2528-9705

Örgütsel Davranış Araştırmaları Dergisi
Journal Of Organizational Behavior Research
Cilt / Vol.: 5, Sayı / Is.: 1, Yıl/Year: 2020, Sayfa/Pages:212-232

THE STRATEGIC ROLE OF PUBLIC POLICIES IN TECHNOLOGICAL INNOVATION IN PAKISTAN AND LESSONS LEARNT FROM ADVANCED COUNTRIES: A COMPARATIVE LITERATURE REVIEW

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ABSTRACT

Technological innovation is becoming one of the primary sources of development for nations, especially in developing countries with limited resources. Pakistan is also striving to find its way in the technology dimension along with conventional agricultural and industrial growth. The government of Pakistan has been increasingly focusing on providing a conducive environment for technological innovation. The question of the effectiveness of such policies, regulations, programs, projects, and initiatives persists though. Fortunately, there are success stories available in the academic as well as non-academic recent literature from countries that have leveraged technological innovation to the best effect with governments playing a key role to facilitate the innovators. This paper aims to review government policies, regulations, programs, focus, and challenges in the context of Pakistan and compare them with technologically advanced countries like the US, Japan, UK, France, and China for the sake of learning from international best practices. The findings reveal some challenges ahead for the Pakistani government that are same as for technologically advanced countries, but with more severity. It also highlights a few problems that are more specific to Pakistan such as political instability, corruption, mal-governance, brain drain, startups funding issues and lack of intellectual property rights protection. Pakistani government can take a leaf out of the book of technologically advanced countries where governments have taken significant measures to counter those challenges.

Keywords: *Public Policies; Technological Innovation; Semi-systematic Literature Review*

INTRODUCTION

Technological innovation is not only important for private businesses and the public sector, but the economies and society in a larger canvas (Rafique et al., 2018). It has tangible and intangible benefits to meet customer demands. It provides a competitive edge to businesses by bringing optimization and efficiency in the operations. The diversification of management methods helps enterprises to be managed more systematically and conveniently. Moreover, it enables organizations to keep up with the pace of change in the market and achieve sustainability in the dynamic market economy. On the other hand, innovative technologies make the lives easier for business customers and the end consumers (Malkanduev et al., 2018). From health care and disease control to building better modes of transport and communication, technological innovation helps almost every aspect of human life and overall sustainable development. From the economics point of view, technological innovation either produces more jobs or changes the nature of jobs to be more creative and productive rather than engaging in mundane tasks that can be easily automated by technological innovation.

Geliş tarihi/Recieved: 21.10.2019 – Kabul tarihi/Accepted: 26.04.2020 – Yayın tarihi/Published: 08.05.2020

This leads to economic growth and improvement in the trade position. Productivity growth ultimately helps in controlling inflation, so indirectly improving human lives in another way (Lehrer, 2018). The impact of technological innovation has not been challenged by the researchers to a considerable extent. However, adopting technological innovation and turning it into a success has been challenging for businesses especially in developing countries like Pakistan (Jiao et al., 2016). So, regardless of organizations' internal challenges, this paper has focused on the relationship between government regulations and technological innovation and the manifestation of that relationship in technologically advanced countries as well as in Pakistan as a developing country.

Pakistan's major economic problem has been a trade deficit, which compels it to knock the International Monetary Fund's (IMF's) door for debt servicing and earning foreign exchange. One of the main reasons for this trade deficit has been technologically unprogressive exports or the dearth of exporting any technologically advanced products. While the demand for technologically advanced products such as new models of mobile phones and vehicles increases with the increase in income and improving global trends towards the preference of using tech-products. This creates a gap between sales and supplies, which can only be reduced by the local production of technologically innovative products, which assists in increasing their exports while reducing imports. This calls for the critical role of government in the promotion of sustained technological innovation by taking inspiration from the proven models and experiences.

Developed countries, such as Germany, Japan, United States, United Kingdom, France, China, etc. have remained quite focused on technological innovation as a roadmap to their future and a critical part of their vision. They have managed to create a right balance between the ease of doing business for technology startups and safeguarding investment of the incumbents contributing positively towards the macroeconomy of the country. Government policies can negatively affect technological innovation in two ways. It can either create barriers for new entrants and build an oligopoly of existing players or conversely, it can make it difficult for the innovators to sustain either by allowing imitators to exploit the investment of innovators or by increasing cost of doing business in the form of taxes and duties (Joo et al., 2018). By studying how developed economies dealt with these challenges successfully, developing countries like Pakistan can take inspiration to create a conducive environment for technological innovation.

Technology entrepreneurship in Pakistan has been flourishing for the last two decades with some fluctuations due to environmental variables. Many startups have come up with technologically innovative solutions. Some of them could not take off while others took off but could not sustain their competitive advantage and growth. While some other factors play a role in the growth and sustainability of technology startups but the role of government in making life easier for technological innovators has been a growing concern in Pakistan striving for economic and socio-political stability. This concern compels us to investigate the following research questions to not only better understand the phenomenon but also to aspire the decision-makers to adopt successful policies and guidelines. This probe aims to explore the strategic role of public policies in technological innovation in Pakistan and unearth lessons from advanced countries via a comparative meta inquiry of literature. Moreover, it ascertains the following research questions:

Research Question 1: What strategic initiatives Pakistan has taken for technological innovation inclusive of government policies, regulations, strategies, and measures?
Research Question 2: How is the Pakistan government contributing (in terms of research and development [R&D] expenditure and innovation scores with trends) towards technological innovation in Pakistan as compared to technologically advanced countries?
Research Question 3: What can the Pakistan government learn from technologically advanced countries to foster technological innovation in the country?

