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Impact of Science Technology and Innovation (STI) on Economic Growth and Development: A Case Study of Pakistan

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ABSTRACT

The study reports the case study research about the impact of STI on economic growth and development. 305 scientists responded the questionnaire. Out of 305, 94% (288) confirmed that STI has the impact on economic growth and economic development. In response to the 2nd question, about the impact of their research on economic growth and development, 85 %(260) scientists supported that STI has the positive impact on economic growth. The STI system of Pakistan is also discussed and found that STI system in Pakistan is very weak. To improve STI system of Pakistan, there is dire need of long-term STI policy. Therefore, at the end of the study on the basis of survey results and STI capacity indicator, the policy recommendations and implications of the study are presented. These recommendations are very useful for STI policy makers and planners for Pakistan as well as developing countries, to improve STI situation.

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1. Introduction

Change in science, technology, and innovation is one of the major driving forces of the long run economic growth & development and social changes in living standard of people of the country. On the other hand, technological changes and innovations bring about the scientific development as well as economic development. The transformation of the country from developing to the developed country by using its natural resources based on knowledge and information. It can only be possible through diffusion & adoption of scientific principal or implementation of innovative technologies. STI activities not only accelerate the economic growth and bring about the social changes of lives but also enhance the capability to create, transmit and use STI knowledge (Ertl *et al*, 2006). Consequently, the transformation of knowledge base economy is required in order to attain science, technology, and innovation-based global competitiveness level. Knowledge base economy is a double edge sword it helps to promote the growth as well as it increases the well-being of the people.

Science, technology and innovation have become increasingly complex, escalating the significance of relationships among different countries to acquire specialized STI knowledge. The countries formulate economic and STI policies that enhance science, technology and innovation environment in the society and economy, most important for sustainable economic growth & development and global competitiveness (Sener and Saridogan, 2011). But the question arises how would the outcomes and impact of STI activities be measured? Although, many information available about the STI activities but it relates only input for example how many people involved in this activity?, how much expenses occurs on that research and development?, what is nature of STI activity? However, these pieces of information do not solve the purpose and helpful for measuring outcomes and impact of STI activities. During literature review, it has been found that large numbers of empirical studies have been conducted to investigate the impact of STI on economic growth but a mix trends have been found. Some found the positive association and some found the negative association between STI and economic growth. Results of the studies are different, model to model, country to county. Confusion is still existed either STI has the positive impact or negative impact on economic growth.

During the literature review, we found shortcomings in the studies that have been carried previously. Although many studies have been conducted to investigate the impact of STI on economic growth, the results and conclusions from these studies vary from model to model and country to country. Researchers have used different methods such as panel estimation, cointegration etc., through the combination of data from developed and developing economies. These methods mostly contain econometric techniques for assessment of the impact of STI on economic growths. Most of the studies used one or two traditional independent variables, like labour force and human capital along with one or two STI indicator. The studies focused more on econometric empirical evidence of the impact of STI on economic growth rather than the survey or directly question/s from an actor of STI. We could not find literature in which opinion survey has been done. It is difficult to suggest the policy recommendations for STI policies for any country. As the data of composite STI indicator are not available more than 20 years, so time series analysis cannot be carried for an individual country. While sometimes, the panel's analysis is not suitable for all set of the countries. Impact of STI on economic growth in numeric or percentage form is not available.

Has the STI significant impact on economic growth in developing countries like Pakistan as compared to developed countries? Therefore, it is decided, to carry out the opinion survey to gather/seek the information from direct agent or actors of STI about the impact of STI on economic growth and development. *The main objective of the study is to seek information from the main actor of STI (Pakistani scientists, engineers, technologists, and researchers working in Universities and R&D organizations) about the impact of STI on economic growth & development and presents the policy recommendations on the basis of results*. What they think and have an opinion about the impact of STI on economic growth and development. In this regard, a short questionnaire has been designed to survey opinion from academicians & professionals. Survey form/questionnaire (Appendix II) consist of some basic information followed by the survey questions. The survey questionnaire was accessible at the Centre for Research, Innovation, and Policy (CRIP) website (http://crip.com.pk/survey.php). On the basis of survey results, the study presents some policy recommendations for Pakistan as well as for developing countries.

The contribution of the study is wide and serves many purposes. It provides new avenues for researchers and economists in measuring the impact of STI on economic growth through opinion survey and how can STI be measured and assessed in quantitatively and numerically. The study attempts to provide, what is the impact of STI on economic growth and development? It provides the strength to the concept of knowledge base economy and will provide the insight about weaknesses, strengths, and opportunities of STI system of a Pakistan not only at a national level but also at an international level. It provides thought-provoking ideas to policy makers and planners for the formulation of policies and allocation of resources to enhance the STI capacity of Pakistan and developing countries. It is unique in a sense that opinion survey from an actor of STI, to measure the impact of science and technology and innovation on the economic growth and development of the country reports first time. It would prove on the empirical evidence that economic development has nexus with its scientific and technological preparedness of a country. The most of developing countries like Pakistan full of natural resources but they are failed to materialize into visible phenomenon due to lack of scientific and technological capabilities. The study also explores that the developing countries need to invest a huge amount in R&D to enhance their scientific and technological capabilities.

The study is organized into five sections. Section one presents the introduction and section 2 of the literature review. Section 3 discusses the overview of STI in Pakistan. Section 4 about data and methodology while sections 5 about results and discussion. Final Section 6 presents policy recommendations and implications of the study.

2. Literature Review

This section illustrates an overview of the available empirical and theoretical literature on the relationship between STI and economic growth & development. The purpose of this review is to highlight the main issues regarding the consequence of STI on economic growth and development that will provide a new avenue for further research. We present the literature review regarding economic growth and economic development.

All schools of thought of economic unanimously agree that the technological progress of the 18th century industrial revolution brought about substantial increases in productivity in the textile industry in the United Kingdom (UK). The concept of technological progress, then, is not new. The relationship between technological progress and economic growth and development became a subject of inquiry and the study of economics or political economy then formed as an organized discipline. A large number of economists have discussed the changes in output and production by the technological progress resulting from the Industrial Revolutions in the mid-eighteenth century.

The role of technological progress in production or output commanded the attention of economists when Nobel laureate Robert Solow argued that technological change plays a vital role in total output / production and demonstrated that 87.5% of the increase in total output between the years 1909-1949 in the United States was the result of the technical change Solow (1957). The pioneering work of Robert Solow provided new dimensions to our understanding of why countries such as the USA and UK show persistent labor productivity growth, while others such as Niger and Zimbabwe become poor (García, 2013). After Solow's groundbreaking paper (Solow,1957), numerous studies have been carried out by economists for whom the growth accounting approach was the dominant methodology for empirical measurements of productivity until the early 1970s. As national accounting figures became available and statistical methodology became more refined, Solow's concept that technological progress accounts for all economic growth became less all-encompassing (Cameron, 1998). Although, Swan (1956) presented the neoclassical growth model after ten months later than Solow (1956), but he argued complete analysis of the technological change, which Solow treated separately in Solow (1957). Reference is sometimes made to the "*Solow-Swan growth model"*, but more commonly reference is made only to the Solow growth model. In the 1960s, many eminent economists like Uzawa (1965), Phelps (1966), Conlisk (1967, 1969), Lutkepohl (1991), Shell (1967), and Nelson and Philips (1966) who applauded the Solow and Swan concept and argued that economic growth based on labour recourses spent for the development of new technologies and ideas and relationship between education and growth which has the significant impact on the proper analysis of economic growth.

But the concept of Solow exogenous growth theory does not retain its dynasty in the field of macroeconomics, it had to face a serious setback when it was challenged by Romer (1986) who presented an endogenous growth model. In contrary to the Solow model, Romer used technology as an endogenous factor in his model and set a foundation of new growth theory. Romer (1986), Luca (1988) and Aghion & Hewitt (1992) who are considered the pioneers of new growth theory, they used the technology changes as an endogenous factor for production of knowledge.

