL CASE OF GOVERNANCE IN INNOVATION: THE GLOBAL INNOVATION INDEX (GII) RANKING OF TURKIYE

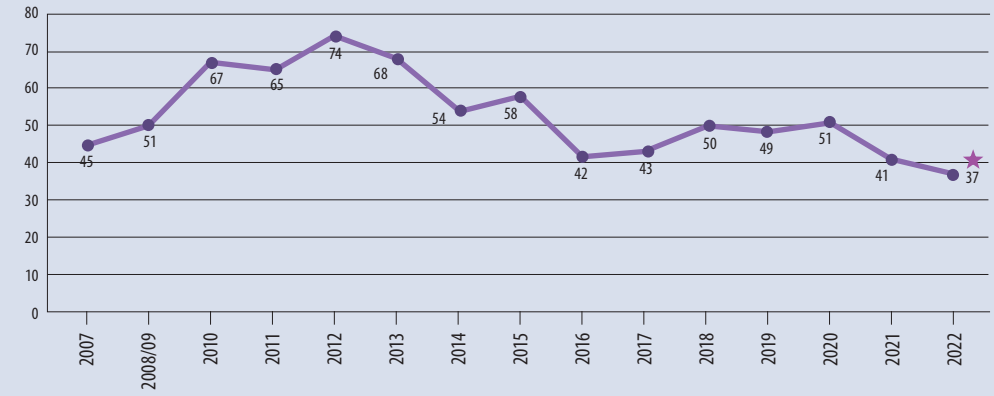
The GII reports provide the best way to track the performance of countries at the macro level. Published annually since 2007 by the World Intellectual Property Organization (WIPO), the GII aims

to provide a comprehensive view of the innovation ecosystem of countries. The report was launched as innovation becomes increasingly important to the growth and development strategies of developed and developing countries. The GII considers the broadest definition of innovation from the OECD 2018 Oslo Manual. It also considers various horizontal parameters, such as social, economic, cultural, and legal factors influencing a country's innovation capability. These effects highlight two subindices, inputs and outputs, and their subcomponents. The index order is calculated according to the average scores obtained in the subindices.

Turkiye has made significant progress in the GII rankings. In the 2021 report, Turkiye rose 10 places and reached the 41st rank (WIPO, 2021). In the 2022 report, Turkiye climbed another four steps and took the 37th place, which is its best ranking in history (Figure 4.6) (WIPO, 2022). Over a period of two years, Turkiye has risen 14 rungs and entered the top 40 for the first time. It has also maintained its 4th place among upper-middle-income countries, as it did in 2021.

FIGURE 4.6

TURKIYE'S RANKING IN GII



Among the 132 countries included in the Index, Turkiye made the second biggest leap and ranked fourth in the group of middle-upper-income countries. In the income group ranking, PR China, Bulgaria, and Malaysia were ahead of Turkiye. PR China is first in this income group and maintained its rising trend from last year and ranked 12th.

Turkiye outperformed the group averages in six out of the seven main components in the upper-middle income group countries, performing the best "Human Capital and Research" component, where it ranked 26th. The report also highlights Istanbul and Ankara as home to leading science and technology clusters.

How Turkiye Succeeded in the GII Rankings?

Turkiye's success in the GII rankings can be attributed to two factors. Firstly, Turkiye has ensured the accuracy and timeliness of statistical information in international databases, such as UNESCO, OECD, World Bank, and WTO, which serve as data sources for the GII indicators. In the 2020 report, Turkiye, which ranks 51st in the 2020 report, had missing data for four indicators and outdated data

for eight indicators. However, eight indicators were updated in the 2021 report, reflecting substantial advancements. This progress was achieved through the dedicated efforts of responsible institutions working under the coordination of the MoIT, along with the Turkish Exporters Assembly (TIM).

Secondly, Turkiye has implemented corporate-level governance and strategies to ensure the sustainability and continuity of its success in the GII. Under the coordination of TIM, an NGO, and MoIT, the issue was brought to the attention of the Coordination Council for the Improvement of Investment Environment (YOIKK) in Turkiye, chaired by the Vice President. In 2020, the "Global Innovation Index Turkiye Roadmap and Action Plan" was prepared. A task force was established to implement the action plan, which included short-, medium-, and long-term actions for 69 of the 80 indicators covered in the GII. Technical studies were conducted with the involvement of 40 experts from 22 different institutions to enhance these indicators. Additionally, TIM organized consultation meetings with academic mentors of the Focused InoSuit Program and formed eight different working groups to address 35 medium- and long-term indicators. As a result of these collaborative efforts, more than 20 academics contributed to the development of 34 medium- and long-term action proposals (Unal, et al., 2022).

The Turkiye Global Innovation Index Coordination and Monitoring Platform (TURKIZ) was launched in 2020 to monitor and track the progress of these action items. Representatives of relevant institutions provide monthly reports on the platform, keeping stakeholders informed about the developments related to the action plans.

CONCLUSION

Turkiye's innovation policies have evolved in parallel with its political developments, with the country becoming a founding member of many European institutions since the 1950s, that encompassed the first years of the EU's formation. As Turkiye's economy began to liberalize in the 1980s, policies and strategies emerged to support technology development, laying the foundation for innovation policies. In the 2000s, Turkiye continued its export-oriented growth preference and made structural reforms in the EU membership process, resulting in a model that was compatible with the EU at the institutional level. The government's adoption of the OECD Oslo Manual's definition of innovation in 2005 signalled Turkiye's alignment with the EU path; and the country subsequently developed its entire innovation system with the perspective of the OECD and the EU. In this framework, encouraging the private sector in innovation, public initiative in critical issues, and sectoral innovation efforts have been developed to create an innovation ecosystem. With the transition to the Presidential system in 2018, more inclusive policy measures were introduced and National Technology Move's vision focuses on target technologies, instead of a sectoral approach. These efforts have increased visibility in society and attracted the interest of all segments, especially young students.

The primary objectives of the strategies established after 2018 are to promote high technology and high-added value production. Innovation efforts focused on priority technologies have yielded fruit, especially in the defense industry. Additionally, the support and incentives provided by institutions, such as TUBITAK and KOSGEB, have also increased and concentrated on these areas. The activities of implementing and accelerator organizations have grown in recent years. However, Turkiye, despite consistently expanding its R&D expenditures as a ratio to GDP over the past five years, still lags behind the averages of the OECD and EU, standing at 1.13% in 2021. Nevertheless,

Turkiye's success in the GIII ranking has steadily increased, reaching the 37th position in 2022. The impact of the policies implemented after 2018 is becoming more evident in terms of both innovation outcomes and the global ranking.

