APPRAISAL OF SOURCES OF PRODUCTIVITY GROWTH IN THE GHANAIAN MANUFACTURING SECTOR

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Abstract

This paper sought to establish the sources of total factor productivity growth (TFP) growth which is the part of output not explained by production inputs. TFP comprises of technical change, technical efficiency change and scale change. With the focus on the manufacturing sector particularly small businesses in the apparel sub-sector in Ghana, the paper employed the Malmquist productivity index methodology and based on data collected from 140 firms in Ghana. One finding was that, contrary to the view that traditional sectors such as textile and apparel manufacturing are not affected by new technologies, this study ascertained that new technologies are making a difference in the apparel sector in Ghana. Another finding was that small businesses in the apparel manufacturing industry for instance need considerable reduction in production cost, speed up the production process and improve upon efficiency levels of operations to match consumers taste, variety and demand in general. In all, the paper established increasing application of new apparel manufacturing technologies by small and medium-sized businesses (SMEs) as indicated by widespread technical change. More worrying is the widespread technical inefficiencies which need to be curb through further training and development of relevant technical skills of the producers.

Keywords: Apparel Manufacturing, New Technologies, Productivity, Ghana

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1. Introduction

There is a view that is widely held by the New Trade Theory[1] advanced by Krugman (1984, and 1987) and Grossman and Helpman (1991) that Africa's manufacturing sector is characterized by technical inefficiencies. High efficiency in manufacturing firms is considered as key to the competitiveness and survival of the industry. In order to ascertain what the situation is with small businesses in the apparel sector in Ghana, a number of questions have being raised.

1. Have technical changes occurred among SMEs in the Apparel sector? And if so, how widespread is the phenomenon?
2. Are there production inefficiencies among these businesses? And if so, how pervasive are they?
3. If there are technical changes, are they being off-set by levels of inefficiencies if any? And
4. What contribution has emanated from scale change? If any, how extensive has scale change been over the period?

2 Technical change as a source of TFP growth: Some theoretical backdrop

Technical change has been an integral part of productivity growth literature and has been an important point of focus in economic growth literature for several decades. In seeking answers to why the rates of profit for example, were falling, David Ricardo (1773-1823) alluded to diminishing returns due to the scarcity of natural resources which then causes a decline in labor productivity. The solution to diminishing returns and falling labour productivity, he noted lies in technical change that can cut back on scarce natural resources and temporarily raise labor productivity and the rate of profit. Marx (1861) also explained that capitalist economies by systematically generating technical change can overcome diminishing returns to scarce factors of production.

Schumpeter's (1939) theory of economic growth and technology divides the technological change process into three stages. The first stage is the invention process, which comprises the generation of new ideas followed by the second stage known as the innovation process which pushes for the development of new ideas into marketable products and processes and the third, is the stage of diffusion where new products and processes spread unto the market. The impact of new technology is realized at the diffusion stage. Thus capturing the impact is very much a measurement of how an economy adjusts with the introduction and use of new technologies.

Solow in the 1950s developed a model which features a neoclassical production function that explains the level of output using labor and capital inputs. To explain the growth of per capita output (a crude measure of the standard of living), Solow introduced the idea of technological change. An assumption of decreasing returns, however, ensures that per capita output does not grow without technological progress. Intuitively, this assumption means that successive increases in the amount of, say, capital used in production (holding the number of workers constant) will yield progressively smaller increases in output. If returns to additional investments do not fall, it will always be profitable to invest, capital will continue to accumulate, and per capita output can continue to rise. Solow's growth model showed that long term growth arose only in the presence of labour augmenting technical change.

The recent literature on endogenous growth[2] was initiated by Romer (1986), who examined the idea that spillovers could be associated with the accumulation of knowledge. (A spillover is an action taken by one person or firm that affects another person or firm). Romer showed that spillovers could be strong enough to outweigh the drag caused by decreasing returns to capital and sustain growth in per capita output. Later, Romer refined his model to explain why companies invest in research and development (R&D) when they know that any ideas that result will eventually benefit their competitors. He found that as long as society does not reach some type of technological limit, continuous innovation can allow per capita output to grow forever. One important advantage of Romer's model is that it does not supplant the neoclassical model. Instead, it fills an important gap in the neoclassical theory by providing a rigorous description of the source of technological progress. Romer points out that if innovation in his model was to stop, then his model would collapse to the neoclassical model.

3 Analytical Framework

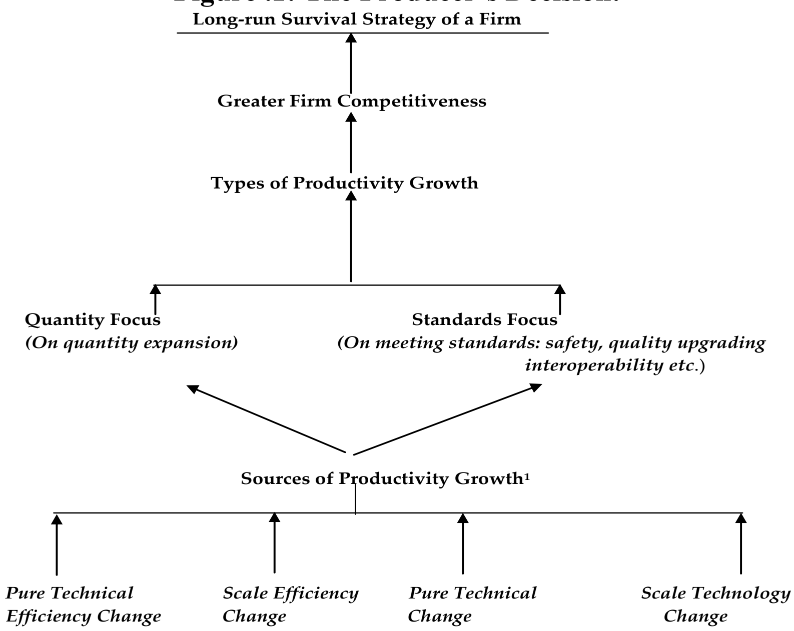
The main sources of productivity growth among the SMEs in the apparel manufacturing sector is assessed within the framework in Figure 1 where the long-run survival strategy of every producer is to make their businesses competitive through productivity growth depends on the choices they make. The assumption here is that there are two types of growth which can be achieved in three

[1] New Trade Theory assumes increasing returns to scale and advocate some restrictions in international trade to allow local businesses to become more competitive.

[2] Endogenous growth literature focuses on new technologies and human capital as the source of economic growth

ways. The first is by just increasing the quantity produced of a product without adding to or reducing its standards leaving its intrinsic value to be the same. The other approach is to maintain the quantity produced of the product by improving on its standards in which case its intrinsic value rises. The third approach is to increase both the quantity of the product and improve upon its standards.

Figure .1: The Producer's Decision:



Sources of productivity growth follow Wheelock and Wilson (1999) decomposition

The main sources of productivity growth can therefore be decomposed into various components using Malmquist productivity index. Relative performance with respect to pure technical efficiency change, scale efficiency change, pure Technical change and Scale technology change as in Figure 1. Pure Technical efficiency change measures a firm's success in producing maximum outputs from a given set of inputs. Scale efficiency change appraises the change in output in relation to percentage change in inputs. Pure Technical change considers the shift in production frontier resulting from the application of new technologies or techniques using the same amount of inputs. Scale technology change also known as the 'residual' shows whether a firm is operating towards constant returns to scale or not.

