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Quantifying Firm Level Innovation in Pakistan and Its Consequences for Public Policy

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In this paper we aim to study, understand and analyse firm level innovation in developing countries; with a special focus on Pakistani private firms. Using data on 696 firms from the Innovation Module of the Enterprise Survey conducted by World Bank over the period 2013-2015, we present a detailed account of innovation in Pakistan. In line with literature, we explain firms' research effort by estimating the Knowledge function. This is done by applying a doubly censored Tobit regression on Total Research Expenditure per worker. This is the sum of intra and extra mural research expenditure, cost of training employees and the cost of acquiring equipment for innovation. We next estimate the probability of product and/or process innovation being conducted by Pakistani firms by estimating the Innovation function. This is done by estimating a bivariate probit regression on the two types of innovation. These two dependent variables are binary. We find that size and age of a firm significantly and positively affect research investment while corruption, measured as an index, is a significant inhibitor of research investment. Our estimations show that an exporting and medium sized firm is more likely to innovate. On the whole, research effort is low in Pakistani firms and the nature of innovation can be described as incremental. The current research effort by the firms exerts little influence on the probability to conduct innovation. We link firms' innovativeness with productivity to test whether innovative firms in Pakistan are productive as well, as theory suggests.

JEL Classification: D22, D24, L25, O31

1. INTRODUCTION

This paper presents a quantitative analysis describing firm level innovation in Pakistan building on the work of Aftab (2016). Understanding firm behaviour regarding innovation is important for several reasons. It not only helps us understand the behaviour of private sector, it can also give insights into public policy prescriptions. If a country wants to achieve macroeconomic goals, it is important to understand the roles of the stakeholders also. More so in developing countries which, chronically, fall short of achieving set targets of macro indicators and whose governments are slowly recognising the importance of supporting private enterprise as job creators, and possibly, centres of innovation. With the recent availability of data, we can now look at whether differences in firm level innovation add to our broader understanding of developing countries performance. This is the first time such an analysis has been conducted for Pakistan—the sequential estimation of the country's Knowledge function, Innovation function and Productivity equation. This work has empirical relevance for Pakistan's policy as well. In

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Vision 2025 [Pakistan (2014)], the Government of Pakistan formally declared medium and long term goals for the country. It has been presented by the Planning Commission at the Ministry of Planning, Development and Reform.

Among the priority areas highlighted by the Government is supporting and developing a buoyant and innovative private sector that helps create jobs. While there is consensus on the importance of an innovative private sector in the country, there is no publicly available document that analyses and models it as is done in this paper.

Very few developing countries have been able to navigate away from pitfalls and challenges to transition to higher income cadres. Examples include, but not limited to, South Korea, Singapore, Taiwan, China and recently Botswana. Most others have had spurts of rapid economic growth which have lasted for a few years at a time, only to be followed by depressions of varying degrees. Examples include, but not limited to, Pakistan, Kenya, and Nigeria. Sustained growth has escaped the majority of developing countries, for the most part. There are many factors that have been put forward explaining the performance of developing countries e.g., institutions, sustainability of external and domestic debt, political structures, dependence on foreign aid and financing, weak domestic fiscal policies and effects of climate change to name a few. With the recent availability of data, we can now look at whether differences in firm level innovation add to our broader understanding of developing countries performance. To that end, this paper provides a framework for studying firm level innovation in developing countries which can be applied to other countries as well and be a useful tool for comparison.

The role of innovation at firm level has been analysed, and continues to be so, in OECD countries. This has been possible on accounts of data availability, the quality of which has been improving also. Surveyors have been mindful of trying to include the same firms in each wave of the survey, whilst taking into account the structural change in these economies. To put another way the surveys conducted, to document firm level innovation in European Union and OECD member countries, put in effort to ensure the relevance and validity of survey population. Now, it is possible to conduct similar exercises for developing countries as well on accounts of data availability.

In line with literature, we have estimated the knowledge function, innovation function, and productivity equation for Pakistan that explain the research effort and link it to innovation outcomes. Aftab (2016) estimated the knowledge function and innovation function. In this paper, we build on that and add the estimation of the productivity equation for Pakistan.

In the first section we present a brief literature review that focuses on firms and innovation. In the second section we analyse firm level innovation in Pakistan. We begin by looking at earlier work done on firm level innovation, in developed and developing countries, and introduce the theoretical model. We present our data source which is the Enterprise Survey conducted by the World Bank Group. We define innovation as used in this analysis. We then present the starting point of the estimation - Knowledge Function. This is followed by the estimated Innovation Function. Here we link innovation outcomes—product and process innovation—to predicted research effort of Pakistani firms. Following this, we estimate the Productivity Equation where we link estimated innovation outcomes to total factor productivity of firms. We conclude by presenting our conclusion and a brief discussion.

2. LITERATURE REVIEW

2.1. A Brief Survey of Literature on Innovation

In this section we explore the theoretical reasoning for studying innovation. We look at innovation's role in explaining economic growth.

Economic growth is important for any country. Governments are judged on their performance of macroeconomic indicators; growth being one of the most popular ones. At a very basic and domestic level, governments have to ensure economic growth to deal with growing population. Economic behaviour and growth have been areas of focus since the advent of our profession as can be seen in the literature of Adam Smith and Karl Marx. In classical political economy, differences in productivity and income were explained away by differences in accumulated capital per worker. Difference in growth rates was on accounts of differing rates of capital accumulation. Here we focus on growth and how it has been dealt with, post-World War II. After the War, we had developed countries: the US and Western Europe; and developing countries: the bulk of former colonies in Asia and Africa and some countries in Eastern Europe.

Around the same time Solow's influential paper [Solow (1956)] was published. This marks the beginning of modern neoclassical theory of growth. Solow's model was set up using assumptions of perfect information and competition, utility maximising, positive and decreasing marginal products of factors of production (capital and labour). In the model, as capital per worker increases, productivity too increases. Eventually, on accounts of the increasing capital per worker, marginal productivity of capital decreases. Then there can be no increases in the capital to labour ratio. Growth in productivity stops when the capital labour ratio reaches a constant. And in the long run, the growth rate and factors of production will grow at the same, exogenously given, rate. If there has to be a change in long run growth in GDP per capita, it would be on accounts of the exogenous technological progress. Whether this is technology or knowledge, it is considered a public good. By definition, a public good is one whose consumption is non-rival and is non-exclusive. So knowledge available in one place is available to anyone who would like to use it anywhere else. In what seemed a natural progression, as neoclassical economists focused on global growth, knowledge was treated as an international commodity. So, knowledge created in say the US would be available, costlessly, in say Pakistan. Everything in these models of growth happens in perfect harmony. Ergo, in the long run, all countries in the world will grow at the same exogenously determined technological progress rate. Initially, poorer countries would grow faster than richer countries because of difference in initial endowments. Poor countries would have low levels of capital, hence low capital to labour ratio. As capital accumulation increases there would be a higher reported growth rate because, to begin with capital was scarce. Moreover, perfectly mobile capital will flow out of low-growth rich countries into the fast-growing developing countries in search of higher profit. This will help the gap in income level between rich and poor countries to decrease, leading to the use of the term 'convergence'. Eventually, the differences will disappear. In a nutshell, the theory of the day was that factor growth explained long run growth. The theory predicted that convergence between developing and developed countries was an inevitability.

