Has Low Productivity Constrained Competitiveness of African Firms? : Comparison of the Firm Performances with Asian Firms

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It has been argued that poor productive performance is one of critical sources of stagnation of the African manufacturing sector, but firm-level empirical supports are limited. Using the inter-regional firm data of the garment industry, technical efficiency and its contribution to competitiveness measured as unit costs were compared between Kenyan and Bangladeshi firms. Our estimates indicated that there is no significant gap in the average technical efficiency of the two industries despite conservative estimation, although unit costs greatly differ between the two industries. Higher unit cost in Kenyan firms mainly stems from high labour cost, while impact of inefficiency is quite small. Productivity accounts little for the stagnation of garment industry in several African countries.

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It has been argued that poor productive performance is one of critical sources of stagnation of the African manufacturing sector, but firm-level empirical supports are limited. Using the inter-regional firm data of the garment industry, technical efficiency and its contribution to competitiveness measured as unit costs were compared between Kenyan and Bangladeshi firms. Our estimates indicated that there is no significant gap in the average technical efficiency of the two industries despite conservative estimation, although unit costs greatly differ between the two industries. Higher unit cost in Kenyan firms mainly stems from high labour cost, while impact of inefficiency is quite small. Productivity accounts little for the stagnation of garment industry in several African countries.

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1. Introduction

Manufacturing sector in sub-Saharan Africa has been stagnated since the 1980s except a few countries. Economic studies on the African industry imply that slow productivity growth as a source of the long stagnation. Literatures on the technical capacity of firms reported that most of the African firms have used obsolete technology and equipment, and that their technical knowledge and skills are poorer than those in Asia (Lall [1999], Biggs et al. [1995], Pack [1993]). They argue that lack of knowledge and skill has hindered efficient use of technology as well as technological upgrading, and under the trade liberalization, such backwardness leads to decline of African industry not only in the export market but in the domestic market where competition with imports (particularly Asian products) has become acute. Other literatures focus on the business environment in Africa. They suggested that African business environment characterized as high risk of contract enforcement, high cost of production and transportation, and great uncertainty in the macroeconomic environment has seriously discouraged African firms from investment (Collier and Gunning [1999]). In fact, investment rate of African firms is shown to be quite low (Bigsten et al [1999]). These studies indicated that investment in technology, such as R&D and skill formation, has been discouraged in African manufacturing sector, and consequently, productivity growth was far behind the rivals in the world.

After the mid-1990s, a growing number of studies measured firm-level productivity due to the increased availability of firm data, and they have revealed the productive performance of African firms in many important aspects. For instance, they found stagnation of productivity growth in the manufacturing sector (Teal [1999], Adenikinjyu et al. [2002], Soderling [2000], Mlambo [2002]), productivity difference by firm characteristics, such as size, age, ethnicity of manager, and market orientation (for example, Bigsten et al [2000], Fafchamps [2001], Mazumdar and Mazaheri [2003], Soderbom and Teal [2004], van Biesebroeck [2005]), and the relationship between entry and exit action with productivity (Fraser [2005], Shiferaw [2007], Bigsten and Gebreeyesus [2007]). However, since most of the studies focused on only African firms, their relative productivity to firms in the other region was investigated in few studies. Exceptionally, Pack [1987] compared total factor productivity of textile firms in Kenya with those in other countries, and reported that Kenyan firms are less productive than firms in developed countries but as productive as Philippine firms. Some studies compared partial factor productivities of African firms with those of Asian firms (for example, Biggs et al [1995], Blattman et al [2004], Shah et al [2005]), but they are only a crude measure of productivity when firms face different factor prices and use different technologies. Despite a shared recognition, relatively poor productivity of African firms has not yet been empirically shown.

Furthermore, productivity is not the sole determinant of competitiveness even in a market where price competition dominates. Factor costs, scale economy and allocation of factors (how efficiently a firm allocate factors to minimize cost) also affect the cost of production. A few studies have explored impact of factor prices on competitiveness, and they focused on unit labour cost gauged typically as labour costs per value added (Lindauer and Velenchik [1994], Mabye and Golub [2003], Blattman et al [2004], Shah et al [2005]). Although they indicated the adverse effect of high wage on competitiveness in some countries, it does not tell about sources of low labour productivity, which can be accounted for by total factor productivity, scale economies and efficiency of factor allocation. Therefore, backgrounds of the competitiveness gap between the industries in Africa and the other regions have not been systematically explored.

Using the original firm data from Asia and Africa, this study attempts to make a consistent comparison of productivity, and to demonstrate its impact on competitiveness together with factor prices, scale economies and factor allocation. Focus is on a single industry, the garment industry. Performance of the garment industry shows sharp contrast between Africa and other countries, and underdevelopment of the sector attracted attention of some development economists (Sachs [2005], Collier [2007]). By narrowly defining an industry to be analyzed, productivity and competitiveness are gauged based on homogenous technology; that is, productivity difference due to heterogenous technology is avoided. Data was collected in Kenya and Bangladesh in 2003. Since Bangladesh is one of the largest exporters of garments and also low-income countries, a comparison of productive performance between the two countries is roughly conditioned on income level, and the possible reverse causality can be minimized. Although the data is cross-section, it has relatively large samples of the single industry in low-income countries, and includes firm information on technology, labour and market, which allows better estimates of firm-level productivity.

In this paper, technical efficiency was estimated as a productivity measure based on the stochastic production frontier model with the pooled samples of Kenyan and Bangladeshi firms. Estimate indicated that the average of technical efficiency does not differ significantly between Kenyan and Bangladeshi firms. Since it is statistically supported that firms in the two countries share a common technology, this result indicated that the two industries are equally productive on average. This result was robust in non-parametric estimation of productivity.

On the other hand, large disparity was found in the firm competitiveness measured by unit cost. The average unit cost of Kenyan local firms is higher by 150% to that of Bangladeshi firms. Deriving unit cost function from production frontier estimation, the unit cost difference was decomposed to technical efficiency, factor prices, scale economy and allocative efficiency. It indicated that wages pushed up cost of Kenyan firms most significantly, while technical and allocative efficiency only slightly inflated the unit cost gap between Kenyan and Bangladeshi firms. Adjustment of wages by worker's tenure did not yield substantial change. The result suggested that a sharp contrast of competitiveness is due to factor price rather than productivity in the garment industry.

In the next section, a framework for an inter-regional comparison of firm performances is described, which includes the methodology used for measurement of productivity and identification of its impact on competitiveness. Results of empirical analysis are shown in the third section, and conclusions are presented in the last section.

2. Framework and Methodology

The garment industry specializes in the assembly process of clothing production. Because of its relatively simple and labour-intensive technology, the garment industry has grown in many developing countries. It had started to grow in the 1960s in East Asia and it gradually shifted to Southeast Asia and Latin America in the 1970s and 80s. Particularly in Asia, exports of clothing preceded industrialization process and lead to economic growth (Lall [2000], World Bank [1993]). Recently, garment exports have grown in low-income countries including Bangladesh, Vietnam, and Cambodia, and they have become large exporters in the world market. In contrast, the garment industry in African countries did not penetrate the export market with exception of Mauritius, and has even lost most of its share in domestic markets after trade liberalization (McCormick and Rogerson [2004]). Lagging for several decades, garment exports started to grow in several African countries after 2000 due to preferential access given by United States. However, the growth trend substantially slowed down after 2005 when termination of the Multi-Fiber Agreement (MFA) led to free market regime in the world textile market. The garment industry is a good case to see the contrast of performance in African and the other regions.

Performance and competitiveness are compared between Kenya and Bangladesh. The Bangladeshi garment industry has grown since the 1980s and has become the eighth largest exporter in the world (2002, WTO [2003]). While growth of the industry was triggered by technical cooperation by a Korean firm, local firms have learned technology swiftly, and now most of exporters are local origin (Rhee and Belot [1989]). Conversely, the Kenyan garment industry used to be the largest cluster in East Africa, but trade liberalization in the early 1990s has resulted in the influx of imports of secondhand and Asian clothing, and the industry has drastically shrunk (McCormick et al. [1999]). Exports have grown since 2000 when the US government provided preferential access to African countries under the African Growth and Opportunity Act (AGOA), but scale is small and all exports are by multinational firms (Fukunishi et al. [2006]).

Similarity of GDP per capita, $418 in Kenya and $386 in Bangladesh (2003, World Bank [2006]) makes the comparison easier. Both industries produce relatively homogenous products, that is, low-priced simple garments. Associations of industrial performance with business environment and human capital are simple in this comparison, because they are little accounted for by the difference of income levels in the two countries. In a comparison between rich and poor countries, such association is contaminated by the reverse causality; that is, good industrial performance facilitates good business environment and rich human capital through increased income level. Our comparison can mitigate such a problem.

2.1 Productivity Measurement

Technical efficiency is estimated from the pooled samples of Kenya and Bangladesh using the stochastic production frontier model. In this methodology, production frontier represents the maximum output that technology exhibits given the quantity of inputs, and actual production of an individual firm may be less than the frontier due to technical inefficiency and a random shock on production. Assuming a Cobb-Douglas form, a standard production function is expresses as

$$Y_i = \alpha\ K_i^{\beta 1} L_i^{\beta 2} * TE_i * error_i\,,$$

where *Y*: output, *K*: capital, *L*: labour, *TE*: technical efficiency between 0 to 1, *error*: stochastic errors with mean at one, and *i* represents an individual producer. For a firm operating on the frontier, technical efficiency is equal to one, and between 0 and 1 for those off the frontier.