4 Estimation Procedure

Taking a set of inputs x_i such that i= 1,2,...,p and a set of outputs y_j such that j=1,2,…,q then the vector of inputs and outputs (x,y) implies $x \in \Re_+^p$ and $y \in \Re_+^q$. The production possibility set for firm s in period t therefore follows:

$$\Psi^{t,s} = \{(x^{t,s}, y^{t,s}) \in R_+^{p+q} \mid x^{t,s} \ can \ produce \, y^{t,s}\} \qquad (1)$$

Using an output oriented set defines for all $y \in \Psi^{t,s}$ with Shephard(1970) distance function gives:

$$\Delta^{t,s}(x^{t,s}, y^{t,s}) = 1/\{\max \phi : (x^{t,s}, \phi y^{t,s}) \in \Psi^{t,s}\}| \qquad (2)$$

Following Wheelock and Wilson (1999), the upper boundary $\Psi^{t,s}$ defines the technology of firm *s* at time *t*. For all $x \in \Re_+^p$ and $y \in \Re_+^q$, $\Psi^{t,s}$ is convex, bounded and both inputs and outputs are disposable implying that at a given technology, firms could adjust their inputs or outputs quantities. The location of the *s* firm in the input-output space in period *t* is measured by the distance function $\Delta^{t,s}(x^{t,s}, y^{t,s})$. Equation 2 can be estimated by assuming constant returns to scale(CRS).

$[\overline{\Delta}_{CRS}^{t,s}(x^{t,s}, y^{t,s})]^{-1} = \max\{\lambda_s \mid X^t\Gamma^s \le x^t, Y^t\Gamma^s \le \lambda y^{t,s}, \Gamma \in \Re_+^N\}$ or by assuming variable returns to scale(VRS)

$$[\overline{\Delta}_{VRS}^{t,s}(x^{t,s}, y^{t,s})]^{-1} = \max\{\lambda_i \mid X^t\Gamma^s \le x^t, Y^t\Gamma^s \le \lambda y^{t,s}, N1'\Gamma = 1, \Gamma^s \in \Re_+^N\}$$

including the term $N1\Gamma^s = 1$ and $X = (x_{1,} x_2, ...x_N)$ and $Y = (y_{1,} y_2, ...y_N)$ describe a vector of observed inputs and outputs respectively with t=1….T, s=1…..N and Γ^s indicating the time periods, the number of firms and intensity variables(or non-negative weights) accordingly.

STEP ONE

The total factor productivity (*TFP*) change over 2002 (denoted by t-5) and 2007 (denoted by t) period employing Malmquist index using the geometric mean of two time periods as the reference point provides the following decomposition based on Wheelock and Wilson (1999).

$$M_o^{t,t-5,s} = \left[\frac{\Delta_{CRS}^{t-5,s}(x^{t,s}, y^{t,s})}{\Delta_{CRS}^{t-5,s}(x^{t-5,s}, y^{t-5,s})} \times \frac{\Delta_{CRS}^{t,s}(x^{t,s}, y^{t,s})}{\Delta_{CRS}^{t,s}(x^{t-5,s}, y^{t-5,s})}\right]^{\frac{1}{2}} ....I$$

$$= \left[\frac{\Delta_{CRS}^{t,s}(x^{t,s}, y^{t,s})}{\Delta_{CRS}^{t-5,s}(x^{t-5,s}, y^{t-5,s})}\right] \times \left[\frac{\Delta_{CRS}^{t-5,s}(x^{t,s}, y^{t,s})}{\Delta_{CRS}^{t,s}(x^{t,s}, y^{t,s})} \times \frac{\Delta_{CRS}^{t-5,s}(x^{t-5,s}, y^{t-5,s})}{\Delta_{CRS}^{t,s}(x^{t-5,s}, y^{t-5,s})}\right]^{\frac{1}{2}}$$

$$\uparrow \textit{Efficiency Change} \quad \uparrow \textit{Technical Change} \quad ......II$$

The STEP ONE comprise of the decomposition of the geometric mean of the two time periods t and t-5 in equation *I* into efficiency change and technical change in *II.*

STEP TWO

But according to Fare et al.(1994), equation *II* which is expressed as:

$$\textit{TFP Change} = \textit{Efficiency Change} \times \textit{Technical Change}$$

can further be decomposed into three components

$$\textit{TFP Change} = \textit{Pure Efficiency Change} \times \textit{Scale Change} \times \textit{Technical Change}$$

as presented in equation *III*.

$$M_o^{t,t-5,s} = \left\{\frac{\Delta_{VRS}^{t,s}(x^{t,s}, y^{t,s})}{\Delta_{VRS}^{t-5,s}(x^{t-5,s}, y^{t-5,s})}\right\} .....\textit{Pure Efficiency Change}$$

$$\times \left\{\frac{\Delta_{CRS}^{t,s}(x^{t,s}, y^{t,s}) / \Delta_{VRS}^{t,s}(x^{t,s}, y^{t,s})}{\Delta_{CRS}^{t-5,s}(x^{t-5,s}, y^{t-5,s}) / \Delta_{VRS}^{t-5,s}(x^{t-5,s}, y^{t-5,s})}\right\} ....\textit{Scale Change}$$

$$\times \left\{\frac{\Delta_{CRS}^{t-5,s}(x^{t,s}, y^{t,s})}{\Delta_{CRS}^{t,s}(x^{t,s}, y^{t,s})} \times \frac{\Delta_{CRS}^{t-5,s}(x^{t-5.s}, y^{t-5,s})}{\Delta_{CRS}^{t,s}(x^{t-5,s}, y^{t-5,s})}\right\}^{\frac{1}{2}} ....\textit{Technical Change}$$

$$.........................III$$

STEP THREE

Finally we arrive at the components in *IV* defined by Wheelock and Wilson (1999) as :

$$TFP\ Change = Pure\ Efficiency\ Change \times Scale\ Change \times Pure\ Technical\ Change \times Scale\ Technology\ Change$$

and expressed as:

$$M_o^{t,t-5,s} = \left\{ \frac{\Delta_{VRS}^{t,s}(x^{t,s}, y^{t,s})}{\Delta_{VRS}^{t-5,s}(x^{t-5,s}, y^{t-5,s})} \right\} .....Pure\ Efficiency\ Change$$

$$\times \left\{ \frac{\Delta_{CRS}^{t,s}(x^{t,s}, y^{t,s}) / \Delta_{VRS}^{t,s}(x^{t,s}, y^{t,s})}{\Delta_{CRS}^{t-5,s}(x^{t-5,s}, y^{t-5,s}) / \Delta_{VRS}^{t-5,s}(x^{t-5,s}, y^{t-5,s})} \right\} ....Scale\ Change$$

$$\times \left\{ \frac{\Delta_{VRS}^{t-5,s}(x^{t,s}, y^{t,s})}{\Delta_{VRS}^{t,s}(x^{t,s}, y^{t,s})} \times \frac{\Delta_{VRS}^{t-5,s}(x^{t-5.s}, y^{t-5,s})}{\Delta_{VRS}^{t,s}(x^{t-5,s}, y^{t-5,s})} \right\}^{\frac{1}{2}} ....Pure\ Technical\ Change$$

$$\times \left\{ \frac{\Delta_{VRS}^{t-5,s}(x^{t,s}, y^{t,s}) / \Delta_{VRS}^{t-5,s}(x^{t,s}, y^{t,s})}{\Delta_{CRS}^{t,s}(x^{t,s}, y^{t,s}) / \Delta_{VRS}^{t,s}(x^{t,s}, y^{t,s})} \times \frac{\Delta_{CRS}^{t-5,s}(x^{t-5,s}, y^{t-5,s}) / \Delta_{VRS}^{t-5,s}(x^{t-5,s}, y^{t-5,s})}{\Delta_{CRS}^{t,s}(x^{t-5,s}, y^{t-5,s}) / \Delta_{VRS}^{t,s}(x^{t-5,s}, y^{t-5,s})} \right\}^{\frac{1}{2}}$$

$$\uparrow$$

$$Scale\ Technology\ Change \qquad ....IV$$

These four components of as sources of productivity growth namely pure efficiency change, scale change, pure technical change and scale technology change are estimated analyzed for both non-standards corrected and standards corrected productivity changes in the subsequent sections.