Empirical work by Abramovitz (1956), Kendrick (1961), Durlauf and Johnson (1995) and Semmler, *et al.* (2005) proved the ineptness of the theory. Not only was there no said convergence, as shown by Islam (2003), actually divergence in income and productivity was experienced as shown by Landes (1998). As such there is a formation of clubs characterising countries' performance rather than convergence.

Fagerberg (2010) defines technology as "The subset of knowledge that deals with how to produce and distribute goods and services."(p.13). It includes knowledge about physical processes and their organisation.

Much work has been done on documenting the 'catch-up' through history. Examples include Gerschenkron (1962) who focuses on Europe, particularly Germany *vis a vis* UK. He laid out conditions for catching up with a leading country successfully and highlighted the role of private and public sector. Abramovitz (1994) makes a similar argument, but says that technological congruence and social capability play a major role in determining whether or not a country does indeed catch up. Technological congruence refers to whether the leading and following country have coinciding factors such as size of market and factors of production, to name a couple. Social capability refers to what is required for a country to develop, such as better education and investment climate. Abramovitz focused on how Western Europe caught up with the US after World War II. There have been similar contributions explaining how countries in Asia have caught up; Johnson (1982) explains Japan's experience while Kim (1980) presents a detailed account of Korea's transition from being one of the poorest countries to an advanced economy in a matter of few decades.

We know that people do not necessarily behave in a utility maximising manner. When it comes to decisions regarding technology, an entrepreneur or firm simply cannot and does not account for every possible outcome and alternative. Profit seeking entrepreneurs will try to do so using not only current information but also past information. They form certain rules of thumb to deal with uncertainty. But we cannot say that their behaviour alone explains economic growth. An interesting approach is presented in evolutionary economics. Here growth is explained by selection and novelty. Competition in a market leads to selection which limits the variety available. The market rewards firms that adapt to changing consumer tastes and production environment. When novelty is generated, we call it innovation. There is constant interaction in this approach. Economic agents' exhibit satisficing behaviour and aim at a successful innovation.

The entrepreneur here can be thought of as satisficing in the Simon (1955) sense. Instead of looking for an 'optimal' solution which may require time and resources, the entrepreneur opts for a satisfactory solution; a "good enough" option. Given the strong demands that rationality requires, Simon's bounded rationality is closer to actual human behaviour.

> "According to Simon's satisficing model, we need not assign a utility to each possible outcome of an action. Instead, we merely evaluate outcomes as satisfactory or unsatisfactory, using a simple two-valued function. To eliminate probabilities from the equation, Simon's rule requires that we seek an alternative action *all* of whose possible outcomes we judge to be satisfactory. In this way, no matter what eventuates from such an alternative, we will be satisfied. Then, to avoid messy calculations, Simon's rule dictates that rational agents choose the first

> alternative whose outcomes are all satisfactory. . . . It is a stopping rule, in that we can use it to determine when to stop searching for alternatives. It uses the idea of choosing an alternative that is 'good enough'. . . . [m]ost importantly, it recognises that rationality permits us to save resources when maximisation would be too costly."(p.313) [Byron (2005)].

Getting back to innovation. It is important to look at how innovation is defined or characterised and linked with uncertainty. In literature, innovation could be radical, something entirely new, as was the steam engine once. It could also be incremental in nature which might lead to economic rewards. But at the time when firms take decisions regarding innovation, they do not know with certainty about the potential payoffs or costs of it. Moreover, knowledge in an economy is not constrained to certain sectors. An invention in one field can have consequences for a seemingly unrelated field. In this way, the outcome of (incremental) innovation and knowledge spillovers, uncertainty is brought in.

We now look at different sets of heuristics that discuss innovation. Dosi (1982) explains that an innovation sets the course for solutions to technical and economic problems for a limited time. The success of the innovation depends on the incremental innovations made which tailor the basic innovation to a particular industry or region's 'circumstances'. These refer to the labour's skill level, social and cultural features where the innovation is being adopted. Another set focuses on clustered innovations. This is based on Schumpeter (1939). He noted that innovations bunch together mostly and did not necessarily follow a pattern. This was observed when firms adopt a successful innovation in quick succession. Firms can well innovate to adopt the innovation which we call incremental innovations.

This offers a different way to approach the question of growth than the neoclassical approach. According to this, innovation affects the pattern of growth. We are not confined by elegant yet unrealistic expectation of smooth and predictable growth patterns in this case. The changing rates of technological change on accounts of innovation gives us an explanation as to why an economy does not operate on a stable arm towards a steady state. Moreover, there is room for institutions in this approach. Institutions can encourage innovation and technological change. Equally, if not rightly structured, they can create an inhibitive environment. [Verspagen (2005)].

Then it becomes important to understand how firms approach innovation. How do firms define innovation? Do they make a conscious attempt to be innovative?

With regards to how firms approach the decision to be innovative, there is literature that documents firm behaviour in developed countries. One way that innovation is interpreted is that it results when firms are looking for solutions to a problem they face. This can be called a technological solution. A firm looks for a solution subject to, mostly, financial constraints. This search can lead to something completely new and novel on one hand. Alternatively, it can result in a marginal improvement, what we understand as incremental innovation. The search is affected by previous stock of information and the skill level of the 'inventor'. The latter is difficult to quantify. Innovative activities are selective and can potentially move in a particular direction.

In any given sector, firms produce differentiated products. Production too, then, is differentiated. So, the way a firm innovates depends largely on in-house efforts and technology. Does this imply there is no significance or relevance of cooperating with other firms and public information? Absolutely not. Firms, then, will look for technological and other types of improvement in areas that concern them, e.g., demand for product, existing technical knowledge, how production is arranged. One way of thinking about firm behaviour regarding innovation is that they will look at how such decisions have done in the past. To use Dosi's words, ". . . the future is narrowly constrained by . . . the past."(p.1130) [Dosi (1988)].

Innovative activities are firm specific. If a firm experiences declining demand for its product(s) or service(s), it will think of offering an innovative product; a new product. If a firm is experiencing a fall in profits and loss in market share relative to its competitors who sell similar product or service, it will rethink the process of production. This can result in cost saving solutions to the problem of decline in profit.

The information about what other firms are doing can and does spread rapidly but this does not necessarily have repercussions for other firms being able to imitate or innovate as is shown by Mansfield (1985). Cooper (1983) shows that a successful innovation is closely related to its existing marketing and technological skills. We know that a firm looks for innovation locally. To put it another way, firms' tendency to be innovative can be explained by what it produces and knows. This sheds light on how firms behave rather than assuming that firms have perfect knowledge, operate with an infinite horizon and are infinitesimally insignificant in affecting decisions about a homogeneous product.