When examining the literature, it becomes apparent that R&D expenditures have a positive contribution to economic growth in the medium and long term, if not in the short term, according to studies on Turkiye dating back to the 1990s. The development of human capital is another factor contributing to growth. Furthermore, it is noteworthy that the increase in the number of patents has a positive effect on labor productivity. Studies conducted at the company level also reveal that innovation effectively penetrates new markets and maintains a strong presence in existing ones. Besides, this study demonstrated a strong correlation between the share of R&D expenditures in GDP and labor productivity both in the total industry and manufacturing sectors. Thus it can be asserted that Turkiye's preferred policies aimed at high technology and high value-added production are realistic.

Understanding the Asian experience and comprehending the innovation systems in Asian economies is crucial for Turkiye, which has an innovation ecosystem similar to the EU model. In Turkiye, where the public sector remains the most prominent actor and funder, it plays a key role in developing critical technologies. Gaining insights from the successful experiences of other countries for Turkiye at this stage will support the cooperation and mutual learning mission of the APO.

CHAPTER 5

VIETNAM

NATIONAL INNOVATION SYSTEM (NIS) IN VIETNAM

Policies Supporting NIS in Vietnam

Vietnam is rapidly growing and advancing economically. The country enjoys high GDP growth, averaging over 6.6% per year between 2000 and 2019. This recent phase of economic development starting from 1986 has seen Vietnam open its borders to trade, attract foreign direct investment (FDI), and move quickly into manufacturing. The rapid shift elevated Vietnam from low-income status to lower-middle-income status by 2015 and has seen over 45 million people lifted out of poverty.

In Vietnam, the Law on Technology Transfer and Decree 76/2018/ND-CP stipulates the following:

- Content on supporting creative start-up ideas
- Recognize property rights to ownership, right to use, and other rights arising from the results of scientific research and technological development, and permit the use of this right as security for investment loan transactions and investment for innovative start-ups
- Organizations and individuals investing in and supporting innovation start-ups are entitled to tax incentives
- Have policies to promote individuals and groups of individuals to kick-up innovation
- Organizations to support start-ups to leverage and use the results of scientific research and technological development
- Build technical infrastructure and support the operation of the national technology start-up support center

Comparing 2016–20 to 2011–15, the number of applications and patents increased by 1.6 times at 3,538 while applications for utility solutions by 1.7 times at 1,849 with a total of 5,387 applications. The number of patents and utility solutions in 2011–15 were 698 and 953, respectively, totalling 1,651 applications.

The 10-year Socioeconomic Development Strategy 2021–2030 made resolutions and strategies as a comprehensive framework for Vietnam's socioeconomic development and digital transformation:

- Resolution 23-NQ/TW dated 22 March 2018 is on orientations for building national industrial development policies to 2030, with a vision to 2045
- Resolution 20-NQ/TW on S&T development is to serve the cause of industrialization and modernization in the context of a socialist-oriented market economy and international integration

- Conclusion 50-KL/TW on continuing to implement Resolution 20-NQ/TW
- Resolution 52-NQ/TW on mechanisms and policies to actively participate in Industry 4.0
- National Strategy on Industry 4.0 to 2030
- Strategy on Intellectual Property to 2030
- National Digital Transformation Program to 2025, with orientation to 2030
- Decision 681/QD-TTG dated 4 June 2019, promulgating a roadmap for the implementation of Vietnam's sustainable development goals until 2030

Recognizing the significance of digital transformation for continued growth and prosperity, the Vietnamese government is committed to driving its implementation across its economy. Currently, various agencies are responsible in supporting and regulating different aspects of Vietnam's digital economy. The regulatory framework consists of commercial regulations and decrees issued by different ministries, such as the Ministry of Information and Communication is primarily involved in the country's telecommunications and ICT industry-related issues.

Establishing a single unified agency or ministry dedicated to enhance the efficiency, coordination, and implementation of the country's digital economy is advisable and viable. Such an agency would understand the importance of the digital economy agenda and ensure consistency, synchronicity, and feasibility in policy formulation, implementation, and amendment. The policies should be regularly updated, in tandem with Vietnam's newly inked Free Trade Agreements. This will facilitate regional cooperation for digitalization, innovation, new global value chains, and quality FDI. Moreover, a principle of the digitalization process should be creativity, openness, and, starting from the government and extending to the society as a whole.

Science, technology, and innovation (STI) play important roles in developing key industries in Vietnam, with a focus on the processing and manufacturing industries and contribute to restructuring toward a modern national economy. This is the highlight in Decision 569 signed on 11 May 2022 by Vietnam's Deputy Prime Minister Vu Duc Dam in issuing a strategy on scientific-technological development and innovation up to 2030.

The Ministry of Science and Technology's Directorate for Standards, Metrology and Quality serves as the focal point for implementing two important decisions: Decision No. 36/QD-TTg dated 11 January 2021 "The National Master Plan to improve productivity on the basis of science, technology and innovation for the period 2021–2030" and Decision No. 1322/QD-TTg "National program to support enterprises to improve productivity and quality of products and goods in the period of 2021–2030".

The National Master Plan emphasizes the goal of improving productivity and helping Vietnamese businesses to improve their productivity through the application of science, technology, and innovation. Major priorities for the upcoming years include promoting comprehensive digital transformation, fostering green productivity, and developing a highly skilled workforce dedicated to productivity improvement.

Vietnam's NIS Achievements

Vietnam is in the process of entering the next phase of economic development. While the previous phase was based on market development and a shift from reliance on agricultural output to manufacturing, the next phase will be focused on efficiency gains. Between 2018 and 2019, Vietnam

rose 10 places on the Global Competitiveness Index (GCI), published by the World Economic Forum, and is now ranked 67th in the world. These are remarkable gains, however, further economic development will require greater focus in elevating labor productivity through technological change that essentially requires both technology adoption and technology creation.

Drivers Of GDP - From Agriculture to Manufacturing and Services

The simultaneous decrease in agriculture's contribution to the GDP in the past two decades is proportionate to the increase in industry and services. The services sector is the largest contributor to national output, accounting for over 40% of total GDP. Vietnam worked towards the aim to improve the combined contribution of industry and services to 85% of total GDP by 2020.

