© *The Pakistan Development Review*
56:2 (Summer 2017) pp. 105–126

The Employment Effect of Innovation: Evidence from Bangladesh and Pakistan

ABDUL WAHEED

The analysis of the impact of innovation on employment growth is an important topic for policy-makers. Unemployment is an important social topic, and the effects of innovation on employment are often poorly understood. Despite the significance of this relationship, very few studies on this topic are yet available for developing countries compared with the developed ones. This paper contributes to this scant literature by investigating the employment effects of innovation for two South Asian developing countries: Bangladesh and Pakistan. We further analyse whether this relationship shows country-specific and industry-specific differences.

Our analysis shows that both product and process innovation spur employment in this region as a whole, in both low-tech and high-tech industries, even after controlling for a number of firm-specific characteristics. Moreover, although both innovation types also have significant, positive impacts on employment growth of all Bangladeshi and of all Pakistani firms separately, they are important factors for employment growth of only high-tech Bangladeshi firms and of only low-tech Pakistani firms. Contrary to most previous studies, we witness an insignificant effect of growth of labour cost on employment growth, perhaps due to the availability of cheaper labour force compared with the developed countries. We notice that some of the innovation determinants exert different influences across industries and across both countries. The same holds true for the determinants of employment growth.

JEL Classification: J23, O31, O33
Keywords: Bangladesh, Employment Growth, Pakistan, Product Innovation, Process Innovation

1. INTRODUCTION

The impact of technological innovation on firm performance can primarily be observed in two ways: the productivity impact of innovation and the effect of innovation on employment.[1] The former is mainly an area of interest for managers/industrialists, while the latter is crucial for policy-makers. The effect of technology on firm productivity is a relatively straightforward phenomenon and often shows a positive link [Geroski, *et al.* (1993); Lööf and Heshmati (2006); Koellinger (2008); Hall, *et al.* (2009)], but the relationship between innovation and employment growth is a complex one.[2] One of the reasons for this complexity is the variety of channels through which both product and process innovation can affect employment growth. Although both types of innovations often coexist, the motivation and implication to have them in place are rather different.

Abdul Waheed <a.waheed@ucp.edu.pk> is Assistant Professor, University of Central Punjab, Lahore, Pakistan.

[1]Innovation can affect both the quantity and quality of employment (skill-biased technical change paradigm). The latter is beyond the scope of this paper.

[2]A very good survey of studies on the innovation-employment relationship can be found in Pianta (2005), Vivarelli (2007), and Chennells and Van Reenen (1999).

One of the desired effects of product innovation is the market expansion[3] (especially when the new product is not a direct substitute of an old one), demanding more labour force. If the innovating firm is a first-mover and launches a radically new product into the market, which is difficult to imitate by latecomers and if it also protects the product through exclusivity rights (e.g., patents, trademarks, etc.), the innovating firm can operate from a monopoly position. The employment effect of product innovation may then be negative, because the monopolist may restrict output and instead raise prices. Process innovations often reduce the amount of labour needed since they are operationalised to make more efficient production processes to obtain the same output with lower cost or less labour (per unit), suggesting a negative impact of process innovation on labour demand. The cost reduction may eventually translate into price reductions, especially in a competitive environment depending on the price elasticity of demand; this may cause an increase in product demand. This demand shift would induce the firm to expand its production which entails an increase in workforce, counterbalancing the "displacement effect" of process innovation. The expansion-related effect of product innovation (compensation effect) may dominate its "displacement effect". This might be the reason why studies generally postulate a positive impact of product innovation on employment growth [Hall, *et al.* (2008); Harrison, *et al.* (2008), inter alia]. However, it is hard to determine unequivocally which effect of process innovation dominates; this explains the empirically mixed findings regarding the link between process innovation and employment.

Comment [T1]: Note comments below, two sources of expansion have not been defined

Comment [T2]: automated or mechanised

Whether technology creates or destroys jobs is a highly investigated topic in the developed world, but very few studies on developing countries exist hitherto.[4] The apparent differences among national innovation systems (NISs) of developed and developing countries and their different economic and societal paradigms assert that the sources, motivations, and implications of innovation (and/or of imitation) differ between both regions. Hence, it is not justifiable to derive conclusions for developing countries on the basis of the outcomes of studies on the innovation-employment relationship for developed countries. And the issue needs to be addressed in the particular context of the developing world. It is also important for developing countries' policy principles to investigate thoroughly which effects innovations have on employment.[5] Hence, this study contributes to this field by investigating whether innovation creates or destroys jobs in the developing countries.

More specifically, we investigated the employment effect of innovation on two South Asian developing economies (Bangladesh and Pakistan) by using the World Bank enterprise survey conducted in 2006-07. As Bogliacino and Pianta (2010) pointed out, one of the problems of the existing literature on innovation and employment is its reliance on the assumption that the employment effect of innovation is uniform across industries. We investigated this relationship for low- and high-tech industries separately,

[3]There are two sources of expansion: innovation may increase product demand in the same product market or may open entirely new markets for the innovator.

[4]One reason for this scarcity is data-driven.

[5]Unemployment, of course, is a problem which developed countries also face, and currently some of them have higher unemployment rates than developing countries. However, developed countries' policy-makers can address this problem, in the short and long run, more aptly with the help of social security benefits, etc. Therefore, the societal problems related to unemployment are more severe in developing countries.

for all firms for each country, to ascertain whether disparities of the employment effect of innovation exist between the sectors.

In the empirical analysis we principally follow Van Reenen's (1997) model, with some modifications since he originally used it in a panel data setting, while we have a cross-sectional data set. We also expanded Van Reenen's specification by including control variables to disentangle the complexity of the innovation-employment relationship more aptly. While observing the relationship of innovation and employment, the endogeneity of innovation could distort the findings of the econometric analysis. We address this endogeneity by applying the appropriate estimation methods. Our results strongly indicate both product and process innovation as factors driving employment growth in Pakistan and Bangladesh as a whole. However, in the low and high tech sectors, we observed differences across the two countries.

This paper is organised as follows: Section 2 describes the findings of past studies. The model is specified in Section 3, while Section 4 discusses the dataset and descriptive statistics. The results of the empirical analysis are presented and discussed in Section 5. Section 6 concludes the paper.

2. LITERATURE REVIEW

The question whether technology creates or destroys jobs is not a new topic. At the beginning of the industrial revolution in the mid-18th century, it was feared that the introduction of machinery would be detrimental to employment.[6] In the chapter "On Machinery" Ricardo (2001) retracted his previous position and propagated the negative effects of technology on employment. Further evolution of the theoretical and empirical framework led analysts to investigate the technology-employment connection more tightly focused, i.e., in terms of the innovation-employment nexus.

The effect of innovation on employment involves a plethora of intricacies, which makes this relationship difficult to understand unequivocally. However, it is not unreasonable to believe that technological innovation influences employment growth through its labour saving (displacement effect) and/or market expansion (compensation effect) effects. It is difficult to determine the dominance of one effect over the other, especially regarding process innovation because it heavily depends on the specific context in which it occurs. These complexities require more research to understand the innovation-employment connection thoroughly and establish a consensus. One possible method to resolve the disagreement is to disentangle the process and the product innovation and to define a clear distinction between them to investigate their impacts on employment [Smolny (1998); Edquist, *et al.* (2001), among others]. Although the relationship is complex, most empirical studies confirmed a significant, positive influence of product innovation on employment, whereas the link between process innovation and employment is observed to be varied. One strand of the literature showed a positive relationship, whereas the other argued a negative association. The studies have also found the relationship between process innovation and employment growth to be insignificant.