In this way, the economists divided into two groups, one group of economists supported the exogenous growth theory and another bunch of economists supported the endogenous growth theory. Although, a large volume of literature is available in favour of new growth theory but some significant studies like Romer (1990, 1994), Aghion & Hewitt (1992), Pyo (1995), Cameron (1998) have mentioned in the literature review. All they agreed that technology is neither conventional goods nor a public good while it is a non-rival as an input variable in the model. The growth outcomes entirely from technological progress based upon the competition among research firms that creates innovations. Growth is an endogenous phenomenon in economic systems, not the outcomes of the forces that intrude from outside and innovation plays a key role to enhance the economic growth.

In the same pattern, a large group of economists is supporting the exogenous growth theory. Some prominent economists like Mankiwe, Romer, & Weil (1992), Jones (1995a), Jones (1995b), Islam (1995), Lee, Pesaran, & Smith (1997), Loo & Soete (1999) who have conducted studies in favor of exogenous growth theory. Leading on the front, Mankiwe, Romer, & Weil (1992) examined the Solow model in detail and found that poor countries have more capacities to grow faster than the rich and empirical relevance of the Solow model. Jones (1995a) rejected both endogenous growth models (AK models and R&D model) and found no connection between R&D and economic growth and further argued that R&D based model inconsistent with time series analysis (Jones, 1995b). Islam (1995) investigated the Solow model with some modifications and supported the concept of exogenous growth theory. Lee, Pesaran, & Smith (1997) observed that growth rate is different considerably across countries and if the heterogeneity is allowed for calculation of beta are higher than described in literature while Loo & Soete (1999) said that R&D based model not able to explain the productivity anomaly in terms of technological change and economic growth.

At the first era of 21st century, many empirical studies have been conducted to investigate the impact of technological progress on economic growth but a mix trend have been found. Some researchers like Yanikkaya (2001), Filho, Silva, & Dinz (2005), Gundlach (2005), Koutun & Karabona (2013) etc have conducted the study in favour of Solow model while Seren (2001), Ulku(2004), Rao(2006), Parham (2007) etc are supporting Romer R&D model. Still there no unanimous agreement of economists whether the growth is affected endogenously or endogenously by technological progress. The indicators like R&D expenditure, patent, numbers of publications etc are used as input variables in these models. Some important studies are Sylwester (2001), Sarac (2009),Seren (2001) and Gulmez and Yardımcıoglu (2012) are worth mentioning. They used the different dataset of OECD countries but the result almost similar. Sylwester (2001) used data from 20 OECD countries found no relationship between variables while Sarac (2009) used the data from 10 OECD countries, Seren (2001) and Gulmez and Yardımcıoglu (2012) employed the data of 21 OECD countries found the positive relationship between economic growth and R&D expenditure.

In case of developing countries, the similar situation is found, Samimi and Alerasoul (2009) found a negative relationship between R&D expenditure and economic growth by using the data of 30 developing countries and Inekwe (2015) found that the impact of R&D investment on economic growth is positive in upper-middle-income economies and insignificant in lower income economies and concluded that R&D investment is favorable to growth. While Kaur & Singh (2016), Gocer (2013), Poorfaraj et al.(2011) and Sadraoui and Zina (2009) have confirmed the positive relationship between R&D expenditure and economic growth.

Although, the concept of economic development exists in the period of earlier economists but it is recognized as a discipline of economics in the 1950s after the linear stages of growth models of Rostow and Harrod-Domar Model. Rostow described the five stage of development while Harrod-Domar discussed the role of investment in taking the simple assumption of production functions. The weakness of these models is that they cannot be applied for all countries because each country has to pass through the same condition, stage by the stage while development process is linear Chenery (1960). In the 1960s the two sectors Lewis model and structural change model were presented by Lewis (1954) and Chenery (1960) respectively. Lewis model focus on the dualist economic development of labor from agriculture sector to industrial sector is considered as the major reason for economic growth. This model is valid in most LDC's. Many models after the Lewis model seems to follow the assumptions made by Lewis. The international dependent model and neoclassical counterrevolution models are introduced in the 1970s and 1980s respectively. First one fails to operate in autarky situation of the country and second flop due to raptorial activities of the developed countries who exploit the resources of developing countries.

Last but not least the theory of coordination failure emphasizes the role of government to solve the issues. The "big push" theory lead massive investment program that may cause to enhance the economy. Although the "big push" theory have to face a lot of criticism by economists but it is recommended by UNDP for developing countries to eradicate the poverty gap. Thirwal (2000) also presented the model by introducing the education along with other important variables for economic development.

2.1 Final Remarks on the Basis of Literature Review

At the beginning of the twenty-first century, new inventions in the fields of agriculture, engineering, industrial engineering, biotechnology, pharmaceuticals, health, electronics, aeronautics and especially in information & communication technologies (ICT) have revolutionized the production process of firms in these industries as well as improving social well-being. In fact, science and technology can be regarded as a primary source of economic growth and development, with the various scientific and technological changes contributing significantly to the development of underdeveloped countries. Scientific and technical progress contributes numerous ways including facilitating the use of potential resources and intensive utilization of resources, supporting exports, contributing to alternatives to imports, the growth of infrastructure, increased efficiency of human resources, promoting industrialization, increase in capital formation, availability of foreign capital, agricultural development, and finally, positive change in social and economic structure.

Although, the current study attempts to present an overview of the studies in the context of economic growth and economic development but kinds of literature regarding the empirical studies of economic development are rare. During literature review, we have found that the economists and researchers agree that technological progress is a key element of factors of production and has a vital role in long-term economic growth and development. By utilizing the latest technologies, a firm, industry or country may enhance output with the same level of employment and capital. The use of new technologies in production and manufacturing, indeed, in every field of life, has been increasing rapidly since the last decade of the twentieth century. But, regarding the impact of STI on economic growth and development, confusion still exists either STI has the positive impact or negative impact on economic growth. Are the STI having a significant impact on economic growth in developing countries as compared to developed countries? The answer is still not available in the context of empirical and comprehensive manners. Impact of STI on economic growth in numeric or percentage form is not available. It needs to investigate the impact of STI on economic growth and development. That is why it is decided to carry out the opinion survey to investigate the impact of STI on economic growth and development in Pakistan.

3. Overview of Science Technology Innovation (STI) in Pakistan

3.1 Geographical

Pakistan is the 5th largest nation in the world with the population of 207.774 million (after Indonesia (4th) slightly ahead Brazil (6th) with an average annual growth rate of 2.4% over a period of 1998-2017 and located in South Asia with an area of 796096 (Sq. Km) (PBS, 2017). Pakistan is the 36th largest country approximately equaling the combined land areas of France and the United Kingdom. Pakistan is at the junction of Central Asia and the Middle East, which gives its location great significance. China is situated in the northeast of Pakistan and nearly 523 kilometers long borderline while to the east of Pakistan, India is situated with border area almost 2,912 kilometers long. To the west of Pakistan, Afghanistan is located with border area of 2430 Kilometer, known as Durand Line and Iran exists to the south west of Pakistan with border area of 1046 kilometers (PBS, 2017).