Interpretation

Part 1 of equation *IV* measures pure efficiency change and this value could be less, equal or more than 1 in which case there is a reduction, no change or an increase in pure efficiency respectively. Scale efficiency change in part 2 of equation *IV*

needs to be greater than 1 for an improvement and less than one 1 for deterioration in efficiency. Pat 3 of equation *IV* which captures pure technical change has to be greater than 1 for any positive technological changes to have occurred. A score that is less than 1 is an indication of deterioration in technical change and if it is equal to 1 then there is zero improvement. Change in scale of technology in part 4 of equation *IV* sometimes refers to as the residual defines the shape of the technology and must be greater than 1 to have the shape of technology flattening and less than 1 to indicate an increasing curvature.

4.1Test for statistical significance: Bootstrapping procedure

Having decomposed growth into various components, the next question we want to answer is the significance of each of these components in terms of their contribution to growth. Our focus would especially be on the contribution that technical change has made. To do this, we have to establish whether the components are significantly different from one or not. This section therefore, seeks to carry out the statistical testing of productivity components in order to establish their relative significance and whether they make any difference in the growth. Simar and Wilson (1998) proposed the bootstrapping method which is a simulation technique that allows confidence intervals to be constructed and statistical inference to be carried out with DEA. This study tries to gain insight into the performance of the productivity components in the apparel sector in Ghana by using Simar and Wilson (1998) technique.

The choice of the bandwidth or smoothing parameter and the type of kernel are two very important determinants of the density that is estimated (Silverman 1986, Sheather and Jones 1991).We follow the approach of Silverman (1986) and specify the bandwidth for bivariate data as $h = 0.96N^{-1/6}$ where N is equal to the 140 apparel manufacturing firms in our sample. Even though there are so many types of kernels that can be employed in non-parametric density estimations, more importance has been attached the choice of the bandwidth which has the characteristics of smoothing out all the relevant features in the data. Care must be excised in the bandwidth selection process as over-smoothing may result from large bandwidth selection and under-smoothing may result from small bandwidth selection.

5 Data Sources

This analysis uses three inputs namely labor (l), capital (k) and amount of fabric and material (m) used in the production of apparel. for 2002 and 2007 respectively. Data was collected in Ghana from January-April 2008 by a stratified sample survey and the stratification was done according to size and location (micro, small & medium sized firms, Greater Accra, Eastern and Ashanti region in Ghana). The 140 apparel manufacturing firms were a vital source of information. Semi-structured questionnaire were used. Data on observed apparel output quantity of each firm measured as the number of garments sewn per year (in cedis). Observed apparel inputs quantities of each firm namely: amount of labour or labour productivity measured in number of garments per person-hour (L), amount of capital or capital productivity measured as the amount of output per machine-hour (K), observed amount of material used (M) measured in yards/month, and observed apparel output standards indices of each firm (s) measured in grades/dozen of material used and captured as a combination of object apparel characteristics and subjective fabric hand in percentage.

6 Presentation and analysis of results

6.1Sources of Productivity Growth

Our main point of interest here is to establish the sources of TFP growth and their level of significance. Of 140 firms, some of them are estimated to have experienced efficiency gains but judging these by looking at the positive scores alone is not enough as some might actually not be significant. Confidence intervals were therefore constructed using the homogeneous bootstrap procedure (Simar and Wilson, 1998) with 2000 replications for 3 inputs (p=3) and 1 output (q=1). The idea here is to establish which firms actually have scores that are significantly different from unity. Any firm with the confidence interval containing unity is considered not significantly different from unity. Firms are considered to make some gains if their lower confidence bounds are greater than unity and making significant lose if their upper bounds are less than unity.

Pure Technical Efficiency

The degree of inefficiencies among the firms is staggering. From a sample of 140 firms, 54(38.6%) and 55(39.3%) of them were established to be battling with various levels of pure technical inefficiencies in non-standards corrected and standards corrected estimates respectively. Only 47(33.6%) of the firm were established to be catching up (Table 1). Whilst it was true that some firms did improve, most did not and so these gains were limited. Consequently, the general contribution of pure technical efficiency to TFP growth of firms in the sample can only be said to be poor.

The 47(33.6%) firms that were catching-up comprised of 25 micro firms (29.4%) and 22 small and medium sized firms (40.0%). This shows that more small and medium sized firms experienced pure technical efficiency gains compared to micro-firms. The regional distribution of firms indicates that 16 from the Volta region (35.6%), 10 firms from the Eastern region (27%), and 21 firms from the Greater Accra Region (36.2%) experienced pure efficiency gains. Greater Accra has therefore experienced the highest pure technical efficiency gains, followed by Volta Region and Eastern Region in that order. The bottom-line is that, only 33.6 % of the 140 firms are established to have experienced significant efficiency gains.

Again, in Table 1, out of 140 firms, 54 (38.6%) are actually falling behind. In Greater Accra Region, 23 firms (39.7%) are established to be falling behind, Eastern and Volta Regions have 14(37.8%) and 17(37.8%) firms respectively falling behind in both non-standards corrected and standards corrected estimates. We therefore conclude in favour of our null hypothesis that that these firms have been characterized by pure technical inefficiencies.

Pure Technical Change

The way pure technical change is captured within these apparel manufacturing firms is based on the principle that any new technique or technology employed at one stage of the production process affects all stages. As an example, firms that adopt newer and more efficiency marker making technologies facilitate the cutting stages of a production process and sewing becomes easier. With this approach, the estimated results of technological change indicate that all the firms in the sample have adopted one new form of technology or another at various stages of their production process between 2002 and 2007. This makes a lot of sense since simple but more efficient designing machines, cutting equipment and sewing machines are readily available on the market at relatively affordable prices. In fact, the results revealed that only 1(0.7%) firm is downgrading compared to 108 (77.1%) which are upgrading in both non-standards corrected and standards corrected estimates respectively (Table 2).

Understandably, old apparel manufacturing machines are fast being replaced by modern and more efficient ones. The interesting finding is that there has been some shift from the application of old technologies to new ones but more important though is the extent of that shift. Even firms that opted for new marker making machines alone were considered to be making some progress and so reflected in the results.

