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Analysing National Innovation System of Pakistan

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Abstract
This paper evaluates the national innovation system of Pakistan. Our analytical framework develops upon the OECD framework to analyze the national innovation systems. The broader frame of analysis includes the dimensions of institutional pattern, institutional functions, and institutional interactions. We discuss the system of innovation in Pakistan under the yardsticks of policy formulation, research and development activities, research and development funding, development of human resource, transfer of technology, and technology entrepreneurship, research and development collaboration among institutions, and technological adoption. It has been found that the Pakistan's system of innovation is yet at the initial stages of its development as compared to many developing countries. Efforts are being made on many fronts to improve the efficiency of the system it is recommended that policy formulation process should include all the stakeholders. More efforts are needed for technological diffusion.
Key words: National Innovation system, technological entrepreneurship, technology diffusion, Pakistan

1. Introduction

National Innovation System (NIS) is the web of institutions taking part in process and the facilitation of innovations in a country. Freeman (Freeman 1987) first put forward the concept of NIS and proposed that the a network of institutions both in the private and public sector make up the system of innovation in country by initiating, importing, modifying, and diffusing new technologies into the economy. An extended explication of NIS holds that the innovation system consists of the relationships and elements within the boundaries of a state which cooperate with each other for the production, diffusion, and use of new and economically lucrative knowledge (Lundvall 2007). National innovation system is a set of institutions which determines the innovativeness of a country's enterprises (Nelson 1991),. Patel & Pavitt regard innovation system as a set of national institutions, their competencies and structure of incentives which guide technological learning in a country (Patel and Pavitt 1994). Metcalfe, however, furthers the concept of NIS and includes the policy formulation process of government into the system of innovation (Metcalfe 1995). According to Metcalfe, NIS is the set of distinguished institutions which separately and collectively develop and diffuse novel technologies. This set of institutions also provides the framework in which governments devise and implement policies in order to stimulate the process of innovation. It is a structure of institutions interconnected with each other to generate, accumulate, and transmit the knowledge, skills, and artefacts which delineate innovative technologies.
The set of institutions in National Innovation System contribute to the development of new technologies. The institutions also play their part in technology diffusion throughout the economy. These actors of the system also provide the mechanism in which government not only makes the policies but also devises the framework to implement those policies. In this way, the system of innovation takes a form of interconnectedness to create, store, and transfer knowledge, skills, and objects which outlines novel technologies. Both the actors of the system and the contextual elements, are important dimensions of innovations system for the creation and use of knowledge for economic growth (Metcalfe 1995).
A well-functioning National Innovation System depends upon how the players of the system including government, firms, academia, research centers, and collaborating entities perform their respective roles and interact with each other (Chang and Shih 2004). Therefore purpose of this paper is to critically analyze the performance of national innovation system of Pakistan by evaluating functions and interactions of different players system. Our analysis of the National Innovations system draws upon the framework of OECD (Organization for Economic Co-operation and Development) despite the fact that Pakistan does make the membership of OECD. The reason behind using this criteria is its comprehensiveness. Previous studies (Chang and Shih 2004) have also used this broader framework to evaluate NIS. The following section sets our broader analytical considerations which we apply in order to meet the outlined objectives of this paper.

2. Analytical Framework

A National Innovation System involves six different institutional functions: formulation of policy, R&D activities, R & D funding, personnel development, diffusion of technology, and technological entrepreneurship (OECD 1999). Science and technology policy must aid and foster reforms in areas like competition, academics, and labor and financial markets in order to stimulate innovations. An important feature of an efficient NIS is to make good use of partnerships among public/private research institutions and commercialization of spin-offs, patents, and licenses. The research and development activities happen to be a main ingredient of NIS and should

be fostered through funding either from state or from other funding agencies. Human resource development on a continuous basis keeps an innovation system functioning. Furthermore, an NIS needs to keep a balance between technology support to the economy and diffusion of technology. Consequently, such a mechanism will stimulate technological entrepreneurship among firms on a larger scale which will ultimately contribute to the national innovation (OECD 1999).

Along with the institutional functions, the interactions among various players of the system may also be regarded as an important function of the institutions. An effective interaction among the institutions in necessary for knowledge flow in the system therefore guarantees an efficient National Innovation System.