3.2 Economic

Pakistan has made significant progress in regaining macroeconomic stability over the past three years. Pakistan has achieved macroeconomic stability in the past three years: the fiscal deficit has shrunk from 8 percent to below 5 percent, international reserves have tripled to over $18b, and the rate of growth has increased by a full percentage point to 4.7 percent (World Bank, 2017). The economy of Pakistan has continued the growth momentum as the GDP growth reached to 5.28 percent in 2016-17 which is the highest in 10 years, on the back of rebound growth in agriculture which registered a growth of 3.46 percent against the growth of 0.27 percent in 2016-17. Industrial sector witnessed the growth of 5.02 percent against 5.80 percent in 2016-17, with 20.9% share of total GDP. Agriculture is the lifeline of Pakistan's economy accounting for 19.5 percent of the gross domestic product, employing 42.3 percent of the labour force and providing the raw material for several value-added industries. It thus plays a central role in national development, food security, and poverty reduction while services sector is the highest contributor of GDP in percentage (59.6%) (PES, 2017)

3.3 STI System in Pakistan

Education and R&D expenditure are considered the lifeline of STI system. In 2015, government expenditure on education stood at merely 2.45% of GDP. Expenditure on Education has been decreeing each year since reaching at 2.75% of GDP in 2008. However, to enhance the primary and higher education government has planned to allocate at least 1% of GDP to higher education alone by 2018 (Planning Commission, 2014)

3.3.1 Pakistan’s first STI policy and National STI Strategy

Science and technology policy plays a great role to enhance the STI system of a country. In this regard, the Pakistan Council for Science and Technology (PCST) beneath the umbrella of the Federal Ministry of Science and Technology has been overseeing the S&T sector since 1962.

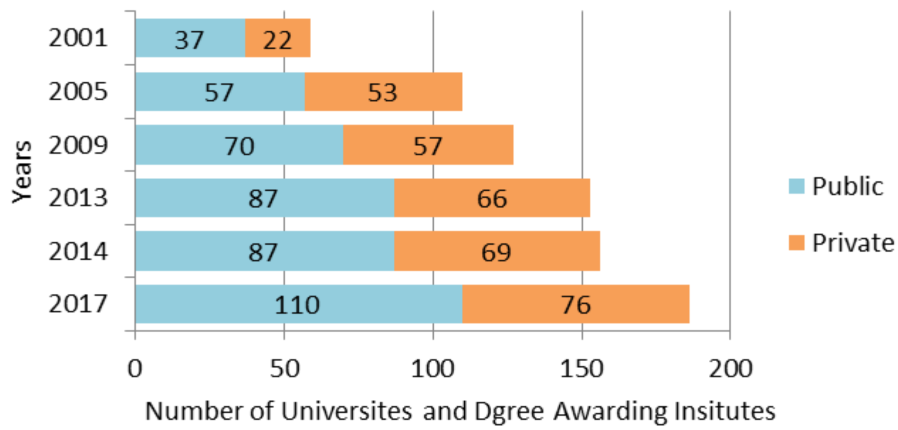
PCST developed Pakistan’s first National Science, Technology and Innovation Policy-2012 (NSTI-2012). It was the first time that innovation had been properly documented as being a long-term strategy for driving economic growth by the government. The policy mainly stresses the need for technology transfer, greater international co-operation in R&D, human resource development, and endogenous technology development. However, no information is available in terms of implementation, whether any part of the policy has been implemented since its release. Furthermore, PCST drafted National Science, Technology and Innovation Strategy (NSTIS) 2014–2018, along with a request for comments from the public. This strategy has been mainstreamed into the government’s long-term development plan, Vision 2025, a first for Pakistan. NSTIS (2014-2018) focused on human development and set the target to raise the R&D spending from 0.29%(2013) to 1% of GDP at end of 2018 (to triple R&D intensity by 2018). The ambitious target of enhancing the GERD/GDP ratio is very fruitful for expansion of STI system in Pakistan but this reform will need to implement to achieve the desired outcomes. However, the government is very keen to enhance the performance of R&D sector both through public investment in civilian technologies and defence and through state-operated bodies. In 2013, an R&D survey was conducted by PCST, the results indicate that 75.3% of R&D spending are received by Public sector R&D organizations. one out of four researchers is engaged in the natural sciences, followed by the agricultural sciences and engineering and technology. The large number of state researchers work in the higher education sector, a trend that has become more obvious since 2011.

3.3.2 Scientific Capacity Indicators of Pakistan

The general scenario of the STI sector in Pakistan is at best a mixed one. Some scientific capacity indicators are presented in Table 1. The growth rate of all STI indicators is increasing year by year except the expenditure on education and R&D. Despite that, the number of universities increased from 59 to 186 between 2001 and 2017 with the growth rate of 87% (Figure 1). Numbers of Ph.D. students have been produced by Pakistani universities also raised from 832 to 1351 between 2010 to 2014 with the growth rate of 62.37% in five years (Figure 2).

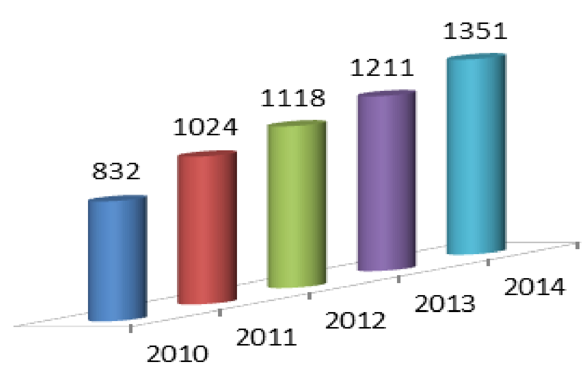
Huge change can be seen in the number of publications. The total number of publications was 886 in 1995 while it has reached to 10976 in 2015 with the growth rate of 54.22% per year during 21 years. As per UNESCO Science report (2015), 41.8% rise has been observed in the number of scientific papers from South Asia including India during the 2009 to 2014. The impressive performance was observed in Pakistan (87.5%) %), Bangladesh (58.2%) and Nepal (54.2%) as compared to India (37.9%) during the same period (UNESCO, 2015).

Figure 1. Growth in number of Pakistani Universities



Source: HEC

Figure 2. Growth in the number of Ph.D. students Produces by Pakistani Universities.



Source: HEC

In 2003 ICT goods imports (% total goods imports) stood at merely 4.47%, ICT goods imports (% total goods imports) has shrunk each year since peaking at 4.9 in 2015. In 1997, total R&D personal (FTE) and researcher per million were 36706 and 77 which have reached to 75658 and 167 in 2013 respectively. High-technology exports (% of manufactured exports) increase from 0.041 to 1.557 between 2003 and 2015 indicates the improvement in the industrial sector in Pakistan.

Ali (2017) stated that the average electricity consumption (kWh per capita) in 2015 for four South Asian Countries (SACs) was 571.92 (India, Bangladesh, Sri Lanka, including Pakistan 472.31), which is 13 times less than the average consumption of four East Asian Countries (EACs) (China, Japan, Korea, Malaysia) (7614.40). It is expensive for South Asian countries to provide this basic utility for their people. About 70% of energy is produced by furnace oil, which is expensive and has to be imported. The government decides to restructure the existing energy mix to control power shortages and to convert furnace oil plants to coal and is investing in several renewable energy projects, which are one of the priorities of Vision 2025 (UNESCO, 2015).

