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Working Paper

Innovation Strategies and Productivity Growth in Developing Countries: Evidence from Pakistan

GLO Discussion Paper, No. 466

Provided in Cooperation with:
Global Labor Organization (GLO)

Innovation Strategies and Productivity Growth in Developing Countries: Evidence from Pakistan

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Abstract

We examine the determinants of product, process, and organizational innovation, and their impact on firm labor productivity using data from a unique innovation survey of firms in Pakistan. We find significant heterogeneity in the impact of different innovations on labor productivity: Organizational innovation has the largest effect followed by process innovation. But unlike much of the literature, we found a negative impact of product innovation suggesting a disruption effect of new products; however, this is mitigated if new products are paired with process or organizational innovations. We find a strong impact of engaging in knowledge creation on product and process innovation. We found that external knowledge networks and innovation cooperation play no significant role in firms' decision to perform R&D and its intensity, though vertical linkages with suppliers (clients) promote product (process) innovations. Foreign competition has a negative effect on product innovation and a positive effect on organizational innovation.

Keywords: Technological Innovation; organizational innovation; labor productivity; developing countries; Labor intensive industries.

JEL Classification: O31, O32, L25, L67, C31, C24, D22.

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Introduction

Productivity growth is critical for the improvements in the standards of living in developing countries. Sustained productivity growth, however, requires constant innovation usually in the form of new products and processes, as well as adoption of new organizational practices that facilitate the effective use of productive resources (Geroski et al., 2009). This link between innovation and growth has been well established in the theoretical literature (see Romer, 1990; Aghion and Howitt, 1992) as well as in a number of cross-country empirical studies (see Hall & Jones, 1999). Recently, firm level innovation studies, especially from the OECD countries, have also established a similar positive link between technological innovation and firm productivity (see Mohnen and Hall, 2013 for an overview; recent studies include Raymond et al., 2015; Loof and Nabavi, 2015; Hashi and Stojcic, 2013; Crespi and Zuniga 2012; Mairesse et al., 2012; Criscuolo, 2009).

While there is strong evidence about the relationship between innovation and higher productivity (as well as the link between higher productivity and growth), there are still some open questions about innovations in developing country firms: first, what characterizes innovation in a developing country's context? Second, what types of innovations are impactful in developing countries (especially since the recent literature has looked at the key role of organizational innovations apart from the technological innovations)? Finally, is it rewarding for firms in low-tech industries of developing countries to engage in knowledge creation by themselves? These are the some of the questions that we attempt to answer in this paper.

These questions are important because while the firm level literature has significantly improved our understanding of how innovation affects firms, much of this literature is focused on developed economies whose production technologies are often different from those in developing countries. But do these same lessons apply to the relationship between innovation and productivity growth in developing countries with low tech-labor intensive industries? Currently our understanding of innovation and its economic impact in developing countries is still limited and the R&D-innovation-productivity relationship is not well established. Most mainstream economists tend to assume that openness and easy access to foreign technology is all that matters in improving firms' productivity in developing countries (Chudnovisky et al., 2006). Imitation and technology acquisition are also theorized to be more important than R&D and innovation for developing countries attempting to catch up (Grossman and Helpman 1991; Bell & Pavitt, 1993; Coe and Helpman 1995; Coe et al. 1997). These ideas are based on the premise that poorer countries need to exhaust their potential for catching up before embarking on their own innovation and R&D activities. However, some of the recent evidence contend that developing countries not only need to access technology but also need to have the ability to absorb this technology in a way conducive to development (Crespi and Zuniga 2012; Mairesse et al., 2012, Atkin et al, 2017).

Also, how do we measure innovation and how can we get data that are comparable across countries especially since patent and R&D statistics tend to be very imperfect proxies in the context of developing countries? As compared to firms in developed countries that have strong property rights, developing country firms operating in an institutional environment with weak property rights will be less likely to patent their innovations. Also, in developing countries, firms generally generate technological advances outside the formal R&D process; for example, many firms acquire embedded technology through the purchase of machinery, hardware, licensing/purchase of patents etc. In such cases, formal R&D fails to capture the true extent of innovative efforts made by firms. One potential way to address this problem is to use the harmonized European Community Innovation Surveys (CIS) adapted to developing countries, but this survey has only been conducted in a few developing countries.

In addition to measurement issues, the question arises about whether innovation outputs, or the types of innovations (and their impact on productivity), differ between developing and developed countries. While much of the literature on innovation has focused on the introduction of new products and manufacturing processes, the recent literature has increasingly stressed the key role of management in the performance of firms (Bloom et al., 2012; Bloom and Van Reenen, 2010; Bloom and Van Reenen, 2007). Bloom et al. (2012) in particular find that firms in developing countries tend to be poorly managed, and within the ownership structure, government and family owned firms are more poorly managed.

Our paper contributes to the discussion on innovation and productivity growth by testing the impact of different types of innovations in a developing country by using unique data from the labor intensive Pakistani textile and apparel manufacturing sector. Our aim is to understand how engaging in R&D helps firms to innovate and improve their productivity in low tech-labor intensive industries in the institutional setup of developing countries. Not only do we use both product and process innovations, we also incorporate organizational innovations which allows us to evaluate the differential impact of various types of innovation.

Our analysis is based on data from our survey of textile and apparel manufacturers in twelve different districts of Pakistan. In many ways, Pakistan is an interesting case study because of its institutions and level of development as well as its reliance on low tech-labor intensive manufacturing technologies. We believe that by focusing on two relatively similar sub-sectors (textile and apparel), we get greater homogeneity in the types of innovations and the propensity of firms to substitute their existing products, processes, and management as compared to much of the literature. This enables us to get more accurate estimates of innovation output as well as labor productivity than those found in typical innovation studies.

The textile and apparel industry of Pakistan is an interesting case in a number of ways: First, sectors like textiles are often the 'leading sectors' because as countries begin to industrialize, these sectors require relatively less investment in terms of physical and human capital (Rostow, 1978). Second, textiles have experienced tremendous growth in recent years. World exports of textiles and clothing increased from $482 billion in 2005 to $797 billion in 2014. This, coupled with increasing wages in China, the leading textile exporting country, provides tremendous scope for countries like Pakistan to increase its share in world textile exports. Third, textiles is one of the few success stories in the Pakistani manufacturing sector and contributes significantly to the local economy, with one-fourth of industrial value added, employing about 40 percent of industrial labor force in Pakistan and constituting 55-60 percent of national exports.[2] Fourth, being very labor intensive, textiles have the potential to contribute to wider

[2] Economic Survey of Pakistan 2015–2016.

social changes by providing employment opportunities for the growing labor force, including the young, women and low-skilled workers.

The model we estimate is similar to Griffith et al. (2006), which includes three relationships: (i) the innovation investment equation linking expenditures on innovation to its determinants, (ii) the knowledge production function linking innovation output to investment in innovation and other determinants, and (iii) the productivity equation relating productivity to innovation output and other inputs. We extend their model to include organizational innovation and model the knowledge production as a joint multivariate system of product, process and organizational innovations.[3] Furthermore, in order to understand interlinks between various types of innovation, we extend the model to look at the individual versus joint impact of these innovations.