There are four facets of interactions among institutions in NIS. These are joint industry activities, public/private interactions, technology diffusion, and personnel mobility. These collaborations take the form of strategic alliances by capitalizing upon each other's capabilities thus eliminating the weaknesses (OECD 1997).

The collaboration among firms takes the form of technical resource pooling, achievement of scale economies, and gaining synergies through sharing of technical and human resources. These collaborations among the institutions are likely to enhance the innovativeness of the system. The linkage between private and public research institutions provides a platform for knowledge flow in the innovation system. Universities and public research institutions are the public part of this interaction, while private enterprises lie on the other side. The strength of public research institutions and their linkage with the industry supports innovation of the system to a larger extent. Public research institutions not only support innovation through basic research but also by making available new skills, methods and instruments to the private sector. Whereas, the public sector research institutions serve as repository of knowledge, the access of industry to such knowledge is also important for the system (OECD 1997).

The knowledge flow occurs in the system through the technology dissemination as innovative machinery and equipment. The process of innovation diffusion may take years to complete. The speed at which firms adopt new technology differs according to not only their own characteristics but also according to the context of the economy in which they are operating. Nonetheless, the firm innovative output largely owes to adopting technology established somewhere else (OECD 1999).

Furthermore, the rate at which people and knowledge move across the sectors of economy is crucial to the national innovation system. Many at times, the transfer of specific knowledge is not much important rather an innovative approach and competence to solve problems. In diffusion of technology studies, the interactive capabilities of personnel are important to technology adoption and implementation. The "capability of adoption" is largely determined by the qualifications of and knowledge of the personnel mobility (OECD 1997).

Apart from the formal linkages, the informal links among different actors of the system also prove beneficial to the system of innovation. The evidence suggests that in some countries informal links innovate more effectively than formal links (OECD 1997).

3. NIS of Pakistan

For Pakistan, innovation is not a new phrase. The history of efforts to stimulate innovations in Pakistan dates back to 1953 with the establishment of Pakistan Council of Scientific and Industrial Research. Similarly, Pakistan Agriculture Research council, and the National Agriculture Research Centre were established in order to give innovative solutions of agricultural problems of country (Higher Education Commision of Pakistan 2010). While on the policy side, the federal Government sanctioned the first draft of the Science and Technology Policy in 1984. These and many other initiatives have developed a web to which we may attribute as the Pakistan' system of innovation, despite the fact that most of these efforts were the result of the requirements of donors and agencies like WFP, UNIDO, WIPO (Shahab 2011).

In this section we will analyze the National Innovation System of Pakistan based on the analytical framework established above. Subsequently, we discuss the institutional pattern, institutional functions, and institutional interactions respectively.

3.1. Institutional Pattern

The state of Pakistan embarked upon its journey in 1947 with very weak science and technology institutional setup. There was only one university, one College of Agriculture, one research institute and three laboratories (Shakeel and Khan 2008). However, over time the government recognized the importance of innovations be establishing different research institutions, councils of science and technology and programs to imbue research and development (Shahab 2011). From the 1947-1976, the government of Pakistan established many research institutions in areas like agriculture, industrial research, medical research, and atomic research. However despite these efforts the policy side has been a neglect (Bhutto, Rashdi et al. 2012). Afterwards, the remark able point in the innovation pattern of Pakistan were the establishment of organizations like COMSTECH, CAMB (Center for Applied Microbiology), National Commission for Science and Technology (NCST), Quaid-e-Azam University, National University of Science and Technology, and above all the Higher Education Commission of Pakistan (2002) in order to look after higher learning institutions (Shakeel and Khan 2008). The latest development in this

scenario is the announcement of National Science Technology and Innovation Policy 2012. Passing through the evolutionary process the NIS of Pakistan has taken the following shape as of today (see **fig 1**).