Using two consecutive waves of the Community Innovation Survey (CIS) (CIS2 and CIS3) for ten European countries, Mastrostefano and Pianta (2009) concluded that

[6]See Rothwell and Zegveld (1979) for industry-level case studies analysing the impact of mechanisation on employment.

new products' sales (both in levels and in percentage changes) are a significant, positive determinant of employment change, along with a positive (negative) influence of demand (wages). In addition, they found that the proportion of innovative firms (usually process innovation was dominant) has a significant, positive impact on employment change; however, increasing this share contributes nothing towards employment change. With data from four European countries, Harrison, *et al.* (2008) divided firms' sales into two mutually exclusive groups: sales of new products (product innovation) and of old ones and introduced a process innovation dummy. They proposed a model relating these innovation measures to employment growth. They found a strong, positive relationship between product innovation and employment, but the effect of process innovation was not as clear as the effect of product innovation. The study of Brouwer, *et al.* (1993) conducted on Dutch firms showed that R&D intensity has a negative (but insignificant) impact on employment growth between 1983 to 1988, while the effect of growth of R&D intensity for the same period is significant and negative. They further considered only product-related R&D and found a significant, positive influence on employment growth. Regarding firm-specific characteristics, the relationships between employment and sales growth (1982-1983) and between employment and firm size is significant and positive and significant and negative respectively.

Freel and Robson (2004) showed that the share of technologists/scientists has a positive influence on employment growth of manufacturing firms in Scotland and Northern England, whereas an increase of professionals/managers in service firms decreases their employment growth. Moreover, product innovation significantly increases employment in both sectors (manufacturing and service); however, the effect of process innovation is insignificant. The work of Antonucci and Pianta (2002) on eight main EU economies revealed that the effect of total innovation expenditure (per sales) on employment demand is negative and mixed in terms of significance (they analysed it in different specifications). Using different proxies for innovation, the general picture of the significance of product and process innovations that arises is that the former has a positive and the latter has a negative effect, although both are mostly insignificant. They further calculated that a positive change in demand (proxied by the value added) induces a positive employment change, while the effect of labour cost is significant and negative.

By utilising the data of 31 two-digit German manufacturing firms, Ross and Zimmermann (1993) reported labour saving technological progress as one of the significant determinants which hinder labour growth, alongside insufficient demand and labour costs. Smolny (1998) developed a theoretical model and applied it to West German manufacturing firms revealing that both product and process innovation are conducive to employment. Doms, *et al.* (1995) observed the effect of advanced manufacturing technologies (process innovations, e.g. computer-controlled machines, lasers, robots, etc.) on employment growth between 1987 to 1991 for firms in the United States, after correcting for the selectivity bias attributable to firms' exit. Their empirical findings suggest that the use of advanced technologies and capital intensity (measured by the capital-labour ratio) is significantly and positively correlated with employment growth and negatively associated with firm exit. Moreover, the effects of capital intensity are not affected by the inclusion of other controls, but the technology-related outcomes are sensitive to firm size. The positive effect of introduction of new technologies on employment in case of Australia and the UK can be found in Blanchflower and Burgess (1998).

The study of Vivarelli, *et al.* (1996) for Italian manufacturers showed a modestly positive effect of total innovation costs on the use of labour. But their further split of innovation variable into different innovation characteristics revealed that R&D expenditure (design and engineering expenditure) has a significant, positive (negative) impact on employment. The effect of process innovations was found to be significant and negative.

The relationship between innovation and employment has been analysed extensively in developed economies, but we can only find very few studies on developing countries. Benavente and Lauterbach (2008) found a significant, positive impact of sales of new products (product innovation) on the employment growth of Chilean firms, but the effect of process innovation appeared to be insignificant. The study of Meriküll (2010) on Estonian enterprises revealed that innovation is an important determinant of employment, when he did not distinguish between product and process innovation. When he made that distinction, he found that both product and process innovation exert a positive effect on employment, but only the impact of process innovation is a significant one. A significant and positive influence of innovative activities (R&D and patents) on employment demand of Taiwanese manufacturing firms can be found in Yang and Lin (2008). Their analysis of splitting patents into both product and process patents showed that both can translate into significant employment growth. The analysis of employment effects of innovation of Costa Rican manufacturing firms conducted by Monge-González, *et al.* (2011) revealed that both product and process innovation are conducive to employment growth.

3. THE MODEL SPECIFICATION

In this section we propose a model to investigate the innovation-employment relationship strictly in a firm-level cross-sectional dataset.

Table 1 provides the definitions and notations of the variables used in this section and in our empirical analysis. To some extent, our model follows the specification of Van Reenen (1997) who derived a static panel data model of labour demand as:[7]

$$\log(employment_{it}) = \beta_1 innovation_{it} + \beta_2 \log(wages_{it}) + \beta_3 \log(capital_{it}) + \tau_t + e_{it} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where τ_t is a vector of time dummies and e_{it} is a white noise error term. We modified Equation (1) according to the cross-sectional nature of our dataset. Firstly, our model does not include the term τ_t for obvious reasons. Moreover, the panel data structure of Equation (1) connotes employment on the left hand side in terms of employment growth.[8] Hence, we defined employment growth in a traditional way and constructed our dependent variable as:[9]

[7] He also used the dynamic panel structure to include a lagged dependent variable. See Van Reenen (1997) for the derivation of 1.

[8] In addition to using employment levels and a lagged dependent variable, Van Reenen (1997) also utilised first differences which define the dependent variable in terms of employment change.

[9] We used only growth in permanent employment due to the unavailability of information pertaining to temporary employment in 2002-2003.

Table 1

Variables and Their Description

Variables	Descriptions
EGROWTH	Change in employment of full-time permanent workers (2002/03 – 2005/06)
WGROWTH	Change in cost of labour (including wages, salaries, bonuses, allowances etc.): from 2002/03 to 2005/06 for Bangladesh and from 2004/05 to 2005/06 for Pakistan
SALES	Total annual sales of a firm in 2005/06 (in log.)
AGE	Age of a firm in years
MATERIAL	Total annual cost of raw material per employee in 2005/06 (in log.)
PRODIN	Ratio of permanent production workers in permanent employment
LBUY	Dummy if a firm's principal buyer is a large firm with more than 100 employees in 2005/06
EXP	Ratio of export sales to total annual sales in 2005/06
IMP	Ratio of imports in total annual purchase of material inputs and/or supplies in 2005/06
INDZONE	Dummy if a firm located in industrial zone (park)
ASSET	Dummy if a firm purchases fixed assets (machinery, vehicles, equipments, land, or buildings) in 2005/06
WEB	Dummy if a firm uses website to communicate with its clients or suppliers.
TRAIN	Dummy if a firm runs formal training programs for its permanent employees in 2005/06
UNION	Dummy if a worker union exists in the firm
PDINN	Dummy if a firm introduces into the market any new or significantly improved product during the last three fiscal years
PRINN	Dummy if a firm introduces into the market any new or significantly improved production process, including methods of supplying services and ways of delivering products, during the last three fiscal year
PAK	Dummy if country is Pakistan

$$EGROWTH = \frac{employment_{2005/06} - employment_{2002/03}}{employment_{2002/03}} \quad \dots \quad \dots \quad \dots \quad (2)$$

We replaced fixed capital with raw material cost since our dataset misses a lot of information for the former. Hence, our employment growth model for the i^{th} firm has the following form:

$$\begin{aligned} EGROWTH_i = {} & \alpha_0 + \beta_0 innovation_i + \beta_1 WGROWTH_i \\ & + \beta_2 MATERIAL_i + \gamma Z_i + e_i \quad \dots \quad \dots \quad \dots \quad \dots \quad (3) \end{aligned}$$

We used PDINN and PRINN as innovation variables. In order to address the complexities of the innovation-employment association more rigorously, we extended Van Reenen's model by including a vector of control variables z_i with the corresponding coefficients vector γ. Our vector of control variables includes the following entries:

$$z = (EXP, IMP, LBUY, UNION, AGE, TRAIN)$$

In addition, all regression analyses include industry intercepts and, whenever needed, a country intercept to control for heterogeneities attributable to the different industry paradigms and to the differences between NISs of both countries.