In line with many of the studies from developed countries, we found a strong impact of engaging in knowledge creation on product as well as on process innovation. However, we found significant heterogeneity in the impact of innovation types on labor productivity growth. Organizational innovation is the largest contributor to the labor productivity growth followed by process innovation. But unlike much of the literature, we found a negative impact of product innovation on labor productivity growth which could be due to the disruption effect of new products and/or due to firm level rigidities in adopting dedicated processes and equipment for new products (at least in the initial years of new products). Our extended analysis indeed showed that this negative impact is mitigated when product innovation is paired with process or organizational innovation.

The remaining of the paper is organized as follows: In the next section we discuss the relevant literature and in section 3 we discuss our data and the model we estimate. In section 4 we present our results and in section 5 we conclude.

Literature review

In this section, we discuss some of the literature on innovation and how there has been a movement towards looking at both innovation input (i.e. investment in innovations) and output (i.e. types of innovations) as well as how researchers have started to analyze the types and impact of innovation in developing countries.

Measuring innovation

Much of the earlier innovation literature commonly used patents and R&D expenditures as indicators of innovation. However, the relevance of patenting and R&D expenditures is often questioned for a number of reasons, especially in the context of developing countries. When it comes to patents, firms have different propensities to patent depending on their sector, production technology and location. Also, patenting might not reflect the commercial success of innovations and all patents do not have the same practical implementation in the production of goods and processes. Additionally, in the context of developing countries where the

[3] Apart from this, there are several explanatory variables such as international quality certification, local and foreign competition that are unique to our study.

intellectual property rights are weak or non-existent, firms tend to avoid filing patents for innovations. At the same time, there are also a number of questions raised on the relevance of formal R&D as a measure of innovation. First, even when well codified, R&D is the measurement of input into the innovation process and not an outcome. Also, performing R&D might not be the only strategy for the introduction of innovations, especially in developing countries where firms generally generate technological advances outside formal R&D processes.

An alternative approach is the use of direct information of firm level innovation obtained through innovation surveys on innovation inputs, outputs, and modalities, and one such set of surveys is the European Community Innovation Surveys (CIS). These surveys are based on the Oslo manual (OECD, 2005), which sets guidelines for collecting data on innovation and in this approach, innovation input is broadly defined as an investment in formal R&D and innovation related non-R&D activities such as the acquisition of machinery, hardware and software, purchase/licensing of patents, workers' training related to innovations. Whereas, innovation output is defined as the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations (OECD, 2005). Also, these surveys used a broader definition of innovation, including not only those that are “new to the world,” but also including those innovations that are “new to the firm” which has the potential to reveal important insights about innovation activities in developing countries.

Innovation decisions and firm performance

Most of the literature using data from innovation surveys frames the relationship between innovation and firm performance on the basis of Griliches’s two production function approach—the knowledge and output production (Griliches, 1979; Pakes and Griliches, 1984). This approach assumes that the production of new knowledge depends on current and past investment in new knowledge (e.g., current and past R&D expenditures) and on other factors such as knowledge flows from outside the firm, and market structure. In the output production function, knowledge (innovation output) affects firm performance. In their pioneering work, Crépon, Duguet and Mairesse (1998) (CDM henceforth) developed a full structural model that links engaging in innovation to productivity. Over the years, with some modifications, the CDM model has been used in most firm level innovation studies for both developed and developing countries.

The first stage of these models involves the determinants of a firm’s decision to engage in R&D and its intensity. A host of factors have been tested for their effect on firm level innovation decisions: A large number of studies have tested the Schumpeterian hypothesis of firm size positively affecting innovation efforts and most studies find a positive impact of firm size (measured as total employment) on the probability of engaging in innovation (Hashi and Stojcic, 2013; Criscuolo, 2009; Loof and Heshmati, 2006). There is also evidence in support of learning by exporting: A number of studies show a positive impact of export orientation on a firm's decision to innovate as well as on resources devoted to innovation (Criscuolo, 2009). However, this literature also identifies a reverse causation from innovation (especially product innovation) to exports in which more innovative firms self-select into an export market which is more competitive (Lachenmaier and Woessmann, 2006; Kleinknecht and Oostendorp, 2002).

External knowledge flows from outside the firm have also been found to contribute to a firm's innovation decision. Criscuolo (2009) reports a strong positive correlation between what firms consider as important sources of cooperation and innovation expenditure. Various sources of information and cooperation with research institutions are also reported to have a positive impact on innovation (Hashi and Stojcic, 2013). Besides these, competition (Castellacci, 2011), and public subsidies are shown to be associated with a firm's increased investment on innovation. Government subsidies have been found to positively impact private R&D (Criscuolo, 2009; Hall and Maffioli, 2008; Busom, 2000).

The second stage of these models involves the question of whether spending on innovation by firms induces innovation. Most of the literature confirms that the firms that invest more intensively in innovation are more likely to develop innovations—products and/or process innovation (Raymond et al., 2015; Mohnen and Hall, 2013; Hashi and Stojcic, 2013; Crespi and Zuniga 2012; Mairesse et al., 2012; Criscuolo, 2009).

The final stage of these models analyzes whether innovations improve firm performance. A large number of studies using various extensions of the CDM model (under different institutional setups) report a positive impact of technological innovation (product and/or process) on labor productivity (Hashi and Stojcic, 2013; Mairesse et al., 2012; Criscuolo, 2009; Crépon et al., 1998), profitability (Jefferson et al. 2006; Loof and Heshmati, 2006), firm growth (Coad and Rao, 2008), openness (Lachenmaier and Woessmann, 2006; Kleinknecht and Oostendorp, 2002) and other firm level outcomes.[4] There is, however, considerable variation in the impact of innovation as measured by the elasticity. Much of this variation is the result of differences in measures of firm performance used, the proxy used for innovation output, the sector being analyzed, the different control variables used (including other forms of capital such as physical and human capital), and the inclusion of other types of innovation (such as organizational and marketing innovations).

Innovation and firm performance in developing countries

Much of the early literature on innovation and its impact on firm performance focused on firms in developed countries. Over the last decade, there has been a small but growing literature that looks at firm level innovation decisions and the impact of innovations on firm performance in developing countries. This literature on R&D investment and innovation in developing countries has found mixed results: the findings reported a positive association between the two in developing countries such as Chile (Crespi and Peirano, 2007), Tanzania (Goedhuys, 2007). However, Oerlemans and Pretorius (2006) reported no significant impact of R&D on innovative sales per worker in South Africa.

The literature focusing on innovation input and output tends to recognize that innovation in developing countries is different from the innovation in developed countries in that knowledge dissemination mechanisms and incremental change account for most of the innovation

[4] See Mohnen and Hall (2013), Hall (2011), and Mairesse and Mohnen (2010) for a detailed review of the literature.

occurring in developing countries (OECD, 2005). This implies that the innovation activity and productivity relationship in developing countries might be different than the one in developed countries. This has generally been borne out in the empirical findings for developing countries, which shows far less homogenous results when testing both the link between investing in innovative activities and innovation, and the link between innovation and firm productivity.