To understand the effect of labour quality, human capital is incorporated in the function. While the literature suggested shortage of skilled labour in the African manufacturing sector, production workers in Kenyan garment firms seem to deal with more variety of tasks than Bangladeshi firms, and accordingly, indicators of human capital (i.e. share of skilled labour and average tenure) are higher in Kenyan firms than Bangladeshi firms (will be discussed in the next section). If our indicators correctly represent labour quality, ignorance of it is likely to overestimate technical efficiency of Kenyan firms. Then, firstly as a rough measure of human capital, labour is separated to skilled labour, *Ls*, and semi-skilled labour, *Lu*. Secondly, following Hall and Jones [1999], number of semi-skilled worker is adjusted by their average skill represented by worker’s education and tenure, as $h_i Lu_i$ where $h_i = e^{\pi_1 Tenuer + \pi_2 Education}$. This formulation is similar to the Micerian earning function in the labour literature, and if earning is related with individual’s productivity, application of Micerian function will be justified. [1] Then, a production function turns to be,

$$Y_i = \alpha\ K_i^{\beta 1} Ls_i^{\beta 2} \left(h_i Lu_i\right)^{\beta 3} * TE_i * error_i \\ h_i = e^{\pi_1 Tenuer + \pi_2 Education} . \quad (1)$$

Estimation is based on log form.

$$\ln Y_i = \beta_0 + \beta_1 \ln K_i + \beta_2 \ln Ls_i + \beta_3 \ln Lu_i + \beta_3 (\pi_1 Tenuer + \pi_2 Experience) - u_i + v_i , \quad (2)$$

where β_0=exp(α), u_i = - ln(TE_i), $u_i > 0$ and v_i = ln($error_i$). Inefficiency, u_i, is assumed to follow a half normal distribution, $N^+(0, \sigma_u^2)$, or a truncated normal distribution, $N^+(\mu, \sigma_u^2)$, and the error component, v_i, is assumed to be normally distributed with mean zero, $N(0, \sigma_v^2)$. Separation of v_i and u_i from regression residuals ($\varepsilon_i = -u_i + v_i$) follows the methodology by Jondrow et al. [1982], which utilizes the conditional distribution of u given ε derived from the distributional assumption on u and v. [2] To have a consistent estimation of efficiency between Kenyan and Bangladeshi samples, an assumption of a common production frontier must be held.

Value added was used instead of gross output as output, because many of the sample firms take subcontract orders in which material is provided by a buyer. Given that output is measured in value (will be transformed to quantity index by deflator), subcontractor's gross outputs do not include material value, and thus, use of gross output underestimates their outputs. Bruno [1978] justified use of value added in a production function when share of material to gross output is constant (Leontief type) and material price is determined in a competitive market. To measure efficiency of transformation from inputs to output precisely, capital value is adjusted by utilization rate.

There are two potential problems in the estimation. As we have only cross-sectional data, a distributional assumption on inefficiency component in residuals (u) must be made. Choice of the distribution may affect estimates of function parameters and technical efficiency, but we do not have prior knowledge. Then, two different distributions, half normal and truncated normal distribution,

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[1] Although wages of all the sample firms differ by tenure but not by education, we followed a standard formulation. Soderbom and Teal [2004] and Fraser [2005] used a similar estimation model for firm-level data.

[2] For loglikelihood functions and estimation methodology of *u*, see Appendix 2.

were assumed, where the latter is more flexible. Also following Olson et al. [1980], the production function was estimated without distributional assumption by OLS, and then, technical efficiency was obtained by method of moments approach. Although distributional assumption is held in the second step, the possible bias in parameter estimates will be avoided. [3]

Secondly, the endogeneity problem on input choice, first discussed by Marschak and Andrews [1944], may arise, if a firm determines amount of input, particularly labour, knowing its own productivity that is unobservable for us. Fixed effect model and some estimation procedures, for example those by Olley and Pakes [1996] and Levinson and Petrin [2003], have been suggested, but they are not applicable to cross-sectional data. Then, alternatively we take a nonparametric approach based on the index number theory, which is free from the endogeneity problem. Following Caves et al. [1982], productivity of individual firm is measured relative to a hypothetical average firm with average inputs, output, and factor shares by the following formula.

$$\left(\ln TFP_i - \overline{\ln TFP}\right) = \left(\ln Y_i - \overline{\ln Y}\right) - \left(\frac{s_i^K + \overline{s^K}}{2}\right)\left(\ln K_i - \overline{\ln K}\right) - \left(\frac{s_i^{Ls} + \overline{s^{Ls}}}{2}\right)\left(\ln Ls_i - \overline{\ln Ls}\right) - \left(\frac{s_i^{Lu} + \overline{s^{Lu}}}{2}\right)\left(\ln Lu_i - \overline{\ln Lu}\right),$$

where s^n (n = K, Ls, Lu) is factor share of capital, skilled and semi-skilled labour, and the variables with upper bar (i.e. $\overline{\ln Y}$) is sample average. Since total factor productivity is deterministically drawn, unlike stochastic frontier model, measured TFP include random shocks on production as well as measurement errors. It also assumes constant returns to scale and cost-minimization of firms (no allocative inefficiency is allowed).

2.2 Contribution of inefficiency to competitiveness

With efficiency measures, we then want to know the contribution of efficiency to competitiveness. In the garment market, competition is determined primarily by quality, delivery and price, while price and delivery are most important for low-priced products that Kenyan and Bangladeshi firms

[3] For detail of the methodology, see Appendix 2.2.

are producing (Lall and Wignaraja [1994]). Although it is not the sole determinant, price is crucial in determining the competitiveness of products. Assuming that price competitiveness is represented by unit cost, we attempt to know how much of the difference of unit costs between Bangladeshi and Kenyan firms is explained by inefficiency.

Exploiting the duality of the Cobb-Douglas function, the cost function can be obtained from the production function and the cost minimization condition. With the production function (1), a firm minimizes cost, $C_i = r_iK_i + ws_iLs_i + wu_i(h_iLu_i)$, where r_i is rental price of capital, ws_i is wage for skilled worker and wu_i is wage for semi-skilled worker adjusted by skill (h_i). It is assumed that the firm may misallocate inputs, and then, actual cost becomes greater than minimum cost (allocative inefficiency). The first order conditions of cost minimization with allocative inefficiency are expressed as

$$\frac{K_i}{Ls_i} = \frac{\beta_1 ws_i}{\beta_2 r_i} AE_{1i}$$
$$\frac{K_i}{h_i Lu_i} = \frac{\beta_1 wu_i}{\beta_3 r_i} AE_{2i} , \qquad (3)$$
$$\frac{Ls_i}{h_i Lu_i} = \frac{\beta_2 wu_i}{\beta_3 ws_i} AE_{3i}$$

where AE_{ni} >0 for all n, and it is equal to one when factor allocation is optimal given factor price ratios.

From the above four equations, the input demand functions are given by

$$K_i = \left[\frac{\beta_1^{\beta 2+\beta 3}}{\beta_2^{\beta 2}\beta_3^{\beta 3}} \alpha^{-1} \frac{ws_i^{\beta 2} wu_i^{\beta 3}}{r_i^{\beta 2+\beta 3}} \left(\frac{Y_i}{TE_i * error_i} \right) AE_{1i}^{\beta 2} AE_{2i}^{\beta 3} \right]^{\frac{1}{\beta}}$$

$$Ls_i = \left[\frac{\beta_2^{\beta 1+\beta 3}}{\beta_1^{\beta 1}\beta_3^{\beta 3}} \alpha^{-1} \frac{r_i^{\beta 1} wu_i^{\beta 3}}{ws_i^{\beta 1+\beta 3}} \left(\frac{Y_i}{TE_i * error_i} \right) AE_{1i}^{-\beta 1} AE_{3i}^{\beta 3} \right]^{\frac{1}{\beta}}$$

$$h_i Lu_i = \left[\frac{\beta_3^{\beta 1+\beta 2}}{\beta_1^{\beta 1}\beta_2^{\beta 2}} \alpha^{-1} \frac{r_i^{\beta 1} ws_i^{\beta 2}}{wu_i^{\beta 1+\beta 2}} \left(\frac{Y_i}{TE_i * error_i} \right) AE_{2i}^{-\beta 1} AE_{3i}^{-\beta 2} \right]^{\frac{1}{\beta}}$$

where $\beta=\beta_1+\beta_2+\beta_3$. Multiplying respectively by a factor price, the cost function is given by

$$\hat{C}_i = r_i K_i + ws_i Ls_i + wu_i (h_i Lu_i) = A\, r_i^{\frac{\beta 1}{\beta}} ws_i^{\frac{\beta 2}{\beta}} wu_i^{\frac{\beta 3}{\beta}} \hat{Y}_i^{\frac{1}{\beta}} TE_i^{\frac{-1}{\beta}} \overline{AE_i} , \qquad (4)$$

where $A=\beta\left(\alpha\prod_n \beta_n{}^{\beta n}\right)^{\frac{-1}{\beta}}$ n=1,2,3, $\hat{Y}_i=\alpha\, K_i{}^{\beta 1} Ls_i{}^{\beta 2}\left(h_i Lu_i\right)^{\beta 3} TE_i$ (predicted output), and

$\overline{AE}_i=\frac{1}{\beta}\left[\beta_1 AE_{1i}{}^{\frac{\beta 2}{\beta}} AE_{2i}{}^{\frac{\beta 3}{\beta}}+\beta_2 AE_{1i}{}^{\frac{-\beta 1}{\beta}} AE_{3i}{}^{\frac{\beta 3}{\beta}}+\beta_3 AE_{2i}{}^{\frac{-\beta 1}{\beta}} AE_{3i}{}^{\frac{-\beta 2}{\beta}}\right]$. The first through sixth terms on the right hand side compose the cost frontier function, and the last two terms represent dispersion of actual cost from the frontier; they are the costs of technical inefficiency and allocative inefficiency respectively.[4] $\overline{AE}\geq 1$ and equality holds when AE_n=1 for all n; the cost of allocative inefficiency is null when there is no inefficiency in input allocation.