Exogenous variables such as public information made available by universities and governments also affect firms' decision to innovate.

There is no substitute for in-house research activities. For a firm to be innovative it has to have a well-integrated R&D department which keeps reviewing the firm's production to distribution channels in the best case; and has the ability to adapt licensed knowledge to the firm's needs, at the least.

It would be an incomplete approach if we do not consider the role of uncertainty in innovative activities. To use Dosi's [Dosi (1988)] words, "In general, the uncertainty associated with innovative activities is much stronger than that with which familiar economic model deals." (p. 1134).

Strong uncertainty is when one simply does not know the consequence of a decision or action. This is different from weak uncertainty in case of imperfect information. In this case we do not know which, of a list of known consequences, would result. In strong uncertainty, even the list of possible consequences to a decision are unknown.

Because research in innovative activities is characterised by uncertainty firms adopt rules of thumb. Parker (1986) finds econometric evidence studying managerial decisions where ". . . the pattern of R&D investment within a firm is essentially a random walk with a relatively low error variance."(p. 10). In another study, Parker, *et al.* (1984) studied 433 large American firms whose R&D expenditure accounts for 48 percent of R&D conducted in the US industry in 1963. These firms belong to the following sectors: chemical and petroleum, electrical and communications equipment, metal products and machinery and transport equipment. They find that a firm's past growth rate is insignificant in determining a firm's R&D intensity. So it is unlikely that a firm would sit on its laurels once it has made an innovation. At the least, we do not expect it to shut down its research and development department. Conversely, if a firm is experiencing sluggish growth it would try to be innovative to increase market share and profitability, *ceterus paribus.* Appropriability conditions of the new information are important in predicting variance in R&D intensity. Conversely, if the appropriability conditions are poor, lesser resources will be directed to research and innovation, as is the case for agricultural sector. Most of the research in this sector is funded by the government rather than private entities.

2. ANALYSING FIRM LEVEL INNOVATION IN PAKISTAN

In this section we analyse the research effort as reported by firms in the Enterprise Survey. To do this we estimate the knowledge function and link it to the innovation function. The knowledge function explains the research effort or research intensity. Depending on data availability, authors have proxied research effort in a variety of way, e.g., by the number of engineers employed in a firm or number of patents filed. Considering the data availability we use as a proxy the total research expenditure per worker. This is the sum of internal and external R&D conducted by the firm, cost of training employees, and cost of acquiring equipment per worker for each firm. This reflects a firm's research effort geared towards innovation. This is reflected in the second step, where we estimate the innovation function. The innovation function estimates how innovation outcomes, product and process innovation, can be achieved. We next estimate the productivity equation whereby we link each firm's total factor productivity to product and/or process innovation. This is how we answer the question about whether innovative firms are productive or not. In line with Crepon, *et al.* (1998) we estimate a sequential model starting from research efforts being translated into innovation outcomes and that, in turn, being linked to productivity. This is the first time, to the best of the author's knowledge that this exercise is done for Pakistan.

We begin by looking at literature that has studied firm level innovation in different countries. Next we detail the data source for estimating the functions for Pakistan. Considering, we study innovation outcomes, we next define them. Then we estimate the knowledge function where we detail the determinants and results. This is followed by the innovation function. Here we explain the methodology and results. The next step entails presenting the productivity equation.

2.1. Earlier Works

To study firm level innovation, the canonical CDM model developed by Crepon, *et al.* (1998) and Griffith, *et al.* (2006) are followed. There are three stages in the model. The first step is to estimate the knowledge function. Second step is to estimate the innovation function. The final step is to test whether innovation affects productivity. The model is solved sequentially. The major assumptions are that first, firms determine the intensity of choice of input; second, choices about different types of innovation are made at the same time; and third that there are no feedback effects. Crepon, *et al.* (1998) have developed a structural model which explains productivity on accounts of innovation output. Innovation output in turn is explained by research investment. The model aims to present the firm's decision regarding research, innovation and the implementation on production activities.

The authors have applied this model to French manufacturing sector. The model includes demand pull and technology push factors. The authors have econometric solutions to correct for selectivity and simultaneity biases. In essence their paper studies the links between innovation, research and productivity at the firm level.

The three important features of the model are now presented. Firstly, the model explicitly states that innovation output affects (increases) productivity. Secondly, over and above the usual data about firms, this paper takes into account patent applications and share of sales on accounts of innovation. This latter approach has been used by many authors in later studies. Proxies for demand pull and technology push indicators are also obtained and incorporated in this model. These are included in the extended version of the model. Moreover, the authors have constructed an average market share variable and a diversification index. Thirdly, the model uses econometric techniques that address problems of selectivity and bias. These, and other, problems are addressed by the authors in the following way:

> "We take care of selection and of the specific nature of variables by using a generalised tobit specification for R&D investment, a heterogeneous count data specification for patents, and an ordered probit specification for the interval data on innovative sales. Our model thus amounts to a system of non-linear equations with limited dependent and count data variables, and we deal with simultaneity in this system by using a two-stage estimation procedure. In the first stage we estimate the reduced form equations parameters by appropriate maximisation methods (M-estimation), and we rely in the second stage on the method of asymptotic least squares (ALS-estimation) to retrieve consistent estimates of the structural parameters. This procedure requires relatively few assumptions on the distributions of the disturbances and is flexible enough with modest computational cost."

It must be noted that this study conducts cross-sectional research, as is true about all the work done in this area. One effect is that the correlation between stock and flow measures of research is high. It is important to review this paper as most of the empirical work done in the last fifteen years cites this model. The authors present equations for research and innovation which are fundamental to our understanding.

Griffith, *et al.* (2006) look at how innovation impacted productivity in Spain, Germany, France and the UK for the period 1998-2000. The authors use firm level data from CIS3, Community Innovation Surveys. CIS is conducted in EU member countries by national agencies coordinated by Eurostat. CIS3 was conducted in 2001 and has data for the three year period prior. This not only provides data on innovation inputs but also on outputs. The authors use the CDM model as the basic framework for analysis. Across the four countries, it is found that the forces driving innovation and productivity are similar; what is different is productivity associated with varying levels of innovative activities. The authors focus on the manufacturing sectors of these countries. Here, they find, the relation between R&D and innovation outcomes and the latter's with productivity can best be seen and analysed.