METHODOLOGY

The methodology of this research is a semi-systematic literature review. In the business and management research, a literature review is rapidly gaining popularity with the rising complexity of evidence collection due to exponentially accelerating changes (Snyder, 2019). Since the research questions are broad, it is not possible to review all the related literature systematically. Therefore, the semi-systematic approach has been taken which is more purposive and provides the flexibility to a researcher to design his literature collection criteria and method to answer the research questions. There are many examples of semi-systematic literature review as a methodology in business research (McColl-Kennedy et al., 2017). Researchers have used alternative terms for similar methodologies, such as meta inquiry and meta-synthesis to interpret various qualitative studies, which assist in building theories too. For data collection and analysis, a comparative literature review method has been used to identify patterns related to technological innovation in Pakistan in comparison with technologically advanced countries (Brummer, 2018). Although a significant number of academic literature has been used but considering the dynamism and modernism of the topic, some non-academic literature has also been availed along with the official sources to collect facts and figures. Most of the sources used in references pertain to the last 5 years' data, along with some older essential older sources. This provides the level of recency required to address such a dynamic and modern theme as technological innovation.
The focus is to analyze the measures taken by the government of Pakistan for harnessing technological innovation, their impact, gaps and the lessons learned, but they have been analyzed in comparison with the technologically advanced countries. Many scholars, such as Doran et al. (2018) and Zargun& Al-Ashaab (2014), have used a comparative technique with developed countries for analyzing states of affairs in developing countries. So, a purposive sample of five (5) technologically advanced countries has been used for which sufficient data and literature were available for thematic analysis. Trustworthiness principles have been taken into account and the latest literature has been reviewed. But the outcome is a recommendation to the government in terms of focus, vision, strategies, policies, and regulations related to technological innovation. All of these elements have a huge impact, which needs more thorough, rigorous and continuous academic and applied research to take action. The amount and depth of literature may not be enough to be converted directly to government actions. However, it will be highly useful to understand Pakistan's current position for technological innovation in comparison with technologically advanced countries having proven models and to find the way forward.

LITERATURE REVIEW

Government Role for Innovation in Technologically Advanced Countries

The overview of innovation policies in some of the technologically advanced countries helps us to take inspiration from and learn from the successful role of governments to foster technological advancement.

Technology Leadership of Unites States

The United States of America is an acknowledged leader in technological innovation. It greatly relies on technology leadership for leading the global economy. Apart from economic well-being, technology also helps the US for better governance in various fields such as healthcare, defense, communication, and energy. Although a significant share of technological developments came from the government programs historically, the role of government in technological innovation has been a debatable subject recently in the US. Experts are suggesting the federal government focus more on long-term scientific research rather than short-term research and technology deployment (Duderstadt, 2016). The government's role in technology deployment is perceived more as "corporate welfare" due to various reasons. Currently, there are four critical policy directions from the US government for the correction of the market and network failures.

Defense Advanced Research Projects Agency (DARPA)

This is an agency empowered by communities aimed towards developing innovative technologies to be used by the military. DARPA focuses on transformational change instead of incremental as well as collaboration among different entities in the innovation ecosystem i.e. academia, corporate and government institutes. Although DARPA was initiated in 1958 to support the military it later diffused to foster innovative technologies related to other government agencies such as alternative energy projects for the Department of Energy (Challenge, 2019).

National Research Laboratories

It is the result of the government's policy to fund all national laboratories. Just Like DARPA, national research laboratories also focused on defense solutions in general and nuclear weapons specifically. But later, it expanded to commercial use. It also encouraged collaboration among academia, corporate and government firms. It was empowered by the "Stevenson–Wydler Act of 1980" (Keller and Reber, 2012).

Public-Private Partnership (PPP)

The federal government resumed funding universities for research and the "Bayh-Dole Act of 1980", which allowed them to patent that research. It relies on the capacity of research in universities and public institutions to contribute towards technological innovation. It started in the 1970s and since then various programs have been launched under public-private engagement and have completed a range of endeavors (Montalvo, 2017)

Demand-Side Measures

US government has taken various measures historically and recently to reward investment in innovative technologies and boost the private sector demand for technological development. The government introduced R&D awards as well as established testing and evaluation centers. It has also provided tax credits for investors in certain technologies according to the national demands (Holtzman, 2018). Similarly, it established certain infrastructure to promote the use of certain technologies. For instance, charging facilities for electric vehicles encouraged the use of electric vehicles throughout the US.

Crisis Management through Technological Innovation by Japan

Japan is a good case to study for the government's role in technological innovation since Japan has been a role model for all the industrial countries trying to restore economic growth after the crisis. It is the third-largest investor in science and Technology in Organization for Economic Cooperation and Development (OECD). Japan faced its first long-term recession in the 1990s after which a fundamental science and technology law was passed. The objective was to revive economic growth through technological innovation (Liu et al., 2019). As a series of four years policies, five basic plans have been launched from time to time depending upon the issues at hand and overall vision of the government in charge.