Table 1: Pure Technical Efficiency Change Performance across Region and Firm between 2002 and 2007 Size

Unit	Catching-up *(Δ>1)* *Non Standards-Corrected*	Catching-up *(Δ>1)* *Standards-Corrected*	Falling behind *(Δ <1)* *Non Standards-Corrected*	Falling behind *(Δ <1)* *Standards-Corrected*
G. Accra Region	21(36.5%)	21(36.5%)	23(39.7%)	23(39.7%)
Eastern Region	10(27.0%)	10(27.0%)	14(37.8%)	15(40.5%)
Volta Region	16(35.6%)	16(35.6%)	17(37.8%)	17(37.8%)
Regional Average	**47(33.6%)**	**47(33.6%)**	**54 (38.6%)**	**55 (39.3%)**
Micro-firms	25(29.4%)	25(29.4%)	35(41.2%)	36(42.4%)
Small & Medium firms	22(40.0%)	22(40.0%)	19(34.5%)	19(34.5%)
Firm-size Average	**47(33.6%)**	**47(33.6%)**	**54(38.6%)**	**55 (39.3%)**

Table 2: Pure Technical Change Performance across Region and Firm Size between 2002 and 2007

Unit	Upgrading *(Δ>1)* *Non Standards-Corrected*	Upgrading *(Δ>1)* *Standards-Corrected*	Downgrading *(Δ <1)* *Non Standards-Corrected*	Downgrading *(Δ <1)* *Standards-Corrected*
G. Accra Region	42(72.4%)	42(72.4%)	1(1.7%)	1(1.7%)
Eastern Region	27(73.0%)	27(73.0%)	0(0%)	0(0%)
Volta Region	39(86.0%)	39(86.0%)	0(0%)	0(0%)
Regional Average	**108(77.1%)**	**108(77.1%)**	**1 (0.7%)**	**1 (0.7%)**
Micro-firms	60(70.6%)	60(70.6%)	1(1.1%)	1(1.1%)
Small & Medium firms	48(87.3%)	48(87.3%)	0(0%)	0(0%)
Firm-size Average	**108(77.1%)**	**108(77.1%)**	**1 (0.7%)**	**1 (0.7%)**

Scale Efficiency

The role of scale efficiency is relevant here because we are exploring firms of various sizes[3] starting from micro sized to small and medium sized firms. Dealing with a sub-sector which is user-driven requires apparel products to meet the taste and style of the buyers. The choice of scale of operation is also very crucial to satisfy the target market. The aim is to establish whether, scale efficiency is widespread across these firms in our sample.

For non-standards corrected estimates (Table 3), 14 firms constituting 10.0% of the firms in our sample were scale efficient compared with 15(10.7%) in the standards corrected estimates that were also scale efficient. Only 4 firms making up 2.9% were established to be scale inefficient in the third and fourth column of Table 3. The 14 scale efficient firms comprised of 9(10.6%) of micro firms and 5(5.9%) small and medium sized firms in the non-standards corrected estimates which is just one firm less than those in the standards corrected estimates. Of the 4 scale inefficient firms, 2(2.4%) are from micro sized firms and 2(3.6%) are from small and medium sized firms in both the non-standards corrected and standards corrected estimates respectively. This shows that in terms of relative percentages, more small and medium sized firms were scale efficient compared to micro-firms. Regional distribution of firms signify that 4(8.9%) from the Volta region, 6(16.2%) of firms from the Eastern region, and 4(6.8%) of firms from the Greater Accra Region were scale efficient in both non-standards corrected and standards corrected estimates correspondingly.

Scale Technology Change

Scale Technology define as the shape of the technology, Simar and Wilson (1999) is interpreted differently and gives insights into whether changes in the scale of technology are helping firms shifting towards constant returns to scale or making them shifting away from it. This means that firms with estimated scores of scale technology <1 are believed to be moving towards constant returns to scale, a sign of technological progress and firms with scores of scale technology >1 are believed not to be moving towards constant returns to scale.

Our results in Table 4 show that 10.7 per cent of firms appear to be moving towards constant returns to scale compared to 2.9 percent of them that are not moving towards constant returns to scale. For those firms that are moving towards constant

returns to scale, they constitute 9(10.6%) of micro firms and 6(10.9%) of small and medium sized firms. Those that are not moving towards constant returns to scale comprised of 2(2.4%) of micro firms and 2(3.6%) of small and medium sized firms respectively for both non-standards corrected and standards corrected estimates.

At the regional level, we have 5(11.1%) of firms from Volta, 6(16.2%) from Eastern and 4(6.9%) from Greater Accra that are moving towards constant returns to scale compared to 0(0%), 1(2.7%) and 3(5.1%) respectively for those moving away from constant returns to scale. Table 8 in appendix shows that firms' number 32, 37, 41 and 44 from the Volta Region all statistically significant and firms' 63, 67, 68, 80, 81, and 82 from the Eastern Region and firm 86, 87, 91, 95, 98, and 102 from Greater Accra Region are all tatistically significant(non-standards corrected scores).

[3] Size measured by the number of employees. Micro sized firms (1-4 persons, small sized firm(5-20 persons), medium sized firms (21-99 persons)

Table 3: Scale Efficiency Change Performance across Region and Firm Size between 2002 and 2007

Unit	Scale Efficient *(Δ>1)* *Non Standards-Corrected*	Scale Efficient *(Δ>1)* *Standards-Corrected*	Scale inefficient *(Δ <1)* *Non Standards-Corrected*	Scale Inefficient *(Δ <1)* *Standards-Corrected*
G. Accra Region	4(6.8%)	4(6.8%)	3(5.1%)	3(5.1%)
Eastern Region	6(16.2%)	6(16.2%)	1(2.7%)	1(2.7%)
Volta Region	4(8.9%)	5(11.1%)	0(0%)	0(0%)
Regional Average	**14(10.0%)**	**15(10.7%)**	**4(2.9%)**	**4(2.9%)**
Micro-firms	9(10.6%)	9(10.6%)	2(2.4%)	2(2.4%)
Small & Medium firms	5(5.9%)	6(7.1%)	2(3.6%)	2(3.6%
Firm-size Average	**14(10.0%)**	**15(10.7%)**	**4(2.9%)**	**4(2.9%)**

Table 4: Scale Technology Change Performance across Region and Firm Size between 2002 and 2007

Unit	Downgrading *(Δ>1)* *Non Standards-Corrected*	Downgrading *(Δ>1)* *Standards-Corrected*	Upgrading *(Δ <1)* *Non Standards-Corrected*	Upgrading *(Δ <1)* *Standards-Corrected*
G. Accra Region	3(5.1%)	3(5.1%)	4(6.9%)	4(6.9%)
Eastern Region	1(2.7%)	1(2.7%)	6(16.2%)	6(16.2%)
Volta Region	0(0%)	0(0%)	5(11.1%)	5(11.1%)
Regional Average	**4(2.9%)**	**4(2.9%)**	**15 (10.7%)**	**15 (10.7%)**
Micro-firms	2(2.4%)	2(2.4%)	9(10.6%)	9(10.6%)
Small & Medium firms	2(3.6%)	2(3.6%)	6(10.9%)	6(10.9%)
Firm-size Average	**4(2.9%)**	**4(2.9%)**	**15 (10.7%)**	**15(10.7%)**

Table 3: Scale Efficiency Change Performance across Region and Firm Size between 2002 and 2007