Compared to the US, up until 2005 at least, these four European countries lagged behind in labour and multi-factor productivity growth rates. Moreover, the US also leads these countries in R&D intensity (defined as gross domestic expenditure on research and development as a percentage of GDP). These, the authors believe, are important issues in

European policy circles. The different aspect of this paper is that the authors apply the CDM model to all firms, not just the innovating firms. They estimate the firm's observable R&D as the investment function in line with CDM. The predicted values are applied to all firms to proxy innovation in the knowledge function. Why do this at all? This is done to circumvent the problem that while some firms might well be undertaking research expenditure, they are not reporting it. As an example, "production workers may well spend a small part of their day considering how the process they are working on could be carried out more efficiently. However, below a certain threshold, a firm will not report this effort as R&D. The output of this innovation effort produces knowledge." (p. 485) *ibid*. Spain, France and Germany ask all firms whether they have engaged in any innovation activities when asking for firm characteristics. Firms that report innovation activities are requested to answer a larger number of questions, hence the authors can differentiate between firms that report innovation and firms that report zero innovation. All of this is done in line with the legalities in mind whereby identifying firms by name etc. is not allowed.

The authors treat innovation as a public good within the firm. For production, they too use a Cobb-Douglas production function with capital, labour and knowledge input. Griffith *et al* are not the only ones who use a modified version of CDM model. There is a host of authors who have developed the CDM model in different directions, examples include Janz, *et al.* (2003) in the case of Swedish and German manufacturing firms and Klomp, *et al.* (2001) in the case of Dutch firms.

The authors make use of various indicators to better analyse the situation. They look at the importance of international market, whether the firm is a recipient of public funding, intellectual property rights in a country, dummy variables are used for size and industry. With regards to R&D intensity, variables such as health and safety, environmental factors, cooperative activities are looked at over and above the traditional log of R&D expenditure per employee. Another important variable is the source of information for innovation at the local, national and EU level provided to a firm.

The two types of innovations considered are product and process innovation. They are measured by dummy variables. If a firm has introduced at least one product or process innovation in the period 1998-2000, the dummy variable(s) will take the value 1, otherwise it will be 0. The authors expect more successful product innovation if customer feedback is taken into account and more successful process innovation if information from suppliers is taken into account. Complementarities between process innovation and investment per employee is also allowed for.

Productivity is measured by taking the log of sales per employee. The model is estimated separately for each country. Moreover, the data being considered is cross-sectional in nature.

This model is employed to study firm level innovation in Pakistan. Although similar studies have been done for developed economies in Europe, e.g., Griffith, *et al.* *ibid* and Hall (2009), it is only possible to conduct similar exercises for developing countries now. The recent availability of data by World Bank has made studying firm level innovation in developing countries possible.

Cirera (2015) studies firm level innovation for Kenya. The author's model of choice is more in line, although with some differences, with Griffith, *et al.* (2006). The two main assumptions are that first firms determine the input intensity and second, choices about innovation outcomes are made simultaneously. The outcomes refer to product, process and organisational innovation. The author estimates innovation components sequentially. First the determinants of innovation inputs and their intensity is considered. This is proxied by R&D per worker, equipment per worker, and total R&D. Next are the determinants of product, process and organisational innovation. The role of inputs in the probability of introduction of a particular type of innovation is also considered. Lastly, innovation's impact on productivity and employment is studied as well.

2.2. Data Source

The World Bank is conducting Enterprise Survey (2014) in developing countries. It has two different sets of questionnaires; one for Manufacturing sector while the other for firms in the Services sector. Upon completion of the Survey, the firms are asked to volunteer to respond to the Innovation module. The innovation module in Enterprise Survey (ES) measures four types of innovation: product, process, organisational and marketing. For each of these, ES gives information about the number of innovations introduced, the impacts on the firm, how automated are the production processes, relevance of innovation in the market (local, national or international), ways of acquiring information, degree of collaboration in the acquisition and development of innovation and contribution of employees in the innovation.

For Pakistan 1247 firms have filled out the Enterprise Survey, out of which 696 firms have responded to the Innovation module. This analysis uses the Innovation module as the source of data. The data is in raw form. I have cleaned it in order to run estimations. Almost 85 percent of the respondents, 592 firms, are from the manufacturing sector. 10 firms belong to the construction sector. 33 firms represent the Hotels and Restaurants sector, 11 represent the transport sector, 8 represent the real estate sector and 42 firms represent the wholesale trade and retail sector. Table 1 shows the distribution of the firms according to sector and size. The size is measured in terms of persons employed. A firm is considered small if it employs between five to nineteen persons; medium if it employs between twenty and ninety nine persons; and large if it employs more than 99 persons.

Table 1

Distribution of Firms by Sector and Size in Innovation Module (2013)

Sector	Large	Medium	Small	Micro	Total
Manufacturing	122	196	243	31	592
Construction	1	5	2	2	10
Hotels and Restaurants	4	7	15	7	33
Transport	2	4	5	0	11
Real Estate	0	6	1	1	8
Wholesale Trade and Retail	9	8	21	4	42
Total Number of Firms	138	226	287	45	**696**

Author's own elaboration from Innovation Module in Enterprise Survey.

According to the framework used for studying firm level innovation: firms invest in knowledge inputs which will, according to the efficiency of the innovation function, be converted into innovation outcomes. These innovation outcomes will affect productivity in the shape of improved products and services and efficiency. This is dependent on how effective firms are in transforming the innovation outcomes into productivity outcomes.

2.3. Types of Innovation

We now take a look at the each of the four types of innovation which are drawn primarily from the Oslo Manual. If there is a new product developed by the firm or it is new to the market or there is some significant improvement made to the current product, this is *product innovation*. If the firm develops a newer method for producing and supplying its products and a new way of delivery and accounting, this is said to be *process innovation*. It entails not only a new way of producing, but also new way of delivering the product (and or service) and maintenance of business. Equally important is knowing what not process innovation is. "The following are not considered to be process innovations: Minor changes or improvements; an increase in production or service capabilities through the addition of manufacturing or logistical systems which are very similar to those already in use; ceasing to use a process; simple capital replacement or extension; changes resulting purely from changes in factor prices; customisation; regular seasonal and other cyclical changes; and trading of new or significantly improved products." (p.7) *ibid.*

Organisational innovation is described as follows,

> "Organisational innovation means the implementation of a new organisational method in business practices, workplace organisation, or external relations. This type of innovation is grouped into: structural innovations which are meant to impact responsibilities, accountability, command lines, and information flows, as well as the number of hierarchical levels; the divisional structure of functions (research and development, production, human resources, financing, etc.) or the separation between line and support functions; and procedural innovations, which consist of changes to routines, processes and operations of a company. Thus, these innovations change or implement new procedures and processes within the company, such as simultaneous engineering or zero buffer rules." (p.7) *ibid.*

Marketing innovation is such that it improves on the current level of marketing to improve the level of competitiveness of the firm. Examples include the inclusion of advances in technology and marketing methods.

For this analysis, we focus on product and process innovation. I will begin by explaining the first step, the knowledge function.

2.4. Knowledge Function

The first thing is the specification of the variables that will be used to measure knowledge capital investment intensity. Literature suggest using R&D expenditure per worker and Total research expenditure per worker. Both of these are count data.