Basic Plans

The first basic plan was launched in 1996. Its salient feature was an emphasis on academic scientific research through which 10,000 doctorates were produced. In addition to this, an impartial evaluation system was established for young researchers. Various forms of funds were introduced and expanded to promote and diversify R&D. This was followed by massive administrative reforms in 2001, which led to the second basic plan. It set a vision to become a science and technology-oriented nation. To attain this vision, the government decided to increase its R&D expenditure and make efficient use of its resources. Initiatives for internationalization of activities related to technological innovation were taken. Setting ethical standards for scientific research was also one of the features of this comprehensive plan. The third basic plan was launched in 2006 amidst recovery from the long term economic recession. Japan started showing signs of sustainability as a result of first and second basic plans. Therefore, the third basic plan not only promised for continuing spending on R&D but also promised contribution to society. However, Fukushima nuclear disaster and a devastating earth-quake in 2011 put brakes on Japan's road to technological glory. Therefore, the fourth basic plan launched in 2011 focused more on reconstruction from the disaster. It also compelled launching more ambitious and more risky competitive funding programs. The fifth basic plan launched in 2016, to be used till 2020, is more futuristic and emphasizes investing in modern technologies such as the internet of things (IoT), Robotics, Data Sciences, Blockchain, Artificial Intelligence, and Machine Learning. It also proposes the government invest 1% of GDP on technological innovation programs whereas 4% of GDP through public-private partnerships (Fukuda, 2019). All of these comprehensive basic plans have resulted in improved performance of Japan related to technological innovation.

Challenges of Japan for Technological Innovation

To improve technological innovation performance further, Japan needs to counter some of the key challenges. Few of those challenges appear socio-economic. For instance, the participation of youth in technological advancement and research is limited. Secondly, although Japan is investing heavily in R&D related to technology, international collaboration and foreign direct investment are must in the era of globalism, which seems lacking in Japan at present. Another challenge is the inadequate participation of women who leave Japan behind other countries with similar dynamics. The fourth challenge is related to digitalization in which Japanese firms usually lead the show but the impact is not visible due to lack of conducive policies for skills development and business drive (Palmer, 2018).

Innovative Economy in the United Kingdom

UK (United Kingdom) enjoys a great position concerning technology and innovation. UK government has a vision of making the country the "world's most innovative economy" (Dean, 2019). To further boost technology innovation in the UK, the government has decided to adopt a well-defined strategy to improve coordination and collaboration. The speed of innovation and emerging technologies has compelled the policymakers to continually review and refresh the strategy and policies though. The UK government's latest strategy on technological innovation can be explicated in three main dimensions i.e. people, process and technology.

People, Process and Technology

People who can continually innovate are often difficult to be found adequately, recruited and retained. Therefore, UK government policy is first to identify such trained professionals and boost their skills to match the desired level. They need to be recruited and assigned to the relevant and best-fit government or semi-government institutions and then be provided all the required ingredients for retention. Their knowledge should be disseminated to other professionals so that a proper backup plan can be created and innovation can be expanded. Apart from leveraging the skills of trained technical professionals, it appears vital to provide them the right socio-economic conditions and organizational culture to make the best out of them. The process is another dimension which is the center of attention of the latest innovation policy. Usually, the red-tapism and bureaucracy associated with procurement and business approvals of government organizations prove to impede technological innovation, which requires timely and agile decision making. So, lightweight agile processes are required for the innovators to have access to the required tools all the time. "Spark" is one of those initiatives which enables the technological innovators to procure right and relevant tools promptly. Finally, the technological infrastructure required to have access to the large volume and depth of data that is generated by technologically innovative people and processes is also a key to success. Two crucial factors in data access to technologically innovative organizations are safety and efficiency. Usually, there is a trade-off between the two. Data and information security is fast gaining emphasis of global stakeholders. UK government is committed to ensuring the security of data, without unnecessary compromise on availability, by using the right technology (Dowden, 2019).

Ventures for Technological Innovation in the United Kingdom

Alongside this strategy, the UK government is planning in three key areas. First is the "Guide to Using AI in the Public Sector" (Peets et al., 2019). It aims to use artificial intelligence across all government departments by "Government Digital Service" and "Office for Artificial Intelligence" in collaboration with the experts from the relevant sector. Secondly, "Spark" has been launched as a marketplace for emerging technologies. This will help technology-based small and medium-sized enterprises (SMEs) in the public sector to benefit from innovative solutions (Fullwiller, 2016). The third is the joint venture with "Digital, Culture, Media, and Sport (DCMS)" that will ensure the secure and active usage of digital entities across the country. Despite all these measures, there are still some outstanding challenges in all the three mentioned dimensions due to which there is a need for continually reviewing the innovation policies to provide enough space for technological innovation (Badran, 2019).

Technological Innovation as a Competitive Advantage in France

The major aspect of French economic growth has been innovation, especially for the last two decades. It was initiated by the "Innovation and Research Act" in 1999 followed by "Act of 18th April" which was related to research. The vision of French policymakers is "intensify innovation and forge closer ties between public and private research" (Ministère de l'Europe et des Affaires étrangères, 2019). France considers innovation as one of its major competitive advantages. France enjoys a great position in R&D in the European economy with 51 research centers in 2016, which grew to 78 in 2017. In terms of patent grants, France is 6th best in the world. It is also a leading medal winner along with the US for competitiveness (Muller et al., 2009). But this has been a result of a systematic and focused approach of the French government regarding innovation.

