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What Determines Innovation in the Manufacturing Sector? Evidence from Pakistan

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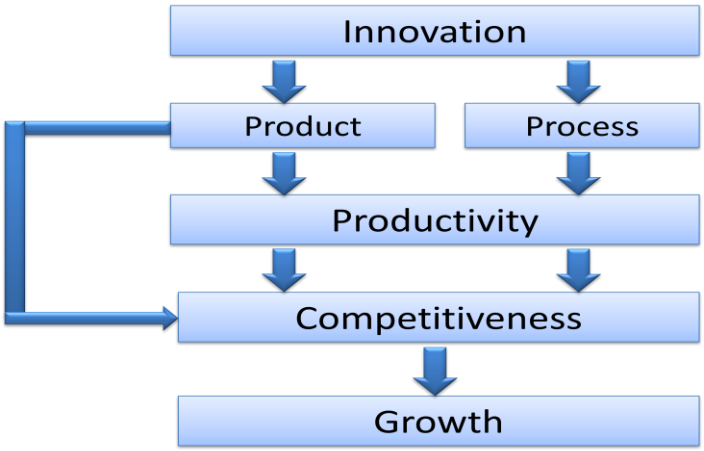
1. INTRODUCTION

Innovation plays a critical role in determining a country's overall competiveness, productivity and hence economic growth. Amongst others, it is considered to be one of the key ingredients in a developing country's growth strategy in order to catch up to the more developed economies. This in turn is also important for shaping and sustaining an economy's global competitiveness. Therefore, the World Economic Forum considers innovation as one of the twelve pillars of its widely disseminated Global Competitiveness Index.

There is a rich body of literature which establishes the innovation and growth link. Figure 1 illustrates the possible linkages between two types of innovative activity (product and process innovation), competitiveness and growth. For product innovation, the link might be directly from the offering of a new product to making the firm more competitive and not necessarily through increasing competitiveness because of enhanced productivity.

Fig. 1. Innovation as a Driver of Growth



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For instance, Crespi and Zuniga (2011) finds for a set of six Latin American countries that firms which innovated had higher labour productivity compared to non-innovating firms. Hall (2011) finds that there is significant effect on revenue productivity and thereby on growth of firms of product innovation. Furthermore, there is a general consensus in literature on the presence of a significant and positive relationship between innovative activity and productivity. A review of various industrialised countries such as Netherlands, Germany, France, Norway, Sweden etc., shows the elasticity of innovation with respect to productivity ranges between 0.035 and 0.29 [see amongst others Van Leeuwen and Klomp (2006); Polder, *et al.* (2009); Mairesse and Robin (2010); Janz, *et al*. (2003)].

This innovation-productivity link can then potentially translate into increases in aggregate productivity for the country. This can work through two channels: firms that innovate tend to produce more efficiently (cost effectively) and also better quality products which is likely to increase demand for products of the sector. Secondly, at the aggregate level firms that innovate will exhibit faster growth than firms which don't. This may drive out inefficient players from the market creating room for more competitive firms and thus contributing to overall productivity gains. Hall (2011) empirically establishes this positive link for a set of 23 OECD countries by comparing aggregate innovation rates (both product and process) with aggregate productivity as measured by GDP per hours worked. His findings are robust to sophisticated econometric estimations.[1] An interesting dimension of his finding is the positive link between size of firm particularly large firms, innovation and productivity.

Defining Innovation

Innovation is considered to be a complex process which is difficult to quantify. Historically, it was measured by the spending on research and development (R&D) activities and/or the number of patents obtained by a firm. The use of R&D data has been criticised on account of being an input variable which may or may not result in the actual development of a new product or process or an up gradation of an existing one [Flor and Oltra (2004); Kleinknecht, *et al.* (2002)]. Thus, it would be an overestimation of the actual level of innovation in the firm. On the other hand, the use of patent data would tend to be an underestimation of actual innovation whenever it is not a new invention by the firm. It would also pose a problem in settings where property rights are not clearly defined as is the case with most developing countries including Pakistan. Also, firms where innovation is largely undertaken by adopting processes and products of other firms in the industry would not be considered.