In some areas relevant to the digital economy, Vietnam is leading the world in:

- **5G networks** - Vietnam is one of the first countries in the world to adopt 5G with a commercial launch (scheduled for 2021)

- **High school performance** - International rankings place Vietnamese students on par with or above high-income nations in science, reading, and maths

- **Affordable Internet service** - Vietnam offers the most affordable fixed broadband prices in the Asia-Pacific region, with rates lower than those of Indonesia, Thailand, and the Philippines when adjusted for purchasing power parity. In the regional comparison of business and innovation, human development, digital infrastructure, and digital economy, Vietnam's strongest areas are high technology exports and performance on the Global Innovation Index (GII)

With its young and dynamic population, strategic location with rapidly growing Asian economies, and high levels of investment, Vietnam is well-positioned to embrace new digital technologies. However, this transformation must be carefully managed to mitigate risks and ensure equitable benefits for all. In these times of rapid change, the greater risks lies in failing to transform at all.

FIGURE 5.1

IMPACT OF INNOVATION AND TECHNOLOGY DEVELOPMENT ON BUSINESSES

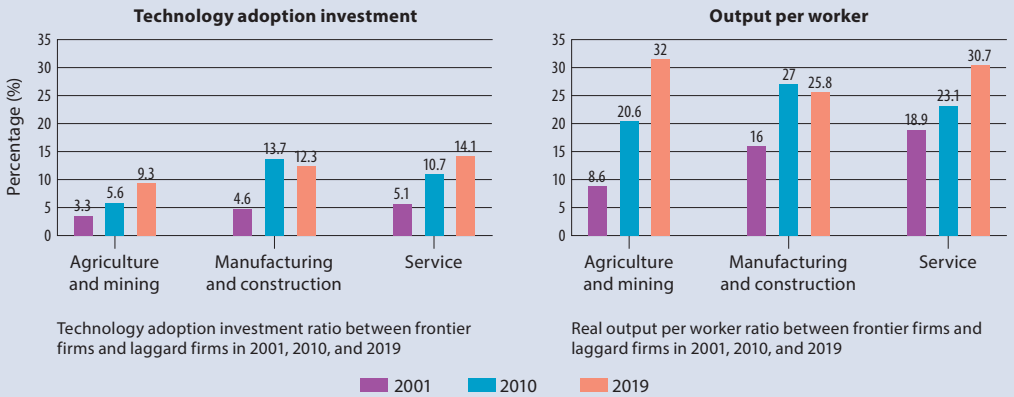


FIGURE 5.2

REAL INVESTMENT IN TECHNOLOGY ADOPTION PER WORKER IN 2001–19

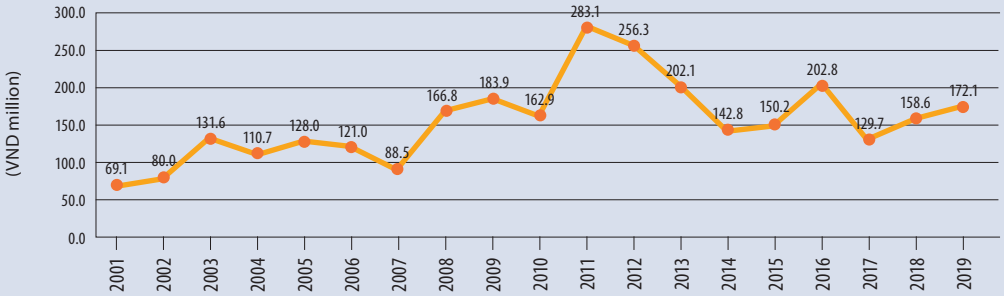
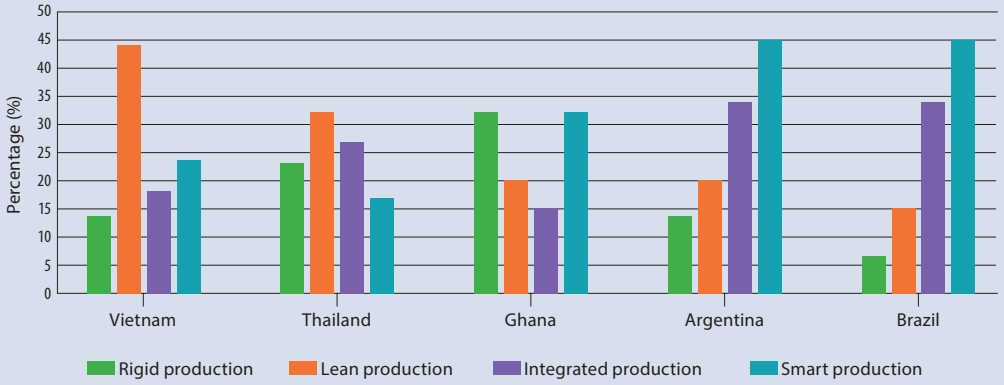


FIGURE 5.3

UPCOMING FIVE TO TEN YEARS PLANS TO IMPLEMENT NEXT GENERATION PRODUCTION TECHNOLOGIES IN VIETNAM AND SELECTED COUNTRIES



Source: Unido.

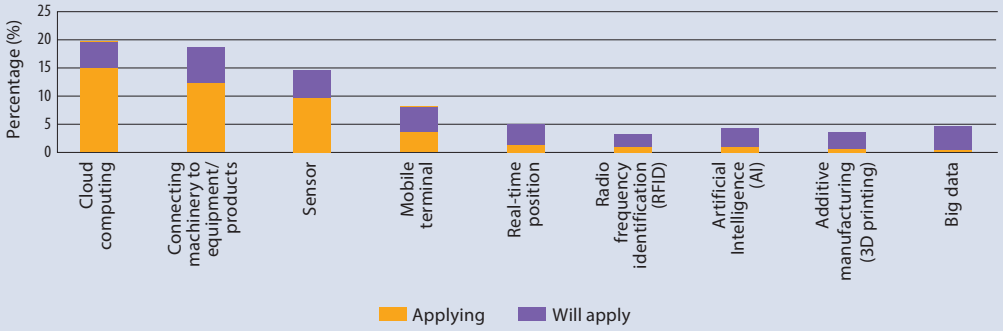
Vietnam is dedicated to provide universal connection coverage across the country. The first universal service program was implemented between 2005 and 2010 with a total investment of over VND5 trillion (Decision No. 74/2006/QD-TTg). The program on the provision of public telecommunications services until 2020 was issued in 2015 and revised in 2018 under Decision No. 868/QD-TTg. Under this program, a total of VND7.3 trillion went to the development of broadband infrastructure nationwide with priority given to remote and isolated areas, disadvantaged areas, border areas, and islands.