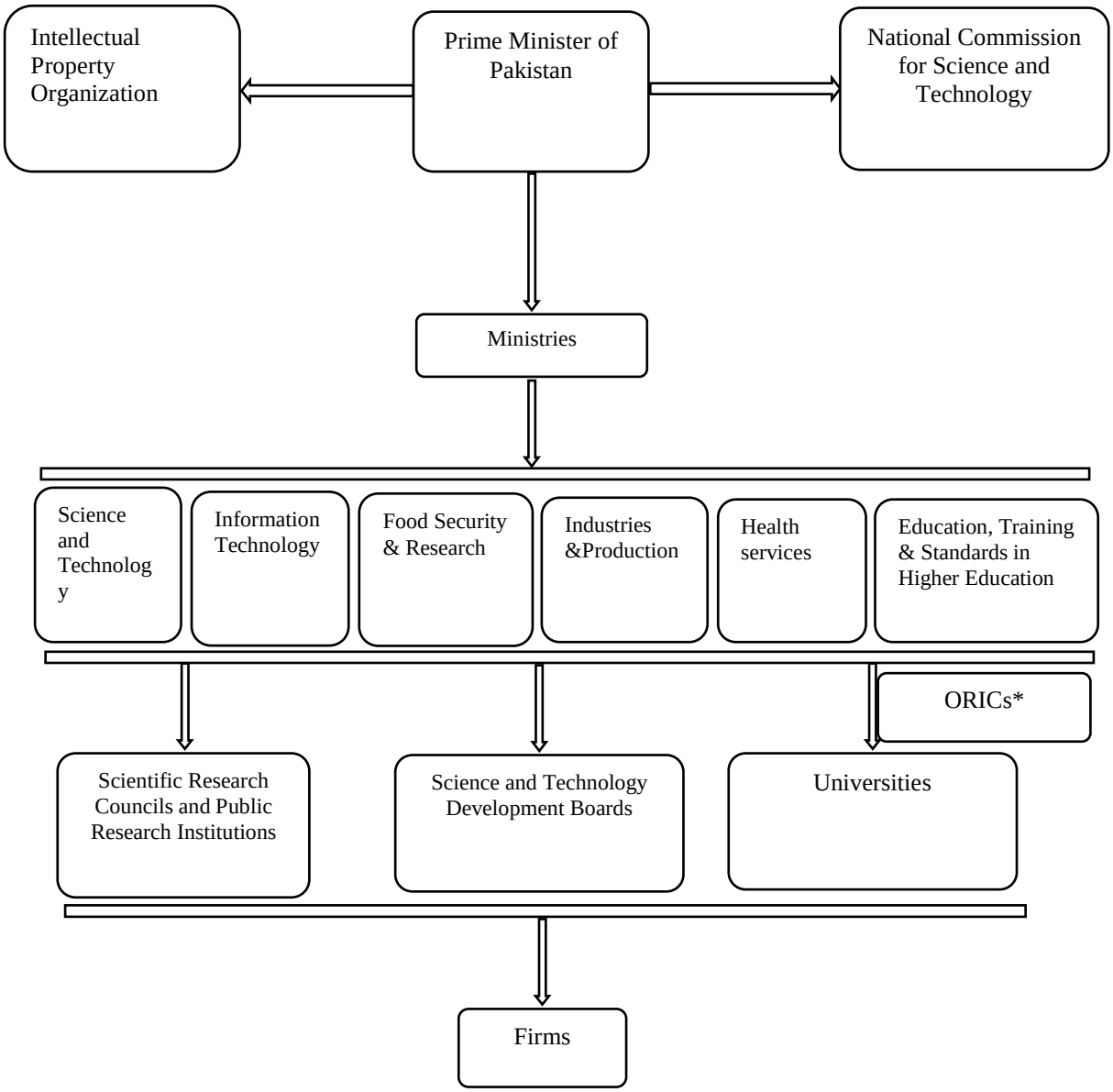

Fig 1: NIS of Pakistan (*Offices of Research Innovation and Commercialization) Adapted from: Asia Science and Technology Portal

3.2. Institutional functions

3.2.1. Policy Formulation

National Council of Science and Technology is the highest policy formulation organ in the innovation system domain of Pakistan. However, science and technology policy formulation has been an area of heightened neglect in Pakistan on the part of government. A recent policy document issued by the Ministry of Science and Technology accepts that the process of policy formulation for Science and Technology 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 established was formulated. As a latest development, the ongoing Science, Technology and Innovation Policy was unveiled in the year 2012 (Government of Pakistan 2012).

The policy formulation process happens at the state level in Pakistan. It involves various organs. The stakeholders of the process include National Council for Science and Technology at the apex. The NCST is directly headed by the Prime Minister Pakistan and holds its meeting from time to time. Furthermore, NCST is also responsible for policy formulation and administration at all tiers of the system of innovation. Pakistan council for science and technology advises the government through its statistical input. Science policy cell housed at the Ministry of Science and Technology is responsible to gather the policy input from the all concerned circles and prepares the policy draft. There is no such mechanism embedded in the system which includes the research organizations, academia, and enterprises in the policy formulation process.