According to Becheikh, *et al.* (2006) a review of empirical studies on innovation from 1993 to 2003 reveals that 81 percent of the authors investigated process, product or both types of innovative activity. This definition stems from the Oslo Manual[2] where innovation refers to the introduction of a new product or process over the past three years.

[1]Such as Leasty Absolute Deviations and Least Median of Squares.

[2]The Oslo Manual was first published by the OECD in 1992 with the objective of developing a framework within which research on innovation can be compared across countries. To that end, the manual defined innovation as "introduction of technologically new products and processes and significant technological improvements in products and processes" as well as laid down a set of survey procedures for conducting research in this domain.

This is also one of the most widely used operational definitions in the literature on innovation and one which we will also be using for this study.

Motivation and Objectives

Pakistan continues to exhibit poor performance in this domain. According to the Global Competitiveness Report 2011-2012, Pakistan ranks at 118th out of a total of 142 countries and it fares worse than the neighbouring countries of Bangladesh (ranked at 108), India (ranked at 56), and Sri Lanka (ranked at 52). Moreover, in the context of Pakistan this becomes especially important in the industrial sector since the composition of industrial production has been largely unchanged since the 1970s.[3] The country seems to be stuck at the low end of the technology ladder while we do know that other Asian countries (such as Malaysia, Thailand, People's Republic of China, Vietnam etc.) have exhibited tremendous growth at the back of transition from low to high technology production [Felipe (2007)]. What made this transition possible is innovation. Given the crucial importance of innovation for competitiveness on the one hand, and Pakistan's poor performance on the other, the objective of this study is to examine the determinants of innovative behaviour for manufacturing firms in Pakistan.

The main overarching question that the study attempts to answer is that, what are the characteristics of firms which innovate versus those that do not? Literature classifies these into two categories namely i.e., those which are (a) internal and those which are (b) external to the firm.

Internal characteristics include those which pertain to size [Greve (2003)], age [Jung, *et al.* (2003); Sorensen and Stuart (2000)], ownership structure [Bishop and Wiseman (1999); Love, *et al.* (1996)] and past performance of the firm [Tsai (2001)]. It also includes trade status of the firm which has been found to be an important determinant of innovative activity in the literature [Landry, *et al.* (2002); Romijn and Albaladejo (2002)]. In addition, characteristics representing the quality of the management of the firm like training, educational background and experience of the managers and entrepreneurs have also been studied [Koellinger (2008); Baldwin and Johnson (1996)].

External determinants of innovation which have been explored in the literature include geographical location of the firm, demand growth in the industry, industry concentration, government policies as well as the general institutional structure prevalent in the area in which the firm operates [Smolny (2003); Sternberg and Arndt (2001); Coombs and Teomlinson (1998); Baptista and Swann (1998)].

The remainder of the paper is organised as follows: Section 2 describes the data and presents basic summary statistics; Section 3 the methodology and the estimation strategy; results are discussed in Section 4 and Section 5 concludes the paper.

2. DATA

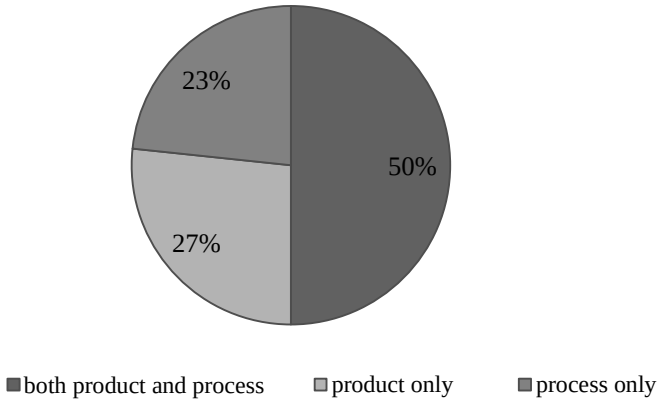
The study uses a panel data provided by the two rounds of the Pakistan Investment Climate Assessment Survey conducted by the World Bank in 2002 and 2006-07 respectively. This panel survey provides detailed information on firm characteristics and