Endogeneity of the innovation variables could exist through various channels. For example, if a firm anticipates an upward demand shift, it will increase its employment and innovate simultaneously to cope with this market expansion [Van Reenen (1997)]. Van Reenen addressed endogeneity by instrumenting innovation variables and using their lagged values, but we have cross-section data. Therefore, we first predicted our innovation variables by using corresponding probit regressions (we have all innovation variables in qualitative form) and used them as instruments in the employment growth equations.

4. DATA AND SUMMARY STATISTICS

The World Bank investment climate survey (enterprise survey) for manufacturing firms of two developing countries (Pakistan and Bangladesh), conducted in 2006-2007, is used for the empirical analysis in this paper. The dataset presents information of firms' innovation activities (of both process and product innovation) as dichotomous variables, along with a large range of other firm-level characteristics important for our analysis. After cleaning for non-responses and potential outliers, we were left with 2,085 firms in total, 62 percent of these are Bangladeshi. Moreover, our data set includes nine manufacturing industries aggregated at a two-digit level.[10]

A divide between low-tech and high-tech industries[11] reveals that we have 1,715 (82 percent) for the former and 370 firms (18 percent) for the latter, suggesting that this region's industrial structure heavily depends on low-tech sector. The distribution of low- and high-tech industries across countries shows that 77 percent of the 1,301 Bangladeshi firms are low-tech firms, while 90 percent of the 784 Pakistani firms belong to this industrial sector. This means that, according to our sample, while low-tech industries abound, the prevalence of low technology firms is higher in Pakistan than in Bangladesh. The survey collected all pecuniary information in local currency units. To achieve homogeneity and acquire comparable results, we converted all monetary variables into a common currency unit: USD.

Table 2 presents the descriptive statistics (averages) of variables for all firms and for Bangladesh and Pakistan separately. According to these statistics, 24.9 percent firms are reported to be product innovators, while the share of process innovators is 31.03 percent. When we consider innovation statistics across countries, Bangladeshi firms have a high proportion of both types of innovations compared with Pakistan: 33.13 percent vs. 12.32 percent for product innovation and 44.96 percent vs. 9.6 percent for process innovation. Contrary to Bangladesh and the whole region, the share of product innovating firms is slightly higher than that of process innovators in Pakistan.

[10]The industries are food, chemicals, garments, non-metallic minerals, leather, textiles, machinery and equipment, electronics, and other manufacturing. Since only 11 firms in this dataset fall in the category of non-metallic minerals industry and none of them is in Bangladesh. Therefore, for computational purposes, we merged these 11 firms into a broader industrial sector: other manufacturing.

[11]To split our sample into low- and high-tech industries, we followed the definition of the OECD. More specifically, chemicals, electronics, and machinery and equipment are categorised as high-tech, and the other industries fall into the low-tech sector.

Table 2

Summary Statistics

	All	Bangladesh	Pakistan
Product innovation (%)	24.9	33.13	12.32
Process innovation (%)	31.03	44.96	9.60
Employment growth (%)	16.24	22.54	10.02
Wage growth (%)	47.25	72.80	34.79
Permanent employment	199.12	264.39	90.38
Material cost per employee (000$)	7.35	5.13	11.09
Net book value per employee (000$)	10.78	28.94	5.93
Export intensity (%)	25.90	33.52	12.21
Import intensity (%)	25.78	34.97	11.69
Purchase of fixed assets (%)	39.27	52.11	17.90
Use of web (%)	25.24	26.13	23.75
Formal training (%)	16.15	21.07	8.59
Large buyer (%)	17.74	23.86	7.48
Workers' union (%)	9.10	11.09	5.79
Production workers intensity (%)	80.60	82.75	77.26

Change in cost of labour in Bangladesh is more than double that in Pakistan,[12] despite the fact that employment growth in Bangladesh at 22.54 percent is more than twice as high as the corresponding value of 10.02 percent in Pakistan. The cost of raw materials in Pakistan appears to be almost double than that of Bangladesh, suggesting that it is more likely to be a substitute than a complement of employment, especially in Pakistan. The average permanent employment in Bangladeshi firms is 264.39, which is considerably higher than the average employment of 90.38 in Pakistani firms. The average net book values show that on average Pakistani firms are worth $28,940, while the corresponding value for Bangladesh is $5,930. The descriptive statistics on human capital (employment and employment growth) and financial capital (raw material cost and net book value) reveal that Bangladeshi firms are more human capital-intensive, whereas Pakistani firms are far ahead in the latter category.

The proportion of Bangladeshi firms reported to purchase fixed assets is 52 percent, while only 18 percent Pakistani firms appear to conduct this kind of purchase. Bangladeshi firms are also more likely to use the internet, have workers' unions, run formal training programmes, and have large buyers than Pakistani ones; the disparities for the first two indicators are not as stark as the last two. The exports and imports are larger in Bangladesh than in Pakistan.

[12]Beware that these figures are not directly comparable, since time span for both countries are not same due to data limitations: wage change for Bangladesh was calculated from 2002-03 to 2005-06, while the values for Pakistan was calculated from 2004-05 to 2005-06.

Table 3 reports the descriptive statistics for low- and high-tech industries separately, for all firms and across both countries. For all firms taken together, both product innovation and process innovation occur more often in the high-tech than the low-tech sector. The wage growth and exports are higher in the low-tech than in the high-tech sector, whereas imports, firm age, material cost, and employment growth are higher in the high-tech than in the low-tech ones. Fixed asset purchase and internet usage are more likely in the high-tech sector, while the occurrence of workers' unions does not substantially differ between both industrial sectors. The descriptive statistics reveal that share of high-tech firms which run formal training programmes is 28 percent, which is almost twice as high as that of low-tech firms. The results for large buyers are the opposite: almost 20 percent low-tech and almost 10 percent high-tech firms have large buyers with more than 100 employees.

Table 3

Summary Statistics for Low-and High-tech Industries

	All		Bangladesh		Pakistan	
Variables	Low-tech	High-tech	Low-tech	High-tech	Low-tech	High-tech
Product innovation (%)	22.01	39.12	29.56	45.83	11.95	15.79
Process innovation (%)	28.14	45.00	42.58	53.41	8.94	15.79
Employment growth (%)	15.77	18.73	22.54	22.57	9.98	10.33
Wage growth (%)	47.81	43.15	80.36	36.79	33.33	48.88
Permanent employment	202.81	182	280.00	210.96	92.70	68.49
Age (years)	17.53	21.15	15.70	21.26	20.14	20.74
Material cost per employee (000$)	6.35	11.87	4.62	6.79	8.80	32.42
Export intensity (%)	30.35	5.96	42.02	4.40	12.23	12.04
Import intensity (%)	22.29	41.90	30.92	48.66	10.94	18.42
Purchase of fixed assets (%)	37.30	48.38	51.04	55.78	38.20	19.74
Use of web (%)	23.74	32.16	24.03	33.33	23.34	27.63
Formal training (%)	13.65	28.24	17.93	32.20	7.95	14.47
Large buyer (%)	19.48	9.73	28.16	9.18	7.01	11.84
Workers union (%)	9.09	9.19	11.84	8.50	5.13	11.84
Production workers intensity (%)	81.43	76.57	84.39	76.94	77.47	75.27

The last four columns of Table 3 depict these descriptive statistics for both countries. The results of the innovation-related variables reveal the same pattern as that for all firms. In addition, wage growth is substantially higher in Bangladeshi low-tech firms than in Bangladeshi high-tech ones, whereas the results are opposite in Pakistan with relatively less significant difference. Firms are older in Bangladeshi high-tech industries than in its low-tech firms. The statistics of this variable shows that they are almost the same for both sectors in Pakistan. The cost of raw material is higher in the group of high-tech industries for both countries; however the difference is much bigger in Pakistan than Bangladesh. All firms taken together, we noticed that employment growth is slightly higher in high-technology firms, but the corresponding point estimates across countries disclose that both sectors have almost the same employment growth in Bangladesh, while the Pakistani high-tech sector has slightly higher employment growth.