HR and R&D Vietnam aims to enhance the quality of its workforce. Between 2005 and 2017, the proportion of state budget spent on education increased from 11% to 15%. 74 Directive 16/CT-TTg also clearly identifies HR as fundamental to implementing IR4.0, setting goals to "Change policies, contents and methods of education and vocational training in order to generate human resources which are able to follow new technological production trends, including the focus on promotion of training in science, technology, engineering and mathematics (STEM), foreign languages, information technology in universal; promote autonomy in higher education and vocational training; pilot regulations on

vocational training and higher education applied to some specific fields. Turn population challenges and golden population into an advantage in international integration and international division of labor."

FIGURE 5.4

VIETNAMESE FIRMS APPLYING OR PLANNING TO APPLY DIGITAL TECHNOLOGIES IN 2018



Source: Ministry of Industry and Trade.

Overall, the government has connected increased innovation, including the development of digital economy, with increasing creativity and experimentation, and a culture of openness and freedom. Vietnam's policies emphasize R&D. Decree No. 95/2014/ND-CP, where one decree requires SOEs to invest 3%–10% of total revenue for R&D activities.

Vietnam also implements various programs to foster the start-up and innovation ecosystem. These include the National Agency for Technology, Entrepreneurship and Commercialization Development (NATECD), National Technology Innovation Fund (NATIF), Hoalac Hitech Service Centre, and the Saigon Silicon City Centre. The government will also build the National Innovation Center and National Start-up Center, where enterprises can set their base, through Resolution No. 1&2/2019/ND-CP in improving the country's business environment and national competitiveness.

In addition to enterprise-level initiatives, the government is also committed to various digitalization initiatives. The adoption of digital technologies across industries, including agriculture, healthcare, security, and defense was promoted in the National Technology Development Program up to 2020.

Recognizing the importance of being a leader in the reform and digitalization process, the Vietnam government established a national e-government committee in 2018 (under Decision No. 1072/2018/QDTTg). The committee is responsible for researching and proposing strategies, mechanisms, and policies, creating a legal environment to promote the construction and development of e-government and facilitating the implementation of IR4.0.

Vietnam is also committed to building smart cities. In 2018, Vietnam joined the ASEAN Smart Cities Network and approved the Sustainable Smart City Development Plan for 2018–2025 and direction until 2030 (Decision No. 950/QDTTg). By 2020, the plan outlined the creation of a legal framework to support sustainable smart city development as well as build and pilot databases to support urban development. By 2030, the plan aims to "establish the network of smart cities in the north, central Vietnam, the south, and Mekong Delta, in which Hanoi City, Ho Chi Minh City, Da Nang City, and Can Tho City shall be nuclear cities, and establish linkages between smart cities."

Review and Data Analysis

Currently, there are no reliable data nor indicators to measure or track technological progress and the impact of science and technology on productivity improvement. The lack of reliable data may be affecting R&D investment.

It is understood that reliable indicators will generate investment confidence in Vietnam's industry and R&D. In comparison to its ASEAN peers, Vietnam's investment in science and technology is low. The low levels of investment and a lack of investor confidence may stem from the perception that the productivity gains from technology adoption and creation have been insufficient. The direct and indirect impacts of low R&D investment in Vietnam on productivity, GDP, and economic growth are still speculative.

The next economic phase is dependent on Vietnam's adoption of new technologies. To avoid the 'middle-income trap' and progress toward higher income status, it is crucial for Vietnam to achieve productivity gains across its industries through technology adoption.

CASE STUDY: VIETNAM'S INNOVATION IN TACKLING THE COVID-19 PANDEMIC

Open Innovation and Promoting Innovative Start-ups in the Context of COVID-19 Pandemic

The COVID-19 pandemic has had a profound impact on every aspect of life and society. However, it has also sparked a vibrant start-up and innovation spirit, which has emerged as a significant force driving the country's economic development and recovery. Despite the challenges posed by the pandemic, Vietnam has witnessed remarkable achievements in its innovative start-up ecosystem. This success can be attributed to the concerted efforts of the government, relevant ministries, sectors, and communication agencies.

Thanks to the unwavering commitment of ministries and the government, Vietnam is making great strides in the field of innovation. The outcome of investments in start-ups and technology-based businesses have been recognized by global organizations. According to the 2022 edition of the GII, published by the World Intellectual Property Organization (WIPO), Vietnam has achieved a score significantly higher than the average of countries in the same income group.

In the 2022 GII ranking, Vietnam ranked 48th position out of 132 countries and economies, placing it among the group of nations that have made remarkable progress over the past decade.

Numerous businesses have swiftly transitioned from traditional to nontraditional business fields, incorporating technology across all aspects, from production and delivery. The comprehensive digital transformation has not only changed the way these businesses are conducted but also transformed the work culture itself.

Businesses are now placing greater emphasis on collaboration with the innovative start-up ecosystem to promote their overall capabilities. Simultaneously, start-ups exhibit flexibility and adaptability in the 'new normal' environment.

Despite the challenging circumstances, such as limited state budget, the National Assembly and the government have introduced a range of policies to support businesses affected by the COVID-19 pandemic. Ministries, localities, and numerous domestic and foreign organizations initiated programs to assist businesses in their digital transformation journey, nurture creative start-up talents, and provide direct or indirect financial support to enterprises, thereby creating an active innovation ecosystem.

Open innovation helps businesses enhance the resilience, products, and services, shorten the delivery of products, facilitate faster product delivery, and boost productivity. Vietnam's science and technology development and innovation strategy until 2030 underscores the crucial need to effectively deploy open innovation platforms and networks, and mobilizing resources from both locally and internationally to create new technologies, new products, and new businesses.

In Vietnam, several businesses have taken active steps to promote open innovation by setting up funds and programs that support research institutes and universities. They also collaborate with organizations to seek suitable and cost-effective technologies. Moreover, they have established open research centers and invited start-ups to join these initiatives. Many start-ups, research groups, universities, and research institutes have formed networks of experts to tackle business challenges. Although Vietnam's start-up innovation ecosystem is relatively young, it is fairly comprehensive, encompassing a range of organizations, such as investment funds, intermediary support organizations, and universities. However, the heart of the ecosystem lies in the talented individuals who created the start-ups.