Some of the studies report a positive and significant impact of innovation on firm productivity (e.g. Chudnovsky et al., 2006 of process innovation in Argentina; Raffo et al., 2008 in Brazil and Mexico). Other studies find no significant impact of innovation on firm productivity including Goedhuys (2007) Raffo et al., (2008) in Argentina, and Chudnovsky et al., (2006) of product innovation in Argentina.

Some more recent studies, however, report a positive and significant relationship (similar to developed countries) between innovation activity, innovation performance and labor productivity in developing countries. Crespi and Zuniga (2012) looked at six Latin American countries and found that firms which invested in knowledge were more able to introduce new technological advances and those firms that innovated had greater labor productivity. Mairesse et al. (2012) also report a positive relationship between innovation input and output, and then a positive impact of innovation on firm performance in four Chinese manufacturing sectors.

Data and Model

Data and survey

In 2015, we surveyed 614 textile and wearing apparel manufacturers from the Punjab and Sindh provinces of Pakistan.[5] Textile and wearing apparel firms are defined as those manufacturing firms classified under sections 13 and 14 of the Pakistan Standard Industrial Classification, PSIC 2010 (International Standard Industrial Classification - ISIC 17 and 18). We took the Pakistan Directory of Industries (which is the official business book) as the main sampling frame and this frame includes all firms with a minimum 10 employees.[6] We then stratified our sample based on the geographic location of firms and drew a stratified random sample representative, first at the provincial level and then at the district/regional level. The total population of the textile and wearing apparel manufacturers in Punjab and Sindh provinces is 4,205 units, and our sample size of 614 firms represents around 15 percent of the population.

The survey questionnaire we used was designed on the basis of the Oslo manual (OECD, 2005) and its recommendations for developing countries while the core questions related to innovation were similar to those used in the European Community Innovation Surveys (CIS). Apart from the standard modules on technological (product and process) innovation, the

[5] Total population of the manufacturers of textiles and wearing apparel in Pakistan is approximately 4,380 units, of which 96 percent (4,205 units) are located in two provinces, Punjab and Sindh.

[6] The frame was updated by cross comparing information with the ministry of textiles Pakistan, various chambers of commerce and industries, all Pakistan textiles mills association (APTMA), Pakistan readymade garments manufacturers and exporters association (PRGMEA), and the Karachi stock exchange.

questionnaire also included modules on non-technological (organizational and marketing) innovations, competition, and information communication technologies. This survey was conducted in 2015 and the innovation related questions were asked for the previous three years (2013-2015). After excluding all firms not reporting turnover in 2015, our final sample size was 377 firms.[7]

The preliminary results from our survey showed that firms in both sectors were engaged in a variety of innovation activities. They performed R&D continuously, invested resources in innovation, and introduced both technological as well as non-technological innovations. Overall, 56 percent of the surveyed enterprises introduced technological or/and non-technological innovations during the three years, 2013-2015, while forty-eight percent of enterprises introduced technological innovations (new products and/or new processes).

Table 1 reports summary statistics of the important variables and their sector-wise levels for the final sample of 377 firms. Here innovation expenditure refers to a broader definition of investing in in-house R&D, external R&D, acquisition of machinery, equipment and software (including lease or rental of machinery or equipment), acquisition of external knowledge, and training for innovative activities.

TABLE 1 HERE

The preliminary results also showed that the firms which spent on innovation, spent an average of 9 percent of turnover in 2015. Also, around one-fourth of firms reported that they performed R&D continuously during the 2013-2015 period. At the same time, one third of firms introduced at least one product innovation, forty-one percent firms introduced at least one process innovation, and 30 percent of firms introduced an organizational innovation during the 2013-2015 period. There are some noticeable differences between the textile and apparel sectors: firms in the apparel sector were bigger in size, spent more on innovation and introduced more innovations.

The reported innovation rates found in our survey are comparable to those reported in the literature for developed countries. This is, however, not unexpected since firms in developing countries can benefit from imitation of technologies already in use in the developed countries, so they may be more likely to introduce the “new to the firm” innovations than their counterparts in developed countries. This was actually evident from the degree of novelty reported by the product innovators in our sample: the majority of the innovative products were incremental in nature with seventy-nine percent of innovative products being characterized as “new to the firm”, and only 21 percent characterized as “new to the market”.

[7] The survey response rate was 70 percent and a total of 431 firms voluntarily participated in the survey. The majority of the non-respondents were the firms which did not exist or were permanently closed at the time of survey (139 firms out of a total 183 non-respondents). From the 431 respondents, there were firms who did not report their annual turnover due to confidentiality issues. Since we did not find systematic refusal based on firm characteristics or geographic location, we believe that the randomness of the sample is intact.

Model specification

The model we estimate is a modified version of the Crépon-Douget-Mairesse (1998) (CDM) structural model as in Griffith et al. (2006) and Mairesse and Robin (2009). The CDM-type models are generally built as three-stage econometric models that relate firm level productivity to new knowledge, which depends on a firm's R&D effort, which is in turn determined by a number of firm and environment-specific factors. The original 3-stage model by Crépon et al. (1998) was first estimated sequentially, and then simultaneously using Asymptotic Least Squares (ALS). However, subsequent applications of the CDM framework usually estimate the three stages sequentially, with the predicted output of a given stage being used as an explanatory variable in the next one.[8] Griffith et al. (2006) extended the CDM model by taking into account process as well as product innovations. Mairesse and Robin (2009) further extended the CDM model in Griffith et al. (2006) by accounting for both product and process innovation, as a simultaneous-equation model estimated using maximum likelihood.

In this paper, we extend Mairesse and Robin (2009) model by taking into account for not only product and process innovation but also organizational innovation, in a simultaneous-equation model estimated using maximum likelihood. As in Mairesse and Robin (2009), we assume that the unobservable factors that affect product, process, and organizational innovation are correlated so the model can be written as a recursive system of six equations. The model is estimated sequentially in three stages with the predicted output of a given stage being used as an explanatory variable in the next one.

The basic structure of the model is as follows: Let g_i^* be an unobserved decision variable for a firm's innovation effort and k_i^* the unobserved level of a firm's investment in innovation, with g_i and k_i being their observable counterparts. The first stage comprising two equations of the system can be defined as follows:

$$g_i = \beta_0 x_{0i} + \mu_{0i} \tag{1}$$

$g_i = 1$, if $g_i^* > 0$, otherwise $g_i = 0$

and

$$k_i \mid g_i > 0 = \beta_1 x_{1i} + \mu_{1i} \tag{2}$$

$k_i = k_i$, if $k_i^* > 0$, otherwise $k_i = 0$

where x_{0i} and x_{1i} are vectors of independent variables; β_o and β_1 are vectors of unknown parameters to be estimated reflecting the impact of various factors on the probability of engaging in continuous R&D and the intensity of R&D, respectively; and μ_{0i} and μ_{1i} are

[8] In a multi-equation system, innovation input is an explanatory variable in the innovation output equation, and innovation output is an explanatory variable in the productivity equation. This generates an endogeneity problem where the explanatory variables and the disturbance terms might be correlated. The CDM model handles some of the endogeneity by using a reduced form model to derive consistent estimators.

random error terms with mean zero, constant variances and are uncorrelated with the explanatory variables but are correlated with each other. The first equation models the probability that a firm does R&D on a continuous basis, and is specified as a Probit model. The second equation describes the R&D intensity, conditional on doing continuous R&D.