Table 1. Some Selected Scientific and Capacity Indicators of Pakistan

Name of Indicators	1995-1997	2005	2011	2011-2015
Government expenditure on education as % of GDP (%)¥	2.817[a]	2.254	2.222	2.455[g]
GERD as a percentage of GDP¥	0.160[c]	0.440	0.330	0.290[f]
GERD in '000 PPP$ (in constant prices - 2005) ¥	605386.000[c]	2402904.000	2200236.000	2105703.000[f]
Gross enrolment ratio, primary to tertiary, both sexes (%)¥	35.936[d]	40.623	45.609	50.174[h]
Total No. of Publication†	886.000[b]	2771.000	9065.000	10976.000[h]
Scientific and technical journal articles€	313.200[a]	493.100	1267.900	1267.900
Citations per Document†	8.880[c]	9.090	4.130	6.990[g]
Total patent grants (direct and PCT national phase entries) χ	21.000 [c]	143.000	92.000	209.000[h]
Total patent grants (direct and PCT national phase entries) per million χ	0.171[a]	0.932	0.530	1.106[h]
Researchers per million inhabitants (FTE) ¥	77.000[c]	83.000	151.000	167.000[g]
Total R&D personnel (FTE) - Total¥	36706.000[c]	53159.000	70380.000	75658.000[f]
High-technology exports (% of manufactured exports) €	0.041[a]	1.380	1.760	1.557[h]
Charges for the use of intellectual property, receipts (BoP, current US$)€	15000000.000[e]	15000000.000	7160000.000	15000000.000[h]
ICT goods imports (% total goods imports) €	4.470[d]	8.700	3.555	4.900[h]
Electric power consumption (kWh per capita) €	358.598[a]	464.728	456.672	472.319[g]
Fixed telephone + Mobile cellular subscriptions (per 100 people) €	1.712[a]	11.394	65.061	75.978[h]
Internet users (per 100 people) €	0.028[c]	6.332	9.000	13.800[h]

Source: '†'= SCOPUS Data, '€'= WDI, World Bank, '¥' = UIS Data, UNESCO, 'χ' = WIPO:
'a'=1995, 'b'=1996, 'c'=1997, 'd'=2003, 'e'= 2005, 'f'= 2013, 'g'=2014, 'h'= 2015

Similarly, the average fixed telephone plus mobile cellular subscription cost (per 100 people) is 154.75 and 86.21 in EACs and SACs respectively. Use of this old technology in EACs is almost two times higher than in SACs (Ali, 2017). The state of Internet use in East South Asian Countries (ESACs) is presented in Figure 3 and Table 1. It can be observed in Figure 3 that all eight ESACs had the same position in 1995, but the gap between East Asian countries (EACs) and South Asian countries (SACs) is increasing year by year. EACs have overtaken SACs rapidly in the last two decades (Figure 3). Korea Republic (90) Japan (93) and Malaysia are the leaders (figures indicate the percentage of people who are Internet users), while Bangladesh (14), Pakistan (18) and India (26) trail behind

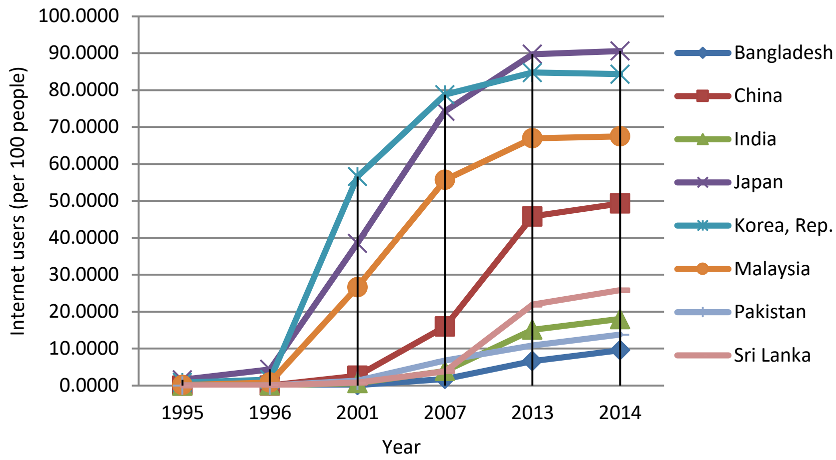


Figure 3. Internet user's subscribers per 100 inhabitants in Pakistan
Source: World Bank

As shown in Table1, the number of mobile phone subscribers is much higher in Pakistan than the number of internet users. Mobile phone technology is increasingly being used by teachers in developing economies for both educational and administrative purposes (Valk et al., 2010). Similarly increase in a number of patents granted to resident can also be observed from 21 (1997) to 209 (2015). Although the STI indicators clearly show growth in higher education and STI, it does not mean that the quality of education & R&D has also improved.

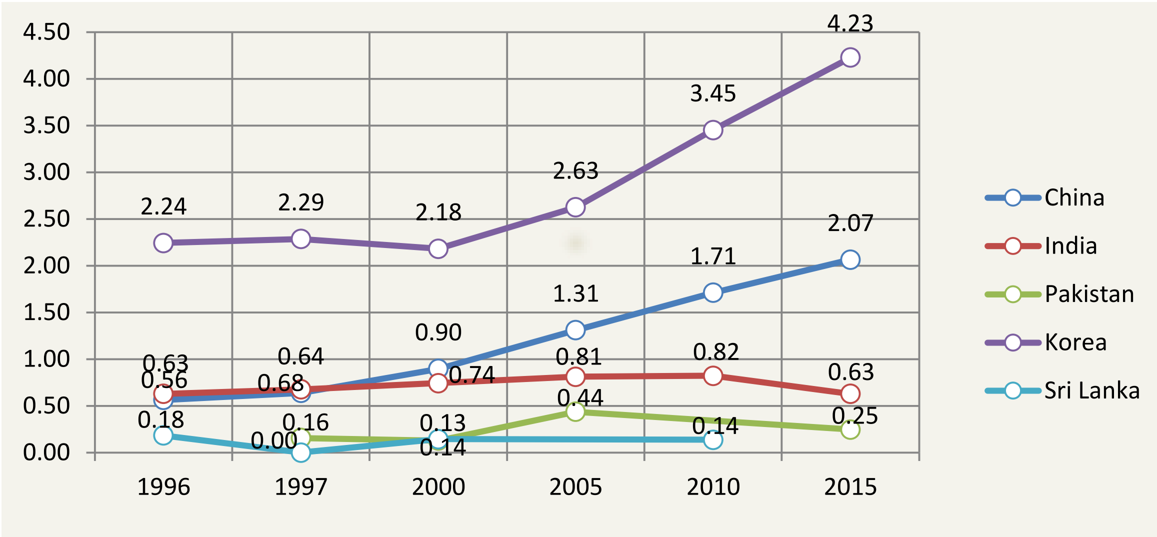
3.3.3 University-Industry(U-I) Linkage

It can be examined through a number of the patent application filed increase from 58 to 96 between 2001 and 2012 but the success rate of the application during the same period drop from 20.7% between 2001 and 2012. This indicates that no strong nexuses between university reforms and their impact on the industry is exists (Lundvall, 2009). This happened due to lack of University-industry linkage in Pakistan. Although some efforts are made in this regard but still need to speed up. The deep collaboration between academia and industry brings about the economic development of the country (Quintas et al. 1992). The major constraint for the failure to develop proper S&T in Pakistan is the lack of lack of coordination between the stakeholders in the innovation system. This lack of coordination and linkage has also been responsible for the lack of innovative products and processes in Pakistan (Qureshi and Kazi, 1997). Although, there is no proper forum is exist in Pakistan to enhance and develop the relationship between university and industries. However, few efforts have been made at the different level.

3.3.4 R&D Effort

As per UNESCO Science report (2015), the countries in South Asia invest the small amount of research and development (R&D). Gross domestic expenditure on R&D has decreased from 0.44 to 0.25% of GDP during the period from 2005 to 2015 and declining trend can also be seen in India from 0.81 to 0.63% of GDP during the period from 2005 to 2015(Figure 4). R&D investment remains stable in Sri Lanka (0.14% of GDP in 2010) but low as compared to China (0.90%) which has enhanced evidently since 2008, and far behind that of Korea (2.18%). India and Pakistan are showing decreasing trends in R&D investment as compared to China and Korea. The low investment on R&D associates with low researcher intensity and limited integration in global research networks

The recent data is available for researchers only for India Nepal, Pakistan, and Sri Lanka. It would be difficult to reach any conclusions for the region as a whole. However, from the available data, you may find some interesting trends. Although, the researcher and technicians per million inhabitants are very low in India, Pakistan and Sri Lanka than Korea, but Pakistan is showing impressive performance in the researcher per million inhabitants with the increase in growth rate of 0.95% as compared to India (0.38%), Sri Lanka (0.04%), and Korea (0.21%) respectively, during the period (Figure 5).