R&D per worker is the sum of intramural and extramural research expenditure incurred by the firm divided by the number of full time workers. A second measure of research intensity is Total research expenditure per worker. This is the sum of intramural and extramural research, cost of training employees and cost of acquiring new equipment per worker.

These were calculated for each of the 696 Pakistani firms that have filled out the Innovation module of the Enterprise Survey. Some firms report zero research expenditure (hence zero research intensity), they are also included in the sample. Zero research intensity is considered as an important outcome of investment in knowledge capital. Although firms might report zero research intensity, this does not necessarily imply that firms are not being innovative. This is an expected consequence of survey data. There are several reasons why the reported research intensity is zero. One apparent reason is that firms do not want to provide information to surveyors. Considering this is the first time such a survey has been conducted in Pakistan, it is understandable that firms are hesitant to provide what they might consider sensitive information. Moreover, in the future, as this survey is repeated, its credibility will improve. This could potentially motivate firms to provide more information. Another reason is that firms conduct incremental innovation due to which they report zero research intensity. In this analysis, we are interested in any type of innovation conducted by firms so we allow for incremental innovation as well. When analysing firm level innovation in Kenya, the author reports the same problem: firms have not declared how much they spend on R&D. The consequence of this is that there are many zeros in the data set.

There are many instances when authors have attempted to analyse a dependent variable which has a sizable proportion of zeros and have had to censor the data, e.g., Tobin (1958), Fair (1978) and Jarque (1987). They have censored the data to reach more meaningful conclusions. Moreover, according to Greene (2003), "The tobit model remains the standard approach to modeling a dependent variable that displays a large cluster of limit values, usually zeros," (p. 778). Data is usually censored to reach better conclusions when using surveys that have count data, as is the case here. This has been documented by Greene (2003) as well. Data is said to be count data when it takes the value of nonnegative integers not representing a ranking.

For this analysis, we used both measures as the dependent variable. Results presented here are for total research expenditure as the dependent variable. The reason being that it has better data available in the Pakistani data set. To estimate the knowledge function, which explains the research effort, we conducted a doubly censored Tobit regression.

2.4.1. *Determinants of Knowledge Function*

In this section I will explain the determinants of the knowledge function. Firm characteristics are one set of determinants. Demand factors are another set of determinants. Investment climate measures are the third set of determinants. All of these are included in the estimation.

Firm characteristics considered, subject to data availability, in case of Pakistani firms are: age, whether the firm has foreign ownership and size of the firm. If a firm's ownership is at least 20 percent foreign owned, then this variable takes the value 1; otherwise it is zero. I have considered medium and large firms. Medium firms are those that have between 20 and 99 workers. Large firms are those that have more than 99 workers. Both these variables are binary variables.

Demand factors considered, subject to data availability, in case of Pakistani firms are: firm's market share at the start of sample period and whether the firm is an exporting firm. The former is estimated by dividing a firm's sales at the beginning of the period with total sales of the sample. The latter is a binary variable, taking the value 1 if the firm is an exporting firm and 0 if it is not.

Investment climate measures, subject to data availability, considered in case of Pakistani firms are: access to finance obstacles, telecommunication obstacles, tax rates obstacles, political instability obstacles and corruption. These five are measured as indices. For each of these, the firms are asked to rate, on a scale of zero to four, how big of an obstacle they perceive it to be. Each index is in ascending order of severity.

2.4.2. *Main Findings from Estimations*

To estimate the knowledge function the following steps, in line with Greene (2003), were taken. We conducted a Tobit regression, with eleven explanatory variables and *R&D per worker* and *Total research expenditure per worker* as the dependent variable, in turn. The statistically insignificant explanatory variables were dropped and Tobit regression was conducted again with the limited set of explanatory variables. An uncensored Tobit regression was conducted first. Next we conducted a doubly censored Tobit regression with a lower limit of zero and an upper limit of 100, 000 (of local currency). As the estimated coefficients are in the Pakistani currency, called Pak Rupee (PKR), in the tables the results are normalised by declaring one unit as PKR 100, 000. In the interpretation below we present the actual coefficient.

Here we will discuss the results of the doubly censored Tobit regression with Total research expenditure as the dependent variable. The upper limit was chosen as PKR. 100, 000 because only less than ten firms in the data set spend more than this threshold on Total research expenditure. By censoring the data at the upper limit, any observation that is higher than the threshold takes the value of the threshold thereby preventing bias in estimates. All estimations have been conducted in STATA 14. The results are presented in Table 2.

We now turn to interpreting the results. As mentioned above, the dependent variable is Total research expenditure per worker. Column 1 lists the coefficients of each explanatory variable. Column (2) is the associated t statistic of the coefficient. Column 3 shows the calculated marginal effect with the corresponding z statistic in column 4. The marginal effect calculates the change in the latent variable, Total research expenditure* (y*), with respect to the explanatory variable, while holding all other explanatory variables at their mean values. The standard errors are presented in () under each estimate.

Looking at Column 1, which gives the estimated coefficient of determinants of knowledge capital investment intensity proxied by Total research expenditure per worker we observe the following. If a Pakistani firm is an exporter, as against not an exporter, it will increase its R&D intensity by Rs 35,960 (0.359 in Table 1, column 1) holding all other variables constant. Market share three years ago is an important predictor of investment in Total research. Holding all other variables constant, a one percent increase in market share increases Total research expenditure per worker by Rs 12,898.59. Holding all other variables constant, a one unit increase in perceived corruption decreases Total research expenditure per worker by Rs 8924.27. This tells us that corruption is an important inhibitor of investment in Total research expenditure per worker. Holding all other variables constant, a one year increase in age of firm increases the Total research expenditure per worker by Rs 1137.69.

Looking at Column 3, which gives the marginal effect of each variable. It is calculated using the Delta method. Holding all other variables at their mean, if a firm is an exporter, as against not an exporter, it will spend Rs 2330.69 (0.023 in Table 1, column 3) on the margin on Total research expenditure per worker. Similarly, a firm trying to increase its market share will spend Rs 835.98 on Total research expenditure per worker, holding all other variables at their mean values. An increase in perceived corruption will decrease while an increase in age will increase their marginal effects on Total research expenditure by Rs 578.39 and Rs 73.74 respectively.

σ is an ancillary statistic with the value 94275.92. It can be used to compare with the standard deviation of the dependent variable, 191239.9. Our analysis brings a substantial reduction in the standard deviation of the predicted dependent variable.

The scale factor, with explanatory variables at the sample mean and the parameters set equal to the maximum likelihood estimates, is 0.0648.

After the double censoring, the range of variation has decreased substantially as can be seen by comparing Column 3 of Table 2 and Column 3 of Table 3. Table 2 presents results of a Tobit regression without an upper limit specified. The decrease in range of variation can be considered as evidence for favoring the doubly censored Tobit over the uncensored Tobit.

