Innovation and firm-level productivity: econometric evidence from Bangladesh and Pakistan

Abdul Waheed*
United Nations University (UNU-MERIT)

Abstract

The labor productivity impact of innovation of manufacturing firms in Bangladesh and Pakistan, a highly neglected region for such studies compared with developed world, is studied in this paper by using World Bank Enterprise Survey data conducted in 2006. To achieve this end, we apply the Cobb-Douglas production function, augmented with innovation-related (and other expected sources of productivity) inputs in a three-equation simultaneous equations system – connecting R&D to its determinants, innovation output to R&D, and productivity to innovation output – and in a two-equation system – connecting innovation output to its determinants, and productivity to innovation output – after correction for the biases attributable to the selectivity problem of R&D and to the endogenous nature of both R&D and innovation output.

Our results reveal that Bangladeshi firms are more often innovators as compared to Pakistani ones; however, the productivity output appears to be relatively large in Pakistan. We are generally not able to reject the constant returns to scale assumption. In addition, our econometric analysis indicates a strongly positive influence on firm productivity of both material and capital inputs; moreover, the productivity effect of process innovation is straightforwardly positive, but product innovation seems to be less connected to productivity outputs. Finally, we notice that the traditional production inputs (material and capital) have more significant effect on productivity output as compared to non-traditional input factors (controls in our case).

JEL classification: O31; O32; O33; L60
Keywords: Product and process innovation; Labor productivity; Pakistan; Bangladesh

* E-mail: waheed@merit.unu.edu

1. Introduction

The impact of innovation on firm performance has been ascertained many a times in the growing literature of the link between innovation and economic growth. The debate on this relationship can be split into two streams: the productivity effect of innovation input, especially R&D (see, e.g., Griliches 1998), and the influence of innovation output on firm performance (labor productivity, for example). More specifically, the emphasis in this last type of literature was on the effect of innovation input on its output, and in turn the productivity effect of innovation output, in line with the pioneering work of Crepon, Duguet, and Mairesse (1998), henceforth CDM. In earlier works, one of the reasons to investigate R&D instead of innovation output as a determinant of the firm productivity changes was the non-availability of the information related to innovation output[1]. The general perception, nowadays, is that it is innovation output rather than input which contributes to productivity, and the existence of innovation surveys enables innovation scholars to interrogate this relationship extensively. More specifically, the CDM model contributed in this direction by investigating the effect on productivity of innovation input implicitly (through its impact on innovation output) and of innovation output explicitly by using a (four-equation) system of simultaneous equations in three steps: linking R&D to its determinants (involving two equations), observing the innovation output impact of R&D (knowledge output phase), and connecting firm productivity to its innovation output (productivity output stage). Our methodology in this paper is partly based on the CDM model since we will use its full version (having all of the four equations), henceforth FCDM, and its reduced specification (involving innovation output and productivity equations), henceforth RCDM.

The technological change and growth relationship has been studied quite often in developed countries (see, e.g., Griffith et al. 2006; Hall and Mairesse 1995; Harhoff 1998; Verspagen 1995), but developing countries did not contribute much to this debate. Gu (1999) argued that national innovation systems (NIS) of developing counties do not operate optimally, and the lack of institutional sophistication, and the lack of links among organizational units surround in their NIS. Growth in these countries heavily depends on capital investment compared with knowledge and learning. In particular, like other developing regions (see, e.g., Alcorta and Peres 1998, for

[1] The reason of such non-availability was the lack of innovation-related surveys, even in developed countries.

Latin American and Caribbean), the study of Dahlman (2007) asserted that innovation systems of South Asian countries are plagued with institutional and societal problems, and they are far behind the global technological frontier. He argued that South Asian countries' economies are not largely knowledge-based owing to the illiterate and unskilled societies, and also due to emigration of skillful workforce. The region is also confronting the problem of poor links between university and firm scientists. However, despite the above stated innovation-related limitations, the region generally witnessed economic growth since the 1980s (Collin 2007). According to Collin, although we cannot ignore the noticeable role of capital accumulation and efficient use of other factors in economic growth of this region, more investment in both physical and human capital is still wanted.

One of the contributions of this paper is to investigate the link between firm performance (proxied by labor productivity in our case) and innovative activities for two developing South Asian countries: Bangladesh and Pakistan, a highly neglected region for such kinds of studies. Moreover, we enhance the CDM model (1) by including process innovation alongside product innovation in the knowledge output phase in order to examine the influence on (labor) productivity of the cost reduction and labor efficiency benefits, and (2) by using added information acquired by the inclusion of more explanatory factors at the productivity output phase. More specifically, we estimate our productivity output equation by using an innovation-augmented Cobb-Douglas production function in two ways: (1) including traditional production inputs, i.e., labor, capital, and raw material (we call this the basic model); (2) extending the basic model by including some additional potential inputs as determinants of labor productivity (called the extended model). In addition to that, we use two different systems of equations: (1) a four-equation system, exactly similar to the CDM, which we apply only to Bangladesh because we do not have information of the R&D investments for Pakistani firms; (2) a two-equation system which estimates the link of innovation output with its determinants, without R&D as one of them, and measures the link of labor productivity with innovation output, which we apply both for Pakistan and for Bangladesh. Hence, briefly speaking, our estimation models have the following four forms: (1) four-equation basic system (henceforth, FEBS); (2) four-equation extended system (henceforth, FEES); (3) two-equation basic system (henceforth, TEBS); (4) two-equation extended system (henceforth, TEES). Note that, FEBS and FEES will apply only to the Bangladeshi firms, while TEBS and TEES will employ both to Pakistan and Bangladesh, and additionally to the all firms taken together. Alongside the richness of the model and exploration of the dynamics of labor productivity more extensively, the extended version also serves as a robustness check for the basic model. It would be interesting to examine whether, for developing countries, the effect of innovation output on productivity remains the same or changed when we include R&D at the knowledge output stage or do not include it (i.e., whether we strictly need an FCDM or not).[2] We anticipate no differences in our case since the innovations in developing countries are generally less connected to formal R&D activities (see, e.g., Arocena and Sutz 2000). The estimates of four and two equations systems for Bangladesh will provide us with a mechanism in order to observe this hypothesis empirically.

We find a substantial effect of firm size only on Bangladeshi firms' R&D and process innovation. Pakistani firms' trade orientation appears to be a significant factor explaining both innovations; however the results for Bangladesh are rather mixed. Furthermore, material and physical capital observed to be conducive to productivity. The productivity effect of process innovation is straightforwardly positive, but product innovation seems to be less connected to productivity outputs. Moreover, we show, on the basis of Bangladesh data, that one could be indifferent between the use of FCDM and of RCDM.

The organization of this paper is the following. Section (2) is devoted to the literature review, and section (3) discusses the models theoretically, which are used in our empirical econometric analyses. Section (4) explains the dataset with descriptive statistics, while section (5) describes the empirical findings, with discussion on them. Section (6) concludes the paper.

2. Literature review

The analysis of the effect of technical change on productivity (and economic growth, in general) at macro and micro level is not a new topic. However, one of the main issues (the others are model specifications and estimation methodologies) in this research area is how can we measure technical change? The pioneers of this particular literature often relied on the measurements which were not directly measurable quantitatively. For instance, Solow (1957), one of the pioneers of technology-productivity relationship literature, calculated the impact of technological

[2] For French manufacturing firms, Mairesse, Mohnen, and Kremp (2005) also estimated and compared various versions of the CDM model. They estimated the complete CDM, the reduced CDM by estimating productivity semi-elasticities (elasticities) of R&D occurrence (intensity) and of (different definitions of) innovation occurrence (intensity) directly, with and without correcting for selectivity and endogeneity of these variables, and with correcting only for selectivity and only for endogeneity.

progress as a residual. The obvious limitations of this routine led to further evolution which reached the existence of a more direct and easily quantifiable measurement: research and development (R&D). Although, the use of R&D[3] as an indicator of technological change explaining the productivity output has also been questioned many times (see, for example, Griliches 1978, 1998), it has been used extensively owing to its quantifiability and, perhaps primarily, to the non-availability of innovation surveys which can quantify innovation activities in terms of more plausible determinants of productivity such as innovation outputs rather than inputs (as in case of R&D). Empirically, the analysis of R&D activities in developed countries often confirmed its significant influence on productivity[4]. Griliches (1998, chapter 4) estimated a positive impact of R&D activities on firms' productivity in the USA – both in terms of value-added and of sales growth rates. A positive link between R&D and firm performance can also be found in Hall and Mairesse (1995) for French and in Harhoff (1998) for German manufacturing firms. Verspagen (1995), using a translog production function and 11 OECD countries, also concluded that R&D is a significant determinant of productivity, particularly for high-tech industries.

As mentioned earlier, the adoption of R&D in order to investigate the productivity impact of technological change was always questionable, and the thirst to employ more appropriate indicators which would be related to innovation outputs (instead of innovation inputs) has been quenched, to some extent, by the use of patent, and by the advent of the innovation surveys. Furthermore, to follow the CDM strategy, the innovation-productivity relationship analysis also observed the influence on productivity output of innovation input indirectly, via the innovation output impact of R&D (and/or alike inputs), and of innovation output directly, by building up a recursive simultaneous equations system which works in three phases: relating R&D to its determinants, innovation output to R&D, and in turn productivity output to innovation output. For developed countries, the empirical findings, whether the CDM approach is used or not, generally produced a positive link between innovation and firm performance (see Geroski, Machin, and Van Reenen 1993, for the UK; Koellinger 2008, for Eurpean enterprises; Lööf and

[3] The impact of R&D on productivity (in levels or in terms of growth rates) has usually been estimated by including R&D as an additional input factor (with traditional inputs: labor and physical capital) in the production function.

[4] Mairesse and Sassenou (1991) provided a good survey of the studies focused on the firm productivity effect of R&D, measured by the econometric analysis of production function. Another survey can also be seen in Griliches (1998).