Unit	Scale Efficient *(Δ>1)* *Non Standards-Corrected*	Scale Efficient *(Δ>1)* *Standards-Corrected*	Scale inefficient *(Δ <1)* *Non Standards-Corrected*	Scale Inefficient *(Δ <1)* *Standards-Corrected*
G. Accra Region	4(6.8%)	4(6.8%)	3(5.1%)	3(5.1%)
Eastern Region	6(16.2%)	6(16.2%)	1(2.7%)	1(2.7%)
Volta Region	4(8.9%)	5(11.1%)	0(0%)	0(0%)
Regional Average	**14(10.0%)**	**15(10.7%)**	**4(2.9%)**	**4(2.9%)**
Micro-firms	9(10.6%)	9(10.6%)	2(2.4%)	2(2.4%)
Small & Medium firms	5(5.9%)	6(7.1%)	2(3.6%)	2(3.6%
Firm-size Average	**14(10.0%)**	**15(10.7%)**	**4(2.9%)**	**4(2.9%)**

Table 4: Scale Technology Change Performance across Region and Firm Size between 2002 and 2007

Unit	Downgrading (Δ>1) Non Standards-Corrected	Downgrading (Δ>1) Standards-Corrected	Upgrading (Δ <1) Non Standards-Corrected	Upgrading (Δ <1) Standards-Corrected
G. Accra Region	3(5.1%)	3(5.1%)	4(6.9%)	4(6.9%)
Eastern Region	1(2.7%)	1(2.7%)	6(16.2%)	6(16.2%)
Volta Region	0(0%)	0(0%)	5(11.1%)	5(11.1%)
Regional Average	**4(2.9%)**	**4(2.9%)**	**15 (10.7%)**	**15 (10.7%)**
Micro-firms	2(2.4%)	2(2.4%)	9(10.6%)	9(10.6%)
Small & Medium firms	2(3.6%)	2(3.6%)	6(10.9%)	6(10.9%)
Firm-size Average	**4(2.9%)**	**4(2.9%)**	**15 (10.7%)**	**15(10.7%)**

7. Summary and Conclusion

The paper sought to establish the sources of total factor productivity growth growth in the apparel sector in Ghana. A key finding was that 77.1 per cent of the 140 firms experienced significant pure technical change. Also, small and medium sized firms appear to have performed better than micro sized firms. On the average, micro firms appear to have upgraded by 12 per cent over the period whilst small and medium sized firms upgraded by 14 percentage points.

Pure technical inefficiencies on the other hand have been established to be widespread. Scale efficiency has basically remained relatively unchanged. Scale technology change referred to as the residual which defines the shape of the technology must be greater than 1 to have the shape of technology flattening and less than 1 to indicate an increasing curvature. Firms on the average had scale technology scores below unity which implies that they are moving towards constant returns to scale which is good news.

In conclusion therefore, we established that there is increasing application of new apparel manufacturing technologies as indicated by widespread pure technical change. Their full positive effects is however being undone by the pure technical inefficiencies which are widespread among firms in the sub-sector.

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Appendix

Table 5: Confidence intervals obtained based on homogeneous bootstrap procedure(non standards corrected scores)

Estimation of change in Pure Technical Efficiency of firms between 2002 and 2007 (2000 bootstrap replications)

Firm	ΔPure Efficiency	Lower Bound	Upper Bound	Firm	ΔPure Efficiency	Lower Bound	Upper Bound	Firm	ΔPure Efficiency	Lower Bound	Upper Bound
1	1.0000	0.7629	1.3985	48	0.9704	0.9432	1.0447	95	1.2185**	1.1095	1.3617
2	0.8730**	0.8235	0.9401	49	0.8376**	0.8155	0.8690	96	0.8886**	0.8793	0.9287
3	0.9826	0.9331	1.0137	50	1.0578	0.9737	1.1736	97	1.4312**	1.3838	1.5628
4	1.0872**	1.0709	1.1438	51	0.7762**	0.7454	0.7905	98	1.0000	0.7478	1.3892
5	1.0000	0.9777	1.0339	52	0.7540**	0.6596	0.8325	99	0.7908**	0.7736	0.8195
6	1.1836**	1.1589	1.2551	53	1.0000	0.7489	1.3824	100	0.7261**	0.7134	0.7560
7	0.9848	0.9246	1.0292	54	1.1649**	1.1001	1.2035	101	0.9207	0.8322	1.0005
8	1.0730**	1.0405	1.1659	55	0.8185**	0.7972	0.8687	102	0.8197**	0.8183	0.8556
9	0.9572	0.8839	1.0671	56	1.0000	0.7579	1.3805	103	0.8917**	0.8723	0.9302
10	0.8153**	0.7908	0.8566	57	1.1565	0.9864	1.3941	104	1.1417**	1.1320	1.1825
11	1.0422**	1.0170	1.0778	58	1.3628**	1.3500	1.4643	105	1.1060**	1.0524	1.1802
12	0.8797**	0.7955	0.9670	59	1.1330**	1.1157	1.1889	106	1.1146**	1.0411	1.2050
13	0.8184**	0.8013	0.8557	60	1.0000	0.7506	1.3818	107	0.9168**	0.8174	0.9694
14	1.1605**	1.1026	1.2589	61	0.9565	0.8703	1.0150	108	0.9267**	0.9045	0.9495
15	1.0000	0.7548	1.3877	62	1.4571**	1.3975	1.5369	109	0.9376**	0.8665	0.9808
16	1.6031**	1.5589	1.6515	63	0.5978**	0.5903	0.6424	110	1.2948**	1.2694	1.3334
17	1.2225**	1.1319	1.3618	64	1.1874**	1.1505	1.2102	111	1.0000	0.7486	1.3928
18	1.1124**	1.0007	1.2198	65	0.9574**	0.9109	0.9962	112	1.0468**	1.0159	1.1227
19	0.9845	0.9554	1.0409	66	0.9332**	0.9168	0.9627	113	1.0000	0.7551	1.2945
20	1.2475**	1.2154	1.3191	67	0.9878	0.9759	1.0261	114	0.7693**	0.7576	0.8085
21	1.0198	0.9939	1.0929	68	0.7193**	0.7004	0.7465	115	0.8678**	0.8502	0.9109
22	1.2059**	1.1602	1.2322	69	0.8547**	0.8352	0.8842	116	1.1757**	1.0979	1.2288
23	1.0985**	1.0767	1.1637	70	0.8497**	0.7933	0.9041	117	1.1368**	1.1101	1.1860
24	0.8912**	0.8536	0.9217	71	1.0000	0.7761	1.2427	118	0.9305	0.8242	1.0634
25	0.7634**	0.7510	0.8084	72	0.8305**	0.8050	0.8670	119	1.1169**	1.1031	1.1719
26	0.7793**	0.7581	0.7976	73	1.0000	0.7410	1.3777	120	1.1073**	1.0725	1.1729
27	0.8866**	0.8734	0.9186	74	0.9989	0.9314	1.0411	121	1.3754**	1.2348	1.5357
28	0.8936**	0.8541	0.9164	75	0.8534**	0.8152	0.8651	122	0.8115**	0.7838	0.8305
29	0.9495	0.9282	1.0120	76	1.0937**	1.0561	1.1873	123	1.0500	0.9850	1.1303
30	1.2606**	1.1917	1.3224	77	1.1153**	1.1024	1.1699	124	1.1413**	1.1145	1.1795
31	0.9380**	0.8525	0.9753	78	1.3609**	1.2712	1.5769	125	1.0000	0.7462	1.4137
32	1.4624**	1.4402	1.5781	79	1.0014	0.9555	1.0545	126	0.9943	0.8298	1.1345
33	0.8543**	0.8178	0.9081	80	1.0000	0.7553	1.4066	127	0.8377**	0.8185	0.8637
34	0.8403**	0.7451	0.9939	81	1.0880**	1.0437	1.1738	128	0.9383**	0.9128	0.9986
35	1.0252	0.9547	1.1783	82	1.0618**	1.0502	1.1483	129	1.2577**	1.2419	1.3228
36	1.2043**	1.1543	1.2419	83	1.0980**	1.0073	1.2195	130	0.6421**	0.6031	0.6682
37	0.8985**	0.8919	0.9337	84	0.9715	0.9426	1.0459	131	0.8786**	0.8570	0.9064
38	0.9574	0.8005	1.1059	85	1.1413**	1.1035	1.2194	132	1.0000	0.7545	1.3943
39	0.8420	0.8087	0.8613	86	1.1464**	1.1305	1.1940	133	0.8654**	0.8365	0.8831
40	0.9743	0.9628	1.0038	87	0.7708**	0.7596	0.8277	134	1.0468**	1.0220	1.0923
41	0.8987**	0.8922	0.9339	88	0.8895**	0.7586	0.9867	135	1.0153	0.9955	1.0380
42	1.0465**	1.0366	1.0905	89	0.8805**	0.8206	0.9548	136	1.0065	0.9564	1.0573
43	0.9367**	0.9116	0.9615	90	0.9839	0.9634	1.0193	137	1.0776**	1.0447	1.1247
44	1.1077**	1.0916	1.1529	91	0.7951**	0.7843	0.8196	138	0.7496**	0.7114	0.7982
45	0.8963**	0.8799	0.9339	92	1.2429**	1.2140	1.2870	139	0.7305**	0.6962	0.7467
46	0.5799**	0.5664	0.6058	93	1.0000	0.7719	1.3417	140	0.9005**	0.8492	0.9782
47	0.6806**	0.6626	0.7010	94	1.1637**	1.1385	1.2035				