Source: UNESCO Insstitute of Statistics, October 2017

Figure 4. GERD as a percentage of GDP

Figure 5: Researchers (HC) and technicians in South-East Asia per million inhabitants
Source: UNESCO Report 2015

The women participation as researchers and technicians in Pakistan (30%), Sri Lanka (37%) and Nepal (8%) is very low as compared to men. In regard of researcher density, the Nepal is attempting to catchup the Sri Lanka but the share of women in the Nepalese research pool fall to half in 2010 that in 2002 (Figure 6). The women participation rate in Sri Lanka is lower in 2013 than 2007, however, share of women researchers is the greatest of three. Pakistan is performing well in terms of researcher density of three but the lowest in density of technicians, furthermore, no progress has been seen in any STI indicators since 2007.

As mentioned above, the public sector is playing a leading role in STI market while private sector seems to be lagging behind (Auerswald et al., 2012). This indicate that an appropriate entrepreneurial avenue (or culture) is not existed, resultantly, harming Pakistan's global economic competitiveness. Inspite of good the national STI policy within national development policy, its possible effect on programmatic interventions does not seen. Pakistan still needs a daring vision from decision-makers, policy makers, planners at all levels of government to achieve its goal of becoming a knowledge economy.

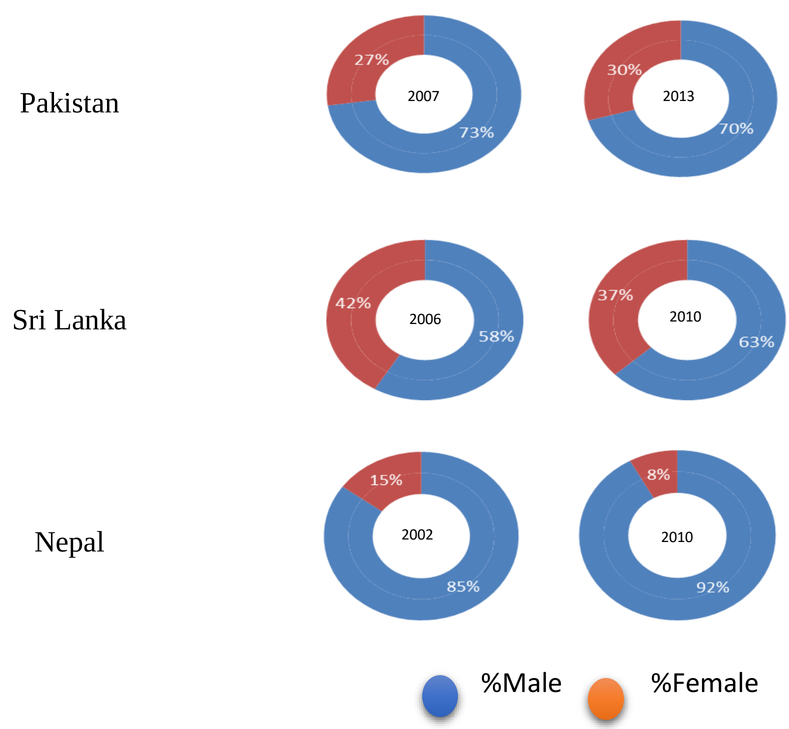


Figure 6: Researchers (HC) and technicians in South Asia by gender, 2007 and 2013 or closest years
Source: UNESCO Report 2015

4. Materials and Methods

To the accomplishment of the objective of the study, the case study is designed to seek the information from Pakistani scientists, engineers, technologists, and researchers about the impact of STI on economic growth and development. What they think and have an opinion about the impact of STI on economic growth and development. In this regard, a short questionnaire has been designed to survey opinion from academicians & professionals. Survey form/questionnaire (Appendix II) consist of some basic information followed by the survey questions. Along with four simple questions, some basic information also asked by the people like qualification, age, subject, institution type, which are described next section.

An email was sent to 4048 Pakistani scientists, engineers, technologists, and researchers and invited to participate in a short case study. The survey questionnaire was accessible at the Centre for Research, Innovation, and Policy (CRIP) website (http://crip.com.pk/survey.php). Emails were got from PCST database[1]. Out of 4048 scientists, 305 scientists responded to survey questionnaire. 7.5% response received which is considered very well in such type of study.

5. Results and Discussion

5.1 Basic information

As already mentioned, that instead of four simple questions, some basic information were also asked by the people like qualification, age, subject, institution type, which are described under this section.

5.1.1 Gender wise Response

The E-mail sent to 4049 to scientists, engineers, technologists, and researchers working at different Universities and R&D organizations of Pakistan to gather information. 7.5% response received, 305 out of 4049 people responded the email including male (249) and female (57). It can be conceived that strength of male in scientists and researchers is higher as compared to the women (Annexure -I).

5.1.2 Qualification Wise Response

Out 305 scientists and researchers who responded, 166 people hold the degree of Ph.D. (54%), 60 M.Phil (20%), 44 Post Doc (15%), 22 BS/BE (7%) and 13 Master (4%). This indicates a massive number of people have highest qualification Ph.D. and Post Doc (69%) who responded questionnaire (Annexure -I).

5.1.3 Age Wise

Highest number (171) of people who responded comes underage category of 31-45 years. While 74 have age 46-60, 23 over the 60 and 18-30 and 14 people are under 18 years old. It can be conceived that the response of adult people (age of 31-45 years old) is high as compared to another category of age (Annexure -I).

5.1.4 Subject Wise

The subject wise response is presented in (Annexure -I). It has been observed that response from scientists /researchers in the field of biological sciences is very high (22%). While scientists /researchers belong to agricultural sciences, chemistry, physics, social science, engineering sciences, health sciences, pharmaceutical science, environmental science, earth sciences and mathematics responded at 16%, 14%, 11%, 11%, 9%, 5%, 3%, 3%, 1% and 1% respectively.

5.1.5 Institution Type

The response was received by 89% by the public sector and 11% by the private sector (Annexure -I). 70% responses were received by Universities and 30% by R&D organizations (Annexure -I). It clearly indicates a large number of people work in public sector and university as compared to the private sector and R&D organizations.

5.1.6 Location Wise (Province wise)

The study also attempts to find out the response from different provinces of Pakistan. It has be found that the highest number of researchers (116) responded from Punjab, followed by Islamabad ICT (75), Khyber Pakhtunkhwa (44), Sindh (43), Other-abroad(12), Baluchistan (9), Azad Jammu Kashmir (4), and Gilgit Baltistan (2) (Annexure -I).

5.2 Survey Questions

Very simple four questions were asked by Pakistani scientists, researchers and technologists to seek information about the impact of STI on economic growth and development. Following are the questions and their results.

[1] We are highly indebted to Dr. Saima Nasir (SRO) for providing the Email of Pakistan Scientists for this short case study.

5.2.1 Q. No. 1: Whether STI has any impact on Economic Growth (National / Gross Domestic Product i.e. GDP)?

284 scientists/researchers responded this question positively while 21 scientists responded negatively. Out of 305, 93% scientists (288) confirmed that science, technology and innovation has the impact on economic growth while only 7% researchers (17) think that STI has no impact on economic growth (Annexure -I).

The second part of this question linked with the first question was; if yes, then state how much? Five options have been given for selection; i) Very High, ii) High, iii) Medium, iv) Low, v) Very Low. Out of 288 who responded positively, 45% scientists (130) apprehend that impact of STI on economic growth is high, 27% researchers (83) think that STI impact on economic growth is very high. While 18%, 5%, and 3% researchers endorsed the impact of STI on economic growth is medium, low and very low respectively (Figure 14(b)). From these results, it has been concluded that majority of the scientists/researchers think that impact of STI on economic growth is high or more than high (or very high).