Heshmati 2002, 2006, for Swedish firms, among others). In particular, Bogliacino and Pianta(2011) observed that innovation inputs (R&D and new machinery expenditures) of eight major EU countries contribute significantly to labor productivity growth. They further replaced patent applications with R&D in Science-Based industries (Pavitt's taxonomy) and again found significant results (with insignificance of machinery expenditures). Crespi and Pianta (2008) used both input and output indicators of innovation and concluded that both are remarkably well to transform into productivity output, for six European countries. Furthermore, Klomp and Van Leeuwen (2001) showed that those Dutch firms that perform R&D on permanent basis are largely innovators, and the innovative sales has a significant contribution towards total turnover growth, and its effect is modestly negative on employment growth rates. They further showed that (a dummy of) process innovation increases both performance measures considerably. However, in another study, they (Van Leeuwen and Klomp 2006) estimated insignificant (significant) impact of innovative sales on value-added per employee (sales per employment growth), and a negative influence of process innovation on sales growth rates (scaled by employment). The positive effect of innovation input on innovation output and innovation output on firm performance (productivity in levels and growth rates) can also be found in Lööf and Heshmati (2002), for Swedish firms. Griffith et al. (2006), by utilizing the third Community Innovation Surveys (CIS3) for France, Germany, Spain, and the UK, asserted the substantial influence of R&D intensity on both product and process innovation. They also found a significant relationship between product innovation and labor productivity, except Germany. However, in case of process innovation, they observed a statistically significant estimate only for France. Another strong relationship between R&D and both innovation types (product and process) has been found by Hall, Lotti, and Mairesse (2009), with a significant influence of both innovation outputs on firm productivity output. However, the significance of process innovation collapsed when they introduced investment intensity as a proxy of physical capital. The study of Parisi, Schiantarelli, and Sembenelli (2006) concluded with the finding that process innovation has a larger effect on productivity as compared to product innovation. It is extremely hard to encompass the innovation-productivity relationship literature completely in one study, but we may argue that in developed economies product innovation generally seems to hava a more robust and remarkable influence on productivity (growth) than process innovation.

For developing countries, Yang and Huang (2005) demonstrated an important role of R&D in employment growth of Taiwanese electronics firms. Furthermore, Benavente (2006) showed that Chilean firms' innovative sales do not depend upon their R&D intensity, and innovation output does not enhance the productivity per worker. For 6 Latin American countries, Crespi and Zuniga (2011) observed that investment in innovation activities results in a notable increase in the likelihood of introducing product or process innovation in all countries, and innovation expenditures have considerable impact on labor productivity, except for Costa Rica. The productivity effect of innovation output also produced statistically significant outcomes, except again for Cost Rica. In addition, Lee (2011) found inconsequence of both process and product innovation on Malaysian firms' value addition. The work of Goedhuys and Veugelers (2011) on Brazilian manufacturing firms showed some support to product innovation compared with process innovation, as an explanatory factor of sales growth, but they found a remarkably significant impact of combined process and product innovations.

3. Model specification

Our econometric analysis can be divided into two systematic approaches: a three-step procedure (FCDM) for Bangladesh, and a two-step method (RCDM) for both Bangladesh and Pakistan. The steps involved in three-step approach are the following: (1) the link of R&D activities to firm specific and external explanatory factors; (2) the relationship of knowledge output (measured by some indicator(s) of innovation output) with R&D and other potential determinants; (3) the connection of productivity output with knowledge output and other traditional productivity inputs. The two-step procedure is a modified version involving the second and third stage of the three-step approach, without using R&D as one of the determinants of knowledge output. Before starting the following subsections, it is imperative to have a look at Table (1) for descriptions and labels of the variables used in our econometric analysis.

3.1 The research (R&D) equation

As discussed earlier, the first step is to relate the firm's R&D efforts to its determinants. To do so, we relied on the Heckman selection model[5] in order to resolve the well- known phenomenon

[5] The other commonly used names for the Heckman selection model are tobit 2 model, sample selection model, and generalized tobit model.

of selectivity bias attributable to the huge amount of non-R&D performing (and/or reporting) firms. For empirical estimation of the model, we applied the Heckman two-step procedure.

In particular, we assume that the *ith* firm's R&D decision is based on some latent selection criterion which has the following form:

$$rd_i^* = x_{0i}\beta_0 + \varepsilon_{0i} \tag{1}$$

where x_{0i} is the vector of determinants of R&D decision, β_0 is the vector of corresponding coefficients, and ε_{0i} is an error term. We assume that the firm will decide to initiate an R&D project if its latent variable exceeds some industry threshold level c. Hence, our binary R&D decision variable (the information which we actually have) would be:

$$\begin{aligned} rd_i &= 1 \qquad && if \quad rd_i^* > c \\ rd_i &= 0 \qquad && if \quad rd_i^* \le c \end{aligned}$$

Moreover, we approximate the latent R&D intensity of the *ith* firm by the following equation:

$$rds_i^* = x_{1i}\beta_1 + \varepsilon_{1i} \tag{2}$$

where, similar to equation (1), x_{1i} and β_1 are the vectors of R&D intensity determinants and associated coefficients respectively, and ε_{1i} is a disturbance term that captures all kinds of measurements and other sources of errors. The actual R&D intensity, rds_i, is equal to the latent R&D intensity, conditional on R&D performance (i.e., if $rd_i = 1$), and zero otherwise (i.e., if $rd_i = 0$). In addition to assuming that $(\varepsilon_{1i}, \varepsilon_{2i})$ are independent of the covariates of equation (1) and (2), we have to rely on their distributional assumptions in order to estimate the model econometrically. To do so, we assume the distributions of error terms as:

$$\begin{pmatrix} \varepsilon_{0i} \\ \varepsilon_{1i} \end{pmatrix} \overset{NID}{\sim} \left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{\varepsilon_0}^2 & \rho\sigma_{\varepsilon_0}\sigma_{\varepsilon_1} \\ \rho\sigma_{\varepsilon_0}\sigma_{\varepsilon_1} & \sigma_{\varepsilon_1}^2 \end{pmatrix} \right)$$

where ρ is the correlation coefficient between both disturbances, and $\sigma^2_{\varepsilon_0}$ and $\sigma^2_{\varepsilon_1}$ are respective variances. Moreover, the model in equation (1) is in fact a probit model, which requires a normalization restriction that can be obtained by setting $\sigma^2_{\varepsilon_0} = 1$.

We use *LRDI* as a dependent variable in equation (2) for the approximation of research intensity. The explanatory variables used for both of the covariates vectors are:

$$x_1 = (LSALES, EXP, IMP, LICE, UNION, TRAIN, WEB, MEMBER)$$
$$x_0 = (x_1, EXPER, EDU, INDZONE)$$

Both sets of covariates also include industry intercepts in order to address the sector-specific heterogeneity. Note that x_0 includes the whole of x_1, plus three additional variables because a crucial assumption of the Heckman selection procedure is that at least one of the explanatory variables of the selection equation (equation 1) should not be included in the outcome equation (equation 2), in order to obtain a well-identified model.[6] It is very hard to determine those variables that could affect the R&D choice, but do not influence the subsequent R&D expenditures conditional on someone's decision to perform R&D, since both phenomena are quite alike. However, our intuition to exclude EXPER, EDU and INDZONE from the outcome equation is the following. The start of an R&D project always involves a risk of failure or at least a risk of not having optimal results. Therefore, older managers could be against the initiation of an R&D project owing to their risk-averse attitude compared to young ones, and this reluctance seems to be more significant at the stage of start of a new R&D project rather than the allocation of budget to an already approved R&D project. Therefore, in sum, we anticipate a negative influence of EXPER on R&D decision, and we believe that EXPER is not heavily connected to R&D expenditures. An educated workforce could instigate R&D decision makers to perform it because of its relatively high absorptive capacity (one of the prerequisites to successful R&D projects) to assimilate new knowledge. However, it would perhaps the less likely to influence R&D budget allocation. One of the advantages of an industrial park is a well embedded industrial infrastructure, which is complementary to R&D, and this complementarity would perhaps be stronger for R&D choice as compared to subsequent R&D expenditures. Hence, we

[6] In the literature, this is often called the exclusion restriction. This crucial restriction is also used to avoid the collinearity between the mills ratio and other explanatory variables used in the outcome equation (Wooldridge 2009, chapter 17). However, the validity of exclusion restriction depends too much on the variable(s) used to exclude in the outcome equation.

contend that INDZONE would be a plausible candidate for exclusion (with a positive effect on R&D decision). It is important to recall that the empirical results of R&D equation will only be obtained for Bangladesh.

3.2. The knowledge (innovation) output equation

The second step is to regress innovation output on R&D and other potential sources which contribute to its variability. Following Griffith et al. (2006) and Hall, Lotti, and Mairesse (2009), we use both process and product innovation in order to measure the innovation output. Hence, our model of knowledge output for the *ith* firm is the following:

$$\begin{aligned} pd_i &= 1 \qquad if \quad pd_i^* = rd_i + y_i\gamma + u_{1i} > c \\ pr_i &= 1 \qquad if \quad pr_i^* = rd_i + y_i\gamma + u_{2i} > c \end{aligned} \tag{3}$$

where rd_i here is the predicted value of R&D intensity (LRDI) obtained from the Heckman selection model in step (1). We use the predicted values from equation (2) as an instrument of research intensity to avoid the biases caused by the endogenous nature of R&D variable in the knowledge output equation.[7] Our pd_i and pr_i are the dummies of product and process innovations (i.e., PDINN and PRINN) both separately take the value of one if the corresponding latent variables $(pd_i^*$ and $pr_i^*)$ are greater than some threshold level c. The vector y_i is a vector of covariates (other than research intensity) influencing both types of innovation outputs, and γ is the corresponding coefficients vector. Furthermore, we suppose that both disturbance terms (u_{1i}, u_{2i}) are jointly distributed as normal with the following point estimates:

$$E\left(u_{1i}/y_i\right) = E\left(u_{2i}/y_i\right) = 0, \ \mathrm{var}\left(u_{1i}/y_i\right) = \mathrm{var}\left(u_{2i}/y_i\right) = 1, \text{ and } \mathrm{cov}\left(u_{1i}, u_{2i}/y_i\right) = \rho \neq 0$$ [8]

The explanatory variables, in addition to the sector dummies, used in the covariates vector are:

$$y_i = (LSALES, EXPER, ASSET, LICE, EDU, AGE, INDZONE, MEMBER)$$

[7] By using the expected values of R&D investment, we do not restrict our analysis only to the R&D-reporting firms, but employ relatively rich information by including all firms.