The second stage of the model is the knowledge production function which relates new knowledge (innovations) to innovation inputs (R&D expenditures). This stage comprises of three equations and models the probability that a firm introduces a product, process or organizational innovation during the 2013-15 period:

$$\begin{cases} prod_i = \alpha_k \hat{k}_i + \beta_2 x_{2i} + \mu_{2i} \\ proc_i = \alpha_k \hat{k}_i + \beta_3 x_{3i} + \mu_{3i} \\ orgn_i = \beta_4 x_{4i} + \mu_{4i} \end{cases} \quad (3)$$

Each equation in this stage models the probability that a firm introduces a product, process or organizational innovation and is specified as a separate Probit model. In the equations for product and process innovation $\hat{k}_i$ is the latent innovation effort proxied by the predicted values of R&D intensity from the first step and α_k is its coefficient. By including the predicted values of R&D, we take into account the fact that all firms may make some kind of innovative effort, although, only some of them invest in innovation and report it. This also allows us to instrument for simultaneity between innovation effort and knowledge production (see Hall et al., 2011). The vectors of other explanatory variables are given by x_{2i}, x_{3i} and x_{4i} and β_2, β_3 and β_4 are their corresponding coefficient vectors; μ_{2i}, μ_{3i} and μ_{4i} are the random error terms with mean zero and constant variance and they are uncorrelated with the explanatory variables. However, assuming that they are correlated with each other, these three equations define a *trivariate Probit* model.[9]

The final equation of the system models firm performance, proxied by labor productivity growth, as a function of product, process, and organizational innovation and a number of other controls including human capital:

$$q_i = \alpha_1 prod_i + \alpha_2 proc_i + \alpha_3 orgn_i + \beta_5 x_{5i} + \mu_{5i} \quad (4)$$

where q_i is the change in the log of labor productivity; $prod_i$, $proc_i$, and $orgn_i$ are the predicted probabilities of product, process and organizational innovation from the previous stage; x_{5i} is a vector of other explanatory variables and controls with β_5 their corresponding coefficient vector; and μ_{5i} is the random error term with mean zero and constant variance uncorrelated with the explanatory variables.

[9] We estimate our *trivariate Probit* model using the *mvprobit* Stata program developed by Cappellari and Jenkins (2003). This program uses simulated maximum likelihood techniques to solve the computational problem of evaluating multi-dimensional integrals. The procedure uses the Geweke-Hajivassiliou-Keane (GHK) simulator to evaluate the M-dimensional Normal integrals in the likelihood function.

In equation (1), the probability that a firm does R&D on a continuous basis is modelled as a function of a series of firm characteristics: firm size (in time *t-1*); whether the firm has ISO quality certifications; the legal form of the company (whether the firm is a partnership, private limited company, or public limited company); the firm's market orientation (whether it is exporting, whether the firm is facing local or foreign competition, and whether a firm is an apparel manufacturer); the factors hampering innovation in the firm (cost factors, knowledge factors, and other factors); the firm's main sources of information and cooperation (internal sources, foreign suppliers, local suppliers, foreign clients, local clients, and active cooperation on innovation with other firms); and the innovation objectives of the firm (product outcomes, and process outcomes).

In equation (2), the dependent variable is innovation input measured as the natural logarithm of total expenditure per worker on innovation activities in 2015. Innovation input is also modelled as a function of a series of firm characteristics: the legal form of the company; the firm's market orientation (whether it is exporting, the firm's export intensity in time *t-1*, whether the firm is facing local or foreign competition, and whether a firm is an apparel manufacturer); the factors hampering innovation in the firm; the firm's main sources of information and cooperation; innovation objectives of the firm; and whether the firm is receiving a national subsidy from the government.[10] For correct identification of the Heckman model, we also impose exclusion restrictions: the variables in our model that are included in the selection equation and excluded from the outcome equation are firm size (in *t-1*) and whether the firm has ISO quality certifications.[11]

In equation (3), the dependent variable is innovation output which is measured as whether a firm introduced a product, process, or organizational innovation during 2013-15 period. Both product and process innovation are modelled symmetrically as a function of: innovation investment intensity (predicted); firm characteristics (the firm's size and age in 2013, and whether the firm has ISO quality certifications); the firm's market orientation (export intensity in 2013, whether the firm is facing local or foreign competition, whether a firm is an apparel manufacturer, and whether a firm is located in the province of Sindh); the factors hampering innovation in the firm; the firm's main sources of information and cooperation; and the innovation objectives of the firm. However, since innovation investment intensity, the factors hampering innovation, and the sources of information and cooperation are only related to technological innovations,[12] these variables are excluded from the organizational innovation equation.

In equation (4), the dependent variable is labor productivity growth which is measured by the growth in labor productivity between 2013 and 2015. Labor productivity growth is modelled as a function of: product, process, and organizational innovations (all predicted from the previous

[10] Mairesse and Robin, (2009) also introduced subsidies only in the R&D intensity equation.

[11] Generally, there is no set standard on exclusion in innovation literature, however, other studies also exclude firm size (Crespi and Zunega, 2012; Mairesse and Robin, 2009; Criscuolo, 2009; Griffith et al., 2006). Griffith et al., (2006) also excluded sources of information.

[12] This is how the Oslo manual proposes and were used in our survey questionnaire.

stage); the firm's human capital; the firm's size in 2013 (both in terms of employment and sales); and the firm's age in 2013.[13]

A detailed description and measurement of all variables used in estimations are provided in Table A of appendix A.

Results

In this section, we present the results of our estimations. For the sake of clarity, we report these below in three sequential stages.

First stage (Continuous R&D and innovation investment intensity)

In the first stage we analyze the determinants of a firm's decision to engage in continuous R&D and the R&D intensity (conditional on doing R&D continuously). Table 2 reports the estimation results of the determinants of the decision to engage in continuous R&D over the period 2013–2015 (column 1) and the determinants of R&D intensity (column 2).

TABLE 2 HERE

So, what are the factors that affect a firm's decision to engage in continuous R&D and do these or other factors also affect the amount of investment that firms invest in R&D? First, our results show that larger firms are more likely to engage in continuous R&D, which is in line with the Schumpeterian theory of firm size affecting innovation. Also, we find that firms which obtain ISO certifications are more likely to engage in innovation on a continuous basis which is in line with the results of Goedhuys and Sleuwaegen (2013) who found that international standards certifications raise the productivity of firms through improved efficiency.

The impact of exporting and competition is interesting: the fact that a firm exports does not impact the probability that it will decide to engage in continuous R&D, but those exporting firms that do engage in R&D tend to invest more. This may be because innovative exporting firms invest more in embedded technology (in the form of machinery and equipment) rather than in in-house R&D. Also, export intensity has no impact on the intensity of R&D investment which implies that firms that export more don't invest more in R&D. In terms of competition, we tested to see whether firms facing competition from medium to large sized local firms and foreign firms in their main market were more likely to decide to innovate and invest more in R&D. Interestingly, we found that competition has no significant impact on a firm's likelihood to engage in R&D on a continuous basis or on R&D intensity.