Deputy Minister of Science and Technology Bùi Thế Duy said that since 2017, Vietnam has referred to the GII, published annually by WIPO, to identify its strengths and weaknesses, seek appropriate solutions, and introduce relevant policies to address them.

Several policies that were implemented in response to the findings include Resolution No.05-NQ/TW of the Fourth Conference of the 12th Party Central Committee that focuses on renewing the growth model, improving growth quality and labor productivity, and enhancing the economy's competitiveness; the Resolution of the 13th National Party Congress; the 10-year Socioeconomic Development Strategy for 2021–2030; and the Strategy for Science, Technology and Innovation Development by 2030. These initiatives provide a framework for Vietnam's progress and development in these areas.

The Deputy Minister also highlighted the country's commitment in promoting the development of artificial intelligence (AI). In 2022, the ministry organized the event "Việt Nam Artificial Intelligence Day 2022" and collaborated with partners to create capacity rankings for research and training institutions in the field of AI in Vietnam. These capacity rankings will serve as valuable references for the academic community and students when selecting educational and career opportunities. Additionally, the rankings will provide institutions with insights to excel in research and training.

The capacity rankings also provide the state managerial agencies a pool of information for evaluation purposes, enabling them to assign relevant tasks to the institutions. Furthermore, the rankings play a significant role in realizing the national strategy on research, development, and application of AI by 2030.

Looking ahead, the ministry plans to continue refining and updating mechanisms and policies related to STI. This focus will be on implementing a number of key tasks in the national strategy to position Vietnam as a hub of innovation and development of AI applications in the ASEAN region and the world.

At the conference to deploy STI tasks for 2023, Minister of Science and Technology Huỳnh Thành Đạt emphasized that Vietnam witnessed the establishment of numerous innovative start-up support networks at local and regional levels the previous year. These signify the remarkable growth of the innovative start-up ecosystem and have ignited a strong entrepreneurial spirit throughout the country. The achievements are the result of eight years of work since Vietnam hosted the first National Innovation and Entrepreneurship Festival (Techfest).

COVID -19 Catapulted Innovation in Education

The COVID-19 pandemic has caused unprecedented impacts on education and children globally, and Vietnam is no exception. Approximately 4.4 million Vietnamese preschool children experienced disruptions in their learning while around 22 million students across 40 out of 63 provinces and cities had to switch to online classes.

Although the pandemic presented numerous challenges for students and teachers, it also created huge opportunities for innovation and digitalization in the education sector as well as the growth of the education technology (EdTech) market in Vietnam.

Recognizing the importance of education, the government identified it as one of eight priority sectors in the national digital transformation program until 2025, with further plans outlined until 2030. The development of online learning platforms and policies to encourage investment in education are viewed as key tasks and solutions to digital transformation. In line with this agenda, Prime Minister Pham Minh Chinh issued Decision No. 1373/QD-TTg in 2021, approving the "Building a society of learning in the 2021–2030 period" project. This project sets ambitious goal for Vietnam, aiming for 70% of universities to implement digital universities and develop digital learning materials by 2025 as well as having 70% of community learning centers utilizing IT for educational management and activities.

More recently, Deputy Prime Minister Vu Duc Dam signed off a five-year program focused on the digital transformation of vocational training. This program aims to facilitate vocational training activities in the digital environment and strengthen the application of IT in vocational training, ultimately improving the quality of Vietnam's HR and labor productivity. The initiatives underscore Vietnam's commitment to leverage digital technologies to enhance the education sector and develop a skilled workforce.

Meanwhile, the Ministry of Education and Training (MOET) accelerated efforts to boost ICT application in the education sector and bridge the gap between technology and educators. These efforts were evident through the implementation of various regulations, such as Decision 4003 issued in October 2020, which provided guidance on ICT application in line with the government's digital transformation agenda. Additionally, Circular 09 was issued in March 2021, officially approving online schooling as a viable education method. MOET also established a dedicated section on its information portal to support online teaching and collaborated with the Ministry of Information and Communications (MIC) in launching the 'Internet and computers for students' program, which aimed to collect donations of online learning resources for students in disadvantaged regions.

The surge in demand for online learning has positively impacted EdTech market. According to media reports, the country's EdTech market is now valued at an estimated USD3 billion, up from about USD2 billion in 2019. Vietnam, which is home to approximately 200 EdTech start-ups, is among the top five countries receiving investments in educational technology. With the government's supportive policies and initiatives aimed at fostering the growth of EdTech and start-ups, it is evident that this market will continue to flourish.

RECOMMENDATIONS

Megatrends and Scope for Growth

Innovation systems play a crucial role as they directly impact the success of an economy. The effectiveness of an NIS is vital for sustaining productivity and fostering innovation. It is imperative to comprehend the functioning of an NIS to identify its core strengths and weaknesses, which ultimately determines

its performance and provides insights into the measures required to enhance a country's overall innovation capabilities.

Seven megatrends are expected to drive the development of Vietnam's future digital economy. These megatrends will shape the landscape and give rise to four potential future scenarios. The megatrends are:

i) **Emerging digital technologies:** The rapid development of digital technologies, such as blockchain, AI, big data analytics, and IoT presents significant opportunities for industries. These technologies can leapfrog industry infrastructure upgrades, simplify supply chains and logistics, and improve operational efficiency for business.

ii) **A smaller world by embracing internationalization:** The digital economy can greatly benefit from Vietnam's integration into the global market - opening up to new export markets, knowledge and skills transfer, and attracting foreign investment.

iii) **Increasing need for cybersecurity and privacy:** As businesses and consumers increasingly engage in digital economy, ensuring cybersecurity and privacy becomes paramount. The digitalization of critical systems, such as finance and government also necessitates prioritizing safety and privacy.

iv) **Modern digital infrastructure:** A strong digital economy requires reliable digital and energy infrastructure. This is especially crucial for power-intensive technologies, like IoT and AI. Additionally, the development of new telecommunications networks is essential to ensure widespread broadband availability, which is vital for handling the large volumes of digital data needed for new applications.

v) **Push for smart cities:** With rapid urbanization and an aging population, the concept of smart cities presents opportunities to optimize resource utilization, reduce waste, minimize pollution, and alleviate traffic congestion.

vi) **Rise of digital skills, services, gig economy, and entrepreneurship:** The increasing demand in the services sector, digital services, and products calls for further investment in higher education, digital skills, entrepreneurial skills, and Vietnam's innovation ecosystem. Further, the emergence of labor and product platforms offers new avenues for income generation and creative avenues for industrial transitions into labor markets while the trend moves away from secure, structured, and long-term work.

vii) **Changing consumer behaviors - digital tribes, influencers, and higher value consumption:** The rise of the Asian middle class and their demand for higher-value goods and services, including those from the digital economy, is shaping consumer behaviors. Additionally, the growing influence of digital tribes and influencers has a significant impact on both suppliers and consumer preferences, stressing the need for businesses to adapt and cater to evolving customer trends.