Systematic Approach of the French Government

In recent years, the French government has taken sizable steps for fostering innovation. One such step is setting the goal of making the country a "Startup Nation" (Schmelck, 2018). This is complemented by various funds such as breakthrough-innovation funds along with endowment funds. Secondly, the government has launched programs for French startups to make their mark internationally. These programs include incubators and accelerators to support technology entrepreneurship. On top of it, the French government is also committed to bring foreign investment into the French innovation ecosystem to upsize the volume of technological innovation. New Technology Venture Initiative (NETVA) and Young Entrepreneur Initiative (YEI) are the two latest programs to support this goal of making France an ideal place to launch a technology startup (Mercier-Laurent, 2015). "French Tech Initiative" was launched in 2015 to increase the attractiveness of European and foreign startups towards the French innovation ecosystem. The year 2018 proved to be a golden year for the French Tech initiative when well-performing startups were announced incentive and encouraged to provide solutions to the problems faced by the society and the global world (Akrout et al., 2018). So, the investment in technology for social goods has also become one of the salient features of French innovation policy.

China Capturing Global Market through Technological Innovation

China's emergence as a world-leading economy in many respects has been a remarkable phenomenon in modern history. Among its exports, technologically innovative products have been a significant contributor. China has performed exceptionally well in mobilizing resources for science and technology. It has the second largest number of researchers in the world due to its spending on R&D. It is believed that more than 36% of the scientific publications belong to Chinese researchers, which is a huge number for a single country. Foreign investment in R&D has also increased significantly (Xie and Freeman, 2019). More importantly, in the early 2000s the first wave of Chinese technology startups established their brand equity across the world, such firms are now influencing the global markets strongly through mergers and acquisitions. These achievements of China in science and technology innovation are beneficial not only for China but also for the global economy (Zhang et al., 2018). However, China still has some challenges to address sustainable technological innovation goals.

Sustainability Challenges for China

The major challenge created by heavy foreign investment in technological products is having an inadequate infrastructure and human resources. Although China has got a huge infrastructure and human resources still there is a gap in the growth rate of foreign investment and expansion of human resources for science and technology in various business sectors (Ye, 2019). Secondly, the overall regulation and law enforcement system in China is yet lagging far behind than other technologically advanced countries in terms of having an open system of innovation. Rules like intellectual property rights affect the growth of technology entrepreneurship in China to some extent. Some of these conditions are perceived as redundant by the business sector (Chen et al., 2016). Another important challenge is China's increasing role in the global technology economy, which demands even more researchers and scholars in science and technology by Chinese universities than they are currently producing (Wasserstrom and Cunningham, 2018).

Recommendations for China to Sustain Technology Leadership

To overcome the challenges faced by the Chinese government to boost technological innovation further and make it sustainable, some authors have provided certain recommendations. One of these conditions is to improve framework conditions for innovators and waive unnecessary regulations and restrictions, which will encourage more technological innovators (Malerba et al., 2017). Another important recommendation is to have dedicated policies and regulations for science and technology instead of using generalized laws and strategies to manage the technological ecosystem. A bunch of specific recommendations has also been provided by scholars to review the role of government for technological innovation and to bridge the gap between industry and academia (Kergroach, 2019).

Technological Innovations in Pakistan

Technology advancement and growth initiatives in Pakistan have been taken care of by the Ministry of Science and Technology (MoST). The major objectives of MoST are to build technological competence in Pakistan to counter the brain drain that happened in the last several years, to enter new markets of technologically innovative products and services and to

continuously upgrade the technological infrastructure to be used by innovative technology organizations in Pakistan. MoST are also focused on better governance of science and technology research to improve the innovation ecosystem in Pakistan. The latest "ThinkFuture" program launched by the minister of science in technology in 2019 is focused towards seven innovative and emerging technologies i.e. "3D Printing", "Artificial Intelligence", "Augmented Reality", "Blockchain", "Internet of Things", "Intelligent Vehicles" and "Smart Robots". MoSTis carrying out various programs and projects to promote technological innovation in Pakistan (Government of Pakistan, 2019). Apart from this, the following organizations have been working under the umbrella of MoST to make the most out of opportunities for innovation without ministry having to manage it directly (as portrayed in Table 1 below). They include Council for Work and Housing Research, COMSATS University Islamabad, National Institute of Electronics and others.

Table 1. Umbrella Organizations of Ministry of Science and Technology, Pakistan

• Council for Work and Housing Research
• COMSATS University Islamabad
• National Institute of Electronics
• National University of Science and Technology
• Pakistan Council for Renewable Energy Technologies
• Pakistan Council for Science and Technology
• Pakistan Council of Research for Water Resources
• Pakistan Council of Scientific and Industrial Research
• Pakistan Engineering Council
• Pakistan Halal Authority
• Pakistan National Accreditation Council
• Pakistan Science Foundation
• Pakistan Standards and Quality Control Authority
• STEDEC Technology Commercialization Corporation of Pakistan (Private) Limited

Source: Ministry of Science and Technology (2019)

National Science, Technology and Innovation Policy

Scientific and technological innovation had been realized as a significant foundation for Pakistan since its inception because of its security as well as socio-economic needs. In both dimensions i.e. science and technology as well as research and development, Pakistan started from scratch and established infrastructure and organizations in all major disciplines. In the regime of the former premier, Mr. Z. A. Bhutto during the early 1970s, Pakistan took various initiatives to uphold science and technology. Pakistan partnered with China in this regard and spurred the United Nations to set up its office of the United Nations Educational, Scientific and Cultural Office (UNESCO) in Pakistan (Qureshi, 2018). The formation of the National Scientific Commission of Pakistan was a first milestone towards aligning scientific research objectives with national development. For national science and technology policy, the recommendations of this commission opened the doors for academic and industrial research in educational and R&D institutes. In 1984, first "National Science and Technology Policy" was

formed, which was followed by "National Commission for Science and Technology" meeting in which some recommendations were given which laid the foundation of current policy for science and technology (United Nations Education, Scientific and Cultural Organization et al. 2007).