[3]See Table 3 on page 15 [Felipe (2007)].

on various aspects of business environment in the country. The former includes information on an establishment's sales, employment and productivity. Key dimensions of business environment include infrastructure and services, courts, crime, government-business relations, degree of competition and factor markets (land, labour and finance). The surveyed firms are located in thirteen cities across the country with a large share coming from big cities such as Karachi. Firms belong to seven different industries with a sixty percent share coming from the Textiles, Food and Garments industries.

The panel consists of 402 manufacturing firms of which 107 firms (26.7 percent) innovated either by introducing new products, new processes or both. Combining data from several innovation surveys across the world, Hall (2011) estimates that on average 30-50 percent of firms introduced a new product and/or process over the last three years. The innovation rate of 26.7 percent in the manufacturing industry for the sample under study shows that Pakistan still has a long way to go in terms of catching up to innovation rates in the developed world. However, in line with evidence from these countries, within the firms which are innovating, there is an equally likelihood of undertaking product or process innovation in Pakistan (Figure 2).

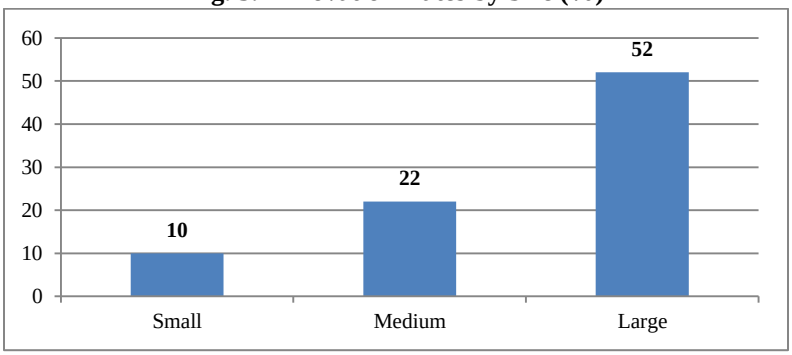
Fig. 2. Innovators by Type



Raw data suggests that there are significant differences in innovations rates across both internal and external characteristics. Internally, both product and process innovations rates differ significantly by a firms size. Large firms are 5 times more likely to innovate in the 2004 to 2007 period than a small firm[4] (Figure 3). When innovation by product and process was separately studied, percentage of innovators was fairly consistent across firm size. Innovators appear to have more access to external finance compared to non-innovators since twice as many firms in the sample of innovators report positive external financing compared to the sample of non-innovating firms.

[4]Where size is defined as: Small: 0 to 20 workers, Medium: 20 to 100 workers and Large: More than 100 workers.

Fig. 3. Innovation Rates by Size (%)



Source: Author's Own calculation, Investment Climate Assessment Survey, 2002 and 2007.

Externally, innovation rates differ across industry and region (Tables 1 and 2). Industry wise differences might arise due to the potential for greater innovation in certain industries than others. Further, a possible factor that explains the differences across regions could be the presence of the firm in a cluster. Of the innovating firms, 50 percent of the firms are part of a cluster.[5]

Table 1

Innovation Rates by Industry (%)

Industry	Product	Process
Food	18.8	20.3
Garments	14.7	17.6
Textiles	27	25
Machinery and Equipment	0	0
Chemicals	27.3	27.3
Electronics	16.7	16.7
Leather and Products	13	13
Other Manufacturing	27.4	23.2

Source: Author's Own calculation, Investment Climate Assessment Survey, 2007.