3.2.2. R&D Activities

Research and development activities in Pakistan mainly conducted in public research institutions and universities. The public research and development are attached establishments of different ministries of provincial and federal governments. The public research institutions range from areas like agricultural sciences, engineering and technology, medical sciences, energy, biotechnology, and water resources. Most of the research activities in Pakistan are concentrated in the agriculture science with 44 research organizations operating in this particular sector. While there are only 19 Science and technology organizations operating in the engineering and technology. There are, only 5 research organizations are concerned with research in medical science (Pakistan Council of Science and Technology 2009). Despite the higher number of research organizations in agriculture, the fruits are far away from realization for the country where Pakistan has not yet reached at the level of self-sufficiency in food items. There is also a need to diversify research efforts into the areas of engineering and technology, and medical sciences also. The R & D activities are also being carried out in the academic sphere as well. However, enterprises are not very active in research and development in Pakistan.

3.2.3. R & D Funding

The system of innovation in Pakistan gets funding mainly from the government. Firms, the third tier of innovation plays a meager role in research and development funding. According to latest available statistics compiled by Pakistan Council of Science and Technology gross expenditure on R&D in Pakistan is 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 research and development include higher education, business sector, private non-profit, and funding from abroad with 10 %, 3%, 2%, 1%, and 1% respective share in the overall funding. A deeper look into the R&D expenditure reveals that major recipient of R&D funding is agricultural sciences, with industrial research, defense, health, engineering and technology in respective order (Pakistan Council of Science and Technology 2009). These figures suggest there is still a long way to go for the system of innovation in Pakistan. There is a need to enhance the role of commercial sector in innovation funding. Moreover agriculture sector being the highest recipient of funds has not produced the results up to the expectations. The allocation of funds should be diversified to create a balance in the system of innovation. The ratio of expenditure on research and development also rests a very lower level.

3.2.4. Human Resource Development

The total number of researchers in Pakistan are 26129 which counts to only 162 individuals per million of population, a number far below many developing countries. Of the total researchers 17147 are employed in Higher Education Institutions and 8982 are working in R&D organizations. Out of these scientists many are working in natural sciences domain followed by engineering and technology, medical sciences, agricultural sciences, social sciences, humanities and other fields. An odd to the human resources of Pakistan working contributing in innovation system is the lack of higher qualification. At the moment, only 10 % of the researchers hold PhD qualification (Pakistan Council of Science and Technology 2009). However, the ratio PhD qualification is on the rise over the last few years. There are nearly 8500 PhDs by the end of year 2013 in Pakistan.

Higher Education Commission has played a major role in developing the human resources in Pakistan. Various scholarship schemes were introduced over the last few year to motivate the student to pursue higher studies. In a recent press statement, an HEC official (Naqvi 2012) claimed that researchers trained through these schemes are likely to play an major role for the improvement of research and development potential universities and will also

contribute to the development of industry.

3.2.5. Technology Transfer

There is no common mechanism in the Pakistan to bridge the technology between the research and development institutions and the commercial sector. The R&D institutions are themselves responsible to market their innovation to the industry. Pakistan Council of Scientific and Industrial Research (PCSIR) the apex institution for industrial research, the National Agriculture Research Council (NARC), and universities have themselves established linkages with industry for technology bridging. The Industrial Linkage Program of PCSIR has been started with the aim to strengthen R&D capability and establish linkages with pharmaceutical, material sciences, food, textiles, and chemical industry. Technology transfer with the Leather Research Centre, and local food manufacture is under process. Nearly 57 agreements have been signed for technology (PCSIR 2013). National Agriculture Research Council of Pakistan has established an agricultural marketing company in order to commercialize R&D based agricultural innovations to the agricultural sector. The functions of company are consultancy, joint projects, quality assurance, and standardization (PARC 2008). For the commercialization of academic research, Offices of Innovation Research and commercialization (ORIC) have been established in universities. ORICs are trying to establish and strengthen the university-industry relationships (HEC 2012).