5.2.2 Q.No. 2: Whether your research output[2] has any impact on Economic Growth?

The second question was asked by the scientists and researchers of Pakistan is: whether your research output has any impact on Economic Growth? The answers to this question were received by the scientists/researchers are different from previous one. 85% scientists think that their research has the positive impact on economic growth while only 15% people responded that their research has no impact on economic growth as shown in (Annexure -I).

The second part of this question linked with the previous one; if yes, then state how much? Five options have been given for selection as mentioned in section 5.2.1. Out of 260, 34% scientists recommended that impact of STI on economic growth is high, 34% researchers think that impact of STI on economic growth is medium. While 14%, 10%, and 8% researchers endorsed the impact of STI on economic growth is very high, low and very low respectively (Annexure -I).

This indicates that most of the research is being carried out in Pakistan is just only research for sake of research. It is not related to practical application. This is a very alarming situation that majority of Pakistani scientists (68%) think that their research has the medium and high impact on economic growth while only 14% scientists think that their research has very high impact on economic growth. It can also be conceived that applied research in Pakistan is not at that level that it can contribute to economic growth. Although a number of publications in international and national journal increasing day by day but the practical implication of this research is very low.

5.2.3 Q. No. 3: Whether STI has any impact on living standard/society?

Similar results have been found like Q.No.1. 94% scientists/ researchers (284) out of 305 said that STI has an impact on economic development (living standard of society) while 6% scientists (21) said STI has no impact on economic development (Annexure -I). This mean high majority of scientists think that STI has the impact on living standard and society.

Among 284 scientists, 46% scientists think that STI has the high impact on economic development while 26% 19%, 7%, and 2% scientists confirmed that impact of STI on economic development is very high, medium, low and very low respectively (Annexure -I).

5.2.4 Q. No. 4: Whether your research output[3] has impact on living standard/society?

[2] Research papers, patents, inventions, innovations, crop varieties, livestock breeds, machinery/equipment or any other form of research output

[3] Research papers, patents, inventions, innovations, crop varieties, livestock breeds, machinery/equipment or any other form of research output

The last question was asked by the scientists/researchers of Pakistan is whether your research output has the impact on living standard and society? Out of 305, 81% scientists responded that their research has the impact on living standard and society while 19% scientists/researchers said their research has no impact on economic development (Annexure -I).

246 scientists who responded positively, out of them, 33% (82) said that the impact of their research on the economic development is high while 31% (77) scientists/researchers said their research has the medium impact on economic development. Very high, low and very low impact of their research on economic development was observed by 16%, 14%, and 6% scientists respectively (Figure 17 (b)).

6. Conclusion and Policy Recommendations

6.1 Conclusion

As already mentioned in the introductory section that the main objective of the study is to seek information from the main actor of STI (Pakistani scientists, engineers, technologists, and researchers working in Universities and R&D organizations) about the impact of STI on economic growth & development and presents the policy recommendations on the basis of results. The results of the opinion survey indicate that 305 scientists responded the questionnaire and out of 305, 94% (288) confirmed that STI has the impact on economic growth and economic development. Out of 288 who responded positively, 74 % scientists think that STI has high impact on economic growth while 71% scientists supported that STI has high impact on economic development, while rest of them considered that STI impact is low or very low on economic growth and development. In response to the question, about the impact of their research on economic growth and development, 85 %(260) scientists supported that STI has the positive impact on economic growth. Out of 260 scientists, 49% scientists think the impact of STI on economic growth is more than high or very high. It can be clearly understood that impact of their research is very low as compared to the overall impact of STI on economic growth.

On the basis of the survey results, it is concluded that science technology and innovation (STI) are the direct, positive, and significant association with economic growth and development. Majority of the Pakistani scientists think that the impact of STI on economic growth and development is high or very high but their own research has no much impact on economic growth and development.

As indicated under the discussion of STI system of Pakistan, in terms of STI capacity indicator, Pakistan has very low in R&D, patent creation, inventions, innovation and creation of new technologies. So there is the dire need for developing countries like Pakistan that they enhance their research capabilities and invest more in education, R&D to improve the situation. It can be conceived that Pakistan has to purchase and import a lot of equipment, machinery, and raw materials used in the production process from the developed economies. The developing countries like Pakistan depend highly on the foreign technologies (like IT, telecommunication, health, agriculture, space science, biotechnology, nanotechnology, electronics, mechanics, auto-industry equipment etc.) in the production process.

6.2 Policy Recommendations

The study provides valuable and significant information to the S&T policy makers and planners, especially for developing countries to formulate science, technology and innovation policies. The results can help them to decide where to take the first step in the long voyage of building adequate scientific and technological capabilities fitted to the socio-economic requirements of their people.

The general scenario of the STI sector in Pakistan is at best a mixed one while Pakistan is facing many challenges in the higher education sector, one of major challenge the enhancement of quality education rather than quantity of education. Although, growth cab seen in the indicators of higher education, but it doesn't imply that the quality of education and research has also improved. Similarly, the growth in Ph.D. graduates and scientific publications can be seen but their impact on innovation, economic development is not evident. It can be measured by patent activity. The patent indicators clearly show growth. The number of patent applications filed increased from 58 to 96 between 2001 to 2012, while the ratio of successful applications over the same period drop from 20.7% to 13.5% (WIPO). This clearly depicts the poor performance due to lack of university-industry linkage, resultantly, the impact on the production process of industry. Therefore, it is dire need to encourage the U-I linkage in Pakistan as well as in developing countries

It has been also observed in the above discussion of STI system of Pakistan and survey results that share of the public sector is very high in the STI market, while the private sector is very far behind. This indicate that an appropriate entrepreneurial avenue (or culture) is not existed, resultantly, harming Pakistan's global economic competitiveness. Thus, private sector should come forward to invest in R&D. In order to achieve its goal of becoming a knowledge base economy, Pakistan still requires a bolder vision from decision-makers at all levels of government.

From the above discussion, it is clearly understood that ESACs, especially SACs, require the capability to manage and adapt new creation, technologies for their local needs. To adopt and disseminate modern scientific innovative technologies, ability and knowledge are required but the lack of scientific & technical knowledge and human skill make conditions in these countries unfavorable. SACs are not only far behind in science, technology and innovation but also in economic and human development. Although SACs are enriched with natural resources, they are unable to fully utilize these resources to the benefit of the public owing to these deficiencies in capacity. SACs under study are still lagging behind in old inventions and utilities, such as telecommunications and electricity, and completely unable to adopt recent high tech innovations. Large portions of rural areas are still deprived of basic technologies and utilities (telephones and electricity) which are structural and functional units of scientific and technological progress that serve as prerequisites to adopt and diffuse the new advanced technologies and innovation in the 21st century.

Technology simply cannot be spread and the capacity to innovate cannot be attained without the vital presence of energy infrastructure (gas and electrical power). It is a mistake to assume that by applying external knowledge and equipment, the technology can be easily transferred, diffused, and adopted. Actually, to adopt and implement new technology in a country, a minimum level of infrastructure and capacity is required. Therefore, SACs have to improve their capacity building to be able to consume foreign new innovative technologies and integrate them into their countries. This will enable them to create and develop new technologies to fulfill their local requirements.

The momentous actions are needed to accelerate the technological progress in SACs. Improvement in human skills, in particular, is vital to boost technological competency. Pakistan and rest of developing economies can follow the model of rising economies like Korea, Singapore, Hong Kong and Taiwan who have been spending a high percentage of their budget on the basic facilities of twenty-first-century global life, applied research, health and education. In the long run, ESACs and especially SACs have to invest more in a number of areas. These include the energy sector (to increase capacity for power and gas), education, research & development (to obtain the spillover effect of investments on invention), technology creation (in the form of high-tech export, patents, and royalties) and human development.