[8] Another possibility is to assume that $\rho = 0$, but we avoid to use it directly owing to the fact that product and process innovation could be correlated, and thereby there could be a high probability of association among the unobserved characteristics (captured by u_1 and u_2) influencing both types of innovation activities. Having said that, we empirically observe the null hypothesis of zero correlation and find its rejection in all of our bivariate regressions (details will be in the empirical part), implying the validity of our non-zero correlation assumption.

We further suppose that someone does not know the R&D information of Bangladeshi firms, meaning that he/she has to rely on the RCDM. For this purpose, we define another knowledge production function, which in principle should be a reduced form equation of innovation output, as:

$$\begin{aligned} pd_i &= 1 \quad if \quad pd_i^* = y_{1i}\gamma_1 + u_{3i} > c \\ pr_i &= 1 \quad if \quad pr_i^* = y_{1i}\gamma_1 + u_{4i} > c \end{aligned} \tag{4}$$

where (u_{3i}, u_{4i}) are the error terms, and the definitions of all variables are as defined earlier in the context of model (3), except y_{1i} with associated coefficients vector γ_1 , which is defined as:

$$y_{1i} = (y_i, EXP, IMP, UNION, TRAIN, WEB)$$

Note that the vector y_{1i} includes the vector y_i and some additional variables (i.e., all exogenous variables of equation 2 and 3), since equation (4) actually is a reduced form equation of innovation output. Equation (3) is a second equation of the FCDM, while equation (4) is a first equation of the RCDM.

Due to the unavailability of R&D investment for Pakistan, the above discussed equation (3) cannot be used for Pakistan. One possibility is to employ equation (4) to Pakistan as well, but we cannot follow this route because we do not have information of the variable MEMBER for Pakistan. Therefore, we define another model as:

$$\begin{aligned} pd_i &= 1 \quad if \quad pd_i^* = w_i\delta + \upsilon_{1i} > c \\ pr_i &= 0 \quad if \quad pr_i^* = w_i\delta + \upsilon_{2i} > c \end{aligned} \tag{5}$$

The latent dependent variables are as defined earlier, and the error terms $(\upsilon_{1i}, \upsilon_{2i})$ have the same distributional assumptions as (u_{1i}, u_{2i}). Although we already defined the knowledge output model for Bangladesh in equation (3) and (4), we use model (5) for all firms taken together and for Pakistan and Bangladesh separately. The reason to apply model (5) also on Bangladesh is to obtain comparable results for both countries in same model specification. The covariates vector w_i is defined as:

$$w_i = (LSALES, EXP, IMP, ASSET, LICE, EDU, AGE, INDZONE, TRAIN)$$

The vector w_i also includes the Pakistan dummy (PAK) when apply to all firms in order to control for country-specific effects, and includes the industry dummies as well.

3.3. The productivity output equation

The final equation both for model (3), (4), and (5) is the productivity output equation. To formulate this equation, we employ the widely used Cobb-Douglas production function, augmented with product and process innovation. By following Griffith et al. (2006) and Hall, Lotti, and Mairesse (2009), we also use both innovation outputs together in one equation, but they empirically happen to be highly collinear (the details will be in the empirical part). Therefore, in order to avoid the distortion of the estimation outcomes due to such high multicollinearity, we insert process and product innovations into the production function separately. Hence, we define two separate productivity equations for the ith firm as:

$$\begin{aligned} lp_i &= l_i\alpha_1 + m_i\alpha_2 + pd_i\lambda_1 + z_i\varsigma + \xi_{1i} \\ lp_i &= l_i\alpha_1 + m_i\alpha_2 + pr_i\lambda_2 + z_i\varsigma + \xi_{2i} \end{aligned} \tag{6}$$

where lp_i is the productivity (sales per employment, in logarithm) and labeled as LPROD, l_i is the (log of) employment ,i.e., LEMP, the (2×1) vector m_i has two other (scaled by employment) traditional production inputs: raw material cost and net book value (both in logarithmic forms), and we labeled them as LMATERIAL and LNETBOOK respectively. This is necessary to emphasize here that we do not assume constant returns to scale (henceforth, CRS) but endeavor to examine it empirically. For pd_i and pr_i, we use the predicted values of PDINN and PRINN respectively, which are obtained either from equation (3), or equation (4), or from equation (5), depending upon the context in which model (6) is being used. The advantage of the predicted values of innovation outputs is to control for the endogeneity of these variables in productivity output equation. Moreover, all our production function estimations involve industry dummies and, wherever needed, a country dummy. We estimate model (6) in two different settings: a basic model having no additional controls (z_i is a null vector) and an extended model having control variables (z_i is not a null vector). When the FCDM model is used (i.e., when we apply R&D,

innovation, and productivity output equations), and when the RCDM (innovation and productivity equations) is used only for Bangladesh, the controls, if used, are the following:

$$z_i = (EDU, WEB, BONUS, LICE, PRODIN)$$

We do not have BONUS data for Pakistan; therefore, when we employ the RCDM to all firms, to Pakistan, and to Bangladesh, the vector z_i has the variables as:

$$z_i = (EDU, WEB, LICE, PRODIN)$$

Note that we calculate the RCDM twice for Bangladesh; the former is to compare the results of FCDM with its reduced version in same variable setting, and the later is to compare the results of RCDM for both of the countries again in same model specification.

4. Data and descriptive statistics

The study in this paper is based on the World Bank enterprise survey of two South Asian countries: Bangladesh and Pakistan, conducted in 2006-07 and covering the immediately preceding three fiscal years (i.e., from 1st July 2003 to 30th June 2006).[9] The sample was selected by using stratified random sampling following the commonly used three criteria: size, sector, and geographical location.[10] Overall, we have 2085 manufacturing firms (784 for Pakistan and the rest for Bangladesh) over nine two-digit industrial classifications.[11] We have only 11 non-metallic minerals firms, and none of them is from Bangladesh. Hence, for computational purposes, we merge these firms with relatively broader manufacturing sector: other manufacturing.[12] Of course, as usual to survey data, we do not have complete information for all of the variables included in our study, and we also have to delete some unusual outliers; therefore, our econometric analyses will not depend on the whole 2085 observations but will be based on the number of firms with all available information for one particular model setting or the other.

[9] The fiscal years of Pakistan and Bangladesh start from 1st July and end on 30th June. Some of our variables collect information for last fiscal year and others for last three fiscal years (see Table 1 for details).
[10] The complete details of the survey can be seen at https://www.enterprisesurveys.org.
[11] Our sample includes the following two-digit manufacturing sectors: Food, Chemical, Garments, Non-metallic minerals, Leather, Textiles, Machinery and equipments, Electronics, and Other manufacturing.
[12] Note that this does not affect the econometric estimations of our main variables.

[Please insert Table 2]

[Please insert Table 3]

Table (2) and (3) report the summary statistics of all of the variables used in our econometric analyses. In the survey, the information of all monetary variables was gathered in respective country' currency unit, so we convert them in USD, in order to obtain comparable estimates. The first striking result is that, although Pakistan has many SMEs compared with Bangladesh (compare average employment of 293.40 for Bangladesh with that of only 114.11 for Pakistan), the average sales of its firms, $5.03 million, is more than twice than Bangladesh, i.e., $2.23 million.[13] In addition, Bangladeshi firms are observed to be more often trade oriented and innovators (both product and process). Moreover, these point estimates reveal that workers in Bangladeshi firms are more often educated and have formal training programs. On the other hand, compared with Bangladesh, companies in Pakistan are older on average, have more experienced top managers, and are more often located in industrial parks. Furthermore, regarding two important production function inputs: raw material cost and net book value of fixed asset[14] (both scaled by employment), Pakistani firms appear to have much higher values than Bangladesh, especially the difference is very large for net book value of fixed assets (see the last two rows of Table 2). Note that for both measurements, we take only those firms that report non-zero monetary values. In case of net book value, 301 (among 647 of total of 784 which answer this particular survey question) Pakistani firms responded zero net book value. The exclusion of these 301 firms as compared to only 3 (among 1293 of 1301) for Bangladesh could induce bias favoring overestimation of the average net book value for Pakistan. Hence, we also estimate averages of net book value (per employee) by including these zero-reporting firms, for both of the countries separately; the difference is still very large ($15.41 thousand for Pakistan, while the average value for Bangladesh is only $5.92 thousand), suggesting that Pakistani firms really have

[13] These findings should be considered with caution because there might be some firms in Pakistan having very high sales relative to others. We observe the possibility and find that two firms have high sales figures compared with the remaining pool. The average sales volume for Pakistan by excluding these two firms is $2.72 million (quite near to the figure of Bangladesh). The immediate effect of such large sales volume of these two companies could be the sharp upward shift of the labor productivity because we measure it by sales/employment, but we notice that it is not changed substantially: average labor productivity of Pakistan is $23.77 thousand by including these two firms and is $23.05 thousand by excluding them, implying that these large sales values are not the wrong entries due to the data gathering errors (because they also have large employment). Having said that, we are concerned about the distortions of our econometric results (will be discussed subsequently) owing to these large sales values. Therefore, in empirical part of this study, we also estimate all of our models by excluding these two firms (the results will not be reported with econometric estimation outputs in order to conserve space) and find no difference.