In terms of the impact of the various factors that could hinder the innovation decisions of firms, we found that firms that consider knowledge factors as a highly important constraint to innovation are more likely to engage in innovation activities by themselves. But, it does not have any significant impact on R&D spending. This may be because firms are divided into those that understand the importance of knowledge and information and those that don't, with those who realize the importance of knowledge and innovation being more likely to innovate. The firms listing 'others' as a highly important factor hampering innovation have a lower probability

[13]Unfortunately, we do not have a good proxy for physical capital. We did ask information about physical capital in our survey, but the number of responding firms to this question was small.

of engaging in innovation. There are a few potential reasons for this: first, when asked about this 'others' category, many firms reported the ongoing national energy crisis as a problem[14] which could potentially explain why firms were less likely to engage in innovation. Second, external shocks such as oil price hikes and political instability combined with the deterioration in security could explain why firms were less likely to engage in continuous R&D.

As an extension of the impact of knowledge and informational constraints affecting firm level innovation decisions, it is also important to examine the impact of sources of information for firms. Our results suggest that firms who reported that internal sources of information and cooperation were important, were more likely to make the decision to innovate and also likely to invest more in innovation. However, there is no significant impact of market sources, be it suppliers or clients (both within country and outside), on a firm's decision to engage in R&D and its intensity. These two results may reflect the limited significance of knowledge exchange among actors in developing countries and the reliance of firms on internal sources. Also, firms considering local clients as important sources are less likely to engage in innovation activities which could reflect the inferior quality of information or the limited capacity of firms to take advantage of available information. Similarly, cooperation on innovation has no significant impact on a firm's propensity to engage in innovation or a firm's R&D intensity. This is in contrast to findings from developed countries, e.g. Griffith et al., (2006) show that such collaboration is associated with higher R&D investment. A possible explanation for this is the absence or weak development of innovation networks (Crespi and Zuniga, 2012) or the nature of cooperation between firms in developing countries which could be at more mature stages of innovation activities such as the introduction of new products and processes (as we find in the next section).

In terms of firms' innovation objectives, our results find that firms reporting product outcomes and process outcomes as the main objective for technological innovations, are more likely to engage in innovation activities but do not invest more in R&D. However, firms which reported product outcomes as their main objective tend to not only have a greater chance of deciding to innovate but also tend to invest more in R&D.

Because of the importance of the textile sector in the local economy, it has benefited from considerable government subsidies over the years. Our results show that national subsidies seem to have a crowding-out effect on firms' R&D investment since firms receiving national financial support for innovation activities invest less in innovation. This result is in contrast to much of the literature that has found that public financial support has led to additional private R&D (Criscuolo, 2009; Hall and Maffioli, 2008; Griffith et al., 2006; Busom, 2000). Even in the case of Latin America, Crespi and Zuniga (2012) show a positive impact of public subsidies on R&D investment in three out of the six countries studied. Though we do not have detailed information about the nature of public support and its conditionalities, we suspect that in the absence of effective monitoring, firms might be directing subsidies to other purposes. Rodrick (2004) discusses the failure of similar first best R&D subsidies for the subsidization of new and non-traditional industries. Having said this, one has to take care in interpreting the policy

[14] Electricity shortages were quite intense in 2013-15, and electricity breakdowns of 10 hours per day on average were reported for many months.

implications of this result, particularly since the subsidy coefficient may reflect the combination of 'assistance' and 'selection' effects.[15]

Second stage (Knowledge production function)

In the second stage of our analysis, we test the impact of innovation input on innovation output. Here we take three types of potential innovations: product, process and organizational innovations. To do this, we estimate the three-equation system as a *trivariate* probit, accounting for the mutual dependence of the error terms and we use the predicted values for R&D investment from the previous stage as an explanatory variable to account for possible endogeneity. Since, the innovation expenditures referred to expenditures for product and process innovations, we excluded these expenditures from the organizational innovation equation. Table 3 reports the estimation results of the knowledge production using three binary variables as indicators for whether a firm had a product, process, and organization innovation in 2013-15.

TABLE 3 HERE

Our results find a positive and significant impact of investing in R&D on the probability of introducing product and process innovations which is in line with most of the CDM literature. This clearly indicates that firms investing in R&D are more likely to introduce new products as well as new processes.

Again looking at the size of firms, we find that larger firms are more likely to introduce process innovations as well as organizational innovations. Though interestingly larger firms are not more likely to introduce new products. We also find that younger firms are more likely to introduce process innovations but not product or organizational innovations. As in the previous stage, ISO quality certifications has a positive impact on a firm's innovation behavior: firms with ISO certifications are more likely to introduce product innovations and organizational innovations.

The results for the impact of exporting and competition also present interesting results: we find that the amount a firm exports has no significant impact on the probability of a firm introducing any of the three types of innovation. Moreover, the impact of competition depends on the location of the competitor (local or foreign). While local competition does not affect a firm's innovation decisions, foreign competition does. In particular, firms facing foreign competition are more likely to introduce organizational innovations, but at the same time are less likely to introduce product innovations. This suggests that in the wake of increased competition, firms are willing to change their organizational structures and business practices but not products. The negative impact on product innovation could potentially be explained by the 'Schumpeterian effect' in which increased competition discourages innovation by laggard firms in unleveled sectors (Aghion et al., 2005; Aghion et al., 2014).

In terms of the constraints that firms face, our results suggest that knowledge factors are not impacting the types of innovations that firms are engaging in. At the same time, cost factors

[15] Dealing with such selection effects requires a different methodology than the one used here, which is beyond the scope of this study.

negatively affect the probability of a firm introducing product and process innovation, though, the impact is significant only for product innovation. As discussed in the first stage, the 'others' category may be capturing macroeconomic instability and energy related problems which tend to decrease the probability that firms will introduce product and process innovations.

Finally, in this stage we find that market sources of information play a significant role in a firm's decision to introduce product and process innovations. Suppliers (both local and foreign) positively impact the firms' propensity to introduce new products, and clients (both local and foreign) positively impact the firms' propensity to introduce new processes. This clearly suggests that suppliers are an important source of information for new products and markets, whereas clients are an important source of information on production processes. Our results provide an interesting contrast to those of Griffith et al., (2006) who modelled and found that only suppliers had a positive effect on process innovation in four European countries, and only clients have a positive effect on product innovation. Our results may reflect the fact that knowledge sources and networks in developing countries tend to carry different information than those found in developed countries. We also find that cooperation on innovation increases the probability that a firm will introduce new processes. This result combined with the ones in the first stage imply that innovation collaborations in this sector tend to occur more at the innovation output stage than at the innovation input stage.

Third stage (Productivity equation)

In the third stage, we test to see the impact of innovations on labor productivity and the results are given in Table 4. We use growth in labor productivity between 2013 and 2015 as the dependent variable (column 3). In order to determine the channels through which innovation affects labor productivity, we also estimate separate equations for employment and sales growth that are reported in columns 1 and 2, respectively. We used predicted values of product, process, and organizational innovations from the previous stage to control for endogeneity and all of the regressions control for human capital, firm size in 2013 (both in terms of employment and sales) and firm age.