Table 2

Innovation Rates by Location (%)

Region/City	Product	Process
Karachi	50.6	50.6
Lahore	24.2	29
Sheikhupura	0	0
Sialkot	18.6	11.4
Faisalabad	11.9	13.4
Gujranwala	2	2
Wazirabad	9.1	9.1
Islamabad/Rawalpindi	0	0

Source: Author's Own calculation, Investment Climate Assessment Survey, 2007.

[5]Cluster is defined as an area where at least 30 percent of the firms in a particular industry in the sample are located.

3. METHODOLOGY

3.1. Empirical Framework

A major issue with studying the determinants of innovation is that most of the characteristics of innovating firms identified in literature could pose endogeneity issues. This is because observing firms after they have innovated makes it difficult to determine whether these characteristics are a result of innovation or they in fact let to the innovating activity of the firm. For instance when exploring the relation between a firm's trade status and innovation, is it that entry into international markets allowed easier diffusion of foreign technology and hence led to innovation or is it that innovating firms as a result of it are able to become more competitive thereby allowing them to break into the export market. This problem of reverse causality is present in most of the variables of interest in determining innovation. To circumvent this problem, we will be making use of the unique panel which will allow us to look at the impact of pre-innovation characteristics of the firm in 2002 on incidence of innovation in 2006-07. To that end the following model is specified:

$$I_{jt} = \alpha_0 + \sum \beta_i X_{jt-1} + \sum \gamma_i Y_{jt-1} + \varepsilon_0 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where I_{jt} is a dummy variable taking on a value of 1 if firm *j* is an innovator in year 2006-07 and 0 otherwise. In line with the discussion above, a firm is characterised as an innovator if it has introduced a new product (process) in the 2003-06 period. *t* refers to the second round of the panel (2006-07) while *t*–1 refers to the first round conducted in 2002. $X_{jt-1}(Y_{jt-1})$ is a vector of internal (external) characteristics that the firm *j* had in 2002. Finally, α_0, β, γ are parameters while ε_0 is the error term.

The internal characteristics include the trade status, size of the firm, growth of the firm, quality of the top manager and the organisational type. Trade status is a dummy variable which equals 1 if the firm is an exporter, 0 otherwise. A priori it is expected that an exporting firm is more likely to innovate since in order to sustain in the global markets, the firm needs to be competitive which in turn requires a continuous process of improving existing processes. Furthermore, it is easier for these firms to acquire the latest technology.

Size has been defined in terms of the number of people working in the organisation. A firm is small if the number of employees is less than 20, medium if between 20 and 100 and large if more than 100. The base category for our analysis is a small firm while dummies for large and medium sized firms are included. Larger firms are expected to have an advantage over smaller firms due to their capacity for investing in R&D and the acquisition of new technology.

Growth has been defined in terms of the growth in labour force in the 1999–2002 period. An alternate possibility of the sales growth rate but due to concerns about the validity of the data reported this was not used. Fast growing firms on average are more likely than slow growing or stagnant firms to have the resources to innovate.

We also include measures for quality of management for which we proxy by the education attainment and experience of the top manager in that particular firm. Organisational form of the firm has been captured by including a dummy variable which equals 1 if a firm is a private organisation and 0 otherwise.

In order to innovate, firms need to invest in costly research and development. Literature shows that ease of access to external finance has a significant positive impact on the probability of innovation as it can potentially serve to relax the resource constraints that firms face. In order to capture this dimension we measure external finance by the percentage of working capital financed through institutional sources which include private commercial banks, state owned banks and non-bank financial institutions.

