What Determines Innovation in the Manufacturing Sector? Evidence from Pakistan

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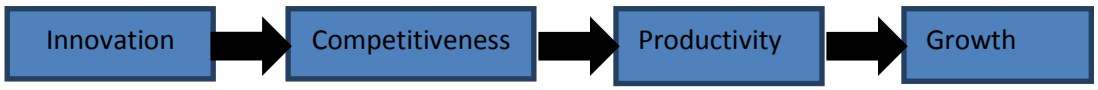
1. Introduction

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). For instance, Crespi (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 industrialized 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 othersVan Leeuwenand Klomp, 2006; Polder et al.,2009;Mairesse and Robin,2010; Janz et al.,2003)

Figure 1: Innovation as a Driver of Growth



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[2]. An interesting dimension of his finding is the positive link between size of firm particularly large firms, innovation and productivity.

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 criticized 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.

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

According to Becheikh et al.(2006)a review of empirical studies on innovation from 1993 to 2003 reveals that 81% of the authors investigated process, product or both types of innovative activity. This definition stems from the Oslo Manual[3] where innovation refers to the introduction of a new product or process over the past three years. 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.

Pakistan continues to exhibit poor performance in this domain. According to the Global Competitiveness Report 2011-2012, Pakistan ranks at 118thout of a total of 142countries.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 behavior 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

[3] 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.

themanagement of the firm like training,educational background and experience of the managers and entrepreneurshave 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).

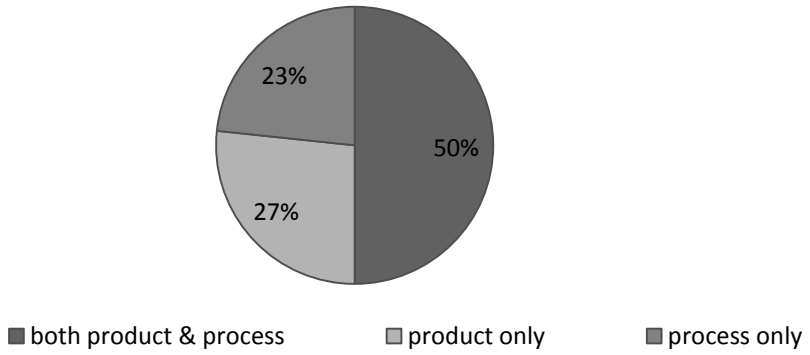
The remainder of the paper is organized as follows: Section 2 describes the data and presents basic summary statistics; Section 3 the methodology and the estimation strategy; results are discussed in section 4 and section 5 concludes the paper.

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 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, labor 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%) 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% of firms introduced a new product and/or process over the last three years.The innovation rate of 26.7% 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).

Figure 2: Innovators by type

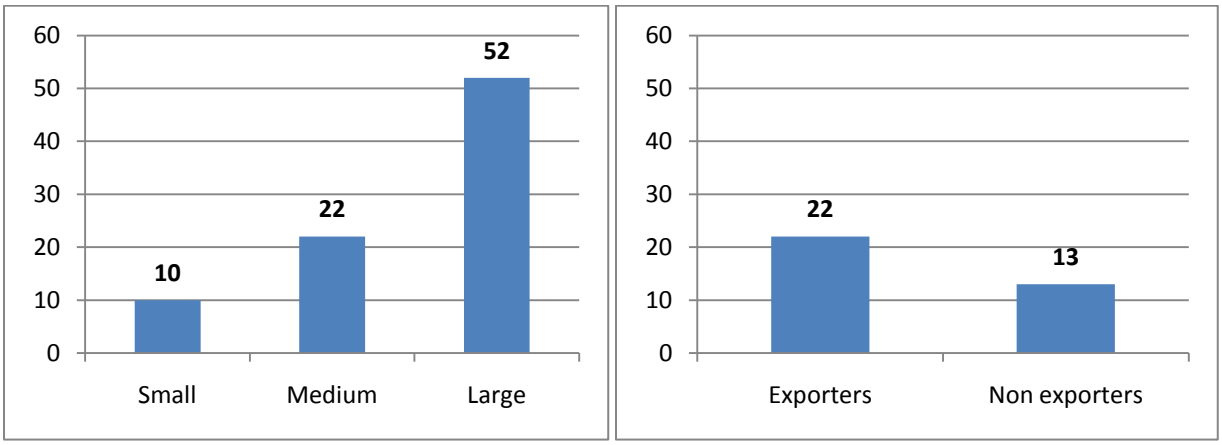


Raw data suggests that there are significant differences in innovations rates across both internal and external characteristics. Internally, both product and process innovations rates differ significantly by a firms size, and trade status. Large firms are 5 times more likely to innovate in the 2004 to 2007 period than a small firm[4]. Also, exporters are twice as likely to introduce a new product and/or process over the same time period (Table 1). When innovation by product and process was separately studied, percentage of innovators was fairly consistent across both firm

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

size and trade status. 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.