TABLE 4 HERE

What is extremely interesting to note is that the impact of different innovations on productivity growth (given in column 3) varies significantly in both size and sign. Introducing a process innovation or an organizational innovation leads to higher labor productivity growth and the impact of an organizational innovation is more than twice the size of the impact of a process innovation. This result clearly indicates the critical role that improvements in management practices play in firm productivity growth in our sample. Our findings suggest that firms in developing countries can potentially reap large productivity gains by improving their management practices and can reduce the productivity gap between them and firms in developed countries beyond the commonly discussed catch-up technology mechanisms. This is especially important since implementing organizational innovations might even be an easier strategy than imitating foreign production practices in early stages of firm development.

Columns 1 and 2 present interesting evidence of the channel through which organizational innovations work. These results show that organizational innovations affect productivity through their impact on sales growth. So organizational innovations lead to higher sales growth while at the same time having no significant impact on employment growth, suggesting that higher productivity growth resulting from organizational innovations is achieved through better utilization of existing resources such as labor.

Process innovations on the other hand lead to both employment and sales growth, however, they have a larger impact on the latter than the former. Mohnen and Hall, (2013) provided a possible explanation on the productivity effect of process innovation through two main channels: first, process innovation is a priori expected to directly increase productivity since new processes are often introduced in order to reduce production costs by reducing some of the costlier inputs (often labor). Second, process innovations can also have an indirect effect on productivity when initial productivity improvements lead to lower prices, which in turn leads to a more than proportional increase in sales (if demand is sufficiently price responsive). In our case, we do find evidence supporting the second channel since process innovation does lead to sales growth; however, we find a different result in terms of the first channel discussed above—in our case process innovation leads to employment growth. So our results suggest that the process innovation is accompanied by an expansion of business and hence higher employment. Apart from the price reduction mechanism discussed above, this could potentially be because process innovation can lead to improved quality of existing products or improved efficiency in the production of new products, which leads to increased demand and sales. This is also supported by our survey results since the majority of innovators reported that improving quality of goods was their main objective for technological innovation.

We also find that product innovations lead to lower labor productivity growth. This is an unexpected result given the overwhelming evidence of product innovation leading to higher productivity in the existing literature (Mohnen and Hall, 2013). Though unexpected, the negative effect of product innovation on productivity growth is not unique to our study: Love et al., (2011) found a similar result for UK business services, while Roper et al., (2008) also found a negative impact of product innovations in for manufacturing firms in Ireland and Northern Ireland. However, unlike our results, both Love et al., (2011) and Roper et al. (2008) found a positive and significant impact of product innovation on sales growth. Griffith et al., (2006) also found a negative coefficient of product innovation for Germany but it was not statistically significant.

Given that there is a lot that is unique to this study i.e. focusing only on two sectors that are very homogenous, the low tech-labor intensive nature of the sectors, the institutional surroundings of a developing country, the degree of novelty of product innovations (around 80 percent are only new to the firm), and the introduction of significantly impactful organizational innovations, one could expect any of these factors or a combination of them to potentially explain why the impact of product innovations is found to be so different in our case. For example, since most of the innovations are only incremental in nature, one could expect that firms were replacing low value added products with other low value added products that do not improve labor productivity.

The existing literature also provides some potential explanations for the negative impact of product innovations on productivity: one explanation is that new products tend to disrupt established production process. It has been found that the introduction of new products generally involves startup and debugging phases of varying length in which new equipment or new task are specified and learned, which can reduce productivity (Griliches, 1998; ch 6). Similar productivity losses could occur if new products change the production patterns, such as bespoke production which involves one-offs or smaller batch production (a common phenomenon especially for apparel exporters). A second explanation for the negative impact of product innovation is given by the 'product life-cycle effect' (Roper et al., 2008). In this case, newly introduced products are initially produced inefficiently with negative productivity consequences. A third explanation is that even when firms produce new products, they might stay with more adaptable and flexible process technology. For example, to keep processes more flexible, firms may adopt avoiding dedicated process or equipment to new products. In such a scenario, flexibility in process technology is achieved at the expense of productivity.

With respect to the other control variables, human capital leads to significant increase in labor productivity growth. And firm size in terms of sales has a negative effect, suggesting that the smaller firms experience higher growth in the labor productivity.

As a robustness check, we estimated our three innovation equations in the second stage as separate probit equations rather than a multivariate probit equation. Symmetric to the base model, we used predicted propensities of innovations as an explanatory variable in the labor productivity growth equation. The results in this case are qualitatively similar to the results reported in Table 4: Product innovation significantly decreases labor productivity growth, while process and organizational innovation significantly increase labor productivity growth.[16]

Joint innovation strategies and labor productivity

In this section, we move beyond the standard analyses by evaluating the impact of product, process and organization innovations individually and in combination with each other. The results from this exercise add value in two important ways: first, by looking at the combination of innovations, we should be able to better understand the interactions among the types of innovation and their impact on firm performance. Given the recent emphasis on organizational innovations in the literature, it would be especially interesting to analyze the interaction of organizational innovations with the other two types of innovations (product and process) which tend to be more technological in nature. Second, looking at the impact of individual and combinations of innovations may help us understand why product innovations are found to have a negative impact on productivity in the previous section.

In our analysis, the seven potential combinations of innovations are represented by binary arrays[17]: (1,0,0), (0,1,0), (0,0,1), (1,1,0), (1,0,1), (0,1,1), and (1,1,1). Since, these innovation combinations are endogenous, we again use predicted propensities from the multivariate regression of the second stage (the knowledge production equation). We use no innovation (0,0,0) as the reference category and since predicted values are the propensities of different

[16] For the sack of brevity, results are not reported here.

[17] 1 represents a particular innovation occurring and 0 representing an innovation not occurring.

combinations that add up to one, we also make the combination (1,1,1) as the reference category in order to avoid perfect collinearity.

Table 5 reports the estimation results from the labor productivity equation where the dependent variable is growth in labor productivity between 2013 and 2015.

TABLE 5 HERE

To start with, we find a negative and significant impact of product only innovation, confirming the negative impact of new products on labor productivity growth. A significant negative coefficient in the sales growth equation (column 2) confirms the disruption effects discussed in the previous section. What is interesting is that the impact of new products on labor productivity growth becomes positive when product innovation is introduced in combination with process or organizational innovation. Even though these coefficients are not statistically significant, these results still signal that the negative productivity effect of new products is mitigated when these new products are combined with improvements in processes and managerial practices. Though a proper evaluation of the disruption effect of new products requires time series data which allows for an analysis of dynamic effects, the positive coefficients of the product and process combination, and the product and organizational combination hint towards the complementary effect of these two innovations on productivity.

On the other hand, both process innovations on their own and organizational innovations on their own are found to significantly increase labor productivity growth, which supports our earlier findings. However, we find that the combination of process and organizational innovations has a significantly negative impact on labor productivity growth. This could suggest that there is a disruption effect when processes are changed at the same time as management practices[18] and this negative effect works through a drop in sales growth.