5. MICROECONOMETRIC ANALYSIS

As mentioned already, we used the predicted values of the innovation variables as instruments in the employment growth equations to avoid endogeneity problems. These predicted values were obtained from separate probit regressions of both product and process innovation.

5.1. Determinants of Innovation

Although the primary objective of the probit regressions is to obtain innovation instruments, the results are helpful, to acquire an insight into the innovation determinants in this region as well.

Table 4 shows the results of probit regressions of both types of innovations separately, for all firms and after splitting the dataset into low-tech and high-tech industries. For all firms taken together (reported in the first two columns), it is observed that firm size (sales) appears to be an insignificant determinant of product innovation and a significant, positive factor for process innovation. The exports significantly decrease the chance of product innovation and do not have an effect on process innovation. The variable capturing the import intensity is a significant, positive determinant for both innovation types. The factors captured by WEB (which could be a proxy for a firm's international exposure, especially in developing countries and a measure of internet use), purchase of fixed assets, and whether or not the firm is located in an industrial zone are important indicators of both types of innovations. Older firms are less likely to be process innovators than younger ones, whereas the effect of age on product innovation is statistically insignificant. Our results also disclose that an increase of production workers' share of the workforce decreases the likelihood of product innovation. Production workers are, in principle, hired for production purposes, not for innovation. The relative increase of production workers implies a relative decrease of non-production workers, e.g. administrators, managers, R&D personnel, etc., which are more responsible for innovation. Hence, the results that a decrease in non-production workers reduces the chances of product innovation are quite intuitive. Production workers' share of the workforce has an insignificant, negative impact on the occurrence of process innovation.

The demand side variable measured by LBUY[13] does not contribute to either product or process innovation. Recall that the descriptive statistics showed that Pakistani firms are less frequently innovators than Bangladeshi ones; this is confirmed econometrically since we obtained statistically significant and negative signs for the coefficients of the Pakistan dummy (PAK), for both types of innovations. A further split into low and high technology firms reveals more interesting results.

The findings of the low-tech sector almost follow the pattern we discussed above in the context of all firms. Two differences are as follows. The significant (although at 10 percent), positive (negative) impact of import (age) on process innovation vanishes. Recall that firm size (sales) does not contribute to low-tech firms' likelihood of product innovation, but it is an important determinant in the case of high-tech industries. One reason for this difference may be that high-tech firms are more R&D-intensive by

[13]Of course, our variable LBUY does not capture the "demand-pull" indicator used in the innovation literature. Hence, we cannot interpret the results of LBUY as an innovation effect of the demand-pull.

Table 4

Probit Regressions of PDINN and PRINN for All Firms
Robust SEs are in Parentheses

	All		Low-tech		High-tech	
Independent Variables	PDINN	PRINN	PDINN	PRINN	PDINN	PRINN
SALES	0.030	0.094*	0.007	0.072#	0.139*	0.203*
	(0.024)	(0.025)	(0.027)	(0.029)	(0.048)	(0.054)
EXP	–0.398*	–0.162	–0.395*	–0.129	0.592	0.660
	(0.122)	(0.120)	(0.130)	(0.127)	(0.500)	(0.592)
IMP	0.372*	0.193†	0.320#	0.205	0.351	0.011
	(0.110)	(0.109)	(0.128)	(0.125)	(0.230)	(0.237)
WEB	0.514*	0.405*	0.536*	0.373*	0.406#	0.486#
	(0.091)	(0.091)	(0.105)	(0.104)	(0.192)	(0.197)
ASSET	0.350*	0.410*	0.356*	0.421*	0.381#	0.465*
	(0.078)	(0.076)	(0.089)	(0.086)	(0.170)	(0.170)
PRODIN	–0.404†	–0.307	–0.473†	–0.446	–0.046	0.400
	(0.238)	(0.239)	(0.279)	(0.275)	(0.467)	(0.487)
INDZONE	0.355*	0.447*	0.350*	0.401*	0.475#	0.749*
	(0.084)	(0.086)	(0.095)	(0.096)	(0.192)	(0.199)
AGE	–0.004	–0.005†	–0.005	–0.004	–0.002	–0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.006)
LBUY	–0.038	0.110	–0.028	0.063	0.080	0.625†
	(0.101)	(0.098)	(0.110)	(0.105)	(0.300)	(0.333)
PAK	–0.619*	–1.195*	–0.594*	–1.224*	–1.034*	–1.416*
	(0.110)	(0.118)	(0.121)	(0.130)	(0.244)	(0.285)
Intercept	–0.887*	–1.456*	–0.552	–1.021*	–2.652*	–3.453*
	(0.337)	(0.351)	(0.380)	(0.390)	(0.709)	(0.782)
No. of obs.	1825	1826	1492	1493	333	333
Pseudo R^2	0.164	0.239	0.127	0.213	0.273	0.337

* Significance at 1 percent level # Significance at 5 percent level † Significance at 10 percent level.
Note: All regressions include industry dummies.

definition; it is generally believed that R&D induces innovation and that large firms undertake more formal R&D activities (through their R&D departments). There is a possibility that large firms' formal R&D activities translate more aptly into product innovations compared to small firms' R&D activities. Similar to low technology industries, firm size is beneficial for process innovation.

The results of WEB, ASSET, and INDZONE, follow the same pattern in low and high technology sectors, and showing significant, positive effects of these indicators on both types of innovations. The negative significance of PRODIN for low-tech industries' product innovation disappears in the high-tech sector, although the coefficient still has a negative sign. This means that the previously found effect of the production workers' share is not as strong in the high-tech as is in the low-tech sector. The insignificant, negative impact of firm age on both product and process innovation for low-tech firms also prevail for the group of high-tech firms, meaning that in both sectors firms innovate regardless of their age. Large buyers appear to be an influential determinant of high-tech firms' inclination towards process innovation, while these have no impact on their product innovation efforts.

The results of the probit regressions on PDINN and PRINN, for all Bangladeshi firms and for low and high technology Bangladeshi firms, are depicted in Table 5. Most of the results for all Bangladeshi firms are similar to those that were obtained for all Bangladeshi and Pakistani firms taken together (compare the first two columns of Table 4 with the respective columns of Table 5). We do not discuss the same findings but shed some light on the differences. The significance of imports as a predictor of process innovation of all firms disappears when we consider only Bangladeshi firms' process innovation. The significant, negative effect of the share of production workers in total permanent employment is also vanished. The negative effect of age is more prominent in case of Bangladesh than all firms taken together**.**

Table 5

Probit Regressions of PDINN and PRINN for Bangladesh
Robust SEs are in Parentheses

	All		Low-tech		High-tech	
Independent Variables	PDINN	PRINN	PDINN	PRINN	PDINN	PRINN
SALES	0.037	0.113*	–0.014	0.064†	0.155*	0.248*
	(0.029)	(0.028)	(0.037)	(0.034)	(0.053)	(0.058)
EXP	–0.443*	–0.173	–0.308†	–0.003	0.076	–0.138
	(0.148)	(0.139)	(0.164)	(0.151)	(0.557)	(0.600)
IMP	0.343*	0.105	0.274†	0.105	0.330	–0.043
	(0.123)	(0.117)	(0.145)	(0.136)	(0.246)	(0.259)
WEB	0.465*	0.326*	0.504*	0.257#	0.361†	0.532#
	(0.106)	(0.101)	(0.125)	(0.117)	(0.203)	(0.207)
ASSET	0.250*	0.302*	0.236#	0.295*	0.332†	0.431#
	(0.087)	(0.083)	(0.102)	(0.095)	(0.179)	(0.183)
PRODIN	–0.341	–0.231	–0.475	–0.442	0.214	0.740
	(0.286)	(0.281)	(0.355)	(0.346)	(0.484)	(0.499)
INDZONE	0.396*	0.454*	0.376*	0.395*	0.403†	0.656*
	(0.105)	(0.103)	(0.121)	(0.117)	(0.221)	(0.226)
AGE	–0.011*	–0.010*	–0.016*	–0.011#	–0.003	–0.008
	(0.003)	(0.003)	(0.005)	(0.004)	(0.006)	(0.006)
LBUY	–0.169	0.056	–0.161	0.033	–0.053	0.450
	(0.112)	(0.107)	(0.120)	(0.113)	(0.329)	(0.364)
Intercept	–0.858†	–1.586*	–0.073	–0.810	–2.928*	–4.073*
	(0.515)	(0.509)	(0.580)	(0.553)	(0.741)	(0.826)
No. of obs.	1152	1152	889	889	263	263
Pseudo R^2	0.102	0.092	0.074	0.054	0.189	0.258

* Significance at 1 percent level # Significance at 5 percent level † Significance at 10 percent level.
Note: All regressions include industry dummies.