Table 2

Knowledge Intensity Function

Explanatory Variables	Coefficient (1)	t (2)	Marginal Effect (3)	z (4)
Constant	–1.820***	–6.01	–	–
	(0.302)		–	
Exporting Firm	0.359**	2.30	0.023	2.38
	(0.156)		(0.009)	
Market Share (t-3)	0.129***	2.70	0.008	2.62
	(0.048)		(0.003)	
Tax Rates Obstacle	0.028	0.55	0.0018	0.55
	(0.523)		(0.003)	
Corruption	–0.089*	–1.62	–0.005	–1.66
	(0.0549)		(0.003)	
Age	0.011***	2.64	0.0007	2.74
	(0.0043)		(0.00026)	
σ	0.943			
	(0.125)			
Log Likelihood	–192.750			
Likelihood Ratio $\chi^2(5)$	(35.80)***			

–Standard errors in ( ) below estimate.
***p<0.01, **p<0.05, *p<0.1

Table 3

Tobit Regression Left Censored at 0 only

Explanatory variables	Coefficient (1)	t (2)	Marginal Effect (3)	z (4)
Constant	–14.478***	–6.98	–	–
	(2.074)		–	
Exporting Firm	3.327**	2.69	0.209	2.70
	(1.237)		(0.077)	
Market Share ($t-3$)	0.515***	3.18	0.032	2.96
	(0.162)		(0.011)	
Tax Rates Obstacle	0.634	1.49	0.039	1.49
	(0.425)		(0.027)	
Corruption	–0.874**	–1.97	–0.055	–1.99
	(0.444)		(0.028)	
Age	0.792**	2.30	0.005	2.32
	(0.034)		(0.002)	
σ	7.574			
	(0.769)			
Log Likelihood	–304.292			
Likelihood Ratio $\chi^2(5)$	(30.58)***			

–Standard errors in ( ) below estimate.
***p<0.01, **p<0.05, *p<0.1

2.5. Innovation Function

In this section I will explain the innovation function and present the estimates. Innovation function relates innovation outcomes to a set of determinants. Innovation outcomes are product innovation and process innovation. Both are binary variables. If a firm has done product innovation, the variable takes the value 1. If the response is No or Don't Know, the value zero is assigned. The same applies to process innovation. In the innovation function, the estimates of knowledge intensity, from the prior section, are brought in. The estimates of innovation function in turn are present as determinants in the productivity equation. In this way the model is sequential. The marginal effects of innovation function estimates are the probabilities of introducing different types of innovation with respect to a given determinant.

Table 4 presents the bivariate probit estimates, where it is assumed that product and process innovation decisions are made simultaneously. Here the predicted values of Total research expenditure from are used as an explanatory variable. The innovation function explains how knowledge inputs result in innovation outcomes.

2.5.1. *Bivariate Probit Regressions*

In this section we will present the results, in Table 4, when we assume that a firm takes the decision to undertake product and process innovation at the same time.

The dependent variables are product and process innovation. The explanatory variables used are: an index measuring how severe lack of an adequately trained labour force is, size of the firm and observed values of R&D per worker and predicted value of Total research expenditure per worker. The constant represents the probability of an innovation being introduced if all the explanatory variables in the model are set to zero.

Here we bring in the predicted values of Total research expenditure per worker obtained from conducting a doubly censored Tobit regression. (The results of which were presented in Table 2) All estimations have been done using Stata 14. Columns 1 and 2 show the estimated probability of an innovation being introduced with respect to each explanatory variable. The standard errors of each variable is in () below the coefficient.

We begin by looking at column 1. It shows the probabilities of conducting product innovation, with respect to different determinants, given the decision to undertake process innovation. We find that, lack of an adequately trained work force decreases the probability of product innovation being introduced when knowledge capital investment is proxied by the estimated Total research expenditure per worker. Size affects the probability to innovate positively only in case of medium sized firms. The constant terms shows the probability of product innovation taking place if all the explanatory variables are set to zero. This tells us that in the absence of the explanatory variables we have used in the model, the probability of a product innovation is less than zero. The coefficient of the predicted value of Total research expenditure per worker shows that it increases the probability of product innovation being introduced.

We now look at column 2. It shows the probabilities of process innovation with respect to different determinants given the decision to undertake product innovation. Lack of educated labour force reduces the probability of process innovation. Size does not affect the probability of process innovation. The estimate knowledge capital investment, increases the probability of process innovation being conducted.

After conducting the biprobit regression we can calculate marginal effects as well. The marginal effect for the marginal probability of product innovation is 0.2218, against the true proportion of product innovation in the sample, 0.2270. The marginal effect for the marginal probability of process innovation is 0.2233, against the true proportion of process innovation in the sample, 0.2256. Further we can say that for a firm that conducts product innovation but not process innovation, lack of an adequately trained labour force makes it 1.8 percent less likely to conduct innovation. For a firm that does both product and process innovation, the lack of adequately trained labour forces makes it less likely (3.1 percent) to innovate. If this firm is medium sized, it is more likely (3.97 percent), to innovate. And lastly, if such a firm spends on Total research expenditure, it is more likely, (0.00015 percent), to innovate.

While in Pakistan, a developing country, a medium sized firm is more like to innovate, in developed countries like UK, France and Spain, large firms are more likely to innovate as shown by Griffith, *et al.* (2006).

While studying firm level innovation, ideally, we should be able to take into account a firm's diversification into account as well. Scherer (1990) points to the importance of a diversified firm when undertaking innovation. On accounts of data quality, we could not determine whether the Pakistani firms analysed in this chapter had diversified or not. A similar constraint is observed in the Kenyan study as well. It would be interesting to see how the Survey deals with moving forward.

Table 4

Innovation Function

Explanatory Variables	Product (1)	Process (2)
Skilled Labour Obstacle	–0.1712***	–0.1212***
	(0.0428)	(0.0423)
Medium	0.2282*	0.1465
	(0.1245)	(0.1228)
Large	0.0163	0.0422
	(0.1506)	(0.1480)
$TotalResearch\widehat{Exp}enditureperworker$	8.17e-06***	5.98e-06***
	(1.30e-06)	(1.36e-06)
Constant	0.0015	–0.1835
	(0.2111)	(0.2200)
Log-likelihood (equations)	–340.484	–355.188
Log-likelihood (model)	–636.959	
ρ	0.6845	
	(0.0462)	
$arth\rho$	0.8376***	
	(0.0869)	
Observations	696	

Standard errors in ( ).
***$p<0.01$, **$p<0.05$, *$p<0.1$.

Even so, firm level innovation studies focusing on developed economies too have not really taken diversification of a firm into account. Hopefully, with future renditions of this Survey in developing countries, the samples include the firms surveyed in the first wave. This would give us insights not just into decision making patterns of the said firms but also help identify if they have diversified. Diversification can refer to producing different goods and services, catering to different markets domestically, regionally and/or internationally.

Moreover, it is possible that Pakistani firms are less innovative because they might be caught in technological lock-ins. Lock-in coupled with self-reinforcement for a rational agent can prevent firms from becoming innovative. It could also delay the firm's decision to be innovative. To get out of the lock in, there must be system wide coordination with the following aims. Government must use its power to prevent a monopolistic adoption of a particular technology as a starting point.