On the external side, a particularly interesting question is whether being in a cluster increases the likelihood of a firm innovating through possible benefits from knowledge spillovers and greater competition. This is captured by a dummy variable that takes on a value of 1 if the firm is located in a cluster where cluster is defined as an area where at least 30 percent of the firms in a particular industry in the sample are located.[6] Using firm concentration levels in each location we find the conventionally established clusters such as the textiles cluster at Karachi and Faisalabad, the leather and sports goods cluster at Sialkot (Appendix-A details the location-industry clusters identified).

Another interesting aspect is how the environment in which the firm operates affects the probability of innovation. To answer this question this analysis is based on perceptions based information regarding business climate.[7] These can be broadly categorised as those pertaining to availability of infrastructure, the policy environment and the overall macroeconomic condition of the country. To construct each of these three indices, we employ principal component analysis on the top manager's response to the relevant questions. These responses are on a scale of 1 to 5 where 5 refers to if the manager considers that particular factor to be a major or severe constraint to the firm's operation.

3.2. Estimation Strategy

In line with the nature of the dummy dependant variable, we will be estimating a Probit model using maximum likelihood estimation technique:

$$Prob(I_{jt} = 1|X, Y) = \alpha_0 + \sum \beta_i X_{jt-1} + \sum \gamma_i Y_{jt-1} + \varepsilon_0 \quad \ldots \quad \ldots \quad (2)$$

Existing studies show that product innovations tend to have a different set of determinants compared to process innovations despite their close link.[8] This is because product innovation tends to be a much radical change while process is in most cases is an up gradation of the existing operating/manufacturing procedures. Therefore, the level of investment both in time and capital usually required for product innovation is much greater as compared to process innovation. For instance it could be that being small imposes a greater constraint as far as product innovation is concerned in comparison to process innovation. Against this backdrop product and process innovative activity is separately studied using the specification in (1) with a modified dependant variable:

[6]Conventionally clustering is defined using the Ellison-Glaeser index (1997) based on employment of an industry in a particular location. However, lack of nationally representative industry data in the sample under study does not allow such calculations.

[7]While it would be most accurate to have factual information on the business climate but due to data constraints perceptions based data is being used to capture this dimension.

[8]See amongst others Freer (2003), Gopalakrishnan, *et al.* (1999), Lager and Horte (2002), Michie and Sheehan (2003), Papadakis and Bourantas (1998), Sternberg and Arndt (2001).

$$Prob(Prod_{jt} = 1|X, Y) = \alpha_0 + \sum \beta_i X_{jt-1} + \sum \gamma_i Y_{jt-1} + \varepsilon_0 \quad \ldots \quad \ldots \quad (3)$$

$$Prob(Proc_{jt} = 1|X, Y) = \alpha_0 + \sum \beta_i X_{jt-1} + \sum \gamma_i Y_{jt-1} + \varepsilon_0 \quad \ldots \quad \ldots \quad (4)$$

Where prod (proc) refers to product (process) innovation in the 2003-06 period, respectively. Hence, estimates on the determinants of innovation are calculated separately for product and process innovators.

4. RESULTS

We begin by estimation of Equation (2) where the dependant variable captures firms which innovate either by introducing a new product or process or both. Results from the Probit estimation show (Table 3) that of the internal characteristics firm size and quality of human capital are significant in explaining innovation. The probability of innovation is 17 percent (51 percent) higher for medium (large) firms compared to small firms. Further, the quality of human capital in the organisation appears to have a significant but a smaller impact than firm size. This is evident from the positive and statistically significant coefficients on top manager's experience (1 percent) and education (3 percent).