[14] These fixed assets are machinery, vehicle, equipments, land, and buildings.

large capital assets compared with Bangladesh. The point estimates also reveal that 52% Bangladeshi firms purchase fixed assets in fiscal year 2005-06 compared with the value of 18% for Pakistani companies. One implication of this finding, coupled with the results of net book value, is that although Bangladeshi firms are far behind in terms of capital, they are trying to catch-up. Another significant finding from these descriptive statistics is that labor productivity (sales per employee) is substantially higher in Pakistan as compared to Bangladesh. We believe that two of the reasons for such a difference of productivity between Pakistan and Bangladesh are the relatively sizeable flow of raw material and comparatively large stock of fixed assets for Pakistan. Moreover, their complementarities in production process also play a significant role in high productivity output for Pakistan. In addition to that, we observe the relationship between these two production inputs and productivity output by sketching two scatter plots (see Figure 1 and 2).[15]

[Please insert Figure 1]

[Please insert Figure 2]

Both of the figures depict positive relationships of both input indicators with productivity output, for both of the countries. Moreover, the less dispersed scatter points for raw material as compared to net book value seem to imply more significance of the former than the later, in order to explain the variability in the labor productivity output. In terms usage of internet and of foreign-licensed technology, both countries behave virtually similar, with a slightly larger percentage of Bangladesh for the former and of Pakistan for the later. The raw estimates show that 19% of the Pakistani firms have ISO certification; the similar indicator has a proportion of 15% for Bangladesh. Surprisingly, almost 43% Bangladeshi firms reported to engage in R&D activities, while the R&D investment (scaled by sales) was found to be 0.55% for all firms of Bangladesh and 1.28% when we consider only R&D performers.[16]

[15] Of course, we also observe such relationships in rigorous econometric settings. The details will be described later.
[16] Note that we do not have R&D information for Pakistani firms.

5. Econometric analysis

5.1. The research equation

As we already know that R&D expenditures information is only available for Bangladesh, the results of this subsection are applicable solely to Bangladesh and reported in Table (4).

[Please insert Table 4]

The significance of λ suggests that our data suffer from selectivity bias and underpins the use of the Heckman selection model in order to control for it. The influence of firm sales is observed to be significantly positive on R&D decision and on R&D investment. Moreover, although firm sales has a positive influence on R&D expenditures, the increase in R&D investment is proportionally less than the increase in firm sales. Firm export has no influence on Bangladeshi R&D expenditures, but the R&D budget increases with imports; however, both have no contributions to R&D choice. The results reveal that those firms that use foreign-licensed technology have significantly high research budgets than others. One possible interpretation could be that the presence of LICE is complementary to R&D investment. The effect of unionization is significantly increasing for R&D decision and insignificant for R&D intensity variable, whereas formal training depicts just the opposite. The variable labeled as WEB (an indication of firm broad exposure, especially in developing countries context) shows a highly positive influence on R&D indicator and slightly positive (significant at 10%) effect on subsequent R&D expenditures. Moreover, membership of a business association (e.g., chamber of commerce) does not contribute to both of our R&D-related variables, suggesting institutional apathy for innovation efforts through R&D. Finally, the signs and significances of the regression coefficients of EXPER, EDU, and INDZONE empirically confirm the ideas which we have outlined in the discussion of exclusion restriction in section (3).

5.2. The innovation output equation

Unlike the research equation, we estimate the knowledge output equation for all firms and for Pakistan and Bangladesh separately. It should bear in mind that we estimate two innovation equations for Bangladesh: one with R&D (used in the FCDM) and another without R&D (used in the RCDM) as an input in the innovation output model.

[Please insert Table 5]

Table (5) shows the innovation output equation results for Bangladesh based on equation (3) and (4), and we call them model (3A) and (4A) respectively. Subsequently, we will again estimate the innovation output equation for Bangladesh without considering R&D (i.e., by using vector w), but the reason to estimate model (4A) here in Table (5) is to compare both models (including and excluding R&D) in alike model specification because the vectors y_1 and w do not include the same variable inputs.[17] Model (3A) is the second equation of the FCDM model, and model (4A) is the first equation of the RCDM. The research intensity and innovation output could be simultaneous in innovation output equation, so in model (3A) we utilize predicted values of LRDI obtained in Table (4) as an instrument in order to avoid the biases due to such simultaneity.[18] The hypothesis of zero correlation between the disturbance terms of our PDINN and PRINN equations is rejected throughout the Table (5), suggesting that both innovation outputs are influenced by some common unknown forces (see footnote (8) also). The outcomes of Table (5) reveal that research intensity is a significant determinant of both product and process innovation. In addition, at a reasonable significance level (i.e., 5%), both models produce similar results for both innovation outputs (product and process) except LSALES for product innovation. In model (3A), firm sales show a positive effect on product innovation, but it becomes insignificant for model (4A). To dig out this phenomenon more deeply, we perform another bivariate probit by including (predicted values of) LRDI and by excluding LSALES (results are not reported) and obtain insignificance of LRDI as a predictor of PDINN. Hence, we observe that LRDI and LSALES have a significant impact on PDINN only if they come together, implying strong complementarities between them in order to influence PDINN. Moreover, we always observe a significantly positive effect of firm sales on process innovation. Recall that in Table (4) we find a negative impact of top managers' experience on R&D decision; here we observe their insignificant contribution to both innovations, again showing at least their indifference towards innovativeness. According to Table (5), purchase of fixed assets, use of foreign-licensed technology and internet, and having premises at an industrial park are significantly beneficial for both knowledge outputs, while firm age is influenced negatively to

[17] One reason for such difference is that, since the w - included estimations are based on both Pakistan and Bangladesh, and we include same set of inputs for both countries in order to acquire comparable results.

[18] The other preventive measure to avoid endogeneity could be the plugging of lagged values of research efforts, but we do not have a panel data; therefore, we rely on the predicted values.

both innovations. Furthermore, we produce a significantly increasing influence on product innovation of educated workforce, but we get its insignificant contribution to process innovation. The reason might be that our variable EDU is related to education of typical production workers, which arguably affect product innovation more directly as compared to process innovation because a product innovation is ultimately a final outcome of a firm's research efforts and/or adaptation of developed world technologies (in case of developing countries innovations). In both cases, the occurrence of novelty depends heavily on the capability and adaptability (absorptive capacity to assimilate new knowledge) of the typical workforce responsible to manufacture this novelty (product innovation). On the other hand, our process innovation variable does not harvest largly these benefits of educated production-related labor force since it focuses primarily on non-production-related activities of a firm[19]. The regression coefficients of Table (5) also disclose that UNION is an insignificant determinant of both types of innovations, and MEMBER also is almost an insignificant factor (with slightly negative influence on product innovation in case of model 3A). So, we can argue that the previously observed institutional aloofness for R&D efforts also prevails for output phases of innovations. Finally, the outcomes of trade-orientation and formal training have the results same as of Table (6) and are discussed therein.

[Please insert Table 6]

Table (6) depicts the empirical results of the knowledge output equations by employing equation (5), for all firms taken together and for Pakistan and Bangladesh separately. Note that Table (6) does not include R&D information, meaning that it can be considered as the first equation of the RCDM. Moreover, we introduce EXP, IMP, and TRAIN in the explanatory variables list in order to ascertain their direct effect on innovation output, contrary to model (3A) which interrogates their indirect impact coming via the research equation. Similar to Table (5), we find a strong correlation between the error terms of both PDINN and PRINN equation. Both ASSET and LICE produce significant coefficients for both process and product innovation, for all of our estimation outputs (i.e., for all firms and for Pakistan and Bangladesh separately). For product innovation, firm sales happens to be an insignificant determinant in all of our regressions;

[19] However, our process innovation variable also gathers some information about improvements in production process, among other things (see description of PRINN in Table 1), which could also be linked with production-related employees. However, in our opinion, such link will not be as much vigorous as in case of product innovation, which is an ultimate outcome manufactured mainly by production department's employment.

however, its influence on process innovation is significant for Bangladesh and when we consider all firms together, but still insignificant for Pakistan. Hence, these findings suggest that size does not matter for Pakistani firms in order to be innovators. Regarding trade orientation, the empirical findings for Pakistan (both for PDINN and PRINN) are in line with the general idea of a positive link between import/export and innovation; however, in case of Bangladesh, exports have a negative and imports have a positive influence on firms' product innovation, and both of them have insignificant contribution to PRINN. If we have a look on these trade-related results, coupled with research equation outcomes (Table 4), we come to the conclusion that Bangladeshi exporters are generally not strong innovation-seekers. Moreover, firm age also has mixed results: a negative influence on both dependent variables, for Bangladesh and for the whole dataset, but it has an insignificant effect for Pakistan. Our results suggest that INDZONE is an insignificant determinant of both innovation outputs for Pakistan, but significant factor for rest of the estimations. Formal training shows nothing important towards the innovation outputs in all of the regressions of Table (6). Note that in Table (4) we find that training is a substantive predictor of research intensity. One possible reason, we argue, for the contrasting results for innovation output might be that both research intensity and training are contemporaneous, but the innovation outputs questions also cover two preceding years (in addition to the year of training and research intensity).[20] We find that education (of production workers) is an important stimulus to PDINN and to PRINN for Pakistan and for all firms. Similar to Table (5), education is a (an) significant (insignificant) predictor of product (process) innovation of Bangladeshi firms. Having bear in mind our argument, discussed in Table (5), of this difference for Bangladeshi firms, significant impact of education on process innovation (along with product innovation) of Pakistani firms may lead to one aspect (of many) to conclude that Pakistani firms are more often vertically integrated than Bangladeshi firms. Our results disclose that the coefficient of the Pakistan dummy (PAK) produces significantly negative signs for both innovation outputs, confirming econometrically already obtained point estimators in Table (3) that Bangladeshi manufacturing firms are more often innovators than Pakistan. Finally, we notice that our results for all firms in Table (6) generally follow the pattern (with respect to sign and significance) of Bangladeshi

[20] However, we do not know when the particular innovation output occured. It might be in the year of training and/or in one of the two preceding years and/or in both of the preceding years. Unfortunately, we cannot explore such phenomenon any further due to the cross-sectional nature of our dataset.

firms. The probable cause could be the large representation of Bangladeshi firms compared with Pakistan (63% vs. 37%), in making the pool of all firms.