Note that the cost expressed in (4) accounts only for utilized inputs, since capital in the production function is adjusted by the utilization rate. Thus, actual cost is greater than the cost given by (4) if the firm has idle capital (in fact most of firms do), and this also should be included in the cost of allocative efficiency. Adding the cost of idle capital, η, in multiplicative form, the actual cost is described as

$$C_i=\hat{C}_i\,\eta_i\,,$$

where $\eta\geq 1$. Dividing the cost by predicted output, the unit cost is expressed by factor prices, production scale, and inefficiency.

$$D_i=\frac{C_i}{\hat{Y}_i}=A\, r_i{}^{\frac{\beta 1}{\beta}} ws_i{}^{\frac{\beta 2}{\beta}} wu_i{}^{\frac{\beta 3}{\beta}} \hat{Y}_i{}^{\frac{1-\beta}{\beta}} TE_i{}^{\frac{-1}{\beta}} \overline{AE}_i\ \eta_i\,.$$

A comparison of unit cost between Kenyan and Bangladeshi firms and the contribution of each component to this difference are of our interest. By taking the ratio of the unit cost of firm *i* to firm *j*, we have the following identity.

$$\frac{D_i}{D_j}=\left(\frac{r_i}{r_j}\right)^{\frac{\beta 1}{\beta}}\left(\frac{ws_i}{ws_j}\right)^{\frac{\beta 2}{\beta}}\left(\frac{wu_i}{wu_j}\right)^{\frac{\beta 3}{\beta}}\left(\frac{\hat{Y}_i}{\hat{Y}_j}\right)^{\frac{1-\beta}{\beta}}\left(\frac{TE_i}{TE_j}\right)^{\frac{-1}{\beta}}\frac{\overline{AE}_i\cdot\eta_i}{\overline{AE}_j\cdot\eta_j} \qquad (5)$$

The first to third terms in the right hand side are contributions of the difference of factor prices to the difference of unit costs, and the fourth term represents the contribution of scale economy. The fifth

[4] In the frontier analysis literature, costs of technical and allocative inefficiency are jointly termed as cost (in)efficiency (see for example, Kumbhakar and Lovell [2000]).

term is the contribution of technical inefficiency followed by allocative inefficiency. Use of production function for decomposition has advantage that effect of technical efficiency and allocative efficiency can be measured separately, and in more practical aspect, rental price that is often unobservable is not needed for production frontier estimation. Possible measurement error of rental price affect only on allocative efficiency estimates but not on parameter estimates and technical efficiency. Decomposition of unit cost using production function was proposed by Nishimizu and Page [1986], and our methodology differs with it in incorporating stochastic efficiency and allowing cross-sectional comparison.[5] Also, while Nishimizu and Page [1986] assumed zero profit to measure cost of allocative inefficiency, non-zero profit is allowed in the above procedure.

To have decomposition by (5), a cost function must be known. It is noted that the cost function (4) is deterministic because the stochastic error is absorbed by $\hat{Y} = Y/error$. Parameters and technical efficiency are given by the production function, and the cost of allocative inefficiency, $\overline{AE}$, is calculated from AE, which is estimated from the equation (3). From the definition, η is given by dividing C by $\hat{C}$. With this information, the difference of the unit costs of two firms can be decomposed to factor prices, scale economies and inefficiencies.

2.3 Data

Firm data were collected in Bangladesh and Kenya in 2003 under the UNIDO COMPID project. The sample was drawn from firms with more than 10 employees, and the data consist of 222 firms in Bangladesh and 71 firms in Kenya. The number of samples reflects the size of industry, where the Bangladeshi industry has more than 3000 firms and the Kenyan industry is estimated to consist of 120-150 firms.[6] While the Bangladeshi sample was drawn by stratified sampling method, the Kenyan sample is a result of exhaustive survey based on several incomplete firm lists due to

[5] Nishimizu and Page [1986] decomposed growth rate of unit cost based on time-series data, while we decompose ratio of unit costs across observation units.
[6] Estimation by the author for the firms employing more than 10 employees.

non-existence of a complete list. [7] It is noted that main characteristics of Kenyan sample are comparable with those from the World Bank firm survey in 2003. Excluding outliers and those with insufficient information, 165 firms in Bangladesh and 47 in Kenya were retained for analysis.

Output values were collected in local currency. Although purchasing power parity (PPP) is the standard instrument for converting value in local currency to quantity index utilizing it as an international price deflator, we have used exchange rate instead of PPP because of the following reasons. All products of Bangladeshi firms and multinational firms in Kenya are exported and priced in US or EU markets, and thus, conversion by exchange rate is appropriate. On the other hand, most Kenyan local firms supply to the domestic market, but comparisons of prices in the Kenyan and US/EU markets showed that exchange rate is more consistent international price deflator than PPP. [8] Since the exchange rate gives a higher price to Kenyan products than the PPP, deflation by the exchange rate leads to a smaller output quantity index of Kenyan local firms, and results in lower technical efficiency estimates than deflation by the PPP.

Capital value and the number of employees are used as input, where capital value was constructed using the perpetual inventory method and converted by the exchange rate.[9] Use of the exchange rate is reasonable provided that all equipment is imported in the both countries.

Regarding factor prices, wages are obtained as labour costs per worker, while capital rental price is not explicitly observable. Rental price can be estimated from capital service cost, which is available in the dataset, but reported capital service cost does not include interest and/or dividends for owner’s contribution to capital purchase. Therefore, rental price was estimated from the arbitrage condition of investment. Assuming all investments yield the same rate of return and perfect foresight, the arbitrage condition is

$$R_i = r_{i,t} p_{i,t} - \delta p_{i,t} + (p_{i,t+1} - p_{i,t}),$$

where R: rate of return (real interest rate), δ: depreciation rate, and p_t: asset price of capital at t. Since

[7] The last census of Kenyan industry was carried out in 1977. See Appendix 1.1 for sampling method.
[8] See Appendix 1.4 regarding choice of an international price deflator.
[9] See appendix 1.3 for detail of capital value construction.

all firms have used imported equipment, it is assumed that asset prices are same for all samples, $p_i = p$. Arranging the arbitrage condition, rental price is given as

$$r_{i,t} = \left(R_i + \delta - \frac{p_{t+1} - p_t}{p_t} \right) p_t \,. \tag{6}$$

The real interest rates of Kenya and Bangladesh were obtained from World Development Indicators. For multinational firms which often finance investment in a home country, the real interest rate of India where many of them originate was used. The asset price change was calculated from the US deflator, and thus, it is common to all observations. Given all equipments imported, asset price, p_t, is assumed constant for all observations, and is normalized at p_t=1. Consequently, the rental price of capital varies with nationality of firms and does not consider individual price variation according to, for example, credit constraint.

This may cause downward bias in estimation of allocative efficiency for firms suffering severe credit constraint (these firms may be misestimated as less efficient than actual). To check the bias, alternative rental price is estimated from the reported capital service cost and compared with one based on the equation (6). The two estimates are similar and the main results of analysis do not alter (see Appendix 1.5). Note that estimates of production function parameters and technical efficiency are not affected by the estimates of rental price.

3. Empirical Analysis

3.1 Overview of the Statistics

Reflecting the strong export orientation of the Bangladeshi garment industry, all Bangladeshi samples are exporting their products to the US and/or EU markets. On the other hand, only seven firms export to those markets in the Kenyan samples and the rest supply to the domestic or African markets. Major exporters are multinational firms established after 2000, and they are registered as an Export Processing Zone (EPZ) firm in order to utilize the advantages of AGOA. 35 EPZ firms were in operation at the time of the survey, of which five firms are included in the sample. Growth of exports was so rapid that production for the US market has far exceeded that for the domestic market, but local firms in Kenya have not responded to the export boom and remained in the domestic market with a few exceptions.

Basic production statistics of the sample firms are described in Table A. It shows that on average, Bangladeshi firms are about five times larger than Kenyan local firms in production, while Kenyan EPZ firms are the largest among the three groups. In terms of inputs, Kenyan firms are more capital intensive than Bangladeshi firms on average, and this is consistent with the relative factor prices as we will see later. It also indicates that Bangladeshi firms are highly profitable; the average share of profit to value added is about 70%, while the profit share of Kenyan firms, including EPZ firms, is much less.

From the author's field observation, the production system appears different between Kenyan local firms (non-exporters) and other firms (exporters) in two aspects. Exporters to US/EU markets have highly decomposed assembly lines where machine operators specialize in small tasks, while Kenyan local firms have less decomposed lines, or sometimes no assembly line in the sewing process. In such cases, one operator sews a whole product. Secondly, the number of floor-level workers per sewing machine in Kenyan local firms is less than that of exporting firms. [10] This means that they allocate fewer helpers to assembly lines, and thus, operators in a Kenyan local firm have to cover a wider range of processes than those in an exporting firm. Accordingly, Kenyan local firms show the longest average tenure of operator and highest share of skilled worker among all (Table A). This may indicate that labour is substituted by skill of workers. Kenyan EPZ firms, on the other hand, maintain a highly decomposed assembly line whereas number of worker per machine is less than Bangladeshi firms. They equip new and high-tech equipment (i.e. specialized and computerized sewing machine), and thus, labour seems to be substituted by machines.

Unit cost is defined as capital and labour service costs per value added, and capital service cost

[10] The average number of floor-level workers per sewing machine is 1.78 for Bangladeshi firms, 1.47 for EPZ firms and 1.13 for Kenyan local firms (the number of sewing machines is adjusted by the utilization rate and workers are restricted to those working in sewing section so that the figure reflects the production characteristics in sewing process).

includes only equipment. The average unit cost of a Kenyan local firm is 2.46 times higher than that of Bangladeshi firms. It is partly explained by the labour cost per worker, given that the labour cost in Kenyan local firms is 2.84 times higher, while the rental price and average labour productivity is almost same between the two groups. Cost statistics of EPZ firms shows a similar trend though their unit cost and labour cost are slightly lower.

Cost structure is consistent with market performance of the garment industry in two countries. With high production costs, Kenyan firms cannot compete with imports in the domestic market. In the export market, increased competition due to abolishment of the quota system leads to stagnation of Kenyan export while the Bangladeshi industry has kept growing. Cost statistics clearly shows that the Bangladeshi industry performs better than the Kenyan industry in the liberalized export market.