Table 3

Maximum Likelihood Probit Estimates

	Coefficient	Marginal Effects	t-stat	Coefficient	Marginal Effects	t-stat
Internal						
Trade Status	–0.24	–0.07	–1.19	–0.27	–0.08	–1.32
Medium Size	0.54***	0.17	2.77	–0.12	–0.03	–0.37
Large Size	1.41***	0.51	5.05	0.86**	0.31	2.16
Growth Rate	–0.00	0.00	–0.29	–0.00	0.00	–0.18
Private Limited	0.04	0.01	0.22	0.04	0.01	0.08
Manager Experience	0.03**	0.01	2.16	0.03**	0.01	0.26
Manager Education	0.09**	0.03	2.05	0.09*	0.03	2.00
External						
Cluster	0.63***	0.18	3.46	–0.06	–0.02	1.87
Access to External Finance	–0.00	0.00	–0.07	0.00	0.00	–0.35
Infrastructure Index	0.03	0.01	0.46	0.00	0.00	0.02
Policy Index	–0.02	0.00	–0.24	–0.01	0.00	–0.15
Macro Environment Index	–0.01	0.00	–0.18	–0.01	0.00	–0.15
Medium * Cluster	–	–		0.96**	0.32	2.38
Large * Cluster	–	–		0.88*	0.32	1.74
Constant	–2.15***	–	–7.34	–1.64***	–	–4.79

*** p<0.01, ** p<0.05, *p<0.1.

Trade status of the firm turns out to be insignificant in increasing firm's likelihood of innovating. Literature identifies two possible channels through which trade status is linked with innovation. One is it that entry into international markets allowed easier diffusion of foreign technology and hence led to innovation. Alternatively it could be the case that innovating firms as a result of it are able to become more competitive thereby allowing them to break into the export markets. Given the insignificance of trade status clearly for the sample under study the first channel does not hold. However, a look at raw data suggests that the latter channel might be working in Pakistan since the number of exporters within the innovating firms doubled between 2002 and 2007 while for non-innovating firms there was no change. But to establish this casual link one obviously needs to investigate more rigorously

Further Growth is insignificant which is not surprising given the fact that the period for which we are taking the growth rate is 1999-2002 which we all know was one of the worst time periods for the country's manufacturing sector. Also, literature finds that private firms may be more likely to innovate compared to public sector firms but we get an insignificant relation.

On the external side, presence of the firm in a cluster increases the probability of innovation by 18 percent. However, all variables capturing the business climate in which the firm operates come out to be insignificant. This might be attributable to the perceptions based nature of the data used in the construction of these indices as these perceptions may not be accurately representative of the true environment in which the firm operates.

While presence in a cluster is significant in determining innovative activity but this impact may vary according to a firm's size. Therefore we augment Equation (2) by introducing size-cluster interactions. We find that mere presence in a cluster is not enough in determining innovative activity. This is evident from the fact that cluster is no longer significant once the size-cluster interactions are incorporated in the model. Results (Table 3) suggest that for the sample of firms under study, medium (large) firms in a cluster are 17 percent (47 percent) more likely to innovate compared to firms of the same size not located in a cluster. Medium firms per se do not have an advantage over small firms in innovating. It is only when medium firms are located in a cluster that their probability of innovating significantly increases relative to other small and medium firms outside of cluster as illustrated by the insignificant coefficient on the medium dummy. However, large firms still have an advantage over small firms outside of a cluster as evident by the significance of the dummy indicating a large firm and this advantage further increase with presence in a cluster.

Further, Equations (3) and (4) were estimated and results are in Table 4. A comparison of results by product and process innovators shows that both types of innovative activity is more or less determined by the same set of explanatory variables. This is also in line with literature that establishes the linkage and closely connected nature of both product and process innovations [for e.g. Martinez-Ros (1999)]. The one noteworthy difference is the significance of presence in a cluster. While this variable is insignificant for process innovators it is significant and positive for product innovators. This is in line with the inherent difference between these two types of innovative activities as discussed above. Product innovation being a more visible change in the organisation compared to the introduction of a new or improvised process is likely to benefit more from the knowledge spillovers that is a characteristic of being in a cluster.