3.2.6. Technological Entrepreneurship

For the promotion of technological entrepreneurship, an economy needs to have efficient venture capitalists and technology parks. Venture capital firms provide seed capital to the aspiring entrepreneurs, while technology parks play their role in commercializing the academic innovations. In Pakistan, venture capital firms have been operating since last two decades while the idea of science and technology Parks is at the very initial stages. A recent survey of the economy of Pakistan notes that only 18-20% of the final requirements of IT companies are fulfilled by financial institutions and venture capitalists. Venture capitalists should focus on providing the seed capital to such sectors (Ministry of Finance 2005). Furthermore, the entrepreneurs themselves are not inclined towards raising the capital through venture capitalists since they do not want to share their family ownership of their business with other firms. Moreover, the culture hinders the riskier endeavors, because failures are termed as losers (Imamuddin 2009).

The academic sphere has started to recognize the importance of science and technology parks for the promotion of technological entrepreneurship. National University of Science and Technology (NUST), situated in Islamabad, the federal capital of Pakistan, is in the process of establishment of National Science and Technology Park. The plan of establishment of Park has been prepared after wider research and with the help of international and domestic organizations namely World Bank, International Finance Corporation, Pakistan Ministry of Science and Technology, Higher Education Commission of Pakistan, and Pakistan Software Export Board. Among the stakeholders of NSTP are university itself, research institutions, venture capitalists, nascent entrepreneurs and the Government. NSTP aims to develop and strengthen research and development collaboration between university and industry. The main purpose of NSTP is to work for knowledge-intensive ventures while operating on the “services” model as opposed to “landlord” model. Moreover, the interaction will be strengthened by provision of training facility to firms (Hashmi and Shah 2012).

3.3. *Interactions of institutions*

3.3.1. R & D collaboration

Inventions which are unable to meet the market rigor may not contribute towards prosperity of country. In Pakistan, public sector research institutions and university are conducting their research without linkage with the private sector. There is a lack of inclination towards including firms in the setting of research agenda for public sector research organizations. Such an approach makes innovations less competitive (Higher Education Commision of Pakistan 2010). The lack of linkage between research performers further leads to the selection of research projects base on interests of individual researchers rather than the demands of business community. As a result, very few research outputs are adopted by the firms (Butt 2001). A recent strategy of promotion of science and technology in Pakistan outlines the commercialization of research and development as the main policy

objective. They strategy aims to realize this goal through the signing of memorandums of understanding between research and development organizations, academia and industry (PCST 2013).

3.3.2. Technology Diffusion

For proper technology diffusion, research and development collaboration among the actors of innovation system is very important. Higher the rate of adoption of innovation by the firms, higher will be the rate of diffusion, which can only be assured through effective collaboration. In Pakistan, most firms are non-research and development based which is itself impediment to the diffusion of technology. The attitude towards technology adoption also varies from smaller to bigger firms, with bigger having higher orientation towards technology adoption. Likewise, firms having higher sale turnover adopt technology at a faster pace. Domestic firms and firms having acquired certifications adopt technology have a high probability of adoption of technology (Mahmood, Din et al. 2009).

The National Technology Policy 1993, of Pakistan outlined the necessity of extension services as an efficient way of technological knowledge diffusion. It was planned that SMEs will establish their own extension centers for designing, testing, training, and information services with the help of government (Bhutto, Rashdi et al. 2012). Realizing the lower rate of technology diffusion, the National Science Technology and Innovation policy (2012) outlines the measures for the effective and faster diffusion of technology at national, and institutional level. The measure include: capacity building for technology transfer, enhancing capacity absorptive capacity of firms, and industry-university collaboration.

4. Conclusion and Recommendations

The innovation system of Pakistan has evolved over time. In the efforts to make the system of innovation more effective there is a need to diversify the policy formulation process. Unless until all the stakeholder are taken onboard while formulating policy the development of an effective and interactive system will remain a dream. There is also need to diversify the existing research efforts as they are mostly concentrated in the agriculture sector. Furthermore, the research activities are also needed to be carried out in private sphere as well. There is a need develop a structure to enhance the role of private sector research in Pakistan by encouraging both the research activities and research and development funding. One practical step may be to start industrial PhD programs with the collaboration and universities and private sector entities.

In order to enhance the collaborative arrangements among institutions the development of technological parks of universities may be a very practical step wherein the researcher, the entrepreneurs and the funding agencies meet each other. Such collaborations will be fruitful in making research efforts more applied in nature. Moreover, this will give a boost to meagre technology diffusion in innovation system of Pakistan.

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