Science and Technology policy of 2012 was formally launched in the realization that all the efforts made before in this discipline were commendable yet not effective enough. Various stakeholders participated in the preparation of the policy and it focused on supporting the social and production sector. Infrastructure planning is also a key focus on National Science, Technology and Innovation Policy 2012. Human resource development has also been emphasized in the policy as Pakistan has a high potential of producing technically competent professionals who can work on emerging and innovative technologies. The policy also expands to the creation of absorptive capacity through technology transfer and working on advanced technologies. The vision of this policy is "to achieve security, prosperity and social cohesion of Pakistan through equitable and sustainable socio-economic progress using science, technology, and innovation as central pillars of development in all sectors of economic activity". International cooperation is also part of the policy as a collaboration among the countries are paving the way for technological advancement across the globe (Qureshi and Demir, 2019).

Digital Pakistan and Kamyab Jawan Programs

The current Pakistan government has been very focused on programs related to technology and entrepreneurship in the country. One of the major initiatives has been the Digital Pakistan program launched in the last quarter of 2019. Led by the ex-Google star Tania Aidrus as chief Digital officer, this program is working on various aspects of digitization of the country. It expands across the concern areas of but not limited to access and connectivity, digital infrastructure, e-government, digital skills, and training as well as innovation and entrepreneurship (as shown in Table 2).

Table 2. Digital Pakistan (and Concerned Areas)

Access and Connectivity	Digital Infrastructure	E-Government	Digital Skills and Training	Innovation and Entrepreneurship
• Low-cost devices • Internet access • Affordability of data • Taxation of broadband internet	• Regulations and mechanisms for the digital economy • Identity systems • Payment Solutions	• Paperless procurement • Easy sharing of data within depts. • Interlink government resources	• Technical skills • Bootcamps, vocational opportunities • Digital literacy	• Enable startup ecosystem • Ease of business

Source: (Iqbal, 2019)

Although innovation and entrepreneurship have been addressed in the Digital Pakistan program it is more focused on technology startups. There is another program named as "Kamyab Jawan" program which is dealing with entrepreneurship in general and in a much broader scope since it is not the right assumption to make that all startups can be technological

although they must be leveraging the latest technology for efficiency. The vision is to empower youth in the socio-economic arena nationally and internationally. The program is led by the youth affairs wing setup in 2019 under Prime Minister Secretariat. The program is focused on three E's i.e. "Education", "Employment" and "Engagement" and the challenges were laid down after detailed consultation at Federal and provincial levels. The objective is to facilitate provinces to run programs for youth empowerment and increase inter-provincial coordination for the same purpose. It involves various public-private partnership projects for skills development and micro-businesses setup (Jawan, 2019). The program is running quite systematically under National Youth Development Framework 2019 (as shown in Table 3). The program looks to have a different focus than technological innovation but skills development and entrepreneurship have a well-established relationship with technological innovation (Mosey et al. 2017).

Table 3. Thematic Areas of National Youth Development Framework 2019, Pakistan

• Mainstreaming Marginalized Youth
• Employment and Economic Empowerment
• Civic Engagement
• Social Protection
• Health and Wellbeing
• Youth Focused and Institutional Reforms

Source: Associated Press of Pakistan (2019)

Impact of Government Measures on Technological Innovation in Pakistan

Pakistan has emerged as a potential hub of technological innovation. Pakistani innovators have leveraged the policies, strategies, regulations, and programs related to technological innovation pronouncedly. Foremost of them is the start-up community that is taking full advantage of programs by the Pakistani government, UN agencies and investment from the private sector. From the Pakistani government, projects like Ignite Fund (National Technology Fund: Incubation Centers: Seed Fund, n.d.). and National Incubation Centers (NICs) (National Incubation Center, n.d.) are contributing towards harnessing technological innovation in Pakistan and transforming it into a technological hub. In all other walks of life in Pakistan, technological innovation is introducing new ways of doing things. From online education platforms to results transmission in elections and healthcare monitoring to local bodies' governance, technological innovation is paving the way towards success in the advanced eco-system in Pakistan. Through Financial technologies (Fintech), new digital or cashless payment solutions are being introduced in Pakistan to catch up with the pace of innovation in global trading and opening the gates for Pakistani professionals and organizations to deal with international players (Rizvi et al., 2018).

Challenges of Technological Innovation in Pakistan

Despite the tremendous potential for technological growth in Pakistan, there are teething problems, which is affecting the technological innovation diffusion. Some of the challenges faced by the government or faced by innovators due to lack of planning on the part of government are mentioned below:

- Startups are not encouraged enough in terms of financial and non-financial rewards from the government for disruptive and innovative technologies. Although there are few programs for startups, as mentioned in the last section, they are still quite far behind India where IT exports have reached $100 billion (Ahmed, 2016).
- There is no concrete and active legal framework to protect intellectual property rights in Pakistan. Due to this, intellectual property rights violation is quite prevalent in corporate circles and negatively affecting Pakistan's image in the global technology market. It is discouraging the creation of an innovative atmosphere in Pakistan (Mukhtar et al., 2019).
- Pakistan's education system lacks skills development for technological advancement, especially until the college level. It is quite old and obsolete as compared to not only technologically advanced countries but also in contrast to countries like India with a similar culture and economic constraints (Qureshi and Demir, 2019).