2.5.2. *Innovation and Competition*

In their paper, Aghion, *et al.* (2005) investigate the relationship between product market competition and innovation. Their data supports the existence of a relationship between the two as supported as an inverted U. Using patents and the Lerner Index, this relationship is plotted. Using data on 311 firms for the time period 1973-1994 the authors find evidence in support of their hypothesis for UK. This tradition is rooted in the work of Scherer (1967). Scherer conducted a cross-sectional analysis for Fortune 500 companies and found evidence of an inverted U when studying this relationship.

In Aghion, *et al.'s* model, there are two types of firms'—leaders and followers. Any one type can innovate. It is an endogenous model; so incentive to innovate is linked to incumbents' profit pre and post innovation. Let us now comment on the U shape. As competition increases, innovation increases as incremental profits increase. This is the case in sectors which are technologically similar. In cases where innovating firms which are followers, competition affects profits generated post-innovation. The interaction of these two effects gives the inverted U shape. If competition is very low initially, a small increase in it results in a high average innovation rate. The converse holds as well.

Other authors that have looked at the relationship between competition and innovation (or productivity growth) are Salop (1977), Dixit and Stiglitz (1977), Romer (1990) and Aghion and Howitt (1992).

As there is a lot of literature in support of competition influencing the decision to innovate, we conducted an exercise for Pakistan. We used data from the Enterprise Survey for the 696 firms that responded to the Innovation module. Looking at the section entitled Degree of Competition it can be said that the survey asks firms about competition faced from the informal sector. Firms that are competing with firms in the informal sector tend to rate the competition obstacle[1] higher. The other survey questions about competition show significant correlation so we can only use the question that asks about competitors practices' as an obstacle as an additional explanatory variable in the Innovation function. Doing so does not show any statistically significant relationship with product or process innovation. The results are reported in the Appendix (see Table 6). Using this Innovation function and sequentially estimating the Productivity equation shows no change in the regression as well (see Table 7 in the Appendix).

So while the author is cognizant of the importance of competition for innovation decisions, there is not any evidence to substantiate this for Pakistan. The ES and IM do not collect data on competition within the formal sector. To deal with that we could construct the Herfindahl Index but as market share is used as an explanatory variable in the estimation of the Knowledge Function, such a step cannot be undertaken.

2.5.3. *Innovation and State*

The importance of the role of State cannot be overstated enough. Looking at the history of now-developed countries like the US, one can see the importance of a proactive State. As documented and shown by Mazzucato (2015) the State is not just a facilitator to the private sector. For most successful innovations, the State has played a major role. This has been done by funding research in universities, supporting startups (SBIR), creating markets (by commercialising innovations made in seemingly unrelated sectors). The heart of innovation in the US beats because of the role of the State. While Neo-Classical Economics depicts the State to be inefficient, almost inconsequential history begs to differ. For a country to become more innovative, her State has to be entrepreneurial, innovative and risk taking.

If a State thinks big, creates market, there is reasonable optimism for Pakistan as well. This is not a polite version of saying that the State should pick winners. Innovation

[1]Using the response options on the card; "To what degree are Practices of Competitors in the Informal Sector an obstacle to the current operations of this establishment?"

by default is uncertain. The State and public policy is the only way to reduce the uncertainty around it and allowing it to thrive. This implies that the State will also support ventures and ideas that will fail. But if the State in the US had not created the markets, property rights and environment to innovate, amongst other thing, the world would not have had iPhones. To incorporate the role of State in innovation decisions made by Pakistani firms, it is plausible to use data collected by IM. For each type of innovation the Module asks whether it was developed with support of government, private or foreign consultancies, universities etc. Out of the 696 observations in the IM, for product innovation the number of firms that responded "Yes" to government support is 1 (one), "No" is 11 (eleven) and 684 firms did not respond to the question. Out of the 696 observations in the IM, for process innovation the number of firms that responded "Yes" to government support is 0 (zero), "No" is 10 (ten) and 683 firms did not respond to the question.

So while the author is aware of the importance of the role of State as an enabler of innovation, the paucity of data prevents it from being reasonably incorporated in the model.

But Pakistan has been increasingly funding research that links academia to industry e.g., University-Industry Technology Support for Researchers and Technology Development Fund to name a couple. This is a step in the right direction. One of most obvious implications from such abysmal statistics is that increased effective cooperation between public and private sector in Pakistan is the low hanging fruit that the GOP can turn to its favour.

2.6. Productivity Equation

Here we will estimate the productivity equation for Pakistan. We apply OLS regression on our dependent variable—Total Factor Productivity (Revenue)—estimated for each firm in the sample that has non-negative TFPR. These estimates [Unit (2017)] for TFPR have been made publicly available recently by the Enterprise Survey wing at the World Bank. TFPR is estimated based on the assumption of perfect competition and constant elasticity of each input with respect to output. For our analysis we use the TFPR estimates calculated using the YKLM formulation (Firm level output (Y), Capital (K), Labour (L), and Materials (M)). TFPR is estimated separately for each industry for economies that fall in the same income category as specified by the World Bank. The estimation are done in Pakistan's local currency. TFPR estimates are only available for certain ISIC groups subject to data availability and quality of data. To that end, TFPR is available for ISIC 15 to 36.

To determine whether innovative firms are productive as well, we estimate the productivity equation. We use the predicted values of product and process innovation, estimated from the Innovation function. Data for 157 firms is used. These are firms for which there is non-negative TFPR, available. We correct for each firm's market share with respect to the division it belongs to. We find evidence in support of product innovating firms - in Pakistan product innovating firms are also productive. This is in line with literature that says innovative firms are productive as well. The results are presented below in Table 5.

Table 5

Productivity Equation

Explanatory Variables	Coefficient (1)	t (2)
Constant	2.056***	2.55
	(0.807)	
$Product\hat{Innovation}$	3.794*	1.86
	(2.039)	
$Process\hat{Innovation}$	1.907	0.29
	(6.608)	
$Log\,\frac{K}{L}$	-0.017	-0.39
	(0.044)	
$Log\,L$	-0.045	-0.92
	(0.049)	
Observations	157	
R^2	3.5%	

–Standard errors in ( ) below estimates.
***p<0.01, **p<0.05, *p<0.1.

While studying productivity of firms, it would be beneficial to looks at labour in more detail. There is interesting work by North and others [Berron, *et al.* (2007); North (2014)] in this area which focuses on how workers' ethics affect firms' productivity.

For Pakistan, Haq, *et al.* (2015) look at the ethical values of employees and employers of small firms in Azad Jammu and Kashmir's handicraft sector. Workers' ethics are measured by an index incorporating responsibility, justice, generosity, patience, honesty, and sacrifice. Data from 83 firms was collected via direct interviews. The authors find significant positive relationship between ethics and firm productivity.