Improve Technology Adoption among Businesses

Enhancing the ability of firms to adopt new technologies and innovate within their organizations (through structural, strategic, and cultural change) would yield substantial economic benefits to Vietnam in this current stage of development. Designing an effective system to support enterprises, particularly SMEs, in exploiting the advantages of new technology needs to take into account varying levels of technological proficiency among businesses. To improve business capabilities, policies must be implemented to support business education on how to best optimize new technologies. This education should adapt and evolve as the firms evolve and enhance their technological capabilities.

Develop Sectoral-specific Strategies and Policies for Technology Adoption

As discussed earlier, technology adoption activities vary significantly across different industries of Vietnam that result in different impacts. Therefore, sector-specific policies and strategies should be formulated to improve technology adoption within these industries. For instance, sectors, such as telecommunications, banking, and aviation heavily rely on access to new technology from international sources to drive innovation. However, sectors, such as, health or transportation have the potential to develop significant endogenous capabilities and customize technologies to suit the Vietnamese context.

Stimulate Technology Imports

Accessing international technology and information is an important prerequisite for technology adoption. Therefore, technology transfer policies should prioritize the provision of technical information to enterprises. This includes information on the sources, costs, and suitability of foreign technologies for local industries. To support Vietnamese firms in integrating new technologies into their business processes, technical extension services should be provided alongside the technical information. It is critical to provide up-to-date information to local enterprises, especially SMEs with limited technology capabilities. The technical supports and consultancy services offered to SMEs will assist in adopting these new technologies effectively. Programs to support, analyse, and appraise technologies through technology transfer consultancy services are also highly effective for SMEs.

Firms with greater technological capacities that have the potential to participate in creative imitation or technology creation activities require more comprehensive supports. This includes access to comprehensive information on licenses, technologies, and markets as well as in-depth reports on technologies, technology development, and technology application in international markets. Feasibility studies on technology transfer and adoption in Vietnam are also necessary. The government should develop policies to actively encourage businesses to adopt and master technologies through various technology transfer channels, such as licensing, purchasing industrial designs, hiring foreign experts, testing, and collaborating on research with foreign research organizations, MNCs, or others.

Accelerate Digital Transformation and Industry 4.0 Technology Adoption

Digital technologies facilitate the adoption of frontier technologies and enable R&D activities, leading to technology creation. Digital transformation requires timely action to keep pace with rapid technological change and updated capacities in areas, such as skills and culture.

Improve 'Spillover' Effects and Forward and Backward Linkages

FDI has proven to be critical to technology transfer and development. However, its impact varies greatly with the economic characteristics and technology adoption capability of the host economy. Therefore, there should be greater emphasis on policies that target enhanced technology transfer and spillover effects. Investment promotion policies should not only focus on bringing in new investments and generating employment, but also encourage MNCs to upgrade their activities in Vietnam beyond simple assembly. By doing so, local firms, including SOEs and SMEs can benefit more from FDI in terms of productivity improvement and knowledge transfer.

Improve Technical Efficiency among Businesses

Optimizing the use of adopted technologies is vital for businesses to become efficient and competitive producers. While generating frontier technologies is essential at a high level, effective utilization of existing technologies is equally important. This broader concept of effective technology use can be referred to as 'technological capability'. Improving technological capacity requires measures to

strengthen firms' capabilities in deploying and utilizing technology, particularly in management and organizational aspects. These core competencies enable businesses to identify new technological opportunities, develop implementation plan to exploit the opportunities, and cultivate the necessary HR to execute those plan. Despite their significance, measures of management and organizational capabilities are often missing from most innovation indices, including the GII.

Promote R&D and Emerging Industries to Advance the Technology Frontier

Increased investment in R&D enhances the capacity for technology adoption and provides the opportunity for technology creation as Vietnam progresses. R&D efforts are maximized when focus is directed in promoting technology adoption and adaptation across all industries and stages, including importation, reverse engineering, adoption and adaptation.

Given limited resources, priority areas for R&D investment should be identified based on industries with the greatest potential over the medium to long term. These priority areas should encompass both existing and emerging industries. Prioritizing R&D investment is key for the country to leapfrog technological phases and avoid investing in increasingly redundant technologies and systems. Support for industry clusters may also be considered as they create innovative environments. Geographic clusters of businesses or organizations in the same industry offer opportunities for complementary activities, enhanced by opportunities for training, development, and collaborative research. This approach effectively stimulates the spillover effect of technology adoption and creation across businesses.

Develop Policy Instruments and Implementation Mechanisms to Synthesize and Stimulate Technology Development Efforts

As in most countries, the responsibilities and functions that affect technology adoption in Vietnam are scattered over an array of ministries and institutions: finance, trade, industry, labor, education, science and technology, and others. These ministries and institutions often have different objectives and do not communicate with each other on a regular and intimate basis. In Vietnam, it is imperative to align innovation policies with strategies for industry, import and export, and national competitiveness in the medium and long term. Coordination is also required among national research and innovation programs to prevent duplication among similar national programs.

A shift in economic focus to productivity and technology also requires a regulatory shift. Vietnam needs to not only develop comprehensive policies but also to strengthen policy implementation to ensure consistency, synchronicity, and responsiveness across implementing agencies. To better align the innovation activities across various government ministries, the government may consider conducting a number of technology 'foresight' programs, aimed at determining the future role of science and technology in Vietnam and the necessary steps needed to achieve a strong NIS. These programs may encourage participation from all parties' stakeholders to determine the driving forces of change and create scenarios for the future.