Table 4

Maximum Likelihood Probit Estimates by Product and Process Innovators

	Product Only			Process Only		
	Coefficient	Marginal Effects	t-stat	Coefficient	Marginal Effects	t-stat
Internal						
Trade Status	–0.14	–0.04	–0.71	–0.13	–0.03	–0.64
Medium Size	0.47*	0.13	2.30	0.49**	0.12	2.26
Large Size	1.23***	0.43	4.43	1.18***	0.40	4.13
Growth Rate	0.00	0.00	–0.02	0.00	0.00	0.66
Private Limited	–0.01	0.00	–0.06	0.07	0.02	0.39
Manager Experience	0.01	0.00	1.13	0.04***	0.01	2.73
Manager Education	0.10*	0.03	2.05	0.11**	0.03	2.26
External						
Cluster	0.39*	0.10	2.15	0.06	0.01	0.33
Access to External Finance	0.00	0.00	–1.10	0.00	0.00	0.55
Infrastructure Index	0.00	0.00	0.00	0.00	0.00	0.00
Policy Index	–0.05	–0.01	–0.74	0.02	0.00	0.24
Macro Environment Index	0.00	0.00	0.08	–0.05	–0.01	–0.77
Constant	–2.00***	–	–6.65	–2.15***	–	–6.88

*** p<0.01, ** p<0.05, *p<0.1.

5. POLICY IMPLICATION AND CONCLUSION

The objective of this study was to explore the determinants of innovative activity for a sample of manufacturing firms in Pakistan. Operational definition of innovation used in this study refers to the introduction of a new product and/or process in the past three years by the firm. To account for simultaneity bias between innovation and various explanatory variables such as growth of the firm, trade status etc., the study uses characteristics of the firm prior to undertaking innovation.

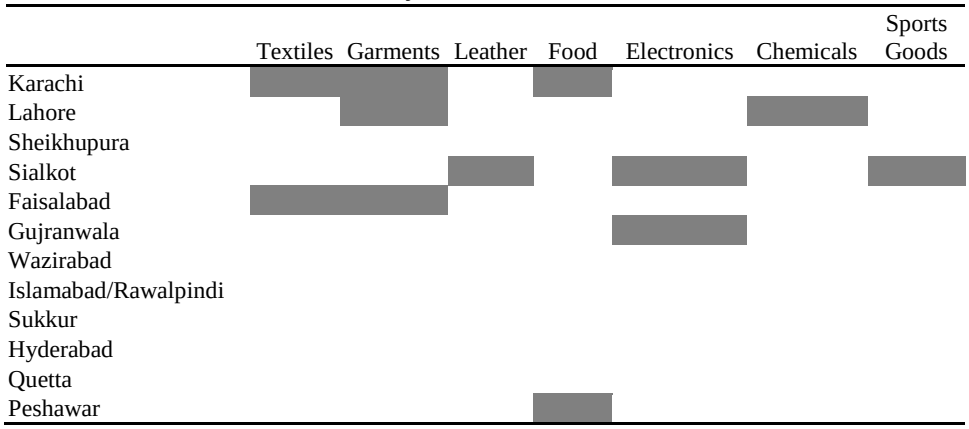
Key findings are that size of the firm, presence in a cluster and management quality are important determinants for the sample of manufacturing firms under study. This points to the need for firm level investment in good quality management and broadly for investment in human resources in the country. Further, there is a need to encourage natural clusters the same as industrial estates since there exists strong policy as far as industrial estates are concerned but not much focus towards natural clusters at present.

Finally, there is casual/anecdotal evidence which suggests that there is a lack of organic growth of firms over time in the country. Our findings suggest that medium and large firms have a clear advantage over small firms and so there is a need to facilitate growth of small firms. Interestingly, the advantage of a medium firm over a small firm is subject to the presence of that firm in a cluster while a large firm is not subject to such constraints but the likelihood of innovating increases further when part of a cluster.

Data constraints did not allow the market structure dimension to be studied and future studies can explore this aspect which can provide further insights into the drivers of innovative activity in the industrial sector.

APPENDIX-A

Industry—Location Clusters



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