Comparing the first two columns of Table 5 (all Bangladeshi firms) with the subsequent two columns of Table5 (low-tech Bangladeshi firms), we notice that all determinants of both innovation types of all Bangladeshi firms (column 1 and 2 of Table 5) and of low technology Bangladeshi firms (columns 3 and 4 of Table 5) are the same with respect to their coefficients' signs and statistical significance. Similar to the full dataset (Table 4), we discover some differences between the outcomes of high-tech and low-tech Bangladeshi firms and between high-tech and all Bangladeshi firms.

Contrary to low-tech Bangladeshi firms and similar to all high-tech firms, firm size (sales) increases the likelihood of product innovation. The significant, negative (positive) effect of exports (imports) on product innovation of all Bangladeshi firms and low-tech Bangladeshi firms becomes insignificant in case of high-tech firms**.** The factors captured by WEB, ASSET, and INDZONE increase the chance of both types of innovation activities for both low and high technology Bangladeshi firms, showing that the effects of these three determinants are similar to those that were observed for the low-tech and high-tech pool of both Bangladeshi and Pakistani firms.

The significance of the negative effect of low tech firms' age on innovations dissipates in the high-tech sector, though the coefficients are still negative. Large buyers exert a negative impact on product innovation in all and in low-tech Bangladeshi firms, and their relationship with process innovation is statistically insignificant in both cases. The previously found insignificant effect of large buyers is again established for the high-tech Bangladeshi firms. Our interpretation of this insignificant relationship is that the innovation in Bangladeshi firms is not large buyer demand-driven. A firm primarily sells products rather than processes to its buyers and large buyers provide an important boost for product demand. The negative coefficient of LBUY for product innovation as compared to positive coefficient for process innovation, although both are insignificant, might hint that this relatively large demand, in comparison with small buyers' demands, is mostly for non-innovating products.

The empirical findings of Pakistani firms are reported in Table 6. Because of the econometric issues, we were unable to carry out the analysis for high-tech firms by using trade orientation (exports and imports) as the predictor of process innovation. Hence, we skipped both exports and imports while performing the above mentioned analysis.

A comparison of these results with Bangladesh's results unveils some interesting differences. We fail to find a significant, positive relationship between firm size (sales) and both innovation types for all Pakistani firms and for both low- and high-tech Pakistani firms. Similar to Bangladesh, the significance of ASSET as an explanatory factor of both types of innovation is established for all Pakistani firms and for low-tech Pakistani industries but, differing from Bangladesh, Pakistani high-tech firms' purchases of fixed assets do not contribute to their innovations (neither product nor process). Throughout the results of Bangladesh PRODIN appears to be an unimportant factor for both types of innovation, but we observe that it substantially decreases the likelihoods of product and process innovation in high-tech Pakistani firms. Use of internet has a positive influence on PDINN and PRINN in all cases (i.e. all and low and high technology Pakistani firms), except for high-tech firms' product innovation. The empirical findings of Bangladesh reveal that firms located in industrial zones enjoy the benefits of a more formally embedded infrastructure and translate it into product and process innovation regardless which industrial sector they belong to. However, in the case of Pakistan this particular variable induces innovations only in the high-tech sector.

Another contradiction is that throughout Table 6 firm age appears to be an insignificant determinant of both product and process innovation. The only exception is for all firms' process innovation. Finally, contrary to Bangladesh, large buyers mostly (a possible proxy of firms' demand) encourage innovation in Pakistani firms, whether they are low-tech or high-tech.

Table 6

Probit Regressions of PDINN and PRINN for Pakistan
Robust SEs are in Parentheses.

	All		Low-tech		High-tech	
Independent Variables	PDINN	PRINN	PDINN	PRINN	PDINN	PRINN
SALES	0.043	0.023	0.050	0.041	0.633	0.068
	(0.045)	(0.055)	(0.048)	(0.060)	(0.425)	(0.120)
EXP	0.246	0.214	0.147	–0.004	5.398*	
	(0.228)	(0.270)	(0.241)	(0.286)	(1.608)	
IMP	0.723*	1.017*	0.625#	0.968*	2.510†	
	(0.248)	(0.266)	(0.267)	(0.284)	(1.432)	
WEB	0.539*	0.654*	0.488#	0.697*	2.816	2.611#
	(0.205)	(0.235)	(0.223)	(0.251)	(1.722)	(1.190)
ASSET	0.681*	0.915*	0.674*	0.944*	–1.114	–0.781
	(0.177)	(0.193)	(0.184)	(0.199)	(2.069)	(0.836)
PRODIN	–0.143	–0.110	–0.074	–0.023	–10.269#	–3.636#
	(0.275)	(0.354)	(0.162)	(0.186)	(4.788)	(1.685)
INDZONE	–0.155	0.067	–0.183	0.004	3.138*	1.708#
	(0.171)	(0.186)	(0.183)	(0.193)	(0.991)	(0.862)
AGE	0.007	0.010†	0.007	0.006	–0.037	0.014
	(0.006)	(0.006)	(0.006)	(0.006)	(0.047)	(0.022)
LBUY	0.771*	0.538#	0.797*	0.381	4.272*	2.229#
	(0.225)	(0.241)	(0.244)	(0.254)	(1.413)	(0.935)
Intercept	–2.221*	–2.664*	–2.310*	–2.793*	–8.037†	–1.189
	(0.509)	(0.671)	(0.514)	(0.671)	(4.296)	(2.623)
No. of obs.	670	664	603	594	67	71
Pseudo R^2	0.269	0.391	0.243	0.364	0.786	0.635

* Significance at 1 percent level # Significance at 5 percent level † Significance at 10 percent level.
Note: All regressions include industry dummies.

5.2. Innovation as a Determinant of Employment Growth

The primary objective of this paper is to investigate the innovation-employment connection. Before going further, it is worthwhile to note that, especially to enable comparisons with similar studies that our dependent variable is the employment growth of permanent employees instead of an employment growth of the whole labour force since our dataset does not have the information on the latter. However, we argue that our results might be more precise because innovation is a long term process, which requires the labour force on a permanent basis to carry out and take care of the innovative activities of a firm or which requires members of the permanent labour force to be dismissed/made redundant after innovation activities have been completed. We do not discard the fact that innovation may generate/destroy temporary employment, but we believe that this effect is significantly lower than the effect on permanent employment.

It is important to note that both innovation types are endogenous in employment growth equation and need to be instrumented. In the all subsequent regression analyses, the corresponding predicted values obtained from the regressions using both product and process innovation as dependent variables (results are discussed in the section 5.1) are used to proxy actual innovation variables, to address the problem of endogeneity.

Table 7 depicts the regression results of the analysis of employment growth determinants of all firms (both Pakistan and Bangladesh), for the full sample and for the low-and high-tech sector separately. We first inserted (the predicted values of) both PDINN and PRINN in a single employment equation and tested for multicollinearity, which was found at a significant level.[14] Hence, we entered these variables in separate employment equations to avoid collinearity.