5.3. The productivity output equation

The final and major objective of this paper is to investigate the determinants of the firms' productivity output, with introduction of innovation as one of its potential inputs, and we follow the traditional Cobb-Douglas model for this purpose. All of our subsequent productivity equations estimations involve (predicted values of) PDINN and PRINN individually, as a determinant of productivity, in separate productivity equations; we call them PDINN-included and PRINN-included, for the sake of convenience.[21]

[Please insert Table 7]

Table (7) reveals the estimation outputs, for Bangladesh, of the productivity equations of FCDM and RCDM in terms of the basic and extended versions. For FEBS and FEES, we utilize the predicted values of PDINN and PRINN obtained from model (3A) in Table (5), i.e., both are final equations of the FCDM, and TEBS and TEES incorporate the predicted values from the bivariate probit of model (4A) in Table (5), meaning that they are final equations of the RCDM. One striking result is that we are unable to reject the assumption of CRS in all of our regressions at a reasonable significance level (i.e., 5%). Moreover, our results also unveil another important finding: the contributions of both innovation outputs describe virtually a similar pattern in both FCDM and RCDM, suggesting that we could be indifferent between these models in order to observe the influence of innovation output on productivity.[22] One very little, even negligible, difference is that, contrary to an insignificance of PDINN in PDINN-included FEBS, we find a significance of PDINN in PDINN-included TEBS at least at 9.97% level. One of the purposes of

---

[21] We also analyze these equations by using both innovation outputs at the same time in one productivity equation (the results are not reported) and investigate our doubts that both might be collinear because they could share many common characteristics, because both predicted values are based on the same model specification, and also because empirically we find that the unknown factors (captured by their respective equations' errors) influencing both of them are highly correlated. Our investigation comes to the conclusion that PDINN and PRINN are highly collinear, so we avoid having them together in one equation.

[22] Our results are not directly comparable to those that were obtained by Mairesse, Mohnen, and Kremp (2005) because of different model specification and of different definitions of innovation outputs. However, for the sake of the nearest possible comparison, they also found that, with respect to significance, the effect of innovative sales on labor productivity show a similar pattern (significant in both cases) in complete and reduced version of the CDM. Moreover, in addition to estimate the full CDM by utilizing R&D choice and intensity at the research equation stage, they also estimated a complete and reduced CDM by using only binary indicators of R&D, product and process innovations. The innovation output variables in this specification were exactly the same as of ours, but the research equation had only an R&D choice indicator. In this specific comparison, they found a pattern similar to what was observed for innovation sales.

having controls in the extended version is to ascertain the robustness of our principal (basic) productivity output model, which is confirmed after obtaining similar results for FEBS and FEBS-related part in FEES and for TEBS and TEBS-related part in TEES. Our findings demonstrate that process innovation of Bangladeshi firms is a significant determinant of their labor productivity, while the role of product innovation is unimportant. Furthermore, the elasticities of productivity output with respect to material cost and net book value are significantly positive, implying the remarkable role of both of them in firm productivity.[23]The insignificance of BONUS and PRODIN prevail both for FEES and for TEES, suggesting that these seemingly beneficial indicators contribute nothing towards productivity. The use of foreign-licensed technology mostly produces insignificant coefficients, and the only significant result is just significant at 10% level. Hence, we can safely argue that LICE is not an influential determinant of productivity output of Bangladeshi companies. In Table (5) and (6), we have concluded that EDU is a significant determinant of PDINN, but not of PRINN, for Bangladesh, and Table (7) affirms that, as an input to Bangladeshi firms' productivity output, education is a more significant determinant in PDINN-included instead of PRINN-included in FEES and only significant (although at 10%) in TEES version of PDINN-included. We notice that the inclusion of PRINN (instead of PDINN) collapses the significance of WEB as a productivity determinant. It means that the importance of usage of web (to communicate with clients or suppliers) is swallowed by the process innovation. Our possible explanation of this finding, coupled with a negative (and insignificant) coefficient of LICE in the PRINN-included FEES and TEES models compared with its positivity and slight significance in the PDINN-included FEES model, and compared with its positive (although insignificant) coefficient in PDINN-included TEES model, is that firms might consider them (LICE and WEB) as a change in their process, and hence their significance is being undermined by the use of a more proper definition of process innovation: PRINN.

It is important to accentuate that our next empirical estimations of productivity equations will be based on the two-equation simultaneous system (i.e., second and final equation of the RCDM). We estimate now both productivity equations (PDINN-included and PRINN-included) by using only LMATERIAL (and call this regression as LM) and by employing both LMATERIAL and

[23] Note that LPROD, LMATERIAL, and LNETBOOK are all used in logarithmic forms; therefore, the estimated coefficients directly give the interpretations of elasticities.

LNETBOOK (called LMN), as determinant(s) of productivity output.[24] Table (8) reports the results of the large pool of all firms. The CRS assumption is accepted in all cases, except PRINN-included LM in extended version (we produce decreasing returns to scale in the later case). It is important to note here that in this particular regression, we have only LMATERIAL, which is not exactly related to the traditional definition of physical capital. When we include LNETBOOK, even together with LMATERIAL, we have the acceptance of CRS[25]. Similar to Table (7), material and net book value intuitively are very important factors of labor productivity for all firms. The values of PDINN and PRINN are the predicted values obtained from the first two columns of Table (6) (i.e., bivariate probit on all firms), and one of the striking findings is that both product and process innovation contribute importantly to productivity output of all firms, contrary to Bangladesh in different model specification (Table 7) and in same model setting (Table 9). For Bangladesh, only PRINN is observed to be highly significant in both tables (the results of Table (9) will be discussed shortly). Again we conclude that our results are quite robust after comparing the basic and extended versions, with only one exception which we have already pointed out in our discussion of CRS. Considering all firms, the role of education towards productivity is completely insignificant in all of our regressions, while the findings of WEB suggest the opposite. The coefficient of LICE is negative but insignificant in both PDINN-included LM and PDINN-included LMN; however LICE is negatively significant in PRINN-included LM and modestly significant (again negative) in PRINN-included LMN. Note that, similar to Table (7), the inclusion of PRINN critically undermines the effect of LICE (compare the insignificant (though negative) outcomes in PDINN-included equations with significantly negative (though one of them is at 10%) coefficients in PRINN-included regressions). The percentage of permanent production workers in permanent employment again produces disappointing results since we produce negative signs in all regressions. Moreover, the coefficient is insignificant in both of the LM regressions and significant in both LMNs. Finally, the Pakistan dummy (PAK) shows highly significant result in all of our regressions, confirming

---

[24] In Table (7), we use LMATERIAL and LNETBOOK together in one equation for Bangladesh. Recall that we have 301 firms for Pakistan with zero figure of net book value and have to leave them out of the analysis for Pakistan, but we do not want to lose other information of these 301 zero-reporting-net book value firms. Hence, we run two regressions by including only LMATERIAL (i.e. LM) and by using both LMATERIAL and LNETBOOK (i.e., LMN). Moreover, we have already emphasized that we want to have comparable results for Pakistan, Bangladesh, and for all firms, so we perform above stated two regressions for all three cases.

[25] We demonstrate that our CRS assumption is with respect to material cost, net book value, and employment, conditional on the inclusion of only first and of both first and second.

the descriptive statistics of large labor productivity output of Pakistan compared with Bangladesh.

Table (9) depicts the results of the productivity equation for Bangladesh. Note that we have also shown the productivity equation for Bangladesh in Table (7), but the focus of both tables is rather different. Table (7) provides a mechanism to compare the full and reduced CDM, but Table (9) is an attempt to have results of Bangladesh which can be comparable for Pakistan and for all firms. In Table (9), the innovation outputs are approximated by the predicted values of Table (6) for Bangladesh. Again, the CRS assumption is accepted at 5% significance level in all cases, but PDINN-included LM for the basic version, for which we observe increasing returns to scale. Similar to previous outcomes, material and net book value elasticities are significantly positive. Recall that for all firms, we concluded the significant impact on labor productivity of both innovations, but here we notice that only PRINN is significant at 5% level, and product innovation is insignificant in the extended versions and only slightly significant in the LMN version of the basic model. This difference (of the effect of product innovation) between all firms and Bangladesh could be an indication that PDINN is an important factor of productivity output for Pakistani firms (we will examine it shortly). The results of EDU, WEB, LICE, and PRODIN in both LMNs (PDINN-included and PRINN-included) are almost the same as of two-equation model of Table (7). Moreover, in the case of LM, education appears to be a highly significant determinant of productivity, WEB is more significant and LICE is also relatively better (although insignificant) in PDINN-included compared with PRINN-included equation, again implying already observed hegemonic position of process innovation compared with WEB and LICE for Bangladesh and compared with LICE for all firms.

The empirical findings of the separate productivity output analysis of Pakistani firms is outlined in Table (10). The innovations are measured by the predicted values acquired from the Pakistani portion of Table (6). Similar to above empirical findings for Bangladesh and for all firms together, both material and physical capital variables intuitively have sizeable impact on productivity output of Pakistani firms. Recall that Figures (1) and (2) reveal that material has a more significant impact than net book value for both countries, and the empirical findings also corroborate such phenomenon (observe the large coefficients of LMATERIAL than LNETBOOK (although both are significant) in all of the productivity analyses of all firms and of

Pakistan and Bangladesh).[26]The results of Table (10) depict that the CRS assumption never rejects at 5% level for Pakistani manufacturers. The significant (although one of them is only slightly significant) regression coefficients of PRINN imply the importance of process innovation for labor productivity; however, the PDINN findings are mixed: insignificant in LM and significant in LMN. Hence, contrary to Bangladesh, we observe some influence of product innovation on productivity as well. Education has an insignificant influence in all cases, opposite to Bangladesh. The possible reason might be that Pakistani firms have, on average, highly less educated workers as revealed by summary statistics, and their low percentages compared with Bangladeshi firms are too small to be substantive to firm productivity. Foreign-licensed technology does not appear to be a significant determinant of productivity, while the results of WEB have significant coefficients in both PDINN-included and PRINN-included LM, and produce insignificant impacts in both LMNs. For Pakistani firms, the presence of process innovation does not undermine the effect of LICE and WEB, contrary to Bangladesh results. Finally, similar to previous results, PRODIN does not contribute significantly positive to productivity; even we have some significantly negative results.

6. Conclusions

In this paper, we primarily observe the (labor) productivity impact of both process and product innovation, for two South Asian economies (Pakistan and Bangladesh), by using World Bank Enterprise Survey data, covering 1st July 2003 through 30th June 2006. In all of our empirical analyses, we correct our econometric estimations for the selectivity bias of R&D and for the endogeneity bias of both R&D and innovation.