Conclusion

While the innovation literature has moved away from broad macroeconomic analyses of R&D and productivity towards firm level analyses of innovation and productivity, much of the work has focused on developed country firms engaging in technological innovations. Two recent strands of the literature have looked at developing country firms as well as a wider definition of innovation which incorporates organizational as well as technological innovations. This paper attempts to combine both strands of the literature by looking at the impact of both technological and organizational innovations in a developing country context.

Using a unique dataset from textile manufacturers surveyed in Pakistan, we look at the factors that affect a firm's decision to innovate and the amount of investment of innovation in this sector. We find that larger firms and firms with ISO certifications are more likely to engage in continuous R&D, while exporting or competition (both local and foreign) does not affect a firm's decision to innovate. Also, firms that were hindered by knowledge factor constraints and other constraints (such as energy) were less likely to innovate while firms that emphasized the

[18] Again, this could be a short run effect only, though testing this requires introducing dynamics in the model which the existing data does not allow.

importance of internal sources of information were more likely to decide to innovate and also invest more in innovation.

We also analyzed the factors that affected the probability of firms introducing different types of innovations. Our results showed that larger firms were more likely to introduce process innovations as well as organizational innovations while younger firms were more likely to introduce process innovations. We also found that firms with ISO certifications were more likely to introduce product innovations and organizational innovations. Our results also showed that firms facing foreign competition were more likely to introduce organizational innovations, but at the same time were less likely to introduce product innovations. Also, suppliers (both local and foreign) positively impacted the firms' propensity to introduce new products, and clients (both local and foreign) and cooperation on innovation positively impacted the firms' propensity to introduce new processes.

Finally, we looked at the impact of various innovation strategies (both individual strategies and joint strategies) on productivity. We found significant variations in the impact of different innovations: in particular, we found that the introduction of a process innovation or an organizational innovation led to higher labor productivity growth and the impact of an organizational innovation was more than twice the size of the impact of a process innovation. We also found evidence that higher productivity growth resulting from organizational innovations is achieved through better utilization of existing resources such as labor. On the other hand, process innovations led to both employment and sales growth.

Interestingly, we found that product innovations lead to lower labor productivity growth. In order to explore this further, we analyzed joint innovation strategies and found that the impact of new products on labor productivity growth becomes positive when product innovation is introduced in combination with process or organizational innovation. We also found that the combination of process and organizational innovations had a significantly negative impact on labor productivity growth.

Our analysis illustrates some of the important differences between innovation in developed country and developing country firms. Also, our results illustrate the importance of organizational innovations in developing country firms, both on their own and in conjunction with product innovations. So, while innovativeness is critical for sustained growth, it is important to realize that firm level decisions to innovate as well as the impact of technological and organizational innovations can be fundamentally different in developing countries.

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Table 1: Descriptive statistics

	Obs	***Size[a]***	***Innovation Expenditure[b]***	***Continuous R&D[c]***	***Product[c]***	***Process[c]***	***Organizational[c]***
		Mean (SD)	*Mean (SD)*	*Mean*	*Mean*	*Mean*	*Mean*
Total	377	348 (1067)	9.3 (13.9)	24	33	41	30
Textile	306	311 (1016)	8.38 (11.54)	19	28	38	26
Apparel	71	509 (1257)	11.68 (18.65)	45	56	52	48

Note: (a) measured as total employment in 2015, (b) innovation expenditure measured as a percentage of turnover in 2015 for firms reporting positive expenditure, and (c) as a percentage.

Table 2: R&D intensity equation

	Continuous R&D	R&D intensity
Firm characteristics		
Employment (t-1)	0.15* (0.082)	--
ISO9000	0.72***(0.261)	--
Partnership	0.94*** (0.305)	4.21**(1.903)
Private Ltd	0.92*** (0.291)	4.50***(1.834)
Public Ltd	1.17*** (0.468)	6.39***(2.587)
Market orientation		
Exporting	0.30 (0.354)	4.30*(2.574)
Export intensity (t-1)	--	-0.32 0.396)
Local competition	0.28(0.328)	2.08 (1.565)
Foreign competition	-0.17 (0.284)	-0.18 (1.330)
Apparel	0.24 (0.292)	2.42*(1.323)
Factors hampering innovation		
Cost factors	-0.34 (0.229)	1.78 (1.246)
Knowledge factors	0.67***(0.271)	0.46 (1.393)
Other factors	-0.62***(0.233)	-1.22(1.408)
Sources of information and cooperation		
Internal	0.44*(0.238)	2.73**(1.254)
Market sources: Foreign suppliers	-0.20 (0.277)	0.58 (1.260)
Market sources: Local suppliers	-0.01 (0.287)	-0.03 (1.295)
Market sources: Foreign clients	0.13 (0.324)	-0.03 (1.675)
Market sources: Local clients	-0.52* (0.282)	2.14 (1.584)
Active cooperation	-0.13 (0.279)	0.53(1.271)
Innovation objectives		
Product outcomes	1.20*** (0.376)	6.36**(2.851)
Process outcomes	0.91*** (0.332)	0.34 (2.005)
National subsidy	--	-5.18***(1.876)
Rho		0.75
Sigma		4.93
Lambda		3.68*(2.27)
No. of observations	377	377

Note: This stage is estimated in a Heckman two-step sample selection model. The parentheses contain standard errors. ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively. Wald Chi2 (20) = 39.85, Prob > chi2 = 0.00

Table 3: Knowledge production function

	Product	**Process**	**Organizational**
R&D	0.11***(0.027)	0.12***(0.028)	--
Firm characteristics			
Employment (t-2)	-0.09 (0.069)	0.17**(0.074)	0.15***(0.051)
Age	-0.12 (0.110)	-0.36***(0.119)	0.05 (0.090)
ISO9000	0.41*(0.230)	0.05(0.243)	0.49***(0.184)
Market orientation			
Export intensity$_{2013}$	0.05 (0.058)	0.06 (0.062)	-0.00 (0.044)
Local competition	-0.04 (0.273)	-0.13 (0.280)	0.20 (0.211)
Foreign competition	-0.56**(0.249)	0.17 (0.249)	0.32*(0.187)
Apparel	0.58**(0.257)	-0.76**(0.317)	0.44**(0.201)
Sindh	0.62***(0.230)	-0.19 (0.251)	0.12 (0.173)
Factors hampering innovation			
Cost factors	-0.39*(0.206)	-0.28 (0.215)	--
Knowledge factors	-0.32 (0.254)	0.24 (0.249)	--
Other factors	-0.72***(0.209)	-0.45**(0.207)	--
Sources of information and cooperation			
Internal	0.17(0.241)	0.07(0.257)	--
Market sources: Foreign suppliers	0.95***(0.289)	-0.53 (0.313)	--
Market sources: Local suppliers	0.51**(0.261)	-0.12 (0.283)	--
Market sources: Foreign clients	0.15 (0.292)	0.88***(0.320)	--
Market sources: Local clients	0.03 (0.260)	0.66**(0.290)	--
Active cooperation	0.28 (0.261)	1.14***(0.371)	--
Rho21	0.16 (0.134)	--	--
Rho31	0.01 (0.116)	--	--
Rho32	0.38***(0.109)	--	--
# of draws	1000	1000	1000
Observations	377	377	377