Table 7

Employment Growth Equation for All Firms

Bootstrapped S.Es. are in Parentheses. Dep. var: EGROWTH

	All		Low-tech		High-tech	
Independent Variables	(1)		(2)		(3)	
PDINN	0.337*		0.244†		0.507	
	(0.111)		(0.132)		(0.338)	
PRINN		0.334#		0.306#		0.583#
		(0.133)		(0.146)		(0.237)
MATERIAL	–0.014#	–0.016#	–0.010	–0.013†	–0.027	–0.033
	(0.007)	(0.007)	(0.007)	(0.007)	(0.034)	(0.029)
WGROWTH	0.003	0.003	0.004	0.004	0.001	0.000
	(0.007)	(0.006)	(0.006)	(0.007)	(0.053)	(0.101)
EXP	0.112*	0.087†	0.092#	0.072†	0.284	0.276
	(0.040)	(0.046)	(0.036)	(0.037)	(0.317)	(0.303)
IMP	–0.106#	–0.090†	–0.073	–0.076	–0.203	–0.161
	(0.043)	(0.050)	(0.052)	(0.055)	(0.129)	(0.131)
Y	0.095*	0.077#	0.107*	0.094#	0.027	–0.040
	(0.032)	(0.039)	(0.036)	(0.039)	(0.166)	(0.162)
AGE	–0.000	–0.000	–0.000	–0.000	–0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0003)	(0.003)
UNION	–0.085*	–0.088#	–0.066†	–0.071#	–0.134	–0.165
	(0.032)	(0.034)	(0.034)	(0.030)	(0.157)	(0.135)
TRAIN	–0.030	–0.032	–0.019	–0.023	–0.086	–0.114
	(0.032)	(0.037)	(0.035)	(0.033)	(0.120)	(0.110)
PAK	–0.079#	–0.025	–0.068†	–0.004	–0.152	–0.092
	(0.037)	(0.044)	(0.037)	(0.052)	(0.109)	(0.103)
Intercept	0.207*	0.185*	0.173*	0.140*	0.402	0.346
	(0.059)	(0.058)	(0.061)	(0.051)	(0.292)	(0.274)
No. of obs.	954	954	833	833	121	121
coeff. of det.	0.114	0.115	0.114	0.117	0.148	0.166

* Significance at 1 percent level # Significance at 5 percent level † Significance at 10 percent level.

Note: All regressions include industry dummies.

If we consider all firms, the result is that both types of innovation have a significant, positive influence on employment growth, even after controlling for a number of firm-specific characteristics. The coefficients of cost of raw materials have negative signs with a statistical significance effect on employment growth. According to our results for all firms, wage growth does not have any effect on employment growth,

[14] It is observed that both types of innovations are often carried out simultaneously, and one of the primary reasons of this collinearity also is that PDINN and PRINN are predicted values obtained from the same model specification.

contrary to a negative effect often observed in the literature. Firms' export induces employment growth, whereas import has a significant, negative effect. This means that to fulfil export requirements, the companies need to hire more people. On the other hand, import of raw material does not complement, in fact substitute, employment. The likely explanation of this result coupled with the negative effect of material on employment growth is that when firms use their financial resources to arrange material inputs, they are reluctant to finance hiring of more people.

The literature often argues that an increase in demand for a firm's products translates into an increase in employment [Ross and Zimmermann (1993); Pianta (2001)]. Our demand side variable (LBUY), although is not a direct indicator of demand for firms' products but denotes that large buyers generate more demand than small ones, also shows a significant and positive influence on employment growth. A negative relationship of employment growth with firm age and with unionization was found by Variyam and Kraybill (1992) and by Blanchflower, *et al.* (1991) respectively. Long (1993), for Canadian firms, and Leonard (1992), for Californian manufacturing plants, also found that these factors hinder employment growth, especially in large firms. According to our results, it appears that the firm age does not have an effect on employment growth, whereas workers' union membership reduces employment growth. The possible reason for the negative impact of unionisation on employment growth could be that a firm's workers primarily take care of their own interest and have a fear of job losses or wage losses due to new employees, and exert pressure through the union to discourage job creation. A union's power to negotiate better conditions for workers (high wages, job security, high severance payments, etc.) may instigate a firm to be hesitant to increase employment.[15] The results for formal training show that it does not contribute to employment growth in our sample, contrary to the findings of Cosh, *et al.* (2000) who found a positive effect of training on employment growth.

Finally, the coefficients of the Pakistan dummy for both PDINN-included (the regression using PDINN as one of the determinants of employment growth) and PRINN-included (the regression using PRINN as one of the determinants of employment growth) equations are negative but the standard errors render them insignificant in case of PRINN-included equation and significant in the other equation. This result might be a hint for higher employment growth in Bangladesh which can also be observed by looking at descriptive statistics.[16]

A further analysis with the sample split into low- and high-tech firms shows that both innovation types are significant, positive predictors of employment growth for both industrial sectors, except for insignificance of product innovation for high-tech sector. The result patterns of wage growth, firm age, and training do not vary between both industrial sectors, and also follow the pattern of all firms taken together. Raw material cost is almost an insignificant determinant for both sectors. The effect of export is significant on low-tech firms' employment growth and insignificant for high-tech sector. The significant, negative effect of import for all firms taken together disappears in separate analyses on both sectors. The effects of large buyers and unionisation in the low-tech sector differ from those of the high-tech sector: large buyer is a significant, positive

[15]See Long (1993) for a number of arguments which shapes the union-employment relationship.

[16]However, more rigorous statistical analysis is needed to conclude this relationship.

and unionisation is a significant, negative predictor of low-tech firms' employment growth, but both are insignificant in the high-tech sector. The general picture is that, for both countries together, innovation induces employment, and many other determinants of employment growth are heavily influenced by the sector-specific factors.

The results of the separate analysis of Bangladeshi firms are shown in Table 8. Both innovation types appear to be important indicators of employment growth in all and high-tech Bangladeshi firms, but they lose their significance looking at low-tech firms separately (the signs are still positive and the magnitudes of the coefficients are reasonably high). Throughout the regressions for Bangladesh (Table 8), wage growth, firm age, and union status do not contribute to employment growth. The export encourages firms to generate employment, for all Bangladeshi firms taken together and for low-tech Bangladeshi firms. The general impression regarding the effect of imports is that it does not spur employment. Large buyers stimulate employment for all and low-tech Bangladeshi firms in case of PDINN-included equation, but this variable shows a significant, negative effect on employment growth in case of PRINN-included equation for high-tech sector. According to the results on formal training, this variable seems to have a significant and negative effect on employment growth.

Table 8

Employment Growth Equation for Bangladesh
Bootstrapped S.Es. are in parentheses. Dep. var: EGROWTH

	All		Low-tech		High-tech	
Independent Variables	(1)		(2)		(3)	
PDINN	0.424†		0.280		1.148$^{\#}$	
	(0.241)		(0.262)		(0.496)	
PRINN		0.466$^{\#}$		0.366		0.819$^{\#}$
		(0.228)		(0.325)		(0.379)
MATERIAL	–0.013	–0.024	0.004	–0.005	–0.135$^{\#}$	–0.135$^{\#}$
	(0.019)	(0.016)	(0.016)	(0.017)	(0.063)	(0.063)
WGROWTH	0.016	0.016	0.015	0.015	0.025	0.022
	(0.011)	(0.027)	(0.031)	(0.010)	(0.227)	(0.224)
EXP	0.162$^{\#}$	0.114†	0.140$^{\#}$	0.104†	–0.161	–0.003
	(0.072)	(0.061)	(0.071)	(0.055)	(0.710)	(2.019)
IMP	–0.159†	–0.139	–0.130	–0.127	–0.018	0.115
	(0.084)	(0.085)	(0.091)	(0.080)	(0.182)	(0.187)
UY	0.087†	0.052	0.109†	0.088	–0.199	–0.306†
	(0.046)	(0.066)	(0.060)	(0.062)	(0.217)	(0.176)
AGE	–0.000	–0.000	–0.001	–0.001	0.002	0.004
	(0.002)	(0.002)	(0.002)	(0.002)	(0.006)	(0.006)
UNION	–0.066	–0.072	–0.067	–0.070	–0.113	–0.100
	(0.046)	(0.056)	(0.050)	(0.049)	(0.251)	(0.202)
TRAIN	–0.088$^{\#}$	–0.092$^{\#}$	–0.085	–0.085†	–0.213†	–0.248
	(0.044)	(0.039)	(0.055)	(0.045)	(0.129)	(0.164)
Intercept	0.012	0.059	–0.092	–0.068	1.034†	0.963†
	(0.150)	(0.139)	(0.149)	(0.153)	(0.563)	(0.518)
No. of obs.	324	324	270	270	54	54
coeff. of det.	0.085	0.091	0.093	0.096	0.232	0.234

* Significance at 1 percent level $^{\#}$ Significance at 5 percent level † Significance at 10 percent level.