Cost statistics also shows that wage in Kenyan firms is strikingly high; the average wage in Kenyan local firms is 2.8 times higher than that of Bangladeshi firms. Due to relatively high wages, Kenyan firms have employed more capital and less labour than their Bangladeshi counterparts, but capital intensity does not raise labour productivity enough to cancel the high labour cost. Simple statistics, however, do not indicate why labour productivity has remained relatively low. It can be attributed to misallocation of inputs (too little capital), inefficient production, or smaller size of Kenyan local firms in the case of increasing returns to scale. The sources of the unit cost difference will be approached in the following sections.

3.2 Measurement of Technical Efficiency

The main production activity in the garment assembly process includes two different types of work; sewing and knitting. While woven garments such as woven shirts and trousers are made by only a sewing process, knitting garments like T-shirts and sweater are made by a knitting process and occasionally a sewing process. The technology of the two processes differs, and thus a dummy variable, *Sewing*, is included in the estimation model to distinguish the firms with a sewing process from those who have an only knitting process. Heteroskedasticity test indicated group-wise heteroskedasticity around the process dummy, *Sewing* (see Appendix 3 for the results), and then, the auxiliary models are added to estimate σ_{ui} and σ_{vi}, as $\ln\sigma_{ui} = \boldsymbol{\delta_1}$ (1, $Sewing_i$) and/or $\ln\sigma_{vi} = \boldsymbol{\delta_2}$ (1, $Sewing_i$). Significant correlation is reported only for σ_{vi}. A dummy for Kenyan local firms, *Klocal*, is also added to pick up possible difference in productivity according to production system.

The benchmark model assuming a half normal distribution for inefficiency has yielded significant coefficients on inputs and the process dummy (*Sewing*), and variance of inefficiency (σ_u) is also significantly different from zero at 5% level (column 1 in Table C). Estimated coefficient for capital is 0.16 and those for skilled and semi-skilled labour are 0.44 and 0.47 respectively. Though elasticity of skilled worker is slightly smaller, marginal productivity is substantially greater than semi-skilled worker. [11] Constant returns to scale can not be rejected at 10% level. The Kenyan local dummy is also not significant, and this implies that Kenyan local firms are not technically different from the others. In column 2, a model with average tenure and education was reported. While parameter estimates for inputs are remained similar, those for average tenure and education had a right sign but not significant.

The assumption of a half normal distribution of inefficiency was replaced by a truncated normal distribution that allows a mode of distribution having any positive values (column 3). The result is quite similar to the benchmarked model with slightly larger coefficient for capital. It is noted that variance and the mode of inefficiency (σ_u and μ) do not significantly differ from zero, that is, there is no statistical support for a truncated normal distribution. OLS estimate which does not require distributional assumption on inefficiency is reported in column 4. It yielded lower parameter for capital and higher parameter for semi-skilled worker, but they are relatively small change. Overall, parameter estimates are stable over variation of estimation models.

The result that production system dummy, *Klocal*, was insignificant suggests that production system of Kenyan local firms is technologically equivalent to that of exporters. [12] This is reasonable because a short assembly line is more efficient when production scale is small. Two systems share

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[11] Marginal productivities for skilled and semi-skilled worker at the mean level are \$10523 and \$1179, respectively. Reversal of the relationship between elasticity and marginal product is due to smaller number of skilled worker than semi-skilled worker.

[12] Different coefficient on inputs for Kenyan local firms is also rejected at 10% level (the result not reported).

the same technology but differ in the optimal size of production. We predicted that labour is substituted by skill of worker rather than capital in Kenyan local firms from the field observation. Parameter estimates for skilled and semi-skilled worker are robustly significant and suggested skilled worker has higher marginal productivity, while tenure and education remained insignificant. Education may not represent skill given that education does not affect wages in semi-skilled worker. In contrast, the wages differ by tenure. Tenure that counts experience only in the current firm may be an incomplete measure of skill if skills are not firm specific and experience in other firms can be effective. This is left for further investigation. However, it is noted that Kenyan local firms substituted semi-skilled labour by skilled labour in order to reduce total labour intensity.

Based on the above results, technical efficiency is recalculated excluding the Kenyan local dummy from the estimation model to avoid that insignificant but negative effect of the dummy gives overestimation of Kenyan local firms. Group-wise heteroskedasticity is kept controlled as ignorance yields a bias in estimates of technical efficiency (Kumbhakar and Lovell [2000]). The averages of technical efficiency are 0.55 (column 1 and 2 in Table C). These estimates are comparable to results of the other studies measuring technical efficiency of garment industry.[13] Sample is divided to Bangladeshi, Kenyan local and Kenyan EPZ firms and group averages of the technical efficiency are also listed. Comparison demonstrated that difference among the three group averages is small in the both models. In particular, the average of Kenyan local firms and Bangladeshi firms are very close, and difference is not significant at 10% level in all the estimates. Because of control of labour quality of semi-skilled worker, the average technical efficiency of Kenyan local firms in column 2 is slightly smaller, while it is opposite for the Bangladeshi average. Distribution of technical efficiency indicates that outlier does not affect the averages (Figure A).

Alternative methodologies did not alter the relationship of average efficiencies by the firm group. The method of moments approach based on OLS residuals yielded lower technical efficiency overall (0.503), but the average of Kenya local firms does not significantly differ from the Bangladeshi

[13] The studies of Columbian and Indonesian textile and garment industries reported that the average technical efficiency is 0.55 and 0.63 (Tyler and Lee [1979], Hill and Kalirajan [1993]). The studies of African textile and garment industries reported mean technical efficiency ranging from 0.40 to 0.69 (Biggs et al. [1995], Mazumdar and Mazaheri [2003], Mlambo [2002], Lundvall et al. [2002]).

average (column 3 in Table C). For relative TFP by the index number approach, while Kenyan local firms marked lower score, the averages of the two groups are not statistically significant (column 4). In terms of transformation of input to output, Kenyan local firms are on average as efficient as the Bangladeshi firms that have been competitive in the US and EU markets for more than two decades.

Estimation also indicates that the technical efficiency of firms participating in the global production network is not higher than those not participating. This result appears inconsistent with the literatures on FDI spillover and learning-by-exporting that showed technological advantage of the firms in global production network.[14] It may not be surprising, because, as mentioned, exporters are not necessarily a technical leader of the production system for a domestic market. In addition, average technical efficiency of Kenyan local firms may have been increased by shrink of the industry for a last decade, which accelerated inefficient producer's exit. Yet, this does not necessarily mean that local firms can start production for the export market immediately. From the author's field interviews, it appears that local firms attempting to enter the export market have learned the design of production lines, quality control, sewing skills, and market linkages from EPZ firms and expatriates. Participation in the global production network needs substantial learning by firms as argued in the literature. Our results indicate that Kenyan local firms manage their own production system as efficient as Bangladeshi exporters do, but they do not imply that Kenyan firms are capable to supply to the export market without learning.

Impacts of business environment and managerial skill, which are argued as a source of poor performance of the African manufacturing sector were investigated. Firm-level information of business environment and manager's characteristics is collected (Table D). It shows that delay of material delivery is most frequently occurred in EPZ firms probably because of import of Asian fabrics, and duration for sales collection is longest in Kenyan local firms. The most frequent blackout is reported by Bangladeshi firms. Overall, no clear difference in the business environment was detected between the two countries. This is consistent with the fact that Bangladesh is evaluated

[14] Although causality between export performance and productivity, and foreign ownership and productivity can be endogenous, superior performance of multinational firms than local firms are generally supported by empirical studies (Crespo and Fontoura [2007]).

as one of the worst countries in terms of governance. For instance, World Bank Institute [2007] ranked it in the bottom quarter of the world with respect to 'rule of law' and 'control of governance'. In terms of manager's characteristics, managers of export firms were received higher education whereas experience is longer for those in Kenyan local firms.

Their impacts on technical efficiency were tested. Following the method by Kumbhakar, Gosh and McGuckin [1991], an exogenous variable is assumed to be correlated with efficiency through the mode of its distribution (μ) as

$$\begin{aligned} \ln Y_i &= \beta_0 + \beta_1 \ln K_i + \beta_2 \ln Ls_i + \beta_3 \ln Lu_i - u_i + v_i \\ \mu_i &= \boldsymbol{\varphi} \mathbf{W}_i \end{aligned},$$

where $u_i \sim N^+ (\mu_i, \sigma_u^2)$, $v_i \sim N(0, \sigma_v^2)$. [15] $\boldsymbol{W}_i$ is a vector of the variables related with manager's characteristics and business environment, namely manager's education dummy (*M-edu*, =1 with post secondary education and =0 otherwise), years of manager's total experience in the industry (*M-exp*), frequency of delivery delay (*Delivery*), days to collect sales (*Sales Collection*), days of blackout (*Blackout)* and its interaction with possession of a generator (*Blackout*Generator*). The result is shown in Table C (column 5). Coefficients of all the variables except *Sales Collection* have right sign, where a negative sign means that increase of the variable leads to reduction of inefficiency, and higher technical efficiency. However, they are not statistically significant at 10%. Business environment and human capital appear to have a weak association with productive performance. This may be interpreted that due to simple and matured technology, production of low-priced garments is less sensitive to business environment, and dose not necessarily require high education and experience. Analysis of production function indicated that gap of technology, human capital and surrounding business environment between internationally competitive firms and local firms is not large, and this allows many firms in low-income countries to compete in the world market.

3.3 Decomposition of Unit Cost Difference

[15] This method can avoid unrealistic assumption that exogenous variables (*Wi*) are irrelevant to output, which is necessary when they are directly regressed on technical efficiency (Kumbhakar and Lovell [2000]).

Based on the estimates of technical efficiency, allocative efficiency, and parameters of the production function, unit cost difference and its decomposition are estimated by the equation (5). Production function estimate is based on the model without worker's tenure and education and the Kenyan local dummy, because of the persistent insignificant signs. So, human capital weigh in the equation (5), h_i, is assumed to be one.