Figure 3: Innovation Rates by Size and Trade Status (%)



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

Externally, innovation rates differ substantially across industry and region (Table 1&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% 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	27.0	25.0
Machinery & equipment	0.0	0.0
Chemicals	27.3	27.3

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

Electronics	16.7	16.7
Leather & Leather products	13.0	13.0
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	29.0
Sheikhupura	0.0	0.0
Sialkot	18.6	11.4
Faisalabad	11.9	13.4
Gujranwala	2.0	2.0
Wazirabad	9.1	9.1
Islamabad/Rawalpindi	0.0	0.0
Sukkur	25.0[6]	25.0
Hyderabad	0.0	0.0
Quetta	0.0	0.0
Peshawar	15.2	9.1

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

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 endogeniety 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

[6] While the percentage seems very high, there are only eight firms that have been surveyed from this location.

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:

$$I_{jt} = \alpha_0 + \sum \boldsymbol{\beta_i} \boldsymbol{X}_{jt-1} + \sum \boldsymbol{\gamma_i} \boldsymbol{Y}_{jt-1} + \varepsilon_0 \qquad (1)$$

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 characterized 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. $\boldsymbol{X}_{jt-1}(\boldsymbol{Y}_{jt-1})$ is a vector of internal (external) characteristics that the firm *j* had in 2002. Finally, α_0, β, γ are parameters while $\varepsilon_0$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 organizational 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 organization. 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 industry. Organizational form of the firm has been captured by including a dummy variable which equals 1 if a firm is a private organization 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% of the firms in a particular industry in the sample are located[7].

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[8]. These can be broadly categorized 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 constraintto the firm's operation.

Literature points to the possibility of certain industries having more room for innovating behavior than others because of a higher level technological dynamism (Evangelista et al, 1997; Kam et al., 2003). Therefore, the industry to which you belong is likely to impact the probability of innovating. This is captured by the inclusion of industry specific dummies.

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:

$$Prob(I_{jt} = 1|X, Y) = \alpha_0 + \sum \boldsymbol{\beta_i} \boldsymbol{X}_{jt-1} + \sum \boldsymbol{\gamma_i} \boldsymbol{Y}_{jt-1} + \varepsilon_0 \qquad (2)$$

[7]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.

[8]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

Existing studies showthat product innovations tend to have a different set of determinants compared to process innovations despite their close link[9]. 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:

$$Prob(Prod_{jt} = 1|X, Y) = \alpha_0 + \sum \boldsymbol{\beta_i} \boldsymbol{X}_{jt-1} + \sum \boldsymbol{\gamma_i} \boldsymbol{Y}_{jt-1} + \varepsilon_0 \qquad (3)$$

$$Prob(Proc_{jt} = 1|X, Y) = \alpha_0 + \sum \boldsymbol{\beta_i} \boldsymbol{X}_{jt-1} + \sum \boldsymbol{\gamma_i} \boldsymbol{Y}_{jt-1} + \varepsilon_0 \qquad (4)$$

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) thatof the internal characteristics trade status, size and quality of human capital are significant in explaining innovation. The probability of innovation is 15% higher for exporting firms and medium(large) firms are 17.5%(48.6%) more likely to innovate

[9] 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)

compared to small firms. Further, the quality of human capital in the organization appears to have a significant but small impact. This is evident from the positive and statistically significant coefficients on top manager's experience (0.6%) and education (2.8%).

Interestingly, the growth of the firm in the period preceding the decision to innovate is insignificant in explaining the subsequent innovation. Further, organizational form as well as the degree of external financial access is also insignificant.

On the external side, presence of the firm in a cluster increases the probability of innovation by 11.2%. 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 24.2% (38.7%) more likely to innovate compared to firms of the same size not located in a cluster. Finally, medium firms outside of a cluster have no advantage over a small firm with regards to innovative activity as illustrated by the insignificant coefficient on the medium dummy.