Note: All regressions include industry dummies.

The findings of the employment growth analysis for Pakistani firms are reported in Table 9. Similar to the previously observed findings of both countries together and of Bangladeshi firms only, both product and process innovation appear to be conducive and important determinants of employment growth of all Pakistani firms. However, we witness some differences between both countries regarding the industrial sectors: both innovation types are significant (insignificant) determinants of low-tech (high-tech) Pakistani firms’ employment growth, exactly the opposite of the result pattern of Bangladesh. This means that the effect of innovation on industry-specific employment growth largely depends on the prevailing national innovation systems (NISs), but inter-country differences are less important when we consider the employment effect of innovation as a whole.

Table 9

Employment Growth Equation for Pakistan
Bootstrapped S.Es. are in Parentheses. Dep. var: EGROWTH

	All		Low-tech		High-tech	
Independent Variables	(1)		(2)		(3)	
PDINN	0.255$^{\#}$		0.255$^{\#}$		0.811	
	(0.106)		(0.114)		(0.567)	
PRINN		0.157†		0.170†		–0.150
		(0.091)		(0.088)		(0.432)
MATERIAL	–0.014†	–0.015†	–0.014†	–0.015†	0.008	0.010
	(0.007)	(0.008)	(0.008)	(0.008)	(0.039)	(0.035)
WGROWTH	–0.001	–0.001	–0.001	–0.001	–0.005	–0.001
	(0.003)	(0.003)	(0.004)	(0.004)	(0.190)	(0.206)
EXP	0.094†	0.126$^{\#}$	0.043	0.072†	0.298	0.567
	(0.052)	(0.059)	(0.042)	(0.041)	(0.199)	(0.362)
IMP	–0.064	–0.041	–0.023	–0.010	–0.428	–0.206
	(0.048)	(0.043)	(0.041)	(0.044)	(0.293)	(0.188)
Y	0.063	0.102	0.017	0.063	0.186	0.388
	(0.063)	(0.070)	(0.038)	(0.039)	(0.336)	(0.451)
AGE	–0.001	–0.000	–0.000	0.000	–0.006	–0.005
	(0.001)	(0.001)	(0.001)	(0.001)	(0.005)	(0.005)
UNION	–0.108*	–0.118*	–0.101$^{\#}$	–0.098$^{\#}$	–0.057	–0.178
	(0.041)	(0.044)	(0.041)	(0.041)	(0.199)	(0.185)
TRAIN	0.042	0.061	0.045	0.052	–0.277	0.273
	(0.042)	(0.042)	(0.041)	(0.045)	(0.372)	(0.245)
Intercept	0.142$^{\#}$	0.151$^{\#}$	0.142$^{\#}$	0.148$^{\#}$	0.090	–0.093
	(0.059)	(0.063)	(0.060)	(0.064)	(0.317)	(0.393)
No. of obs.	627	621	563	554	64	67
coeff. of det.	0.062	0.073	0.048	0.051	0.416	0.332

* Significance at 1 percent level $^{\#}$ Significance at 5 percent level † Significance at 10 percent level.
Note: All regressions include industry dummies.

Higher material costs exhibit less employment growth in all Pakistani firms, meaning that in Pakistan human capital and raw material are substitutes rather than complements. This variable also has a significant, negative effect on low-tech firms’ employment growth but is insignificant for the high-tech sector. Throughout Table 9 we can see that wage growth do not contribute to employment growth.

Export by a firm contributes positively towards the employment growth of all firm taken together and does not have any effect for high-tech sector. The relationship of export with low-tech employment growth is somewhat significant. Surprisingly, in all cases large buyers (our crude proxy of product demand) are unable to stimulate employment, though the coefficients signs are positive. One reason might be that the percentage of large buyers in Pakistan is only 7.48, which is quite low compared to 23.86 percent in Bangladesh, suggesting that Pakistani firms have lower product demand than Bangladeshi ones at an aggregate level. Moreover, firm age appears to be an insignificant predictor throughout Pakistan's results. Unlike the insignificant unionisation effect seen in Bangladesh, unionised Pakistani firms show significantly less employment growth than those with a non-unionised workforce in case of all firms taken together and of low-tech industries. The insignificant relationship between unionisation and employment growth in Bangladeshi high-tech firms can also be found in the corresponding group in Pakistan. In all Pakistani cases (all firms and low- and high-tech sector) training and import are inconsequential predictors of employment growth.

6. CONCLUSIONS AND POLICY DISCUSSION

Albeit knowing whether innovation is conducive or detrimental to job creation in developing countries and is of paramount importance to policy making, very few studies have tried to explore this relationship. This paper contributes to this by analysing the phenomenon in two developing countries: Pakistan and Bangladesh. We examined if this relationship differs across countries or across low-tech and high-tech industries. In our empirical analysis, we took care of the endogeneity of innovation in the employment equation by using its predicted values as an instrument.

Firm size (sales) appears to induce process innovation in the region of analysis as a whole and for Bangladesh separately; however, it does not have an effect for Pakistan. Schumpeter's hypothesis that large firms are more likely to be product innovators is rejected for both countries combined as well as individually. High-tech firms' sales induce product innovation in both countries together and in Bangladesh, while this effect is neither industry-specific nor significant in Pakistan, suggesting a complementarity between large firm size and R&D activities (high-tech firms are more R&D-intensive by definition) in two former cases. The export in this region as a whole and for low-tech sector does not induce product innovation. Similar findings are obtained for Bangladesh. However, this negative effect is diminished for high-tech sector and for all cases in Pakistan. General impression is that import induces innovation, especially process innovation. We find evidence of a negative effect of production workers' share of a firm's workforce on product innovation of all firms which do not apply to the high-tech sector. Our interpretation is that a relative decrease in non-production workers (who are more likely to be responsible for innovation than production workers) implies a relative decrease of innovation activities. According to our results, the effects of the innovation determinants analysed show some disparities across the low and high technology sector as well as across countries.

The innovation-employment analysis reveals that innovation (both product and process) encourages employment growth, even after controlling for a number of firm specific characteristics.[17] This means that the "compensation effect" of innovation dominates its "displacement effect". For product innovation these results are in line with the literature. Our results corroborate the arguments of those who assert a positive effect of process innovation on employment growth instead of a negative influence; the latter may be more dominant, but our empirical analysis validates the former. This means that the short-term "displacement effect" of the labour saving characteristics of process innovation is weaker than the long-term "compensation effect" which works through price reduction and in turn demand expansion. These positive effects of both innovation types are not altered by the geographical locations of firms; they remain significant and positive across countries.

Innovation is also conducive to employment growth in low-tech sector of the region combined. Analysing sectors across countries, the positive effect of innovation on employment growth is confirmed only in high-tech Bangladeshi firms and low-tech Pakistani firms. Due to this disparity we argue that both countries have specific circumstances such as policies (of course, according to their own circumstances) regarding innovation pursuance, labour expertise, societal know how of novelties, etc., which favor one industrial sector or the other. Recall that 90 percent Pakistani firms compared with 77 percent of Bangladeshi ones are low-tech firms, and the very nature of the high-tech sector might lead policies to favour this sector more in Bangladesh than in Pakistan.