The first column of Table E shows the estimations of each component of equation (5) based on the mean values of Bangladeshi and Kenyan local firms, benchmarking on the Bangladeshi mean (it is a denominator). It indicates that the mean unit cost of Kenyan locals is 2.39 times higher than that of Bangladeshi firms.[16] The following figures in the column are contribution of factor prices, scale economies and inefficiencies and if it is greater (smaller) than one, the component contributes to increase (decrease) the unit cost of Kenyan local firms relative to Bangladeshi firms. The difference in semi-skilled wages between the two groups makes the greatest contribution, inflating Kenyan unit cost by 56.2%, followed by skilled wage that pushed up the cost by 31.2%. Jointly, wage increased the cost of Kenyan local firms by 104.9% (1.562*1.312 = 2.049). This is primarily because of the large difference of wages between the two groups and relatively large contribution of labour to production. The average of semi-skilled and skilled wages in Kenyan local firms is higher than the Bangladeshi average by 2.8 times and 2.3 times respectively.

Relatively small size of production of Kenyan local firms increased cost by 14.4% due to scale economy. Technical inefficiency actually contributed to decrease relative costs by 8.0%, because the average of Kenyan local firms is slightly higher. Contribution of allocative inefficiency is estimated to increase by 15.6% and rental price slightly contributed to lower the cost by 1.1%. These two contributions are prone to the possible measurement error of rental price, but estimation using the alternative rental price estimates based on the reported data generated only slight changes to them.[17]

[16] This figure is slightly different from ratio of the average unit costs obtained from Table A. This is because the figure in Table E is calculated from mean factor prices, scale economy, and efficiencies of Bangladeshi and Kenyan local firms, while the figures in Table A are simply the sample average of unit costs. The figure in Table E indicates the difference of unit costs between the hypothetical average Kenyan and Bangladeshi firms endowed with average characteristics.

[17] With the alternative rental price, contributions of allocative efficiency is 1.136 (13.6% increase) and rental price is 1.004 (0.4% increase) respectively. See Appendix 1.5 for the detail.

The comparison based on the average demonstrates that the large gap of unit costs between the two groups is mainly resulted from the difference in wages and to a much lesser extent, by scale economy and allocative inefficiency. Joint contribution of technical and allocative efficiencies is 6.4% increase (0.920*1.156 = 1.064), almost neutral to the cost. The same picture emerges when comparing EPZ firms with Bangladeshi firms (column 2 in Table E).

Kenyan local firms are separated to two groups according to unit cost (lower 50% and upper 50%) and compared with the Bangladeshi mean respectively (Figure B). Comparing the two groups, the lower 50% group is found to produce at half cost of the upper 50% group. The former has lower value for all the components except the rental price set to be equal, and in particular contribution of wages for both skilled and semi-skilled are substantially lower than the upper 50% group. While better performers have higher technical and allocative efficiency, cost reduction is brought mainly by lower wages.

Wage table of the sample firms indicates that wage of semi-skilled worker differs by tenure but not by education and gender (Fukunishi et al [2006]). Given the considerable difference in the average tenure between Kenyan local and the other firms, a part of the wage gap can be attributed to the difference of tenure. Although the average tenure was not significantly correlated with production, netting out its effect on wage will exclude a possible effect of skill on wage. Then, conditional wage at the mean tenure gives comparison of the wage netting out the difference in tenure. Mincerian wage function was estimated,

$$\ln w_i = \rho_0 + \rho_1 Tenuer_i + \rho_2 Sewing_i + \rho_3 Klocal_i + \rho_4 Kenya_i + \varepsilon_i ,$$

where *Kenya* is a country dummy. The process and Kenyan local dummies (*Sewing* and *Klocal*) are to incorporate a possible systematic difference of wage by process and production system. The country dummy is expected to capture difference of the labour markets in the two countries.

The regression yielded significant coefficient estimates for tenure, the process dummy, and the country dummy (Table F). It indicated small elasticity for tenure; 1% increase of tenure leads to 0.05% of increase of wage, while change of the country dummy from one to zero is associated with reduction of wage to half. That is, most of wage difference between Kenyan and Bangladeshi firms is associated with country specific factors such as labour market conditions. Based on the result, wage conditioned by tenure was calculated and its impact on unit cost was obtained (Table G). As expected, it does not make substantial change in contribution of wages.

World Bank report on Kenyan manufacturing sector noted high wage level in the sector. It reported that unit labour costs of Kenyan industries are higher by 20-50% than that of India and China (Blattman et al [2004]). Our result showed that difference is greater when compared with low-income Asian countries, with which Kenyan firms are competing in the domestic and export markets. And more importantly, it demonstrated that such difference is brought mostly by wage difference while technical and allocative efficiencies plays minor role. Most of the wage difference was not attributed to skill in the comparison of Kenyan and Bangladeshi industries.

What causes the wage difference between Kenya and Bangladesh despite quite similar GDP per capita? Although responding this question is beyond scope of this paper, it is noted that minimum wages in the two countries show a large divergence; 64.5US$ per month in Kenya and 16.0US$ in Bangladesh. [18] As semi-skilled wage is affected by the level of minimum wage, it is a basis of the large wage gap. Furthermore, wages converted by PPP shows much smaller difference; the semi-skilled wage for Kenyan firms is higher by only 33.8% than that of Bangladeshi firms (conditioned at the mean tenure). This indicates that much of the difference of wages (and minimum wages) reflects difference of price level of the two countries, and Kenyan workers are not better off than Bangladeshi workers as appeared in the exchange-rate converted wages.

4. Conclusion

It has been argued that African firms have performed lower productivity than firms in other developing countries, and it is a critical source of weak competitiveness under globalization. A

[18] The minimum wages are from Kenya Gazette Supplement No.43 and Bangladesh Gazette on January 12, 1994, converted by the exchange rates in 2003. The Bangladeshi minimum wage has been raised to US$28.6 in 2006 after a long freeze since 1994, which is closer to the semi-skilled wage in our data.

comparison of Kenyan firms with Bangladeshi firms in the garment industry indicates that Kenyan local firms operate as efficiently as Bangladeshi firms on average in terms of transforming input to output, despite conservative estimates. This result is robust to methodology of productivity measurement. It is notable because Kenyan local firms have little experience in the US/EU markets while Bangladeshi firms have been successfully competing in the world market for decades. As argued in the literature, business environment and human capital (particularly for production workers) is poor in Kenyan firms. Yet, because of relatively simple and matured technology, the garment industry is less sensitive to business environment and does not require high human capital. Poor endowment does not seem to significantly affect productivity of Kenyan local firms, and furthermore, internationally competitive Bangladeshi firms are also operating in poor business environment.

However, a large gap between the two groups was found in price competitiveness measured as unit cost; the unit cost of Kenyan local firms was 2.5 times greater on average. The difference of average unit costs was decomposed based on the production frontier estimation. It revealed that the difference of wages between the two groups explained most of the unit cost difference, and technical inefficiency contributed to slightly reduce the cost gap. Kenyan local firms incur higher unit cost primarily due to higher wages, and the inefficiency of technological management makes a minor contribution.

Relatively high labour cost to Asia is not peculiar to Kenya. According to Gibbon [2003], operator's wage in Southern African countries is as high as one in Kenya.[19] Wages in CFA Fran countries are also generally higher than Asian countries (Rama [2000], Mbaye and Golub [2003]). Adverse effect of wages on competitiveness is likely to be most significant in garment industry considering its labour intensiveness. However, given that it is most technically feasible for low-income countries, and it preceded industrialization in many of Asian countries, wage may be one of the important factors in African industrial development. Since the wage gap is corresponded

[19] The monthly wage for operators in Lesotho is 100 US dollars, 80 US dollars in Swaziland, 130-180 US dollars in urban areas of South Africa (Gibbon [2003]), while our data in Kenya is 87-89US$ for local firms, and 68-80 for EPZ firms.

with the poverty line gap in our case, reduction of wage is likely to aggravate poverty in the region. As the Mauritian case shows, the industry can remain competitive with relatively high labour cost through improvement of efficiency and upgrading from bottom-end to middle rage market. [20] Improvement of productivity is a possible solution for African manufacturing sector.

[20] Subramanian and Roy [2003] showed improvement of productivity in the Mauritian industry.

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Table A Production and Cost Statistics by Group

	Bangladeshi Firms	Kenya Local Firms	Kenya EPZ Firms
Gross output (1000US$)	2977.7 (2247.7)	549.8 (1115.5)	13800.0 (21100.0)
Value added (1000US$)	1554.1 (1261.5)	261.5 (720.3)	8739.4 (15100.0)
Number of workers	535.2 (250.7)	78.5 (161.5)	892.4 (376.9)
Capital value (1000US$)	121.1 (85.1)	45.2 (91.0)	716.8 (809.8)
Utilized capital value / worker	372.4 (289.4)	428.2 (475.6)	618.6 (575.5)
Share of Skilled Worker	0.128 (0.055)	0.283 (0.165)	0.054 (0.025)
Average Tenure of Semi-skilled Worker (years)	2.31 (0.77)	3.99 (1.91)	2.00 (1.37)
Average Education of Operator (years)	5.00 (2.25)	9.62 (2.55)	9.60 (2.19)
Profit/VA	0.715 (0.228)	0.252 (0.502)	0.481 (0.486)
Unit Cost	0.266 (0.220)	0.655 (0.437)	0.620 (0.606)
Labour cost per worker (US$)	469.0 (225.6)	1330.5 (688.3)	1064.7 (432.6)
Rental price (estimated)	0.184 (0.000)	0.171 (0.000)	0.144 (0.000)
Labour productivity (US$)	3099.6 (2270.6)	3035.7 (2855.2)	9556.9 (16935.9)

Note: Standard deviations are in parentheses.