For our case, we are constrained by the questionnaire developed by ES. It does not ask questions about worker ethics. As we explore this research agenda in the future, the role of workers' ethics in explaining firm level productivity would surely be explored.

3. CONCLUSION AND DISCUSSION

This paper presents a detailed, data permitting, picture of innovation in Pakistan's private sector. We have looked at product and process information in our data analysis. We estimated the knowledge function which explains research effort. We took this a step further by estimating the innovation function; which links research effort to innovation outcome. This was followed by estimating the productivity equation which linked total factor productivity to innovation outcomes.

We estimated the knowledge function using explanatory variables cited in literature. We proceeded in our analysis with the significant variables. We find that on an average, Pakistani firms are inhibited from investing in developing R&D on accounts of perceived corruption. Instead of relying on the market forces in Pakistan's financial sector, perhaps the way forward is a government-private sector partnership in provision of finance. One option could be the government and private banks contributing equally to set up a fund aimed at improving access to finance. There can be preconditions such as a set proportion of sales be directed to finance R&D. Firms that report and show proof of becoming more innovative can be rewarded by receiving tax credit from the government. As corruption is a significant obstacle, the fund can be supervised and managed by the central bank, State Bank of Pakistan (SBP). SBP can closely monitor that the fund is used by commercial banks to create loans for the private sector and not diverted to buy government backed securities, for example, or convert to foreign currency. To provide information about the existence of such a fund chambers of commerce, mass media and print media can also be used to create awareness about the availability of funds.

Moreover, we find that exporting firms and firms trying to increase their market share, spend positive sums on developing R&D. The government should encourage cooperation between Pakistani firms and universities by encouraging and setting up grants and scholarships that reward innovative ideas. Such tightness between academia and industry are bound to make firms more innovative.

Based on the estimates of the innovation function we can say that the one big takeaway for Pakistan's government here is that the education, technology and industrial policy should be treated as complements. Our estimates show that the lack of a skilled labour force significantly reduces the probability to innovate by Pakistani firms. Not only is creating skilled labour force important, equally important is creating meaningful jobs for them.

If firms are to be more innovative, they have to have skilled labour force. According to UNESCO[2], the gross domestic expenditure on R&D in Pakistan stands at 0.39 percent (2013). The highest this statistic has reached in the past decade was 0.63 percent in 2007. Of the researchers in Pakistan more than 80 percent, on average, are employed in Higher education sector. A step in the right direction would be to facilitate cooperation between the private sector and these researchers for purpose of R&D. Equally important is to calculate and make publicly available data on the breakdown of students enrolled and completing undergraduate studies and beyond in Pakistan. This will help quantify the need for skilled labour in the country.

The current research effort by the Pakistani firms does not contribute significantly in increasing the likelihood of them being more innovative, in line with internationally defined guidelines of innovation. This again hints at the incremental nature of innovation in the country, which is expected in most developing countries. Upon estimating the Productivity equation, we find that Pakistani firms engaged in product innovation tend to be productive as against process innovating firms.

As a development strategy, based on findings from this paper and the history of Pakistan, we see the merit of Pakistan pursuing the innovation route rather than the imitation route that most developing countries have followed. This is motivated not by misplaced optimism about the institutional framework in the country but rather by the current state of affairs. Countries that choose the imitation route end up entering a race to the bottom essentially.

At a time when the country is fighting terrorism domestically, working on improving infrastructure with China's investment, the time is ideal to pursue a fresh course in policy matters. This would be instrumental for domestic producers to regain some of the market share they have lost domestically to the likes of China, India and Turkey. To that end, the policy is closer to import substitution than an export led growth strategy.

[2] *http : //www.uis.unesco.org/DataCentre/P ages/country − prof ile.aspxcodeP AKregioncode* = 40535

The author's concern is that in Pakistan's case, there is no evidence, as yet, of foreign firms contributing significantly to product or process innovation. While the inflow of foreign investment is exciting, it would be wise to be cautiously optimistic. With the expected inflow of investment via CPEC, the Pakistani government can actively try to change this. When estimating the knowledge function, we found that foreign firms do not significantly invest in research and development in Pakistan. For Pakistan to benefit from CPEC in a meaningful way, it would do well to negotiate that if Chinese firms win contracts for building and developing infrastructure, they should devote a proportion of their budget/earnings to research spending within Pakistan. This could be in the shape of grants to Pakistani universities, or funding incubators in the area/region the infrastructure is being developed. Considering that CPEC runs through the entire country, this should also help addressing some of the very valid concerns[3,4] Pakistan's smaller provinces have. Other factors to consider are negotiating training of Pakistan's engineers by China to help sustain this infrastructure. This could plausibly have externalities also. As yet the understanding is that Chinese companies will bring in Chinese engineers.

To make large sized firms more innovative, as is observed in the rest of the world, it is advised that telecommunication obstacle be addressed. Large sized firms tend to rate this obstacle to be a bigger deterrent than medium sized firms. Moreover, corruption needs to be brought down to change the behaviour of large sized firms. Interestingly, firms do not respond significantly to political instability in Pakistan.

APPENDIX

Below are the estimations of the Innovation function and Productivity Equation after controlling for role of competition

Table 6
Innovation Function with Competition

Explanatory Variables	Product (1)	Process (2)
Skilled Labour Obstacle	–0.1569***	–0.1011**
	(0.0461)	(0.0452)
Medium	0.2036	0.1467
	(0.1293)	(0.1269)
Large	–0.1175	–0.0575
	(0.1572)	(0.1534)
$\widehat{TotalResearchExpenditureperworker}$	1.36e-05***	1.01e-05***
	(1.69e-06)	(1.63e-06)
Competition Obstacle	0.0579	0.0479
	(0.0490)	(0.0479)
Constant	0.8842	0.4849
	(0.2672)	(0.2622)
Log-likelihood (Equations)	–315.850	–331.844
Log-likelihood (Model)	–598.700	
ρ	0.6599	
	(0.0501)	
$arth\rho$	0.7926***	
	(0.0888)	
Observations	666	

Standard errors in ( ).
***p<0.01, **p<0.05, *p<0.1.

[3]http://thediplomat.com/2016/02/pakistan-reels-with-internal-unease-regarding-cpec-implementation/
[4]http://thediplomat.com/2016/02/pakistan-what-stands-in-cpecs-way/

Table 7

Productivity Equation with Competition

Explanatory Variables	Coefficient (1)	t (2)
Constant	1.865**	2.30
	(0.810)	
$Product\hat{I}nnovation$	3.608*	1.66
	(2.178)	
$Process\hat{I}nnovation$	4.790	0.70
	(6.879)	
$Log\ \frac{K}{L}$	–0.019	0.654
	(0.044)	
$Log\ L$	–0.0488	0.323
	(0.0490)	
Observations	157	
R^2	4.06%	

–Standard errors in ( ) below estimate.
***p<0.01, **p<0.05, *p<0.1.

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