6.3 Implication of Study

The direct and indirect implications of the study have been summarized in point form as follows:

Direct Implications:

i. We have also found that similar situation exists in many developing countries like Pakistan. They are very weak in the technology creation, old diffusion and human skill development. The developing countries need high investment to improve these indicators like the energy sector to provide basic necessities of life (electricity, gas) to the public, augmented education budget (for primary as well as higher levels) and supporting research and development by increasing the R&D budget, to improve the STI situation of the country, resultantly, enhance the impact of STI on economic growth.

ii. There are many other STI indicators very helpful to improve the STI level and very useful to increase the output like: communication technology (ICT) and high-tech imports. There is a dire need for developing countries to improve the communication technology (ICT) and high-tech import by relaxing excise rates, tariffs, duties, and quotas until they are become self-sufficient in creation, innovation of new technologies.

iii. While allocating the funds for R&D, the most common question asked by political leaders or funding agencies, particularly in developing countries is that how much, innovation and R&D will they contribute to the economy of the country and how? To seek the answers to these questions, the study examines the STI systems of Pakistan and found that it is dire need to enhance university industry-linkage in Pakistan. The inter-linkages among these five sectors (Universities → R&D Organizations → Industry → Agriculture → Services) would be strong then a country may achieve maximum results of R&D investment.

iv. On the basis of STI composite indicators of Pakistan, as discussed above, it can be concluded that Pakistan is weak in the creation of innovation and technologies. These deficiencies and weakness in creation and innovation capacities of Pakistan can be improved by enhancing R&D resources and needs to build indigenous skills and innovation capabilities by investing heavily in science and technology. There is no coordination between R&D organizations, universities and industries to produce high-quality end products. Therefore, Pakistan needs to create university-industry linkage not only within the country but across the region as well. So, the strong implication of policy should be implemented by the government ad target of R&D budget should be set. Moreover, a strategic policy is required to ensure that STI data of Pakistan should be reported yearly at the national level at first and then the government should set benchmark value to enhance it each year.

Indirect Implications:

i. Need for a vision of the future assessment (identifying what the priority areas in STI are)

ii. Quality enhancement (design and launch programme standards which ensure quality services according to local needs)

iii. Bridging the links between research & development and practice (to create up-to-date research environments at universities R&D organizations)

iv. Taking initial steps to support the synthesis of existing knowledge and to build and expand the national knowledge base.

References

Ertl, H., Bordt, M., Earl, L., Lacorix, A., Lonmo, c., McNiven, C., Veenhof, B. (2006). *Toward understanding Impact of Science and Technology and Innovation activities*. Ottawa, Canada: SIEID, Statistics Canada, Blue Sky II Forum.

Sener, S., & Sarıdogan, E. (2011). The Effects of Science-Technology-Innovation on Competitiveness and Economic Growth. Procedia Social and Behavioral Sciences, 24, 815–828.

Solow, R. (1957). Technical Change and the Aggregate Production Function. Review of Economics and Statistic, 39(3), 312-20.

García, E. M. (2013). Technological Progress Is Key to Improving World Living Standards. Economic Letter, 8(4), 1-4.

Cameron, G. (1998). Innovation and Growth: a survey of the empirical evidence. UK: Nuffield College, Oxford, OX1 1NF.

Swan, T. W. (1956). Economic Growth and Capital Accumulation. Economic Record, 32 (63), 334-361.

Uzawa, H. (1965). Optimum Technical Change in an Aggregate Model of Economic Growth. International Economic Review, 6, 18-31.

Phelps, E. (1966). Models of Technical Progress and the Golden Rule of Research. Review of Economic Studies, 33, 133-145.

Conlisk, J. (1967). A Modified Neoclassical Growth Model with Endogenous Technical Change. The Southern Economic Journal, 34, 199-208.

Conlisk, J. (1969). A Neoclassical Growth Model with Endogenously Positioned Technical Change Frontiers. Economic Journal, 79, 348-362.

Lutkepohl, H. (1991). Introduction to multiple time series analysis. Berlin: Springer-Verlag.

Shell, K. (1967). A Model of Innovative Activity and Capital Accumulation. In K. Shell, Essays on the Theory of Optimal Economic Growth (pp. 67-85). Cambridge: MIT Press.

Nelson, R. R., & Phelps, E. S. (1966). Investment in Humans, Technological Diffusion, and Economic Growth. The American Economic Review, 56(1/2), 69-75.

Romer, P. (1986). Increasing return and long-Run Growth. The Journal of Political Economy, 94(5), 1002-1037.

Lucas, R. E. (1988). On the Mechanics of Economic Development. Journal of Monetary Economics, 22, 3-42.

Aghion, P., & Howitt, P. (1992). A model of Growth through Creative Destruction. Econometrica, 60(2), 323-351.

Romer, P. (1990). Endogenous Technological Change. The Journal of Political Economy, 98(5), s71-s102.

Romer, P. (1994). The origins of Endogenous Growth. Journal of Economic Perspective, 8(1), 3-22.

Pyo, H. K. (1995). A time series test of the endogenous growth model with human capital. In e. Takatoshi Ito and Anne O. Krueger, Growth theories in light of the East Asian Experience, NBER-EA (Vol. 4, pp. 229-245). University of Chicago Press.

Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A Contribution to the Empirics of Growth. Quarterly Journal of Economics, 107(2), 407-437.

Jones, C. I. (1995a). Time series test of endogenous growth models. The Quarterly Journal of Economics, 110(2), 495-525.

Jones, C. I. (1995b). R&D Based Models of Economic Growth. The Journal of Political Economy, 103(4), 759-784.

Islam, N. (1995). Growth Empirics: A Panel Data Approach. The Quarterly Journal of Economics, 110(4), 1127-1170.

Lee, K., Persaran, M. H., & Smith, R. (1997). Growth and Convergence in a Multi-Country Empirical Stochastic Solow Model. Journal of Applied Econometrics, 12, 357-392.

Loo, I. D., & Soete, L. (1999). The Impact of Technology on Economic Growth: Some New Ideas and Empirical Consideration. MERIT, Maastrich Economic Research Institute on Innovation and Technology. Netherland: University of Maastrich.

Yanikkaya, H. (2001). A cross-country Empirical Analysis'. Yonetim Ekonomi, 7(1), 139-161.

Filho, M. B., Silva, R. G., & Diniz, E. M. (2005). The Empirics of the Solow Growth Model: Long-term Evidence. Journal of Applied Economics, VIII(I), 31-51.

Gundlach, E. (2005). The Solow Model in the Empirics of Cross-Country Growth. To be presented in the session "The 1956 Contribution to Economic Growth Theory by Robert Solow: The 50th Anniversary Celebration" of the AEA annual meeting in Boston, 6-8, January 2006. Germany: Kiel Institute for World Economics.

Koutun, A., & Karabona, P. (2013). An Empirical Study of the Solow Growth Model. Mälardalen University, Bachelor Thesis in Economic (NAA303), School of Business, Society and Engineering, Sweden.

Seren, M. J. (2001). R&D expenditure in an Endogenous Growth Model. Journal of Economic, 74(1), 39-62.

Ulku, H. (2004). R&D Innovation, and Economic Growth: An Empirical Analysis. IMF Working Paper WP/04/85.

Rao, B. B. (2006). Time Series Econometrics of Growth: Models: A Guide for Applied Economists. MPRA paper No. 1547. University of South Pacific.

Parham, D. (2007). Empirical analysis of the effect of R&D on Productivity Implication for Productivity measurement? OECD workshop on Productivity Measurement and Analysis, (pp. 1-22). Switzerland.