Table B Results of Estimation of the Production Function

Dependent variable: ln Value Added	1	2	3	4	5
	Stochastic Frontier	Stochastic Frontier	Stochastic Frontier	OLS and Method of Moment	Stochastic Frontier
Distribution of u	Half Normal	Half Normal	Truncated Normal	Half Normal	Truncated Normal
lnK	0.157* (0.073)	0.154* (0.073)	0.182* (0.071)	0.119 (0.092)	0.110 (0.072)
lnLs	0.443** (0.110)	0.495** (0.114)	0.481** (0.112)	0.470** (0.136)	0.441** (0.112)
lnLu	0.465** (0.113)	0.434** (0.114)	0.452** (0.118)	0.545** (0.137)	0.525** (0.114)
Tenure		0.035 (0.043)	0.028 (0.042)	0.003 (0.058)	
Education		0.025 (0.023)	0.032 (0.022)	0.040† (0.023)	
Sewing	0.196 (0.133)	0.199 (0.131)	0.332* (0.130)	0.162 (0.122)	0.315* (0.130)
Klocal	-0.069 (0.222)	-0.209 (0.237)	-0.195 (0.268)		
Cons	8.185** (0.646)	7.987** (0.663)	7.421** (0.655)	7.892** § (0.644)	8.297** (0.583)
σ_v^2			0.260** (0.067)	0.210** (0.030)	0.174** (0.057)
σ_u^2	0.855** (0.351)	0.855** (0.340)	6.085 (13.776)	1.162** (0.130)	1.607 (1.197)
$\sigma^2=\sigma_v^2+\sigma_u^2$			6.345 (13.800)	1.371 (0.160)	1.781 (1.213)
$\gamma=\sigma_u^2/\sigma^2$			0.959 (0.086)		0.902 (0.065)
μ			-8.115 (22.349)		
Auxiliary Model 1: Dependent var: $\ln\sigma_v^2$					
Sewing	1.229* (0.557)	1.226* (0.619)			
cons	-2.249** (0.535)	-2.268** (0.625)			
Auxiliary Model 2: Dependent var: μ					
M-edu					-1.071 (0.873)
M-exp					-0.011 (0.033)
Delivery					0.058 (0.057)

Sales Collection					-0.018 (0.023)
Blackout					0.019 (0.015)
Blackout*Generator					-0.028 (0.022)
cons					0.498 (1.294)
Constant Returns to Scale: χ^2 stat and p-value	0.67 [0.413]	1.08 [0.299]	1.85 [0.174]	4.49 [0.035]	
Average Technical Efficiency	0.547 (0.170)	0.546 (0.170)	0.601 (0.190)	0.503 (0.196)	
N	212	212	212	212	182

§: Constant in OLS estimate is adjusted in order to transform mean production function into production frontier. See Appendix 2.2 for detail.

Note: Standard errors are in parentheses (Heteroscedasticity robust SE is reported for OLS estimates). P-values for the test of constant returns to scale are in square brackets. *, ** and † indicate that coefficient is significantly different from zero at respectively 1%, 5% and 10% level.

Table C Average Technical Efficiency and Relative TFP

	1	2	3	4
	Technical Efficiency			
	Stochastic Frontier	Stochastic Frontier	OLS, Method of Moment	
Dependent Var	ln Value Added			Relative TFP
Independent Var	lnK, lnLs, lnLu, Sewing	lnK, lnLs, lnLu, Tenure, Education, Sewing		
Total	0.549 (0.168)	0.549 (0.168)	0.503 (0.196)	-0.047 (0.807)
Bangladeshi Firms n=165	0.547 (0.172)	0.550 (0.171)	0.507 (0.197)	-0.032 (0.813)
Kenyan local firms n=42	0.553 (0.145)	0.546 (0.150)	0.488 (0.181)	-0.155 (0.672)
Kenyan EPZ firms n=5	0.584 (0.233)	0.574 (0.238)	0.516 (0.299)	0.347 (1.526)

Note: Standard deviations are in parentheses.

Table D Business Environment and Manager's Characteristics by Group

	Delay of Delivery (times)	Days to Collect Sales	Blackouts (days)	Post Secondary Education Dummy	Experience in Garment Industry (years)
Bangladeshi Firm	1.1 (3.4)	21.5 (15.2)	17.6 (32.8)	0.96 (0.18)	10.5 (7.0)
Kenyan Local Firm	2.6* (3.6)	62.7* (80.0)	9.4 (8.2)	0.68* (0.47)	15.4* (9.4)
Kenyan EPZ Firm	4.0 (5.0)	22.5 (28.7)	4.3 (1.8)	1.00 (0.00)	14.7 (6.1)

Note: Delivery delay and blackouts in the last three months were surveyed. Standard deviations are in parentheses. * indicates statistically different from the Bangladeshi average at the 5% level.

Table E Decomposition of the Difference of Unit Cost

		Kenyan Local Mean / Bangladeshi Mean	Kenyan EPZ Mean / Bangladeshi Mean
Unit cost (a)	D_i/D_j	2.389	2.475
Rental price (b)	$(r_i/r_j)^{\beta 1/\beta}$	0.989	0.965
Skilled Wage (c)	$(ws_i/ws_j)^{\beta 2/\beta}$	1.312	1.525
Semi-skilled Wage (d)	$(wu_i/wu_j)^{\beta 3/\beta}$	1.562	1.531
Scale Economy (e)	$(Y_i/Y_j)^{1/\beta - 1}$	1.144	0.956
Technical Inefficiency (f)	$(TE_i/TE_j)^{-1/\beta}$	0.920	0.926
Allocative Inefficiency (g)	$AE_i\eta_i/AE_j\eta_j$	1.156	1.305
Process Effect § (h)		0.969	0.951

§: 'Process Effect' captures difference in constants of cost function (*A* in equation 4) by the process dummy (*sewing*).

Note: As indicated by the equation (5), a=b*c*d*e*f*g*h.

Table F Result of Wage Function Estimation

Dependent Variable: log of Semi-skilled Wage

Tenure	0.052† (0.028)
Sewing	-0.237** (0.071)
Klocal	-0.098 (0.192)
Kenya	1.072** (0.183)
_cons	5.798** (0.092)
R^2	0.498

N	212

Note: Heteroskedasticity robust standard errors are in parentheses. *, ** and † indicate that coefficient is significantly different from zero at respectively 1%, 5% and 10% level.

Table G Semi-Skilled Wage Conditioned by Tenure

	Average (US$)	Contribution to Unit Cost Difference*
Bangladeshi Firms	318.1 (34.8)	-
Kenyan Local Firms	808.6 (62.7)	1.511
Kenyan EPZ Firms	869.5 (0.0)	1.561

*: Ratio to the Bangladeshi average in $(wu_i/wu_j)^{\beta 3/\beta}$.

Note: Standard deviations are in parentheses.

Figure A Density Distribution of Technical Efficiency

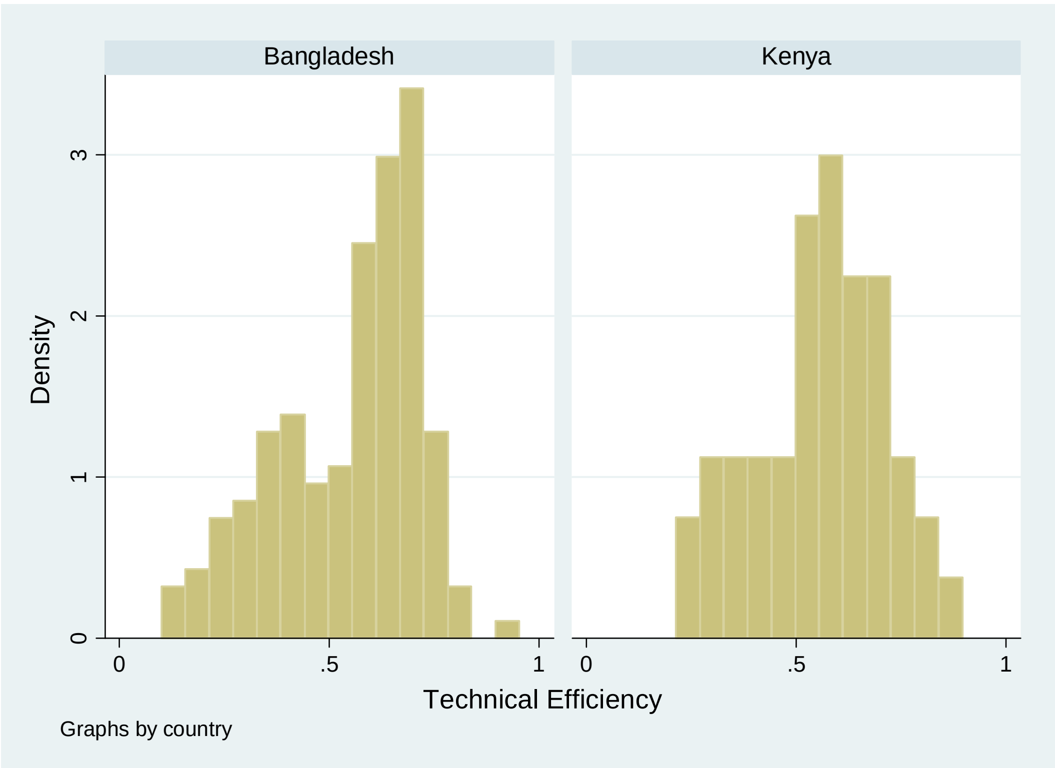
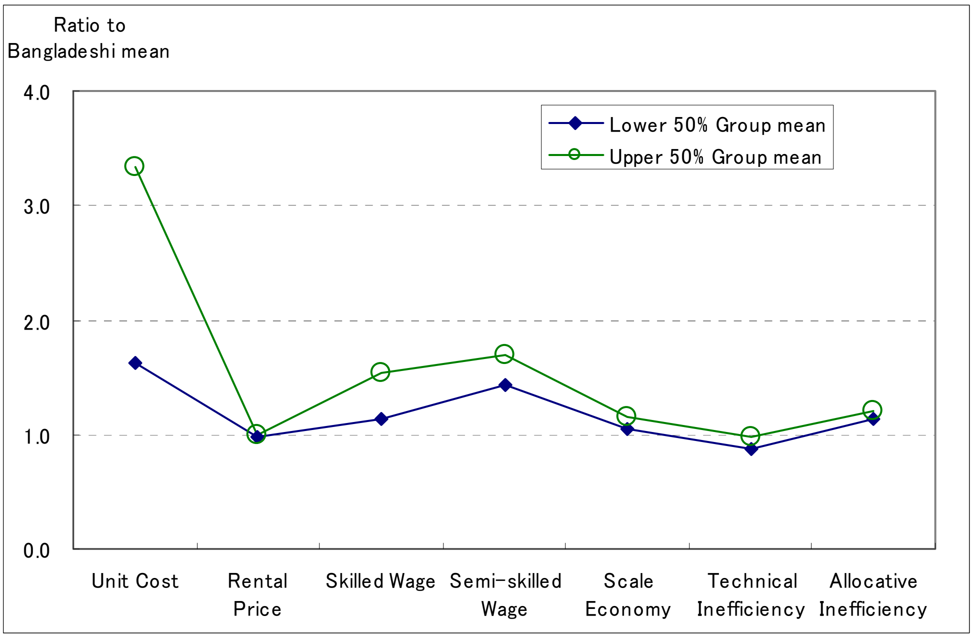


Figure B Contribution to Unit Cost Difference by Two Groups of Kenyan Local Firms



Note: Ratios to the Bangladeshi mean. See text for the grouping of samples.