Table 3: Maximum Likelihood Probit estimates for Innovators

	Innovator (1)	***Marginal effects***	***Innovator (2)***	***Marginal effects***
Trade Staus	0.569*	0.149	0.589*	0.153
	(-1.77)		(-1.81)	
Medium Size	0.558***	0.174	0.162	0.051
	(-2.870)		(-0.58)	
Large Size	1.334***	0.466	0.855**	0.309
	(-4.98)		(-2.51)	
Cluster	0.357**	0.112	-0.233	-0.073
	(-2.2)		(-0.72)	
Growth Rate	-0.00133	-0.004	-0.00127	-0.0004
	(-0.17)		(-0.17)	
External Finance	0.000	0.000	0.000534	0.0001
	(-0.01)		(-0.14)	
Private Limited	0.0402	0.013	0.0485	0.015
	(-0.24)		(-0.29)	
Manager Experience	0.0206*	0.006	0.0178	0.006
	(-1.66)		(-1.43)	
Manager Education	0.0912**	0.029	0.0837**	0.026
	(-2.02)		(-1.85)	
Infrastructure Index	0.0203	0.006	-0.00612	-0.002
	(-0.32)		(-0.09)	
Policy Index	-0.00274	-0.001	0.00438	0.001
	(-0.04)		(-0.07)	
Macro Environment Index	0.00781	0.002	0.0155	0.005
	(-0.13)		(-0.26)	
Medium * Cluster	--	--	0.702*	0.242
			(-1.86)	
Large * Cluster	--	--	1.040*	0.388
			(-2.04)	
Constant	-2.433***	--	-2.070***	--
	(-5.83)		(-4.69)	
N	359		359	

t statistics in parentheses, *** p<0.01, ** p<0.05, *p<0.1

Further, equation (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 eg 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 radical change in the organization 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 (1)	***Marginal effects***	***Process (2)***	***Marginal effects***
Trade Staus	0.361	0.087	0.435	0.093
	(1.14)		(1.24)	
Medium Size	0.480**	0.132	0.468**	0.119
	(2.37)		(2.17)	
Large Size	1.216***	0.423	1.134***	0.378
	(4.48)		(4.09)	
Cluster	0.400**	0.110	0.0621	0.016
	(2.39)		(0.36)	
Growth Rate	0.00140	0.0004	0.00458	0.001
	(0.18)		(0.58)	
External Finance	-0.00451	-0.001	0.00260	0.001
	(-1.04)		(0.70)	
Private Limited	-0.00385	-0.001	0.0624	0.016
	(-0.02)		(0.35)	
Manager Experience	0.0135	0.004	0.0335***	0.009
	(1.05)		(2.62)	
Manager Education	0.101**	0.028	0.108**	0.028
	(2.13)		(2.23)	

Infrastructure Index	-0.00746	-0.002	-0.00302	-0.001
	(-0.11)		(-0.05)	
Policy Index	-0.0392	-0.011	0.0216	0.006
	(-0.58)		(0.32)	
Macro Environment Index	0.0174	0.005	-0.0336	-0.009
	(0.28)		(-0.53)	
Constant	-2.318***	--	-2.561***	--
	(-5.58)		(-5.55)	
N	359		359	

t statistics in parentheses, *** 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.

Size of the firm is found to be an important factor in determining the probability of innovating – large and medium firms have a much a higher probability of innovating than 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. Findings also suggest that firms which were exporting were subsequently more likely to introduce new products and/or processes.

The composition of industrial production in Pakistan has been largely unchanged since the 1970s[10]. The country seems to be stuck at the low end of the technology ladder while other Asian countries (such as Malaysia, Thailand, People's Republic of China, Vietnam etc.) which have exhibited tremendous growth recently have done so by a transition from low technology to high technology production (Felipe, 2007). What has made this transition possible has been successful innovation leading to introduction of new sophisticated products and processes as well as up gradation of existing processes.

The findings of this study can provide important insights for policy makers and stakeholders in the industrial sector for emulating the success of these Asian countries. Industrial estates which give rise to industry concentration can be a key ingredient to encouraging innovative activity particularly for medium sized firms. Also, incentives to small firms which allow them to grow can prove to be important since size proves to be an important factor in likelihood of innovating.

Moreover, being part of the international market provides a promising channel for encouraging firms to engage in innovative activity. Therefore a pro-active trade policy geared towards removing barriers to exportingwhich exist in the country such as those pertaining to quality, marketing, distribution channels etc can be helpful.In order to compete in global markets, these firms will have an incentive to invest in R&D in order to produce new products as well as introduce international best practices in their process of production.

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.

[10] See table 3 on page 15 (Felipe, 2007)

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