Our results suggest that firm size (sales) is an important determinant of R&D and (likelihood of) process innovation of Bangladeshi firms. However, we fail to find a significant relationship between sales and product innovation. For Pakistani firms, it does not, however, matter to be large to be product and/or process innovators. Moreover, the Pakistani firms' imports and exports induce both product and process innovation. However, imports and exports do not prompt Bangladeshi firms to be research intensive and process innovator; furthermore, the effect of trade-orientation on Bangladeshi firms' product innovation is rather mixed: exporters have a

[26] Both coefficients are comparable because we do not encounter any measurement scale issue: both are in same monetary unit, standardized by employment, and in logarithmic forms.

negative and importers have a positive impact. The prevailing conception is that innovation generally does not enjoy its due status in industrial strategies of developing countries. For our dataset, we do not notice any significant commitment at Bangladeshi business association (CoC etc.) level to both R&D activities and innovation outputs. The effect of firm age is observed to be negative for Bangladesh and insignificant for Pakistan, in order to explain the likelihood of both innovation outputs. The education of production workers perhaps appears to be more important determinant of product innovation compared with process innovation: education is a significant determinant of product innovation and has no influence on process innovation for Bangladesh; it has positive effect on both process and product innovation for Pakistan.

Furthermore, the constant returns to scale assumption is generally accepted in all of our empirical findings. One of the important findings of our productivity analysis on Bangladesh is that if we compare the effect on productivity of both process and product innovation, which comes either from R&D-included or from R&D-excluded innovation output stage, we have virtually the same results, implying that someone could be indifferent between the use of full and reduced CDM (we do not have R&D information in order to examine this phenomenon for Pakistan). In addition, we find, quite intuitively, that both material and capital inputs are highly important factors of productivity changes, and these findings are robust with respect to different versions of the CDM. According to our results, process innovation shows its significant importance as a determinant of productivity output in all of our reduced and full versions of the basic and extended CDM, for all firms and for both Pakistan and Bangladesh, except the extended version of the reduced CDM for Pakistan, which includes material and does not include physical capital. We even observe the significance for the latter case, but at a 10% level. It means that, in sum, process innovation is conducive to productivity output. In addition, in case of all firms together, product innovation appears to be helpful for productivity output; however, it fails to have a substantial influence on Bangladeshi firms' productivity (however, one modest (10% level) significance is observed for basic version of the TEBS model). If we look at the results of Pakistani firms, the findings are mixed: product innovation is significantly important for labor productivity in basic and extended LMN versions but insignificant in both LMs. Therefore, in sum, process innovation is a more important determinant of productivity as compared to product innovation. One likely interpretation could be that consumer attracts towards new product often reluctantly, and product takes time to become mature and to earn profit for its launcher(s). On the other hand, process innovation is a tool to modify a production process for cost-cutting, labor-curtailment, and efficiency gains benefits. The ultimate result of these benefits translates into rapid productivity output (also note that our productivity variable is sales/employment). What the innovation-productivity relationship literature on developed countries is generally observed is suggestive of more significant impact on productivity of product than process innovation. These findings seem contrary to ours. The education of Pakistani workers does not contribute to its productivity, while we find some support to education for Bangladesh. The usage of web to communicate its clients and suppliers seems to be important for productivity output of both countries. All other non-traditional inputs fail to contribute to productivity. In sum, the traditional production inputs appear to be more influential than non-traditional (controls in our case) input factors.

Although Pakistani firms are less product and process innovators than Bangladesh, our results show that their labor productivity is substantially higher compared with Bangladeshi firms. Moreover, the descriptive statistics suggest that Pakistani firms have comparatively huge amount of both traditional input factors: material and physical capital, and our econometric analyses show a remarkably significant impact of both of these inputs on both countries' labor productivity. It means the difference between both countries labor productivity is primarily because of the huge stock of capital and of the larger flow material inputs for Pakistani firms. The implication of these findings is that these countries depend heavily on traditional input factors than technological improvements, for their productivity which ultimate goal is sales and in turn profits. These empirical findings are quite in line with the argument of Gu (1999) that growth in developing countries depend mainly on capital investment than knowledge and learning. Our results also corroborate jointly the studies of Dahlman and Collin on this specific region, which stated that the NIS of South Asia confront institutional and societal problems Dahlman (2007); however, the region generally have shown economic growth since the 1980s Collin (2007).

References

Alcorta, L., and W. Peres. 1998. "Innovation systems and technological specialization in Latin America and the Caribbean." *Research Policy* 26(7-8): 857–881.

Arocena, R., and J. Sutz. 2000. "Looking at national systems of innovation from the south." *Industry and Innovation* 7(1): 55–75.

Benavente, J.M. 2006. "The role of research and innovation in promoting productivity in Chile." *Economics of Innovation and New Technology* 15(4-5): 301–315.

Bogliacino, F., and M. Pianta. 2011. "Engines of growth. Innovation and productivity in industry groups." *Structural Change and Economic Dynamics* 22(1): 41-53.

Collin, S.M. 2007. "Economic growth in South Asia: A growth accounting perspective." In *South Asia: Growth and Regional Integration*, eds. A. Ahmed and E. Ghani. Macmillan India Ltd.

Crepon, B., E. Duguet, and J. Mairesse. 1998. "Research, innovation and productivity: an econometric analysis at the firm level." *Economics of Innovation and New technology* 7(2): 115–158.

Crespi, F., and M. Pianta. 2008. "Demand and innovation in productivity growth." *International Review of Applied Economics* 22(6): 655–672.

Crespi, G., and P. Zuniga. 2011. "Innovation and productivity: evidence from six Latin American countries." *World Development, doi: 10.1016/j.worlddev.2011.07.010*.

Dahlman, C.J. 2007. "Improving technology, skills and innovation in South Asia." In *South Asia: Growth and Regional Integration*, eds. A. Ahmed and E. Ghani. Macmillan India Ltd.

Geroski, P., S. Machin, and J. Van Reenen. 1993. "The profitability of innovating firms." *The RAND Journal of Economics* 24(2): 198–211.

Goedhuys, M., and R. Veugelers. 2011. "Innovation strategies, process and product innovations and growth: frim-level evidence from Brazil." *Struct. Change Econ. Dyn., doi: 10.1016/j.strueco.2011.01.004*.

Griffith, R. et al. 2006. "Innovation and productivity across four European countries." *Oxford Review of Economic Policy* 22(4): 483-498.

Griliches, Z. 1978. "Economic problems of measuring returns to research." In *Toward a Metric of Science: The advent of Science Indicators*, eds. Y. Elkana et al. New York: John Wiley & Sons, Inc.

———. 1998. *R&D and productivity: the econometric evidence*. Chicago: University of Chicago press.

Gu, S. 1999. “Implications of national innovation systems for developing countries: managing change and complexity in economic development.” *UNU-INTECH Discussion Paper No. 9903*.

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.

Hall, B.H., and J. Mairesse. 1995. “Exploring the relationship between R&D and productivity in French manufacturing firms.” *Journal of Econometrics* 65(1): 263–293.

Harhoff, D. 1998. “R&D and productivity in German manufacturing firms.” *Economics of Innovation and New Technology* 6(1): 29–49.

Klomp, L., and G. Van Leeuwen. 2001. “Linking innovation and firm performance: a new approach.” *International Journal of the Economics of Business* 8(3): 343–364.

Koellinger, P. 2008. “The relationship between technology, innovation, and firm performance–Empirical evidence from e-business in Europe.” *Research Policy* 37(8): 1317–1328.

Lee, C. 2011. “Trade, productivity, and innovation: Firm-level evidence from Malaysian manufacturing.” *Journal of Asian Economics* 22(4): 284-294.

Van Leeuwen, G., and L. Klomp. 2006. “On the contribution of innovation to multi-factor productivity growth.” *Economics of Innovation and New Technology* 15(4-5): 367–390.

Lööf, H., and A. Heshmati. 2002. “Knowledge capital and performance heterogeneity: an innovation study at firm level.” *International Journal of Production Economics* 76(1): 61–85.

———. 2006. “On the relationship between innovation and performance: A sensitivity analysis.” *Economics of Innovation and New Technology* 15(4-5): 317–344.

Mairesse, J., P. Mohnen, and E. Kremp. 2005. “The importance of R&D and innovation for productivity: a reexamination in light of the French innovation survey.” *Annals of Economics and Statistics / Annales d’Économie et de Statistique* (79/80): 487-527.

Mairesse, J., and M. Sassenou. 1991. “R&D productivity: A survey of econometric studies at the firm level.” *NBER working paper No. 3666*.

Parisi, M.L., F. Schiantarelli, and A. Sembenelli. 2006. “Productivity, innovation and R&D: Micro evidence for Italy.” *European Economic Review* 50(8): 2037–2061.

Solow, R.M. 1957. “Technical change and the aggregate production function.” *The Review of Economics and Statistics* 39(3): 312–320.

Verspagen, B. 1995. “R&D and productivity: A broad cross-section cross-country look.” *Journal of Productivity Analysis* 6(2): 117–135.

Wooldridge, J.M. 2009. *Introductory econometrics: a modern approach*. 4th ed. Mason, OH 45040, USA: South-Western Cengage Learning.

Yang, C.H., and C.H. Huang. 2005. "R&D, size and firm growth in Taiwan‘s electronics industry." *Small Business Economics* 25(5): 477–487.