Sylwester, K. (2001). R&D and economic growth. Knowledge, Technology & Policy, 13(4), 71–84.

Sarac, T. B. (2009). Aras¸tırma-Gelis¸tirme Harcamalarının Ekonomik Büyüme Üzerindeki Etkisi: Panel Veri Analizi [The effect of research-development expenditures on economic growth: A panel data]. EconAnadolu 2009: Anadolu International Conference on Economics, Eskis¸ ehir, Turkey.

Gulmez, A., & Yardımcıoglu, F. (2012). OECD Ulkelerinde Ar-Ge Harcamaları ve Ekonomik Buyume İlis¸ kisi: Panel Es¸ butunles¸ me ve Panel Nedensellik Analizi (1990–2010) [The relationship between R&D expenditures and economic growth in OECD Countries: Panel cointegration and panel causality analysis. Maliye Dergisi, 163, 335–53.

Samimi, A., & Alerasoul, S. M. (2009). R&D and Economic Growth: New Evidence from Some Developing Countries. Australian Journal of Basic and Applied Sciences, 3(4), 3464-3469.

Inekwe, J. N. (2015). The Contribution of R&D Expenditure to Economic Growth in Developing Economies. Social Indicators Research, 124, 727–745.

Kaur, M., & Singh, L. (2016). R&D expenditure and economic growth: An empirical analysis. International Journal of Technology Management & Sustainable Development, 15(3), 195-213.

Gocer, I. (2013). Effects of R&D expenditures on high technology exports, balance of foreign trade and economic growth. Maliye Dergisi, 165, 215-240.

Poorfaraj, A., Samimi, A. J., & Keshavarz, H. (2011). Knowledge and Economic Growth: Evidence from Some Developing Countries. Journal of Education and Vocational Research, 1(1), 21-25.

Sadraoui, T., & Zina, N. B. (2009). A Dynamic Panel Data Analysis for R&D Cooperation and Economic Growth. International Journal of Foresight and Innovation Policy, 5(4), 218-233.

Chenery, H. B. (1960). Patterns of industrial growth. The American Economic Review, 50(4), 624-654.

Lewis, W. A. (1954). Economic Development with Unlimited Supplies of Labo. The Manchester School of Economics and Social Studies, 22, 139-191.

Thirwall, A. (2000). Growth and Development with special reference to Developing Economies. London: Macmillan.

PBS. (2017). Retrieved from Pakistan Bureau of Statistics: http://www.pbscensus.gov.pk/

World Bank. (2017, October 10). Retrieved October 10, 2017, from World Bank: http://www.worldbank.org/en/country/pakistan/overview

PES. (2017). Pakistan Economic Survey 2016-2017. Islamabad: Ministry of Finance, Government of Pakistan.

Planning Commission. (2014). Pakistan Vision 2025. Ministry of Planning, Development, and Reform of Pakistan: Islamabad. See: http://pakistan2025.org.

UNESCO. (2015). UNESCO Science Report Towards 2030. Paris: UNESCO.

Ali, T. M. (2017). Technological Achievements and Economic Development: The Significance of Technological Achievement Gap in Selected East and South Asian Countries. STI Policy Review, 8(1), 113-156.

Valk, J. H., Rashid, A. T., & Elder, L. (2010). Using mobile phones to improve educational outcomes: An analysis of evidence from Asia. International Review of Research in Open and Distributed Learning, 11(1), 117-140.

Lundvall, B. A. (2009). Innovation as an Interactive Process: User-Producer Interaction in the National System of Innovation. Research Paper. See: http://reference.sabinet.co.za

Quintas, P., Wield, D. and Massey, D. (1992). Academia– industry links and innovation: Questioning the science park model. Technovation, 12: 161–75.

Qureshi, M. M. and Kazi, A. Q. (1991). Research and Development in Pakistan – Review (1947–89) and Future Perspective. Islamabad: Pakistan Council for Science and Technology and Pakistan Academy of Sciences

Auerswald, P., Bayrasli, E., & Shroff, S. (2012). Creating a place for the future: Strategies for entrepreneurship-led development in Pakistan. Innovations: Technology, Governance, Globalization, 7(2), 107-134.

Appendix-I

Summary of Survey Results

By Gender		By Type of Institution:		By Category		By Qualification		By Age	
Male	248	Public Sector	271	University	214	Post Doc	44	Under 18	14

Female	57	Private Sector	34	R&D Organization	91	PhD	166	18-30	23
						M.Phil	60	31-45	171
						Master	13	46-60	74
						BS/BE	22	Over 60	23
Total	305	Total	305	Total	305	Total	305	Total	305

By Subject Specialization		By Location (Province)	
Agricultural Sciences	49	Islamabad ICT	75
Biological Sciences	68	Punjab	116
Chemistry	42	Sindh	43
Computer Sciences	8	Khyber Pakhtunkhwa	44
Earth Sciences	2	Balochistan	9
Engineering Sciences	29	Azad Jammu Kashmir	4
Environmental Sciences	8	Gilgit Baltistan	2
Health Sciences	16	Others-Abroad	12
Mathematics	3		
Pharmaceutical Sciences	11		
Physics	33		
Statistics	1		
Social Sciences	33		
Humanities	2		
Empty Space	0		
Total	305	Total	305

S#	Questions	Total*	No	Yes	Very High	High	Medium	Low	Very Low
1	Whether STI has any impact on Economic Growth (National / Gross Domestic Product i.e. GDP)?	305	17	288	83	130	51	14	10
2	Whether your research output* has any impact on Economic Growth?	305	45	260	38	88	88	26	20
3	Whether STI has any impact on living standard/society?	305	21	284	73	130	54	21	6
4	Whether your research output* has the impact on living standard/society?	305	59	246	39	82	77	34	14

* Research papers, patents, inventions, innovations, crop varieties, livestock breeds, machinery/equipment or any other form of research output

** Total Responded

Appendix-II

QUESTIONAIRE:
IMPACT OF SCIENCE, TECHNOLOGY AND INNOVATION (STI) ACTIVITIES ON ECONOMIC GROWTH AND DEVELOPMENT IN PAKISTAN

Section - 1: Basic Information

Title: Mr.

Name: A valid name is required

Gender: ⊙ Male ○ Female

Qualification: ⊙ BS/BE/MBBS/DPharm ○ Masters ○ M.Phil/MS/FCPS ○ PhD ○ Post Doc

Major Field of Study: Select Field...

Subject Specialization (e.g. Physical Chemistry, Nuclear Physics, Economics, Biotechnology etc.):

Email Address:

Tel Number:

Age: ⊙ Under 18 ○ 18-30 ○ 31-45 ○ 46-60 ○ Over 60

Type of Institution: ⊙ Public Sector ○ Private Sector

Category: ⊙ University/Degree Awarding Institution ○ R&D Organization

Participant's Location (Province): Select Location...

Section - 2: Survey Questions

Please state in your opinion

Whether STI has any impact on Economic Growth (National / Gross Domestic Product i.e. GDP)? ○ Yes ○ No
If yes, please state how much? ○ Very Low ○ Low ○ Medium ○ High ○ Very High

Whether yours research output* has any impact on Economic Growth? ○ Yes ○ No
If yes, please state how much? ○ Very Low ○ Low ○ Medium ○ High ○ Very High

Whether STI has any impact on living standard / society? ○ Yes ○ No
If yes, please state how much? ○ Very Low ○ Low ○ Medium ○ High ○ Very High

Whether yours research output* has impact on living standard / society? ○ Yes ○ No
If yes, please state how much? ○ Very Low ○ Low ○ Medium ○ High ○ Very High

Submit

*Research papers, patents, inventions, innovations, crop varieities, livestock breeds, machinery/equipment or any other form of researc

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