NB: Point estimates ** implies significantly different from 1 at 95%

Firm 1-45 from Volta Region, 46-82 from Eastern and 83-140 from Greater Accra

Table 6: Confidence intervals obtained based on homogeneous bootstrap procedure(non standards corrected scores)

Estimation of Pure Technical Change of firms between 2002 and 2007 (2000 bootstrap replications)

Firm	ΔPure Technology	Lower Bound	Upper Bound	Firm	ΔPure Technology	Lower Bound	Upper Bound	Firm	ΔPure Technology	Lower Bound	Upper Bound
1	1.0797	0.7721	1.4153	48	1.1736**	1.0901	1.2074	95	0.9783	0.8754	1.0744
2	1.1422**	1.0605	1.2108	49	1.1646**	1.1225	1.1961	96	1.1746**	1.1238	1.1870
3	1.0897**	1.0562	1.1475	50	1.2092**	1.0899	1.3136	97	1.0986**	1.0061	1.1363
4	1.1354**	1.0792	1.1527	51	1.1307**	1.1102	1.1774	98	0.7383**	0.5315	0.9874
5	1.1528**	1.1151	1.1791	52	1.1195**	1.0140	1.2796	99	1.1686**	1.1277	1.1945
6	1.1507**	1.0852	1.1753	53	1.1214	0.8112	1.4974	100	1.1547**	1.1090	1.1754
7	1.1164**	1.0683	1.1891	54	1.0327	0.9996	1.0936	101	1.0802	0.9940	1.1951
8	1.1480**	1.0564	1.1837	55	1.1444**	1.0783	1.1750	102	1.1897**	1.1398	1.1917
9	1.1306**	1.0141	1.2243	56	1.0683	0.7738	1.4096	103	1.1434**	1.0961	1.1690
10	1.1377**	1.0828	1.1730	57	1.0812	0.8970	1.2676	104	1.1577**	1.1178	1.1676
11	1.1568**	1.1185	1.1855	58	1.2065**	1.1228	1.2178	105	1.0779**	1.0101	1.1328
12	1.0403	0.9464	1.1504	59	1.1720**	1.1169	1.1903	106	1.0367	0.9589	1.1098
13	1.1501**	1.0999	1.1745	60	1.0569	0.7649	1.4081	107	1.0548	0.9976	1.1831
14	1.0981**	1.0122	1.1558	61	1.0640**	1.0027	1.1694	108	1.1487**	1.1211	1.1768
15	1.4075**	1.0143	1.8648	62	1.1528**	1.0930	1.2020	109	1.0619**	1.0151	1.1491
16	1.0990**	1.0668	1.1301	63	1.1964**	1.1134	1.2117	110	1.1594**	1.1257	1.1825
17	1.0353	0.9294	1.1181	64	1.1417**	1.1201	1.1782	111	1.2370	0.8881	1.6523
18	1.1001**	1.0033	1.2230	65	1.1343**	1.0901	1.1922	112	1.1627**	1.0841	1.1980
19	1.1145**	1.0541	1.1484	66	1.1648**	1.1292	1.1858	113	1.0913	0.8430	1.4453
20	1.1648**	1.1017	1.1957	67	1.1781**	1.1342	1.1925	114	1.1750**	1.1181	1.1932
21	1.1352**	1.0593	1.1647	68	1.1433**	1.1016	1.1741	115	1.1496**	1.0952	1.1734
22	1.1291**	1.1050	1.1735	69	1.1614**	1.1227	1.1886	116	1.1171**	1.0688	1.1961
23	1.1803**	1.1141	1.2041	70	1.0452	0.9824	1.1196	117	1.1226**	1.0760	1.1495
24	1.0817**	1.0458	1.1293	71	1.0412	0.8379	1.3415	118	1.1702**	1.0240	1.3212
25	1.1515**	1.0875	1.1705	72	1.1568**	1.1081	1.1935	119	1.1235**	1.0707	1.1375
26	1.1442**	1.1179	1.1762	73	1.0393	0.7543	1.4026	120	1.1253**	1.0623	1.1617
27	1.1475**	1.1076	1.1649	74	1.0357	0.9938	1.1108	121	1.0559	0.9457	1.1761
28	1.1238**	1.0959	1.1758	75	1.1247**	1.1095	1.1774	122	1.1454**	1.1193	1.1858
29	1.1775**	1.1048	1.2045	76	1.1883**	1.0946	1.2306	123	1.0318	0.9585	1.0999
30	1.1260**	1.0733	1.1910	77	1.1472**	1.0936	1.1605	124	1.1558**	1.1185	1.1836
31	1.0070	0.9686	1.1081	78	1.2285**	1.0602	1.3152	125	1.2406	0.8775	1.6626
32	1.1806**	1.0939	1.1987	79	1.1180**	1.0616	1.1716	126	0.9547	0.8368	1.1440
33	1.1185**	1.0522	1.1684	80	1.5508**	1.1025	2.0533	127	1.1592**	1.1243	1.1864
34	1.0750	0.9089	1.2123	81	1.0687	0.9906	1.1141	128	1.1577**	1.0878	1.1900
35	1.1069	0.9631	1.1887	82	1.1984**	1.1081	1.2116	129	1.1497**	1.0931	1.1644
36	1.1291**	1.0949	1.1780	83	1.0033	0.9034	1.0936	130	1.1054**	1.0623	1.1770
37	1.1784**	1.1340	1.1871	84	1.1112**	1.0322	1.1452	131	1.1496**	1.1144	1.1787
38	1.1819**	1.0232	1.4135	85	1.0979**	1.0276	1.1355	132	1.0734	0.7698	1.4227
39	1.1341**	1.1088	1.1809	86	1.1788**	1.1317	1.1954	133	1.1338**	1.1110	1.1729
40	1.1722**	1.1377	1.1862	87	1.1847**	1.1033	1.2022	134	1.1686**	1.1199	1.1969
41	1.1789**	1.1344	1.1875	88	1.1222**	1.0117	1.3160	135	1.1584**	1.1332	1.1815
42	1.1369**	1.0911	1.1478	89	1.0627	0.9800	1.1403	136	1.0353	0.9855	1.0895
43	1.1354**	1.1061	1.1666	90	1.1082**	1.0697	1.1318	137	1.1300**	1.0827	1.1656
44	1.1784**	1.1322	1.1958	91	1.1724**	1.1374	1.1886	138	1.0653**	1.0005	1.1226
45	1.1708**	1.1237	1.1926	92	1.1658**	1.1259	1.1936	139	1.1201**	1.0959	1.1753
46	1.1445**	1.0957	1.1719	93	1.2357	0.9210	1.6007	140	1.0916**	1.0049	1.1575
47	1.1213**	1.0886	1.1518	94	1.1577**	1.1194	1.1833				