ANALYSIS AND DISCUSSION

Table 4. Technological Initiatives in Selected Advanced Countries and Pakistan

Country	Policies and Regulations	Institutions	Programs and Projects	Focus	Challenges
US	• Stevenson– Wydler Act of 1980 • Bayh-Dole Act of 1980 • The American Inventors Protection Act of 1999 • America COMPETES Act of 2007 • 21st Century Nanotechnology Research and Development Act of 2003	• DARPA • National Research Laboratories • Public-Private Partnerships • Demand-side Measures	• Direct Government Funding of R&D • Direct or Indirect Support for Commercialization and Production; Indirect Support for Development • Support of Learning and Diffusion of Knowledge and Technology	• Military Needs • Energy Sources • Public-Private Partnership • Patent Protection • Tax Credits	• No comprehensive policy for Artificial Intelligence • Attracting and retaining talent • Strategic competition with China
Japan	Basic Law on Science & Technology: • Plan 1 (1996-2000) • Plan 2 (2001-2005) • Plan 3 (2006-2010) • Plan 4 (2011-2015) • Plan 5 (2016-2020)	• Japan Institute of Invention and Innovation • Institute of Innovation and Research • Japan Patent Office	• Reinventing Japan Project • R&D Consortia • Innovation 25 • Abenomics	• Scientific Research • International Collaboration • Ethical Standards • Resiliency • Emerging Technologies	• Participation of youth • Lack of foreign investment • Gender parity • Lack of policies for skills development

UK	• General Data Protection Regulation 2018 • Privacy and Electronic Communication Regulations 2003 • Data Protection Act 2018 • Digital Economy Act 2017	• Office of Artificial Intelligence • Digital, Culture, Media, and Sport (DCMS) • Innovate the UK • Research Councils UK	• Guide to Using AI in the Public Sector • Geospatial Commission's Annual Plan • Spark • Government Digital Service	• People • Process • Data • Technology	• Lack of access to data infrastructure • Legacy technology and systems • Capacity building • Lack of technology leaders
France	• Act of 18th April • Innovation and Research Act of 1999 • French Innovation Plan of 2003 • Pacte pour la Recherche 2005	• High Council for Science and Technology • AgenceNationale de la Recherche (ANR) • Agenced'Evaluation de la Recherche et de l'EnseignementSupérieur AERES	• Breakthrough innovation Funds • Endowment Funds • New Technology Venture Initiative (NETVA) • Young Entrepreneur Initiative (YEI) • French Tech Initiative	• Scientific Research • Technology Entrepreneurship • Social Goods	• Territorial equality in fostering innovation • Lesser number of academic scientific research studies • Setting up instruments of innovation policy
China	• Plan for the Establishment and Development of National Field Research and Observation Stations (2019-2025) • State Council's Plan for the Establishment of a National Technology Transfer System • State Council's Plan for the Development of New Generation Artificial Intelligence • 13th Five-year Plan for the Development of National S&T Enterprise Incubators • Medium- and Long-Term Plan for the Development of Science and Technology (2006–2020)	• Committee on Science, Technology, Education, and Health • State Science and Technology Commission (SSTC) • National Development and Reform Commission(NDRC) • Ministry of Industry and Information Technology (MOIIT) • Commission of Science, Technology, and Industry for National Defense (COSTIND) • Chinese Academy of Sciences (CAS) • National Natural Science Foundation of China (NSFC)	• The Reform of the Chinese National STI Funding System • National Natural Science Fund • National S&T Megaprojects • Technology Innovation Guiding Fund in China • Bases and Talents Programme • Thousand Talents Plan	• Scientific Research Publications • Technology Entrepreneurship • Mergers and Acquisitions	• Inadequate infrastructure and human resources • Strict laws and regulations • Demand for even more researchers and scholars • The gap between industry and academia

Pakistan	• National Science & Technology Policy 1984 • Science & Technology Policy 2012 • Prevention of Electronic Crimes Bill 2015 • The Pakistan Council for Science and Technology Act, 2016 • Digital Pakistan Policy • The Trade Marks Ordinance, 2001 • The Copyright Ordinance, 1962 • The Patents Ordinance, 2000 • The Registered Layout-Designs of Integrated Circuits Ordinance, 2000	• Ministry of Science & Technology • National Institute of Electronics • Pakistan Council for Science & Technology • Pakistan Council of Scientific and Industrial Research • Pakistan Engineering Council • STEDEC Technology Commercialization Corporation of Pakistan (Private) Limited • Pakistan Software Export Board (PSEB)	• ThinkFuture • National Incubation Center • Prime Minister's ICT Internship Program • IT Parks • GITEX Technology Week • CeBIT Expo • Technology and Innovation Support Centers • Pakistan Vision 2025	• Entering new Markets • Science & Technology Research • Emerging Technologies • Infrastructure Planning • Human Resource Development • Transfer of Technology • International Cooperation	• Brain Drain • Inadequate Funding for Technology Startups • WeakLegal Framework for Intellectual Property Rights (IPRs) • (Mostly) Outdated Education System • Lack of Foreign Investment • Lack of Incentives for Innovators and Exporters • Political Instability • Corruption

Source: Multiple Sources from Literature

Comparative analysis of technological innovation in Pakistan with technologically advanced countries can be analyzed in three dimensions:

- Measures taken by the government of Pakistan for technological innovation
- Implications of government steps in terms of technological innovation in Pakistan
- Recommendations for the Pakistani government to foster technological innovation in the country

The Pakistani government has taken a lot of measures in terms of regulations and policies regarding technological innovation including data privacy and protection. However, a centralized system for security of technological applications, networks, and customer data yet not exist. So, there exist trust issues in the adoption of many innovative technologies in various sectors of Pakistan. The regulations and policies also focus on the digitization of the economy like first world countries. However, the workforce, especially in the public sector, is not equipped with the right skillset to adopt innovative technologies as a substitute to their manual and conventional ways of doing things, in contrast with advanced countries where the major challenge of skillset is for technology development not for adoption. Although Pakistan has covered intellectual property rights in its overall technology policy to encourage technologically innovative organizations to sustain their competitive advantage, implementation of those laws is no way near as strong as other countries studied. Rampant corruption and mal-governance also put heavy barricades towards the effective execution of such policy initiatives. This poses a serious threat to fostering technologically innovative ideas in Pakistan.

Pakistan has shown positive signs of leveraging technological innovation for social and economic development such as a little improvement in the global innovation index ranging from 109 to 105 from 2018 to 2019. Pakistan's current software export is a total of $1.06 billion, which is 14% more than that of 2018. Pakistan has become the 4th most popular country for freelancing. 7000+

IT companies in Pakistan are providing jobs to hundreds of thousands of professionals across the country. This is contributing to employment in addition to contributing towards raising remittances and foreign investment in Pakistan. Pakistan is also currently producing more than 23,000 graduates every year only in Information Technology along with other disciplines of technology (PASHA, 2019). But despite these positive signs, Pakistan faces some serious challenges some of which are unique to Pakistan, others are shared with either developing countries or the rest of the world.

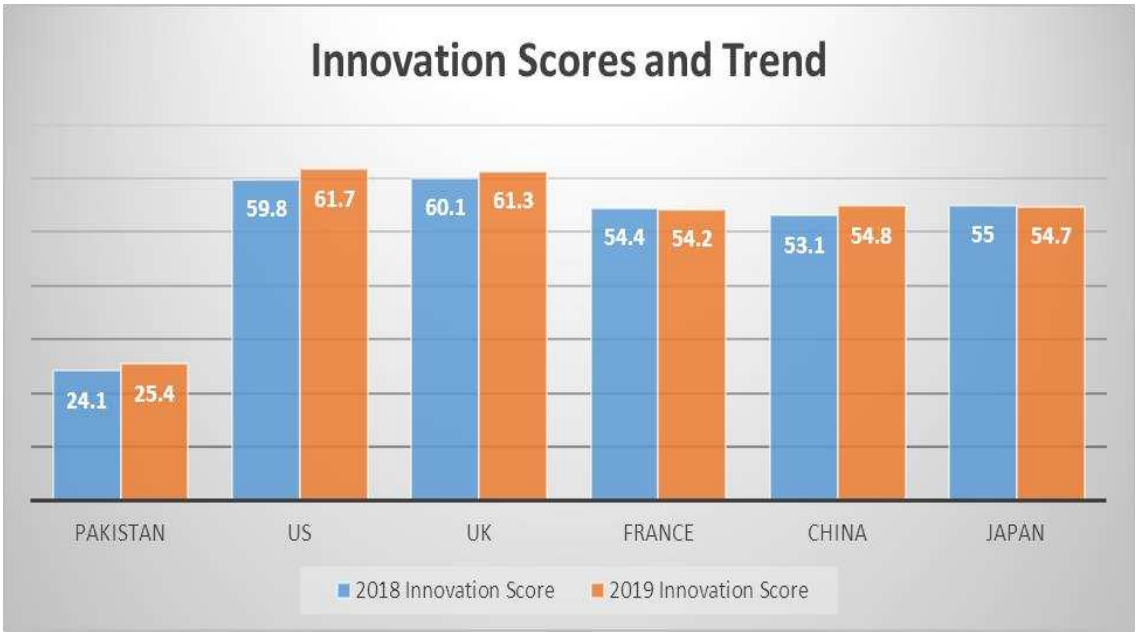

Figure 1. Innovation Scores and Trend

Source: (Cornel University and World Intellectual Property 2019)

The most prominent global challenge for governments is the attraction and retention of talent. As the technological skillset is getting diversified and the demand for various technological professionals is surging, technologically innovative organizations face serious challenges in retaining such professionals. Pakistan has faced severe brain drain over the years, which has caused a huge loss of opportunity for technological advancement in Pakistan. Although the problem of unplanned brain drain is prevailing in most countries especially the developing ones, but Pakistan is facing more of an unplanned brain drain than the planned one with proper cost-benefit analysis. Another serious challenge for Pakistan is the lack of funding from the government for technologically innovative startups. Although the government has launched few programs like National Incubation Centers, with the rise of technology entrepreneurship opportunities and trends, they are far behind the technologically advanced countries to improve the success rate of technology startups and compete globally. Pakistan's

legal framework and intellectual property rights are also discouraging for technological innovators, with Pakistan standing on 15th position of top countries using pirated software (Goff, 2017). A distinctive challenge for Pakistan is its lack of focus on R&D with Pakistan spending just 0.24% of GDP on R&D with countries like Japan spending several times more as a percentage of GDP. Even more severe challenge for Pakistan is political instability, corruption and mal-governance (including bureaucratic red tapes) affecting the return on technological innovation funds, which are already much less than that of technologically advanced countries. These challenges need some grave efforts from the Pakistani government to foster technological innovation in Pakistan.