Tables

Table 1: Variables and their description

Variables	Descriptions
LEMP	Logarithm of number of full- time employees. It includes both permanent and temporary employment.
LSALE	Logarithm of total annual sales of a firm in 2005/06.
LRDI	Log of Ratio of R&D expenditures to sales.
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.
AGE	Age of the firm: 2006 (year of survey)-year of beginning of the operation of the firm
BONUS	Percentage of bonuses, allowances, and other benefits to sales in 2005/06.
LMATERIAL	Logarithm of total annual cost of raw material per employee in 2005/06.
LNETBOOK	Logarithm of net book value of firm assets (machinery, vehicles, equipments, land, and buildings) per employee at the end of 2005/06.
LPROD	Logarithm of labor productivity: sales/employment in 2005/06.
PRODIN	Ratio of permanent production workers in permanent employment
EXPER	Experience of top manager in years.
ISO	Dummy if a firm has ISO or related certificate.
INDZONE	Dummy if a firm located in industrial zone (park).
UNION	Dummy if a worker union exists in the firm.
ASSET	Dummy if the firm purchases fixed assets (machinery, vehicles, equipment, land, or buildings) in 2005/06.
EDU	Dummy if the average education of a typical production worker is 7 years and above.
TRAIN	Dummy if a firm runs formal training program for its permanent employees in 2005/06.
WEB	Dummy if a firm uses website to communicate with its clients or suppliers.
MEMBER	Dummy if firm is a member of any business association (e.g. CoC etc.)
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 years.
RD	Dummy if a firm spends on R&D activities in 2005/06.
LICE	Dummy if a firm uses technology licensed from foreign-owned company.
PAK	Dummy if country is Pakistan.

Table 2: Summary statistics of continuous variables.

Variables	Bangladesh				Pakistan			
	Mean	Median	Q_1	Q_3	Mean	Median	Q_1	Q_3
Employment	293.40	90	22	320	114.11	15	7	50
Sales (in mil.)	2.23	0.29	0.05	1.73	5.03	0.09	0.03	0.67
Export intensity (%)	33.52	0	0	100	12.21	0	0	0
Import intensity (%)	34.97	10	0	80	11.69	0	0	10
Age (in years)	16.95	14	8	22	20.20	18	11	26
Experience of top manger (in years)	14.59	13	8	20	20.81	20	13.5	30
R&D expenditures to sales (%)	0.55	0	0	0.33				
R&D exp. to sales (performers) (%)	1.28	0.16	0.43	1.13				
Production workers intensity[a] (%)	93.42	96.02	91.92	98.68	77.26	80	70	85.71
Skilled production workers intensity[b] (%)					80.90	83.33	71.43	100
Ratio of bonuses to sales (%)	1.67	0.98	0.24	2.2				
Sales per emp. (in thousands)	7.56	3.15	1.43	6.85	23.77	6.02	2.67	13.92
Material cost per emp.[c](in thousand)	5.13	1.81	0.67	4.54	11.09	2.39	0.84	6.68
Net book val. per emp. (in thousand.)	5.93	1.69	0.43	4.94	28.93	4.48	1.73	11.13

[a] It is a ratio of permanent, full-time, production workers to total permanent, full-time employees.

[b] It is a ratio of permanent, full-time, skilled production workers to total permanent, full-time employees production employees.

[c] For material cost and net book value, only those firms that report non-zero monetary values are included.

Table 3: Percentages of occurrences in dummy variables.

variables	Bangladesh %	Pakistan %
Product innovation	33.14	12.32
Process innovation	44.96	9.60
R&D performers	42.52	
ISO certification	15.41	18.66
Located in industrial zone	17.90	34.44
Worker union	11.09	5.79
Usage of web	26.13	23.75
(7+ year) education of a production worker	31.11	14.18
Formal training (of permanent workers)	21.07	8.59
Usage of technology licensed from foreign company	5.33	5.79
Member of any business association	85.01	
Purchase of fixed assets	52.11	17.90

Table 4: R&D equation (Heckman selection model) for Bangladesh. Standard errors are in parentheses.

Independent Variables	Dependent Variables: LRDI (outcome equation)		Dependent Variables: RD (selection equation)	
Intercept	1.171	(1.057)	-2.708*	(0.370)
LSALES	-0.627*	(0.048)	0.136*	(0.031)
EXP	0.155	(0.201)	-0.094	(0.142)
IMP	0.403#	(0.168)	-0.033	(0.122)
LICE	0.458#	(0.222)	0.136	(0.195)
UNION	-0.086	(0.172)	0.301#	(0.134)
TRAIN	0.314#	(0.139)	0.065	(0.109)
WEB	0.327†	(0.183)	0.558*	(0.105)
MEMBER	0.269	(0.239)	0.151	(0.140)
EXPER			-0.013#	(0.005)
EDU			0.36*	(0.096)
INDZONE			0.361*	(0.111)
No. of obs.	1131			
censored obs.	638			
λ	0.785#(0.388)			
Overall goodness of fit test-statistics	493.79*			

* Significance at 1% level # Significance at 5% level † Significance at 10% level

Note: All regressions includes industry dummies

Table 5: Innovation output equation (Bivariate Probit model) based equations 3 and 4, for Bangladesh. Robust SEs are in parentheses.

Independent Variables	Dependent variables			
	PDINN	PRINN	PDINN	PRINN
	Model 3A		Model 4A	
Intercept	-1.161*	-1.888*	-0.849*	-1.631*
	(0.276)	(0.279)	(0.316)	(0.335)
LRDI	0.586*	0.309#		
	(0.162)	(0.158)		
LSALES	0.338*	0.291*	-0.001	0.104*
	(0.093)	(0.089)	(0.028)	(0.030)
EXPER	0.005	0.004	0.006	0.004
	(0.005)	(0.005)	(0.005)	(0.005)
ASSET	0.253*	0.313*	0.254*	0.314*
	(0.086)	(0.084)	(0.087)	(0.084)
LICE	0.447#	0.552#	0.737*	0.709*
	(0.214)	(0.230)	(0.193)	(0.207)
EDU	0.241#	0.122	0.240#	0.119
	(0.097)	(0.095)	(0.098)	(0.096)
AGE	-0.012*	-0.012*	-0.013*	-0.013*
	(0.004)	(0.004)	(0.004)	(0.004)
INDZONE	0.328*	0.415*	0.363*	0.428*
	(0.105)	(0.105)	(0.107)	(0.106)
MEMBER	-0.256†	-0.021	-0.052	0.074
	(0.132)	(0.132)	(0.124)	(0.126)
EXP			-0.509*	-0.220
			(0.146)	(0.138)
IMP			0.267#	0.067
			(0.122)	(0.117)
UNION			0.177	0.177
			(0.126)	(0.128)
TRAIN			0.126	0.045
			(0.108)	(0.106)
WEB			0.391*	0.283*
			(0.107)	(0.104)
No. of obs.	1151		1151	
Wald χ^2	223.92*		244.66*	
LR test for ρ = 0	225.11*		218.73*	

* Significance at 1% level # Significance at 5% level † Significance at 10% level

Note: All regressions includes industry dummies

Table 6: Innovation output equation (Bivariate Probit for PDINN and PRINN) based on model 5, for all firm and for Pakistan and Bangladesh separately. Robust SEs are in parentheses.

Independent Variables	All firms		Bangladesh		Pakistan	
	PDINN	PRINN	PDINN	PRINN	PDINN	PRINN
Intercept	-1.273*	-1.684*	-1.182*	-1.728*	-2.2077*	-2.641*
	(0.260)	(0.285)	(0.310)	(0.323)	(0.555)	(0.688)
LSALES	0.025	0.100*	0.033	0.124*	0.009	0.017
	(0.023)	(0.024)	(0.027)	(0.028)	(0.048)	(0.053)
EXP	-0.325*	-0.053	-0.476*	-0.146	0.618*	0.538#
	(0.119)	(0.118)	(0.144)	(0.136)	(0.212)	(0.248)
IMP	0.339*	0.178†	0.308#	0.116	0.722*	0.723*
	(0.110)	(0.106)	(0.120)	(0.115)	(0.253)	(0.260)
ASSET	0.357*	0.428*	0.271*	0.315*	0.666*	0.954*
	(0.078)	(0.076)	(0.086)	(0.083)	(0.181)	(0.186)
LICE	0.943*	0.765*	0.732*	0.673*	1.327*	0.846*
	(0.167)	(0.163)	(0.192)	(0.203)	(0.289)	(0.280)
EDU	0.355*	0.192#	0.279*	0.139	0.689*	0.491#
	(0.086)	(0.085)	(0.097)	(0.094)	(0.191)	(0.200)
AGE	-0.006#	-0.006#	-0.011*	-0.011*	0.007	0.007
	(0.003)	(0.003)	(0.003)	(0.003)	(0.006)	(0.006)
INDZONE	0.331*	0.427*	0.370*	0.428*	-0.070	0.188
	(0.085)	(0.088)	(0.106)	(0.105)	(0.173)	(0.186)
TRAIN	0.127	0.095	0.165	0.081	0.062	0.160
	(0.100)	(0.098)	(0.108)	(0.106)	(0.258)	(0.261)
PAK	-0.573*	-1.202*				
	(0.112)	(0.121)				
No. of obs.	1825		1155		670	
Wald χ^2	550.52*		223.91*		7890.26*	
LR test for $\rho = 0$	290.63*		223.25*		59.29*	

* Significance at 1% level # Significance at 5% level † Significance at 10% level

Note: All regressions includes industry dummies

Table 7: Productivity equation for Bangladesh (predicted values of PDINN and PRINN are obtained from Table 5). Robust SEs are in parentheses. Dep. var.: LPROD

Independent variables	Basic				Extended			
	FEBS		TEBS		FEES		TEES	
Intercept	2.244*	2.305*	2.235*	2.298*	2.471*	2.415*	2.443*	2.387*
	(0.156)	(0.159)	(0.155)	(0.160)	(0.247)	(0.217)	(0.243)	(0.214)
LMATERIAL	0.710*	0.697*	0.710*	0.697*	0.702*	0.689*	0.702*	0.690*
	(0.019)	(0.020)	(0.019)	(0.021)	(0.022)	(0.024)	(0.022)	(0.024)
LNETBOOK	0.057*	0.054*	0.058*	0.055*	0.053*	0.052*	0.053*	0.053*
	(0.015)	(0.015)	(0.015)	(0.013)	(0.016)	(0.016)	(0.016)	(0.015)
LEMP	0.030†	0.004	0.026†	0.002	0.014	-0.003	0.013	-0.001
	(0.016)	(0.013)	(0.015)	(0.013)	(0.014)	(0.013)	(0.013)	(0.013)
PDINN	0.006		0.120†		-0.373		-0.147	
	(0.102)		(0.073)		(0.227)		(0.150)	
PRINN		0.393*		0.408*		0.383*		0.397*
		(0.090)		(0.100)		(0.114)		(0.128)
EDU					0.100#	0.053†	0.082#	0.053†
					(0.045)	(0.032)	(0.039)	(0.031)
WEB					0.124#	0.057	0.109#	0.034
					(0.051)	(0.035)	(0.050)	(0.035)
BONUS					-0.011	-0.011	-0.012	-0.011
					(0.010)	(0.010)	(0.010)	(0.010)
LICE					0.131†	-0.081	0.060	-0.081
					(0.075)	(0.067)	(0.062)	(0.069)
PRODIN					-0.015	-0.007	-0.017	-0.004
					(0.097)	(0.099)	(0.098)	(0.099)
No. of obs.	1121	1121	1121	1121	1119	1119	1119	1119
F-stat.	649.74*	590.68*	609.00*	604.02*	532.46*	468.37*	512.15*	471.77*
coeff. of det.	0.892	0.893	0.892	0.894	0.894	0.894	0.893	0.894