Focal Points

Building and developing innovation ecosystems across industries, agriculture, and services is requisite, particularly in association with domestic and global value chains and industry clusters. In this context, large enterprises play a significant role in driving innovation activities while state management agencies are responsible for creating a favorable institutional environment and policies that facilitate linkages between enterprises, production organizations, research institutes, universities, and supporting organizations. This collaboration is essential to promote research, application, and innovation activities throughout the ecosystem.

To encourage innovation, it is important to establish and develop a comprehensive system of innovation centers, including the National Innovation Center, regional and industry innovation centers, and support centers for innovative start-ups. By integrating these centers and forming clusters of innovation links with high-tech zones, residential areas, financial centers, venture capital funds, universities, and research institutes, a dynamic and interconnected innovation ecosystem can be created.

The deployment of open innovation platforms and networks is a vital strategy to attract domestic and foreign resources for investment and collaboration. These platforms should encompass the entire innovation process, from basic and applied research to experimentation and creation of new technologies and products that lead to forming new businesses.

Effective cooperation, communication, and promotion activities are necessary to strengthen the connection between domestic and international innovation networks. It is essential to establish the links between innovation centers and R&D centers at home and abroad.

To support and promote technology transfer and innovation activities at the local level, there is a need to improve the functions and tasks of centers for advanced application of science and technology under the Departments of Science and Technology. These centers should receive increased investment in terms of HR, financial support, and infrastructure. Thus they can become focal points for localities, providing essential support and resources for technology transfer and innovation activities.

The main tasks and solutions section encompasses groups:

i) Renovating the mechanism for STI activities and enhancing state management capacity in these areas

ii) Establishing an NIS

iii) Attracting and effectively utilizing investment resources for STI

iv) Developing research institutes, universities, and other S&T organizations as strong research entities

v) Cultivating highly qualified and creative HR for STI infrastructure

vi) Attracting investments and optimizing the utilization of STI infrastructure

vii) Promoting STI activities within enterprises

viii) Actively fostering international cooperation and integration in STI

ix) Enhancing efforts to honor, communicate, and raise awareness about STI

These tasks and solutions will develop a dynamic and vibrant NIS in Vietnam.

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ABBREVIATIONS AND ACRONYMS

GENERAL

ADB	Asian Development Bank
AI	Artificial intelligence
EU	European Union
FDI	Foreign direct investment
GDP	Gross domestic product
GERD	Gross Expenditure on R&D
GII	Global Innovation Index
HEIs	Higher education institutions
HR	Human resources
ICT	Information and communication technologies
IoT	Internet of Things
ILO	International Labour Organization
IP	Intellectual property
IPR	Intellectual property rights
IR4.0	Fourth Industrial Revolution
IT	Information technology
MNC	Multinational corporation
MSMEs	Micro, small, and medium industries
NIS	National innovation system
OECD	Organization for Economic Cooperation and Development
PhD	Doctor of Philosophy
R&D	Research and development
SMEs	Small and medium enterprises
S&T	Science and Technology
STEM	Science, technology, engineering, and mathematics
ST&I	Science Technology and Innovation
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
WIPO	World Intellectual Property Organization

CHAPTER 1 INDIA

AICTE	All India Council for Technical Education
AGNIi	Accelerating the Growth of New India's Innovations
APCTT	Asian and Pacific Centre for Transfer of Technology
ASPIRE	A Scheme for Promoting Innovation, Rural Industry & Entrepreneurship
ATI	Assistance to Training Institutions Scheme
ATL	Atal Tinkering Labs
BIO	Biosciences and Bioengineering
BIRAC	Biotechnology Industry Research Assistance Council
BRICS	Brazil, Russia, India, China, and South Africa
CEL	Central Electronics Limited

CAGR	Compound annual growth rate
CDC	Consultancy Development Centre
CENT	Centre of Excellence Nanotechnology
CHEM	Chemical
CIVIL	Civil Engineering
CS	Computer Science
CSR	Corporate social responsibility
CSIR	Council of Scientific and Industrial Research
CGTMSE	Credit Guarantee Trust Fund for Micro & Small Enterprises
CTPL	CSIR-Tech Private Limited
DAE	Department of Atomic Energy
DGT	Directorate General of Training
DIC	Design Innovation Centre
DIPP	Department of Industrial Policy and Promotion
DOE	Department of Electronics
DOMS	Department of Management Studies
DRDO	Defence Research and Development Organization
DiS4	Design of Innovation & Student Start-up Support System
DSIR	Department of Scientific and Industrial Research
DST	Department of Science & Technology
ECE	Electronics and Communication
EE	Electrical Engineering
EQ	Earthquake Engineering
ES	Earth Science
ESDP	Entrepreneurship and Skill Development Programme Scheme
EVBU	Electric Vehicle Business Unit
FICCI	Federation of Indian Chambers of Commerce & Industry
GITA	Global Innovation and Technology Alliance
GSDP	Gross state domestic product
GVA	Gross value added
GVSA	Gross state value added
HRE	Hydro and Renewable Energy
IBM	International Business Machines
ICAR	Indian Council of Agricultural Research
ICICI	Industrial Credit and Investment Corporation of India
ICMR	Indian Council of Medical Research
ICR	Innovation, creativity, & entrepreneurship
IDBI	Industrial Development Bank of India
IFF	Inclusive Innovation Fund
IIC	Institute Instrumentation Centre
IISc	Indian Institute of Science
IIT	Indian Institutes of Technology
IMPRINT	IMPacting Research INnovation and Technology
INDEST- AICTE	Indian National Digital Library in Engineering, Science & Technology Consortium
INSPIRE	Innovation in Science Pursuit for Inspired Research
IRDPP	Industrial R&D Promotion Programme
ISRO	Indian Space Research Organization