Appendix 1: Sampling Method and Data Construction

1. Sampling Method

Firm surveys were jointly conducted with the Institute of Developing Economies, the Institute of Development Studies, University of Nairobi, and the Institute of Business Administration, University of Dhaka in 2003.

The Kenya survey began with construction of a firm list since there is no comprehensive firm list. Integrating several incomplete lists, including lists compiled by the Central Bureau of Statistics, the Investment Promotion Center, the Export Processing Zones Authority, the Kenyan Association of Manufacturers and the Institute of Development Studies, an extensive firm list containing 322 firms with more than 10 employees in Nairobi, Mombasa, Nakuru, Thika and Eldoret was constructed. Because this list includes firms that had closed down, all firms in the list were contacted and interviews were conducted with those still in operation. They survey collected information of 71 firms out of 104 firms in operation. Neither characteristics of the population nor the remaining 33 firms were known, it is difficult to determine whether our samples have bias or not except that responses from EPZ firm were less than other firms. However, mean values of gross output and employment are similar to those obtained from the World Bank Investment Climate Survey in 2003, which include 18 local garment firms and two EPZ firms[21].

In the Bangladesh survey, samples were selected from the member list of the Bangladesh Garment Manufacturers and Exporters Association (BGMA) using a stratified sampling method. Another industrial association, the Bangladesh Knitwear Manufacturers and Exporters Association (BKMEA), which is mainly constituted by knit wear producers, was not included in order to retain accordance with the Kenyan sample that was mainly composed of woven wear producers. Among 2891 members, data was collected from 222 firms. For detail of the sampling procedure, see Fukunishi et

[21] The average of gross output (total sales form manufacturing goods in 2002) of 18 local firms in garment sector (code 11) is 586,550US$, and the average of employment is 65.4. The average labour cost per worker is 1204.1US$ for local firms (transformation to US dollar is by the author). These values are very close to our statistics in Table A and B. Among the two EPZ firms, one started operation in 2002 and did not provide consistent data. The author thanks World Bank for access to the data.

al. [2006].

2. Sample Restriction

Some samples did not have complete information regarding input and output, particularly in Kenyan sample, due to lack of capital inventory. Only 248 firms out of 293 have full information. Among these, the samples with incorrect information were also excluded. That is, firms with negative value added, unrealistic labour costs per worker, capital value per worker, or share of labour costs in value added were eliminated. The latter three restrictions were imposed based on our belief that number of workers is the most reliable information, and they exclude the samples with unrealistic wages, capital value, and output considering number of workers. Specific restrictions were that labour cost per worker be from US$100 to $2000 for Bangladesh and from $500 to $5000 for Kenya, that capital value per worker be below $5000, and that the share of wage bill in value added be greater than 4%. Incorrect data was seen primarily in the Bangladeshi samples. Excluding these firms, 212 firms (165 Bangladeshi firms and 47 Kenyan firms) were remained in the sample. It should be noted that without the restrictions on labour cost per worker and wage share in value added, the similar results was obtained, and in particular the key finding that average technical efficiency does not significantly differ between Bangladeshi and Kenyan local firms was retained.

Through the restrictions, large firms were more likely to be dropped from the sample, and thus the sample selection problem may be significant.

3. Capital Value Construction

Only the value of equipment was constructed using the perpetual inventory method based on purchase information (price and year) of all equipments. For some Kenyan samples with incomplete capital purchase price data, capital value was estimated from resale value data. For deflation, an US deflator (price indexes for ‘Special industry machinery’ issued by Bureau of Economic Analysis) was used for both Kenya and Bangladeshi samples after capital value was converted to US dollars by the exchange rate. Use of the US deflator is reasonable given that almost all capital equipment was imported. Depreciation rate is set to 10% based on a comparison of constructed capital value with resale value among the Kenyan samples. To check robustness of the results, alternative capital value was constructed using depreciation rate at 5%, and we found that main results including technical efficiency remain unchanged (see Appendix 3.2).

4. International Price Deflator

The data of input and output values is in local currency and need to be converted to quantity when used for production function. Given the diversity of equipment and products, quantity of capital and output is not usually given in a consistent way. Then, a quantity index is normally used, where it is given by dividing value by a price deflator. For imported input (capital equipments) and exported products which are priced in OECD countries, exchange rate from local currency to US dollar is an appropriate price deflator as long as the price levels in OECD countries are similar. All Bangladeshi firms and Kenyan EPZ firms export products to US/EU markets, and all sample firms use imported equipment.

For output sold in the domestic market, purchasing power parity is a standard international price deflator. The PPP rate of Kenyan Shilling to US dollar for consumption goods is 27.59Ksh, while the exchange rate is 75.94Ksh (2003, Penn World Tables). This means that at the exchange rate-converted price, the same goods cost about three times more in US than in Kenya, but the average producer prices of T-shirts, men's shirts and trousers in the Kenyan market are not lower than those for the export market (mainly the US market) at the exchange rate-converted price, despite the relatively low quality of Kenyan products. Therefore, the PPP rate may undervalues Kenyan products, and consequently leads to overestimation of the quantity index of Kenyan local firms supplying the domestic market. To avoid bias, the exchange rate was used as a price deflator. Estimates of technical efficiency of Kenyan local firms tend to be smaller than estimates based on the PPP-converted quantity index.

5. Rental Price Estimation

Rental price of capital can be estimated by the two different methodologies. One is based on the reported capital service cost by sample firms, and the other is based on the arbitrage condition for investment (see section 2.3). Given that capital service cost is rental price multiplied by quantity of capital, $r_i K_t$, rental price is obtained by dividing the service cost by quantity of capital, which can be replaced by capital value, $p_t K_{i,t}$, when asset price of capital is normalized at one (p_t=1).

Though this estimate has an advantage that it reflects heterogeneity of rental price among firms, it also have serious problems that the reported service cost does not includes interests and dividends for capital purchased by owner’s personal fund, in some samples, it includes service cost for land and buildings that are excluded from capital throughout this paper, and measurement errors. Because of the above reasons, rental price was estimated using the arbitrage condition at the cost of ignoring variation of rental prices among firms (but rental price differs between Kenyan local, EPZ and Bangladeshi firms). The choice of estimates affects estimation of allocative efficiency and decomposition of unit cost by the equation (5), while it does not affect production function estimation.

To see the bias that may be borne, two estimates of rental price and the related estimation results are compared in this section. Table A1 shows two estimates of rental price. It indicates that the average of two estimates are similar, and rental price based on the reported value is higher than one based on the theoretical deduction in Kenyan local and EPZ firms, but it is smaller in Bangladeshi firms. It also showed that variation of rental price within the group is not small. Since the reported values may be overvalued due to inclusion of service cost of land and buildings, higher price for Kenyan firms does not necessarily imply actual rental price is higher than the theoretical deduction.

Table A1 Comparison of Estimated Rental Prices

	Rental price based on reported capital costs	Rental price based on arbitrage condition
Bangladesh	0.158	0.184
N=163	(0.116)	(0)
Kenyan Local	0.234	0.171
N=37	(0.183)	(0)
Kenyan EPZ	0.187	0.144
N=3	(0.132)	(0)

Note: Seven observations which rental price is greater than one are excluded from the sample, as it should be less then one with normalization of asset price of capital.

Table A2 shows the unit cost decomposition using the rental price based on the reported information. Since capital-labour ratio is too small for most of firms, increase of rental prices for the Kenyan firms leads to improvement of their allocative efficiency, and accordingly reduction of its contribution to unit cost gap with the Bangladeshi firms. On the other hand, contribution of rental price on unit cost gap becomes larger. Contributions of the other factors (labour cost, scale economies and technical efficiency) would not be affected (however, those figures in Table A3 are slightly different from those in Table F, because seven observations which rental price is greater than one are excluded from the sample).

Table A2 Decomposition of the Difference of Unit Cost

		Kenyan Local Mean / Bangladeshi Mean	Kenyan EPZ Mean / Bangladeshi Mean
Unit cost (a)	D_i/D_j	2.367	2.171
Rental price (b)	$(r_i/r_j)^{\beta 1/\beta}$	1.004	0.983
Skilled Wage (c)	$(ws_i/ws_j)^{\beta 2/\beta}$	1.302	1.794
Semi-skilled Wage (d)	$(wu_i/wu_j)^{\beta 3/\beta}$	1.562	1.589
Scale Economy (e)	$(Y_i/Y_j)^{1/\beta-1}$	1.141	0.932
Technical Inefficiency (f)	$(TE_i/TE_j)^{-1/\beta}$	0.920	0.813
Allocative Inefficiency (g)	$AE_i\eta_i/AE_j\eta_j$	1.136	1.074
Process Effect § (h)		0.972	0.951

§: ‘Process Effect’ captures difference in constants of cost function (*A* in equation 4) by process dummy (*sewing*).

Note: As indicated by the equation (5), a=b*c*d*e*f*g*h.