* Significance at 1% level # Significance at 5% level † Significance at 10% level

Note: All regressions includes industry dummies

Table 8: Productivity equation for all firm taken together. Robust SEs are in parentheses. Dep. var.: LPROD

Independent variables	Basic				Extended			
	(1)	(2)	(3)	(4)	(1a)	(2a)	(3a)	(4a)
Intercept	2.744*	2.398*	2.787*	2.475*	2.918*	2.724*	2.909*	2.784*
	(0.135)	(0.158)	(0.135)	(0.163)	(0.150)	(0.204)	(0.145)	(0.200)
LMATERIAL	0.705*	0.685*	0.682*	0.670*	0.697*	0.680*	0.670*	0.663*
	(0.019)	(0.020)	(0.019)	(0.021)	(0.019)	(0.021)	(0.020)	(0.022)
LNETBOOK		0.060*		0.055*		0.057*		0.051*
		(0.014)		(0.014)		(0.014)		(0.014)
LEMP	0.010	0.014	-0.033	-0.016	-0.008	-0.002	-0.051#	-0.028
	(0.020)	(0.019)	(0.023)	(0.021)	(0.020)	(0.018)	(0.023)	(0.021)
PDINN	0.441*	0.370*			0.523*	0.349#		
	(0.140)	(0.116)			(0.157)	(0.141)		
PRINN			1.008*	0.709*			1.295*	0.822*
			(0.138)	(0.133)			(0.200)	(0.173)
EDU					0.049	0.046	0.022	0.035
					(0.046)	(0.041)	(0.044)	(0.035)
WEB					0.124*	0.094#	0.097#	0.078#
					(0.040)	(0.037)	(0.040)	(0.037)
LICE					-0.189	-0.096	-0.355*	-0.197†
					(0.122)	(0.099)	(0.129)	(0.106)
PRODIN					-0.095	-0.260#	-0.085	-0.261#
					(0.074)	(0.129)	(0.076)	(0.128)
PAK	0.494*	0.588*	0.711*	0.729*	0.490*	0.532*	0.791*	0.717*
	(0.075)	(0.091)	(0.072)	(0.087)	(0.071)	(0.086)	(0.071)	(0.081)
No. of obs.	1788	1435	1788	1435	1787	1435	1787	1435
F-stat.	212.76*	172.16*	221.32*	190.67*	196.98*	179.65*	264.21*	291.11*
coeff. of det.	0.758	0.828	0.764	0.831	0.762	0.830	0.770	0.833

* Significance at 1% level # Significance at 5% level † Significance at 10% level

Note: All regressions includes industry dummies

Table 9: Productivity equation for Bangladesh only (predicted values of PDINN and PRINN are obtained from Bangladeshi part of Table 6). Robust SEs are in parentheses. Dep. var.: LPROD

Independent variables	Basic				Extended			
	(1)	(2)	(3)	(4)	(1a)	(2a)	(3a)	(4a)
Intercept	2.389*	2.236*	2.453*	2.305*	2.521*	2.340*	2.529*	2.364*
	(0.136)	(0.155)	(0.139)	(0.160)	(0.169)	(0.200)	(0.165)	(0.190)
LMATERIAL	0.742*	0.709*	0.724*	0.694*	0.738*	0.708*	0.719*	0.691*
	(0.021)	(0.019)	(0.023)	(0.021)	(0.022)	(0.019)	(0.025)	(0.022)
LNETBOOK		0.057*		0.055*		0.052*		0.052*
		(0.015)		(0.015)		(0.017)		(0.016)
LEMP	0.038*	0.027†	0.010	0.002	0.022†	0.014	-0.002	-0.009
	(0.013)	(0.015)	(0.012)	(0.013)	(0.013)	(0.013)	(0.012)	(0.012)
PDINN	0.125	0.145†			-0.074	0.019		
	(0.084)	(0.083)			(0.117)	(0.128)		
PRINN			0.496*	0.463*			0.513*	0.500*
			(0.106)	(0.107)			(0.135)	(0.134)
EDU					0.110*	0.064†	0.075*	0.039
					(0.031)	(0.038)	(0.027)	(0.030)
WEB					0.083#	0.082#	0.064†	0.066†
					(0.036)	(0.036)	(0.034)	(0.034)
LICE					0.038	0.012	-0.116†	-0.108
					(0.060)	(0.061)	(0.068)	(0.070)
PRODIN					-0.026	-0.007	-0.020	-0.002
					(0.093)	(0.095)	(0.095)	(0.096)
No. of obs.	1131	1124	1131	1124	1131	1124	1131	1124
F-stat.	569.35*	616.18*	579.22*	598.65*	470.06*	517.52*	462.01*	494.44*
coeff. of det.	0.887	0.892	0.890	0.894	0.890	0.893	0.891	0.895

* Significance at 1% level # Significance at 5% level † Significance at 10% level

Note: All regressions includes industry dummies

Table 10: Productivity equation for Pakistan only. Robust SEs are in parentheses. Dep. var.: LPROD

Independent variables	Basic				Extended			
	(1)	(2)	(3)	(4)	(1a)	(2a)	(3a)	(4a)
Intercept	3.772* (0.230)	3.471* (0.390)	3.827* (0.225)	3.511* (0.391)	4.059* (0.259)	4.130* (0.500)	4.092* (0.253)	4.161* (0.498)
LMATERIAL	0.663* (0.032)	0.619* (0.045)	0.661* (0.032)	0.619* (0.045)	0.647* (0.033)	0.597* (0.048)	0.647* (0.032)	0.602* (0.047)
LNETBOOK		0.079# (0.031)		0.079# (0.031)		0.077# (0.031)		0.075# (0.031)
LEMP	-0.036 (0.048)	-0.028 (0.077)	-0.047 (0.049)	-0.035 (0.076)	-0.078 (0.048)	-0.061 (0.074)	-0.084† (0.051)	-0.069 (0.077)
PDINN	0.639 (0.405)	0.985# (0.391)			0.869 (0.628)	1.524* (0.565)		
PRINN			0.837# (0.401)	1.123* (0.422)			0.890† (0.491)	1.252* (0.470)
EDU					-0.036 (0.145)	-0.042 (0.203)	0.015 (0.133)	0.081 (0.179)
WEB					0.277# (0.123)	0.169 (0.157)	0.275# (0.121)	0.187 (0.156)
LICE					-0.338 (0.429)	-0.621 (0.387)	-0.249 (0.353)	-0.364 (0.321)
PRODIN					-0.091 (0.104)	-0.571# (0.268)	-0.084 (0.102)	-0.554# (0.276)
No. of obs.	657	311	657	311	656	311	656	311
F-stat.	75.40*	46.39*	75.73*	46.03*	59.27*	44.02*	58.79*	42.37*
coeff. of det.	0.906	0.673	0.609	0.674	0.614	0.683	0.615	0.682

* Significance at 1% level   # Significance at 5% level   † Significance at 10% level

Figures

Figure 1: Scatter plot of (log of) raw material per employee and (lof of) labor productivity

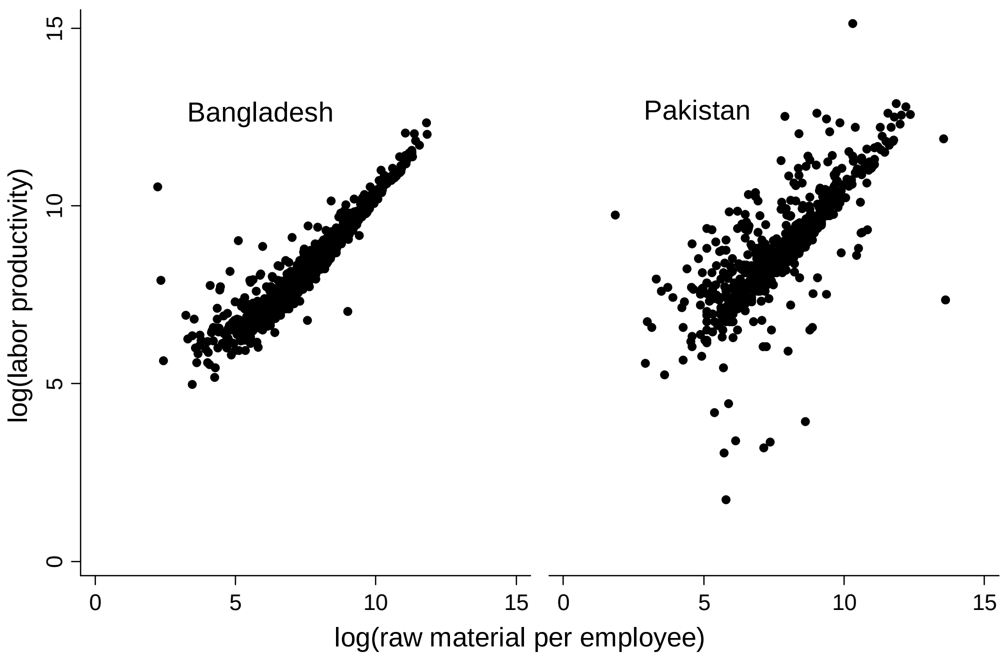

Figure 2: Scatter plot of (log of) net book value per employee and labor productivity