NB: confidence interval estimates **at 95% with the lower bound and its corresponding upper bound

Firm 1-45 from Volta Region, 46-82 from Eastern and 83-140 from Greater Accra

Table 7: Confidence intervals obtained based on homogeneous bootstrap procedure(non standards corrected scores)

Estimation of change in Scale Efficiency of firms between 2002 and 2007 (2000 bootstrap replications)

Firm	ΔScale Efficiency	Lower Bound	Upper Bound	Firm	ΔScale Efficiency	Lower Bound	Upper Bound	Firm	ΔScale Efficiency	Lower Bound	Upper Bound
1	0.9982	0.6997	1.2450	48	1.0192	0.9890	1.0164	95	0.8806**	0.7846	0.9701
2	0.9945	0.9579	1.0338	49	1.0265	0.9799	1.0583	96	1.0463	0.9965	1.0505
3	0.9816	0.9703	1.0225	50	1.0636	0.9602	1.1522	97	0.9983	0.9156	1.0064
4	1.0007	0.9669	1.0150	51	1.0080	0.9763	1.0557	98	0.6551**	0.4776	0.8764
5	1.0326	0.9966	1.0691	52	0.9993	0.9448	1.0670	99	1.0384	0.9887	1.0664
6	1.0359	0.9834	1.0335	53	0.9988	0.7140	1.3343	100	1.0243	0.9868	1.0275
7	0.9970	0.9762	1.0144	54	0.9654	0.9360	1.0016	101	0.9694	0.8994	1.0565
8	1.0109	0.9734	1.0119	55	1.0139	0.9753	1.0140	102	1.0582**	1.0068	1.0616
9	0.9962	0.9052	1.0761	56	0.9510	0.6873	1.2588	103	1.0254	0.9846	1.0278
10	1.0305	1.0000	1.0503	57	0.9985	0.8203	1.1123	104	1.0320	0.9940	1.0314
11	1.0254	0.9820	1.0592	58	1.0629	0.9881	1.0596	105	0.9872	0.9285	1.0074
12	0.9337	0.8606	1.0374	59	1.0623	0.9915	1.0651	106	0.9952	0.9046	1.0392
13	1.0113	0.9770	1.0149	60	0.9851	0.7013	1.3039	107	0.9966	0.9806	1.0272
14	0.9777	0.9064	1.0155	61	0.9793	0.9427	1.0392	108	1.0270	0.9821	1.0587
15	1.2398	0.8817	1.6412	62	0.9771	0.9564	1.0218	109	0.9952	0.9655	1.0264
16	1.0236	0.9969	1.0322	63	1.0489**	1.0079	1.0539	110	1.0163	0.9919	1.0600
17	0.9778	0.8698	1.0431	64	1.0217	0.9854	1.0613	111	1.1156	0.7909	1.4765
18	0.9846	0.8961	1.0698	65	0.9750	0.9446	1.0400	112	1.0194	0.9859	1.0150
19	1.0142	0.9689	1.0252	66	1.0223	0.9999	1.0646	113	1.0199	0.7842	1.3278
20	1.0404	0.9820	1.0440	67	1.0437**	1.0055	1.0618	114	1.0801	0.9911	1.0826
21	1.0232	0.9634	1.0197	68	1.0399**	1.0043	1.0636	115	1.0391	0.9801	1.0373
22	0.9848	0.9634	1.0596	69	1.0278	0.9900	1.0650	116	0.9932	0.9731	1.0228
23	1.0474	0.9844	1.0558	70	0.9668	0.8969	1.0302	117	1.0001	0.9618	1.0094
24	1.0083	0.9903	1.0205	71	0.9418	0.7529	1.1859	118	1.0365	0.8997	1.1668
25	1.0458	0.9922	1.0472	72	1.0060	0.9786	1.0412	119	1.0194	0.9765	1.0162
26	1.0144	0.9890	1.0611	73	0.9892	0.7005	1.3069	120	0.9873	0.9696	1.0083
27	1.0381	0.9984	1.0543	74	0.9979	0.9567	1.0138	121	0.9651	0.8559	1.0788
28	0.9938	0.9654	1.0658	75	1.0027	0.9751	1.0562	122	1.0168	0.9810	1.0561
29	1.0412	0.9775	1.0524	76	1.0460	0.9693	1.0765	123	0.9861	0.9028	1.0282
30	1.0054	0.9850	1.0129	77	1.0121	0.9763	1.0189	124	1.0243	0.9836	1.0597
31	0.9649	0.9226	1.0033	78	1.0402	0.9385	1.1012	125	1.0919	0.7792	1.4882
32	1.0568**	1.0045	1.0692	79	1.0314	0.9648	1.0330	126	0.8666	0.7608	1.0351
33	1.0146	0.9628	1.0142	80	1.3930**	1.0027	1.8549	127	1.0280	0.9902	1.0642
34	0.9698	0.8280	1.0945	81	0.9529**	0.8908	0.9995	128	1.0627	0.9988	1.0757
35	0.9807	0.8618	1.0558	82	1.0388**	1.0030	1.0434	129	1.0159	0.9788	1.0144
36	1.0088	0.9771	1.0694	83	0.9035**	0.8112	0.9874	130	0.9876	0.9590	1.0244
37	1.0469**	1.0018	1.0496	84	1.0097	0.9429	1.0119	131	1.0340	0.9991	1.0725
38	1.0559	0.9039	1.2570	85	0.9807	0.9275	1.0075	132	0.9693	0.7028	1.2841
39	1.0001	0.9685	1.0534	86	1.0392**	1.0059	1.0606	133	1.0061	0.9796	1.0635
40	1.0434	1.0000	1.0653	87	1.0624**	1.0029	1.0695	134	1.0349	0.9828	1.0680
41	1.0474**	1.0021	1.0502	88	0.9931	0.9125	1.1437	135	1.0350	0.9955	1.0645
42	1.0176	0.9923	1.0290	89	0.9427	0.8747	1.0116	136	0.9776	0.9226	1.0086
43	1.0287	0.9987	1.0645	90	1.0192	0.9944	1.0256	137	1.0355	0.9785	1.0313
44	1.0452**	1.0083	1.0751	91	1.0481**	1.0020	1.0667	138	0.9737	0.9161	1.0049
45	1.0341	0.9943	1.0467	92	1.0358	0.9868	1.0653	139	1.0029	0.9778	1.0681
46	1.0448	0.9906	1.0406	93	1.0764	0.8319	1.4054	140	0.9847	0.9111	1.0256
47	1.0338**	1.0009	1.0523	94	1.0227	0.9928	1.0690				