Appendix 2: Estimation Procedure

2.1 Estimation by MLE (Likelihood Functions and Estimation of u_i)

The inefficiency term *u* in equation (2) has the density function as follows:

$$f(u) = \frac{2}{\sqrt{2\pi}\sigma_u} \cdot \exp\left\{-\frac{u^2}{2\sigma_u^2}\right\}$$ when *u* is assumed to follow a half normal distribution, and

$$f(u) = \frac{2}{\sqrt{2\pi}\sigma_u} \cdot \exp\left\{-\frac{u^2}{2\sigma_u^2}\right\}$$ when *u* is assumed to follow a truncated normal distribution.

The density of *v* is

$$f(v) = \frac{1}{\sqrt{2\pi}\sigma_v} \cdot \exp\left\{-\frac{v^2}{2\sigma_v^2}\right\}.$$

The joint density function of *u* and *v* provides the joint density of *u* and *ε*, given *ε*=-*u*+*v*. Then, by integrating *u* out of *f*(*u*, *ε*), the marginal density function of *ε* is

$$f(\varepsilon) = \int_o^\infty \frac{2}{2\pi\sigma_u\sigma_v} \cdot \exp\left\{-\frac{u^2}{2\sigma_u^2} - \frac{(\varepsilon+u)^2}{2\sigma_v^2}\right\} du$$
$$= \frac{2}{\sqrt{2\pi}\sigma} \cdot \left[1 - \Phi\left(\frac{\varepsilon\lambda}{\sigma}\right)\right] \cdot \exp\left(-\frac{\varepsilon^2}{2\sigma^2}\right) \cdot$$

given a half normal distribution, and

$$f(\varepsilon) = \int_o^\infty \frac{1}{2\pi\sigma_u\sigma_v\Phi(-\mu/\sigma_u)} \cdot \exp\left\{-\frac{(u-\mu)^2}{2\sigma_u^2} - \frac{(\varepsilon+u)^2}{2\sigma_v^2}\right\} du$$
$$= \frac{1}{\sqrt{2\pi}\sigma\Phi(-\mu/\sigma_u)} \cdot \Phi\left(\frac{\mu}{\sigma\lambda} - \frac{\varepsilon\lambda}{\sigma}\right) \cdot \exp\left(-\frac{(\varepsilon+\mu)^2}{2\sigma^2}\right)$$

given a truncated normal distribution, where $\sigma=(\sigma_u^2+\sigma_v^2)^{1/2}$, $\lambda=\sigma_u/\sigma_v$, and Φ(.) is the standard normal cumulative distribution function.

Then log-likelihood functions for N observations are,

$$\ln L = \sum_i^N \left\{-\frac{1}{2}\ln(2\pi) - \ln\sigma + \ln\Phi\left(-\frac{\varepsilon_i\lambda}{\sigma}\right) - \frac{\varepsilon_i^2}{2\sigma^2}\right\}$$

given a half normal distribution, and

$$\ln L = \sum_i^N \left\{ -\frac{1}{2}\ln(2\pi) - \ln\sigma - \ln\Phi\left(\frac{\mu}{\sigma\gamma^{1/2}}\right) + \ln\Phi\left(\frac{\mu(1-\gamma)-\varepsilon_i\gamma}{\left[\sigma^2\gamma(1-\gamma)\right]^{1/2}}\right) - \frac{1}{2}\left(\frac{\varepsilon_i+\mu}{\sigma}\right)^2 \right\}$$

given a truncated normal distribution, where $\gamma = \sigma_u^2/\sigma^2$.

The inefficiency of an individual firm i, u_i, is included in the regression residual, ε_i, and not visible. However, it can be estimated from the conditional distribution of u_i given ε_i. Jondrow et al [1982] showed that if $u_i \sim N^+(0, \sigma_u)$, then the conditional distribution is

$$f(u \mid \varepsilon) = \frac{1}{\sqrt{2\pi}\sigma'} \cdot \exp\left\{-\frac{(u+\varepsilon\gamma)^2}{2\sigma'^2}\right\} \Bigg/ \left[1-\Phi\left(\frac{\varepsilon\gamma}{\sigma'}\right)\right],$$

where $\sigma' = \sigma_u^2\sigma_v^2/\sigma^2$. The expected value of u_i conditional on ε_i was used for technical efficiency, which is given by

$$E[u_i \mid \varepsilon_i] = \sigma'\left[\frac{\phi(\varepsilon_i\lambda/\sigma')}{1-\Phi(\varepsilon_i\lambda/\sigma')} - \left(\frac{\varepsilon_i\lambda}{\sigma'}\right)\right].$$

$$TE_i = E[\exp(-u_i \mid \varepsilon_i)]$$

For the truncated normal model,

$$f(u \mid \varepsilon) = \frac{1}{\sqrt{2\pi}\sigma'} \cdot \exp\left\{-\frac{(u-\gamma')^2}{2\sigma'^2}\right\} \Bigg/ \left[1-\Phi\left(-\frac{\gamma'}{\sigma'}\right)\right],$$

$$E[u_i \mid \varepsilon_i] = \sigma'\left[\frac{\phi(\gamma_i'/\sigma')}{1-\Phi(\gamma_i'/\sigma')} - \left(\frac{\gamma_i'}{\sigma'}\right)\right]$$

where $\gamma'_i = (-\varepsilon_i\sigma_u^2+\mu\sigma_v^2)/\sigma^2$.

2.2 Estimation by OLS and Method of Moments

Alternative estimation is based on OLS. Rewriting production function as

$$\ln Y_i = (\beta_0 - E[u_i]) + \beta_1 \ln K_i + \beta_2 \ln Ls_i + \beta_3 \ln Lu_i + \beta_3(\pi_1 Tenuer + \pi_2 Experience) + v_i - (u_i - E[u_i])$$

We assume that v_i has mean zero and $u_i \geq 0$. Since the residual, v_i-(u_i-$E[u_i]$), has means zero and constant variance, OLS can yield consistent estimates on β_1, β_2, β_3. This is done without distributional assumption on u. Then, σ_u and σ_v are estimated by method of moments with the distributional assumptions. Assuming $v_i \sim N(0, \sigma_v^2)$ and $u_i \sim N^+(0, \sigma_u^2)$,

$$E[u_i] = \sqrt{2/\pi}\sigma_u$$
$$V[u_i] = \left[\frac{\pi - 2}{\pi}\right]\sigma_u^2$$
$$E[u_i^3] = -\sqrt{2/\pi}(1 - 4/\pi)\sigma_u^3$$

Thus, the second and third centered moments of $\varepsilon_i = v_i - u_i$ are

$$m_2 = \sigma_v^2 + \left[\frac{\pi - 2}{\pi}\right]\sigma_u^2$$
$$m_3 = -\sqrt{2/\pi}(1 - 4/\pi)\sigma_u^3$$

Since E[u_i] is a constant, the second and third moments of the OLS residuals, v_i- (u_i-$E[u_i]$), are same as those of ε_i. Then, using the two moments of OLS residuals, σ_u and σ_v are estimated as

$$\hat{\sigma}_u^2 = \left(\frac{m_3}{\sqrt{2/\pi}(1 - 4/\pi)}\right)^{2/3}$$
$$\hat{\sigma}_v^2 = m_2 - \left(1 - \frac{2}{\pi}\right)\hat{\sigma}_u^2$$

With those estimates, technical efficiency is obtained by the same way described in the previous section.

Estimate of asymptotic covariance matrix for $(\hat{\sigma}_u^2, \hat{\sigma}_v^2)$ is obtained by

$$\left(\frac{\partial \boldsymbol{\sigma}}{\partial \mathbf{m}}\right)(CovMatrix[m_2, m_3])\left(\frac{\partial \boldsymbol{\sigma}}{\partial \mathbf{m}}\right)' \quad ,$$

where $\boldsymbol{\sigma} = (\hat{\sigma}_u^2, \hat{\sigma}_v^2)$ and $\mathbf{m} = (m_2, m_3)$.

Appendix 3. Estimation Results not Reported in the Text

1. Test of Heteroskedasticity

Breush-Pagan and White's tests were carried out using residuals of OLD regression of lnK, lnLs, lnLu, Tenure, Education, Sewing and Klocal on ln Value-Added. Group-wise heteroskedasticity is tested by separating the sample by the process dummy (Sewing). Null hypothesis of homoskedasticity is rejected by Breush-Pagan test and Goldfield-Quandt test in the model at 1%, while White's test did not reject the null

Table A4 Results of Heteroskedasticity Test

H0=homoskedasticity		
Breush-Pagan Test		
	χ^2 (7)	20.54
	Pvalue	0.005
Whites General test		
	χ^2(33)	31.95
	Pvalue	0.519
Goldfield-Quandt Test		
grp =1, 0		
	F (159, 39)	2.684
	Pvalue	0.000

2. Capital value constructed with depreciation at 5%

The results of production frontier estimation using capital value constructed under depreciation at 5% are in Table A5. Model A1 and A2 are corresponded with model 1 and 4 in Table C respectively. Parameters and average technical efficiency are similar to those under depreciation at 10%. Group average of technical efficiency is also very similar (Table A6).

Table A5 Results of Production Frontier Estimation

	Stochastic Frontier
Distribution of u	Half Normal
lnK	0.164* (0.076)
lnLs	0.467** (0.117)
lnLu	0.480** (0.104)
Tenure	0.018 (0.044)
Education	0.021 (0.021)
Sewing	0.187 (0.131)
cons	7.686** (0.582)
σ_u	0.908 (0.205)
Dependent var: $\ln\sigma_v^2$	
Sewing	1.165* (0.579)
cons	-2.174** (0.569)
CRS	3.15 [0.076]
AV TE	0.551 (0.167)
N	212

Note: Standard errors are in parentheses.

Table A6 Average Technical Efficiency and Relative TFP by Group

	1	2
	Technical Efficiency	Relative TFP
Bangladeshi Firms	0.551 (0.170)	-0.027 (0.812)
Kenyan local firms	0.549 (0.147)	-0.157 (0.671)
Kenyan EPZ firms	0.582 (0.231)	0.816 (1.446)

Note: Standard deviations are in parentheses.