Note: This stage is estimated using the *mvprobit* Stata program developed by Cappellari and Jenkins (2003). The parentheses contain standard errors. ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively. Wald Chi2 (44) = 280.60, Prob > chi2 = 0.0000. Likelihood ratio test of rho21=rho31 = rho32 = 0: chi2(3) = 11.48 Prob > chi2 = 0.00

Table 4: Labor productivity

	Employment growth	**Sales growth**	**Productivity growth**
Product	-0.05 (0.045)	-0.13(0.108)	-0.19** (0.099)
Process	0.14***(0.046)	0.43***(0.100)	0.36***(0.090)
Organizational	-0.07(0.145)	0.84** (0.345)	0.80***(0.288)
Human capital	0.27***(0.049)	0.33*** (0.081)	0.26***(0.105)
Employment (t-2)	-0.38***(0.078)	0.01 (0.153)	-0.08 (0.188)
Sales (t-2)	-0.04***(0.012)	-0.88*** (0.045)	-0.68***(0.032)
Age	-0.18***(0.038)	-0.15(0.107)	-0.01(0.095)
R-squared	0.55	0.86	0.83
P	0.000	0.000	0.000
Observations	377	377	377

Note: This stage is estimated using instrumental variables two-stage least squares (IV 2SLS). The parentheses contain bootstrapped standard errors (100 replications). Significance levels are reported based on bootstrapped standard errors (100 replications). ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Table 5: Labor productivity with interactions

	Employment growth	Sales growth	Productivity growth
Product only	-0.02(0.048)	-0.20*(0.117)	-0.25**(0.106)
Process only	0.11***(0.036)	0.50***(0.108)	0.36***(0.081)
Organizational only	-0.01(0.100)	0.65**(0.266)	0.63***(0.226)
Product & Process	0.04(0.024)	0.08(0.054)	0.01(0.043)
Product & Organizational	-0.02(0.071)	0.12(0.139)	0.11(0.118)
Process & Organizational	-0.01(0.055)	-0.27**(0.141)	-0.27**(0.124)
Human capital	0.27***(0.049)	0.35***(0.083)	0.28***(0.108)
Employment (t-2)	-0.38***(0.075)	0.02(0.142)	-0.06(0.173)
Sales (t-2)	-0.04***(0.012)	-0.88***(0.044)	-0.68***(0.031)
Age	-0.20***(0.040)	-0.11(0.103)	0.02(0.091)
R-squared	0.56	0.86	0.83
P	0.000	0.000	0.000
Observations	377	377	377

Note: This stage is estimated using instrumental variables two-stage least squares (IV 2SLS). The parentheses contain bootstrapped standard errors (100 replications). Significance levels are reported based on bootstrapped standard errors (100 replications). ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Appendix-A

Table A: Description of the variables

Variable	Definition
Continuous R&D	= 1 if a firm reported performing continuous R&D during the 2013-15.
R&D intensity	Measured as the natural logarithm of total expenditure on innovation per worker in 2015. Total expenditure is a sum of expenditure on: (i) in-house R&D, (ii) external R&D, (iii) acquisition of machinery, equipment and software (including lease or rental of machinery or equipment), (iv) acquisition of external knowledge, and (v) training for innovative activities.
Product	= 1 if a firm has introduced new or/and significantly improved products during 2013-15 that are at least new to the firm.
Process	= 1 if a firm has implemented new or/and significantly improved production process, distribution method, or/and supporting activity during 2013-15.
Organizational	= 1 if a firm has implemented a new organizational method in its business practices, workplace organization, or external relations during 2013-15.
Sales	The natural logarithm of total turnover in 2015.
Sales growth	The natural logarithm of total turnover in 2015 minus the natural logarithm of total turnover in 2013.
Productivity	Labor productivity measured as the natural logarithm of turnover per worker in 2015.
Productivity growth	Labor productivity growth measured as the natural logarithm of labor productivity in 2015 minus the natural logarithm of labor productivity in 2013.
Employment	Measured as the natural logarithm of total employment in 2015.
Employment growth	The natural logarithm of total employment in 2015 minus the natural logarithm of total employment in 2013.
Age	Firm age measured as the natural logarithm of number of years in 2013.
Cost factors	= 1 if a firm considered any of the following factors as highly important factor hampering innovation during 2013-15: lack of funds within enterprise or its group; lack of finances from banks; lack of finances from non-bank sources; innovation costs were too high.
Knowledge factors	= 1 if a firm considered any of the following factors as highly important factor hampering innovation during 2013-15: lack of qualified personnel; lack of information on technology; lack of information on markets; and difficulty in finding cooperation partners for innovation.
Other Factors	= 1 if a firm considered any of the following factors as highly important factor hampering innovation during 2013-15: No need due to prior innovations by the enterprise; No need because of no demand for innovations; Macro level uncertainties, and others.
Internal	= 1 if a firm considered within firm or within its enterprise group as highly important source of information and cooperation for technological innovation during 2013-15.
Market sources: Foreign suppliers	= 1 if a firm considered foreign suppliers as highly important source of information and cooperation for technological innovation during 2013-15.
Market sources: Local suppliers	= 1 if a firm considered local suppliers as highly important source of information and cooperation for technological innovation during 2013-15.

Market sources: Foreign clients	= 1 if a firm considered foreign clients as highly important source of information and cooperation for technological innovation during 2013-15.
Market sources: Local clients	= 1 if a firm considered local clients as highly important source of information and cooperation for technological innovation during 2013-15.
Active cooperation	= 1 if a firm has co-operated on any of their innovation activities with other enterprises or institutions, including other enterprises within their group during 2013-15.
Local competition	= 1 if a firm faces competition from medium to large sized local firm in the market where it sells its main product.
Foreign competition	= 1 if a firm faces competition from medium to large sized foreign firm in the market where it sells its main product.
Product outcomes	= 1 if a firm reports any of the following objectives as highly important objectives for its activities to develop product and process innovations during 2013-15: a) increase range of goods, b) enter new markets or increase market share, and c) improve quality of goods.
Process outcomes	= 1 if a firm reports any of the following objectives as highly important objectives for its activities to develop product and process innovations during 2013-15: a) improve flexibility for producing goods, b) increase capacity for producing goods, c) reduce labor costs per unit of output, and d) reduce material and energy costs per unit of output.
Exporting	= 1 if a firm exported its goods in 2015.
Export intensity	Measured as the natural logarithm of the exports in 2015.
ISO9000	=1 if a firm has an internationally-recognized quality certification of ISO9000 during any of the three years from 2013 to 2015.
National subsidy	= 1 if a firm received financial support (subsidy) for innovation activities from the government during 2013-15. Financial support includes tax credits or deduction, grants, subsidized loan, and loan guarantees from the national government (federal).
Human Capital	Measured as the natural logarithm of total number of workers with a university degree and/or professional diploma in 2015.
Partnership	= 1 if a firm's legal structure is partnership.
Private Ltd	= 1 if a firm's legal structure is private limited.
Public Ltd	= 1 if a firm's legal structure is public limited.
Apparel	= 1 for the manufacturers of apparel.
Sindh	= 1 if a firm is located in the province of Sindh.