In addition, we observed an insignificant impact of growth of labour cost on employment growth throughout; this is contrary to the widely observed significant, negative effect in previous studies. One reason might be that labour in these countries is cheaper than in the developed ones, hence firms' cost-related reluctance to hire new labour may not be significant enough to suppress employment growth.

The intermediate input of productivity (raw material) has a significant and negative effect on employment growth in all firms taken together and in Pakistan, in both sectors combined and in low-tech firms, suggesting substitutability with labour. The effect of material in high-tech firms is insignificant. This might be because of the complex nature of the high-tech sector's production processes which does not allow firms to enhance one production factor while sacrificing the other. We do not find this significant, negative effect in Bangladesh but high-tech firms. The descriptive statistics on raw material and employment, coupled with above mentioned relationships of material and employment, suggest that Pakistani firms rely more on material input while Bangladeshi firms rely more on employment for their productivity.

Comment [T3]: Incoherent!
We do not find this significant, negative effect in Bangladesh but **for** high-tech firms.

We find differences between the performance of other control variables across countries and across industries, suggesting that the complex nature of the employment effect is sensitive to the NISs of different countries and to different industrial paradigms.

Based on our empirical analysis, we suggest the initiation of new and further development of ongoing innovation projects on the micro level and the rectification of the problems of NISs on the macro level to reduce unemployment in this region.

[17]This positive relationship between employment quantity and innovation, however, does not indicate the sign of inclusive growth. Innovation may increase employment on one hand but substitute unskilled workers by the skilled ones on the other, suppressing opportunities for unskilled employees. There are no employment quality variables in our dataset to explore this question.

REFERENCES

Antonucci, T. and M. Pianta (2002) Employment Effects of Product and Process Innovation in Europe. *International Review of Applied Economics* 16:3, 295–307.

Benavente, J. M. and R. Lauterbach (2008) Technological Innovation and Employment: Complements or Substitutes? *The European Journal of Development Research* 20:2, 318–329.

Blanchflower, D. G. and S. M. Burgess (1998) New Technology and Jobs: Comparative Evidence from a Two Country Study. *Economics of Innovation and New Technology* 5:2-4, 109–138.

Blanchflower, D. G., N. Millward, and A. J. Oswald (1991) Unionism and Employment behaviour. *The Economic Journal* 101:407, 815–834.

Bogliacino, F. and M. Pianta (2010) Innovation and Employment: A Reinvestigation Using Revised Pavitt Classes. *Research Policy* 39:6, 799–809.

Brouwer, E., A. Kleinknecht, and J. O. N. Reijnen (1993) Employment Growth and Innovation at the Firm Level. *Journal of Evolutionary Economics* 3:2, 153–159.

Chennells, L. and J. Van Reenen (1999) Has Technology Hurt Less Skilled Workers? An Econometric Survey of the Effects of Technical Change on the Structure of Pay and Jobs. (Institute for Fiscal Studies Working Paper No. 99/27).

Collin, S. M. (2007) Economic Growth in South Asia: A Growth Accounting Perspective. In A. Ahmed and E. Ghani (eds.) *South Asia: Growth and Regional Integration*. Macmillan India Ltd.

Cosh, A. D., A. Hughes, and M. Weeks (2000) The Relationship between Training and Employment Growth in Small and Medium-Sized Enterprises. (Department for Education and Employment Research Report No. 245).

Dahlman, C. J. (2007) Improving Technology, Skills and Innovation in South Asia. In A. Ahmed and E. Ghani (eds.) *South Asia: Growth and Regional Integration*. Macmillan India Ltd.

Doms, M., T. Dunne, and M. J. Roberts (1995) The Role of Technology Use in the Survival and Growth of Manufacturing Plants. *International Journal of Industrial Organisation* 13:4, 523–542.

Edquist, C., L. Hommen, and M. McKelvey (2001) *Innovation and Employment: Process versus Product Innovation*. Cheltenham, UK and Northampton, USA: Edward Elgar.

Freel, M. S. and P. J. A.Robson (2004) Small Firm Innovation, Growth and Performance: Evidence from Scotland and Northern England. *International Small Business Journal* 22:6, 561–575.

Geroski, P., S. Machin, and J. Van Reenen (1993) The Profitability of Innovating Firms. *The RAND Journal of Economics* 24:2, 198–211.

Hall, B. H., F. Lotti, and J. Mairesse (2008) Employment, Innovation, and Productivity: Evidence from Italian Microdata. *Industrial and Corporate Change* 17:4, 813–839.

Hall, B. H., F. Lotti, and J. Mairesse (2009) Innovation and Productivity in SMEs: Empirical Evidence for Italy. *Small Business Economics* 33:1, 13–33.

Harrison, R., J. Jaumandreu, J. Mairesse, and B. Peters (2008) Does Innovation Stimulate Employment? A Firm-level Analysis Using Comparable Micro-data from Four European Countries. (NBER Working Paper No. 14216).

Koellinger, P. (2008) The Relationship between Technology, Innovation, and Firm Performance—Empirical Evidence from e-business in Europe. *Research Policy* 37:8, 1317–1328.

Leonard, J. S. (1992) Unions and Employment Growth. *Industrial Relations* 31:1, 80–94.

Long, R. J. (1993) The Effect of Unionization on Employment Growth of Canadian Companies. *Indus. and Lab. Rel. Rev.* 46:4, 691.

Lööf, H. and A. Heshmati (2006) On the Relationship between Innovation and Performance: A Sensitivity Analysis. *Economics of Innovation and New Technology* 15:4-5, 317–344.

Mastrostefano, V. and M. Pianta (2009) Technology and Jobs. *Economics of Innovation and New Technology* 18:8, 729–741.

Meriküll, J. (2010) The Impact of Innovation on Employment. *Eastern European Economics* 48:2, 25–38.

Monge-González, R., J. A. Rodríguez-Alvarez, J. Hewitt, J. Orozco, and K. Ruiz (2011) Innovation and Employment Growth in Costa Rica: A Firm-level Analysis. (IDB Publications No.54278).

Pianta, M. (2001) Innovation, Demand and Employment. In L. Soete and P. Petit (eds.) *Technology and the Future of European Employment*. Aldershot: Edward Elgar.

Pianta, M. (2005) Innovation and Employment. In J. Fagerberg, D. Mowery, and R. R. Nelson (eds.) *The Handbook of Innovation*. Oxford: Oxford University Press.

Ricardo, D. (2001) *On the Principles of Political Economy and Taxation* (3rd ed.). Kitchener, Ontario, Canada: Batoche Books.

Ross, D. R. and K. F. Zimmermann (1993) Evaluating Reported Determinants of Labour Demand. *Labour Economics* 1:1, 71–84.

Rothwell, R. and W. Zegveld (1979) *Technical Change and Employment*. London: Frances Printer.

Smolny, W. (1998) Innovations, Prices and Employment: A Theoretical Model and an Empirical Application for West German Manufacturing Firms. *The Journal of Industrial Economics* 46:3, 359–381.

Van Reenen, J. (1997) Employment and Technological Innovation: Evidence from UK Manufacturing Firms. *Journal of Labour Economics* 15:2, 255–284.

Variyam, J. N. and D. S. Kraybill (1992) Empirical Evidence on Determinants of Firm Growth. *Economics Letters* 38:1, 31–36.

Vivarelli, M. (2007) Innovation and Employment: A Survey. (IZA Discussion Paper No. 2621).

Vivarelli, M., Evangelista, R. and Pianta M. (1996) Innovation and Employment in Italian Manufacturing Industry. *Research Policy* 25:7, 1013–1026.

Yang, C. H. and Lin, C. H. A. (2008) Developing Employment Effects of Innovations: Microeconometric Evidence from Taiwan. *The Developing Economies* 46:2, 109–134.