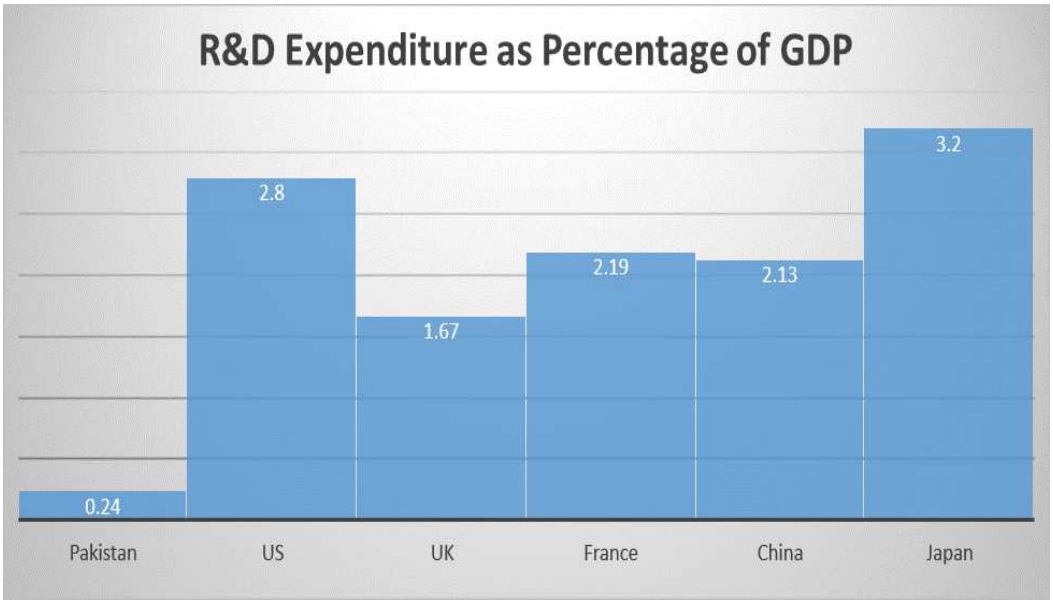

Figure 2. R&D Expenditure as a Percentage of GDP

Source: (Statistics Times, 2018)

CONCLUSION

The age of technological innovation is also the age of opportunities. Without any debate on the significance of technological innovation for countries' progress, governments are highly focused on harnessing technological innovation in different fields of life. The meta-analysis of academic and reliable non-academic literature highlights the various approaches and measures from governments to encourage technological innovation in the public and private sectors. However, not all countries have the same level of success to meet this goal. Therefore, developing countries like Pakistan should learn a few things from technologically advanced countries like the United States, Japan, United Kingdom, France, and China. A comparative analysis of the government's role and the state of technological innovation in advanced countries and Pakistan suggests that they face some common challenges with the increasing demand for technological products, services and the competence required to develop them. However, the severity and nature of challenges faced by Pakistan are far more concerning and need immediate actions by the government to avail of the opportunities. Although Pakistani government has taken few measures in the last two decades with some encouraging signs and it has shown a lot of potential for technological innovation but amidst competition by other

developing countries, Pakistan cannot afford to miss any opportunities by government oversight of the challenges ahead. The Pakistani government should devise short, medium and long-term strategies to resolve the issues of the negative image, mal-governance, corruption, lack of political willingness, startups funding, patent laws and R&D spending to compete globally with respect to technological innovation.

Recommendations

Some of the recommendations that come out as an outcome of this literature review are as follows:

1. The Pakistani government should work to improve perceived political stability, mal-administration, and corruption in Pakistan to bring foreign investment and keep a check on the competitors' threats from countries like India, which has very similar dynamics for off-shore projects and foreign investments in technology.
2. It would be unrealistic in the near future to aim for providing same opportunities for skilled workforce as in technologically advanced countries. However, government should focus on planning to convert the brain drain to brain-export, which is more planned and has a cost-benefit analysis to bring more foreign remittances and building roots in the international technology market, for which access to bank financing under government guarantees can be extended for startups, accelerators and SMEs.
3. The Pakistani government has to gradually increase its spending on R&D, startups funding and improving technical education (Jansma et al., 2018).
4. The Pakistani government has to design a concrete legal framework with regulations and standardization for intellectual property and patent rights protection. This will facilitate the innovators to sustain their competitive advantage and encourage more technological innovation.
5. The collaboration of the public sector with the private sector and donor agencies like the United States Agency for International Development (USAID), Japan International Cooperation Agency (JICA), various umbrella organizations of the United Nations, etc. is needed for technological capacity-building projects and programs.

Contribution, Caveats and Future Directions for Research

This appears a unique inquiry in the context of Pakistan that cross compares Pakistan with five high-tech countries in terms of technological innovation initiatives by governments. This inquiry did not cover the role of the private sector in the realm of technological innovation since its focus remained on the public sector's strategic and policy construction to executing roles. Secondly, it did not directly compare such initiatives in Pakistan with those in Bangladesh or India, or other countries of South Asia, because it intended to learn from international best practices from high-tech countries. Thirdly, a global level inquiry can be undertaken to comprise the most innovative economies (including Germany and Singapore, etc.), where policy measures to execution and impact can also be discovered and analyzed qualitatively as well as quantitatively.

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