NB: confidence interval estimates ** significant at 95% with the lower bound and its corresponding upper bound

Firm 1-45 from Volta Region, 46-82 from Eastern and 83-140 from Greater Accra

Table 8: Confidence intervals obtained based on homogeneous bootstrap procedure(non standards corrected scores)

Estimation of change in Scale Technology of firms between 2002 and 2007 (2000 bootstrap replications)

Firm	ΔScale Technology	Lower Bound	Upper Bound	Firm	ΔScale Technology	Lower Bound	Upper Bound	Firm	ΔScale Technology	Lower Bound	Upper Bound
1	1.0018	0.8032	1.4292	48	0.9812	0.9839	1.0111	95	1.1356**	1.0308	1.2746
2	1.0055	0.9673	1.0439	49	0.9742	0.9449	1.0205	96	0.9557	0.9519	1.0035
3	1.0187	0.9780	1.0306	50	0.9402	0.8679	1.0414	97	1.0016	0.9937	1.0922
4	0.9993	0.9852	1.0342	51	0.9920	0.9472	1.0242	98	1.5264**	1.1411	2.0939
5	0.9685	0.9354	1.0035	52	1.0007	0.9372	1.0584	99	0.9630	0.9377	1.0114
6	0.9653	0.9676	1.0168	53	1.0012	0.7495	1.4006	100	0.9763	0.9732	1.0134
7	1.0030	0.9858	1.0244	54	1.0358	0.9984	1.0684	101	1.0316	0.9465	1.1119
8	0.9892	0.9882	1.0273	55	0.9862	0.9862	1.0253	102	0.9450**	0.9420	0.9933
9	1.0038	0.9293	1.1047	56	1.0515	0.7944	1.4549	103	0.9753	0.9730	1.0156
10	0.9704	0.9521	1.0000	57	1.0015	0.8990	1.2191	104	0.9690	0.9695	1.0061
11	0.9753	0.9441	1.0183	58	0.9408	0.9437	1.0120	105	1.0130	0.9926	1.0771
12	1.0710	0.9639	1.1620	59	0.9414	0.9389	1.0085	106	1.0048	0.9623	1.1054
13	0.9888	0.9853	1.0235	60	1.0151	0.7669	1.4259	107	1.0035	0.9735	1.0198
14	1.0229	0.9847	1.1033	61	1.0212	0.9623	1.0608	108	0.9737	0.9446	1.0183
15	0.8066	0.6093	1.1342	62	1.0235	0.9786	1.0456	109	1.0048	0.9743	1.0358
16	0.9769	0.9688	1.0031	63	0.9534**	0.9488	0.9921	110	0.9840	0.9434	1.0082
17	1.0227	0.9587	1.1497	64	0.9787	0.9422	1.0149	111	0.8964	0.6773	1.2643
18	1.0156	0.9347	1.1159	65	1.0256	0.9615	1.0587	112	0.9810	0.9852	1.0143
19	0.9860	0.9754	1.0321	66	0.9782	0.9393	1.0001	113	0.9805	0.7531	1.2751
20	0.9612	0.9579	1.0183	67	0.9582**	0.9418	0.9946	114	0.9259	0.9237	1.0090
21	0.9773	0.9807	1.0380	68	0.9617**	0.9402	0.9957	115	0.9623	0.9640	1.0203
22	1.0155	0.9438	1.0380	69	0.9729	0.9390	1.0101	116	1.0068	0.9778	1.0276
23	0.9548	0.9471	1.0158	70	1.0343	0.9707	1.1149	117	0.9999	0.9907	1.0397
24	0.9917	0.9799	1.0098	71	1.0618	0.8432	1.3281	118	0.9648	0.8570	1.1114
25	0.9562	0.9550	1.0078	72	0.9941	0.9604	1.0219	119	0.9810	0.9840	1.0241
26	0.9858	0.9424	1.0112	73	1.0109	0.7652	1.4276	120	1.0129	0.9917	1.0314
27	0.9633	0.9485	1.0016	74	1.0021	0.9864	1.0453	121	1.0362	0.9269	1.1683
28	1.0063	0.9383	1.0358	75	0.9973	0.9468	1.0255	122	0.9835	0.9469	1.0194
29	0.9605	0.9503	1.0230	76	0.9560	0.9290	1.0317	123	1.0141	0.9726	1.1076
30	0.9946	0.9873	1.0153	77	0.9880	0.9814	1.0242	124	0.9763	0.9437	1.0166
31	1.0364	0.9967	1.0839	78	0.9613	0.9081	1.0656	125	0.9158	0.6720	1.2834
32	0.9462**	0.9352	0.9955	79	0.9695	0.9681	1.0365	126	1.1540	0.9661	1.3144
33	0.9856	0.9860	1.0387	80	0.7179**	0.5391	0.9973	127	0.9727	0.9397	1.0099
34	1.0312	0.9137	1.2077	81	1.0495**	1.0005	1.1226	128	0.9410	0.9296	1.0012
35	1.0197	0.9471	1.1604	82	0.9626**	0.9584	0.9970	129	0.9844	0.9858	1.0217
36	0.9913	0.9351	1.0235	83	1.1068**	1.0128	1.2328	130	1.0127	0.9762	1.0428
37	0.9552**	0.9527	0.9982	84	0.9904	0.9882	1.0605	131	0.9671	0.9324	1.0009
38	0.9471	0.7956	1.1063	85	1.0197	0.9925	1.0782	132	1.0317	0.7788	1.4229
39	0.9999	0.9493	1.0325	86	0.9623**	0.9429	0.9941	133	0.9939	0.9403	1.0208
40	0.9585	0.9387	1.0000	87	0.9413**	0.9350	0.9971	134	0.9663	0.9363	1.0175
41	0.9548**	0.9522	0.9979	88	1.0070	0.8744	1.0959	135	0.9662	0.9394	1.0045
42	0.9827	0.9718	1.0078	89	1.0608	0.9885	1.1432	136	1.0229	0.9915	1.0839
43	0.9720	0.9394	1.0013	90	0.9811	0.9751	1.0057	137	0.9657	0.9696	1.0220
44	0.9568**	0.9301	0.9917	91	0.9541**	0.9375	0.9980	138	1.0270	0.9952	1.0916
45	0.9670	0.9554	1.0057	92	0.9654	0.9387	1.0133	139	0.9972	0.9362	1.0227
46	0.9572	0.9610	1.0095	93	0.9290	0.7115	1.2020	140	1.0156	0.9750	1.0976
47	0.9673**	0.9503	0.9991	94	0.9779	0.9354	1.0072				

NB: confidence interval estimates ** significant at 95% with the lower bound and its corresponding upper bounds

Firm 1-45 from Volta Region, 46-82 from Eastern and 83-140 from Greater Accra