KMO	Kaiser-Meyer-Olkin
MIE	Mechanical and Industrial Engineering
MeitY	Ministry of Electronics and Information Technology
MME	Metallurgy and Material Engineering
MoE	Ministry of Education
MoEFCC	Ministry of Environment, Forests and Climate Change
MSE-CDP	Micro & Small Enterprises Cluster Development Programme
MSME	Ministry of Micro, Small & Medium Enterprises
NABARD	National Bank for Agriculture and Rural Development
NAS	National Achievement Survey
NASSCOM	National Association of Software and Service Companies
NCVET	National Council for Vocational Education and Training
NEEM	National Employability Enhancement Mission
NIC	National Innovation Council
NIF	National Innovation Foundation
NIRF	National Institutional Ranking Framework
NISP	National Innovation and Startup Policy
NISTADS	National Institute of Science, Technology and Development Studies
NITI Aayog	National Institution for Transforming India Aayog
NMEICT	National Mission on Higher Education Through ICT
NPTEL	National Programme for Technology Enhanced Learning
NRDC	National Research Development Corporation
NSDA	National Skill Development Agency
NSDC	National Skill Development Corporation
NSDF	National Skill Development Fund
NSTIs/NSTI(w)	National Skill Training Institutes
NTDPP	National Technology Development and Promotion Program
PCA	Principal Component Analysis
PHY	Physics
PISA	Program for International Students Assessment
PMEGP	Prime Minister's Employment Generation Programme
PPE	Polymer and Process Engineering
PPP	Public-private partnership
PPT	Paper and Pulp Technology
PSUS	Public-sector undertakings
RDFDI	Foreign direct investment in R&D
RTE	Right to Education Act
SBI	State Bank of India
SIRD	Science, Innovation, and Research & Development
SIROs	Scientific and Industrial Research Organisations
SPARC	Scheme for Promotion of Academic and Research Collaboration
SSCs	Sector Skill Councils
SSR	Scientific Social Responsibility
STI	Science, Technology, and Innovation
TDB	Technology Development Board
TDM	Technology Development Missions
TEQUIP	Technical Education Quality Improvement Programme

TI-DSP	Texas Instruments Digital Signal Processing
TIFAC	Technology Information Forecasting and Assessment Council
TLR	Teaching, learning, and resources
UGC	University Grants Commission
UTs	Union Territories
WRDM	Water Resource Development & Management

CHAPTER 2 PAKISTAN

BBSYDP	Benazir Bhutto Shahid Youth Development Program
BOG	Board of Governors
CAMB	Centre of Applied Molecular Biology
COD	Cash on delivery
COMSTECH	Committee on Scientific and Technological Cooperation
ECO	Economic Cooperation Organization
EdTech	Education technology
HEC	Higher Education Commission
GCI	Global Competitiveness Index
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
FMU	Funds Management Unit
IDAC	Industrial Design and Automation Center
Ignite	Ignite National Technology Fund
IPO	Intellectual Property Organization
IPUs	Investment Promotion Units
ITC	Indigenous technological capabilities
ITPO	Investment and Technology Promotion office
KBE	Knowledge-based economy
KCIL	Karachi Civic Innovation Labs
KEI	Knowledge economy initiatives
LMS	Learning management system
MOPD&R	Ministry of Planning Development and Reforms
NARC	National Agriculture Research Council
NAVTTC	National Vocational and Technical Training Commission
NCST	National College of Science and Technology
NSPAIT	National Strategic Programme for Acquisition of Industrial Technology
NUST	National University of Science and Technology
PAEC	Pakistan Atomic Energy Commission
PARC	Pakistan Agriculture Research Council
PCST	Pakistan Council for Science and Technology
PPP	Purchasing power parity
PSDF	Punjab Skill Development Fund
PSO	Payment service operators
PSP	Payment service providers
QS	Quacquarelli Symonds Limited
SEZ	Special Economic Zones
SMEDA	Small and Medium Enterprise Development Company
STP&F	Science & Technology Policy Framework
STPF	Science and Technology Promotion Offices

TUSDEC	Technology Upgradation and Skill Development Company
UNCTAD	United Nations Conference on Trade and Development
UNIDO	United Nations Industrial Development Corporation

CHAPTER 3 PHILIPPINES

AdMU	Ateneo de Manila University
APP	Accelerated Poverty Profiling
CBMS	Community-Based Monitoring System
CHED	Commission on Higher Education
CLSU	Central Luzon State University
COVID-19	Coronavirus diseases of 2019
CT	Computerized tomography
DILG	Department of Interior and Local Government
DLSU	De La Salle University
DOH	Department of Health
DOST	Department of Science and Technology
DTI	Department of Trade and Industry
FASSSTER	Feasibility Analysis of Syndromic Surveillance using Spatio-Temporal Epidemiological Modeler
FDA	Food and Drug Administration
FTE	Full-time equivalent
GDP	Gross Domestic Product
i3S	Inclusive Innovation Industrial Strategy
IATF-EID	Inter-Agency Task Force on Emerging Infectious Diseases
IFPRI	International Food Policy Research Institute
LGU	Local government unit
NCR	National Capital Region
NEDA	National Economic and Development Authority
NIH	National Institutes of Health
PCHRD	Philippine Council for Health Research and Development
PCIEERD	Philippine Council for Industry, Energy and Emerging Technology Research and Development
PCR	Polymerase chain reaction
PDP	Philippine Development Plan
PIA	Philippine Innovation Act
PIDSR	Philippine Integrated Disease Surveillance and Response
PPE	Personal protective equipment
PTRI	Philippine Textile Research Institute
PUI	Person under Investigation
QR	Quick Response (code)
RA	Republic Act
RIIC	Regional Inclusive Innovation Center
RITM	Research Institute for Tropical Medicine
SAR-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
SDGs	Sustainable Development Goals
SMS	Short Message Service
STI	Science, technology, and innovation
TESDA	Technical Education and Skills Development Authority

TOP	TESDA Online Program
UP	University of the Philippines
USAID STRIDE	United States Agency for International Development—Science, Technology, Research and Innovation for Development
WEF	World Economic Forum
WHO	World Health Organization

CHAPTER 4 TURKIYE

BTYK	Science and Technology High Council
CoSTIP	Council of Presidency Science Technology and Innovation Policies
DENEYAP	Experiment Technology Workshops
ERA	European Research Area
EU	European Union
MoIT	Ministry of Industry and Technology
SBB	Presidency of Strategy and Budget
TARAL	Turkiye's Research Area
TDZ	Technology Development Zones
Tekmers	Technology centers
TEKNOFEST	Aerospace and Technology Festival
TIM	Turkish Exporters Assembly
TTOs	Technology Transfer Offices
TUBITAK	Scientific and Technical Research Council of Turkiye
WTO	World Trade Organization
YOIKK	Coordination Council for the Improvement of Investment Environment

CHAPTER 5 VIETNAM

EdTech	Education technology
IMA	Innovation management assessment
PDCA	Plan, do, check, act
NATECD	National Agency for Technology, Entrepreneurship and Commercialization Development
NATIF	National Technology Innovation Fund

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