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MEASURING THE EFFECTS OF PRODUCTIVITY GROWTH ON POVERTY IN GHANA USING BETA REGRESSION APPROACH

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Abstract

This paper sought to establish the link between the rate of poverty (deprivation) on one hand, and output and productivity growth on the other among the apparel manufacturers in Ghana using primary data collected from 140 apparel manufacturers over 2002 to 2007 period. This is in line with literature that poverty can be reduced by building competitiveness in the manufacturing industry. The study relied on Beta Regression methodology to model the rates of deprivation and productivity growth all defined over the interval (0, 1). This is because, functions define over the interval (0, 1) could be nonlinear and exhibit flexible characteristics which must be captured for accurate predictions. Our results indicate that output growth had some significant effects on poverty reduction albeit not a large one. Specifically, the paper established that, an increase in output growth by one unit holding other factors constant, induces a nominal change in poverty by -0.002 units over the period. However, the hypothesis that total factor productivity growth has had any significant effect on poverty over the period was not borne out by the results. This results corroborates the assertion that poverty reduction can be linked to output growth and firm performance.

Key words: Productivity Growth, Poverty Reduction, Beta Regression, Ghana

1. Introduction

In this paper, we attempt to establish the relationship between enterprises' competitiveness building through output and productivity growth, and poverty reduction among micro, small and medium-scale (MSMEs) apparel manufacturers in Ghana. This is carried out at two levels viz. (1) ascertain the direction of association between deprivation indicators and competitiveness measures and 2) ascertain the significance of the relationship between these poverty indicators and firm competitiveness indicators. Thus, the paper south to establish the effects of: i) output growth as well as, ii) productivity, efficiency and technical change on the rates of deprivation/poverty.

In 2003, operationalizing pro-poor growth (OPPG) programme[1] was initiated by Agence française de développement (AFD), Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ), Kreditanstalt für Wiederaufbau (KfW-entwicklungsbank), Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Department for International Development (DFID) and the World Bank to have a better understanding of how to make growth impact on poverty. The idea is that the issue of poverty reduction must be based on country specific conditions which mean that there is no general policy that can work for all countries because of the variations in the level of their economic development, geographical location and culture and ideologies among others.

To do this therefore, there is the need to better understand, within each regional, country and even sectoral context, the channels for the poor to participate in growth, their level of efficiency and the pace of technical change which form the integral part of productivity growth. Efforts to help advance and deliberate on the need for further investigation into the sources and drivers of poverty in the world at large and developing countries in particular rest on researchers from all fields.

Using parametric approach, this sought to paper establishes the effects of output growth, technical change, efficiency improvement, and scale change and scale technology on poverty. The choice of the methodology is guided by the nature of data generated.

2. Brief theoretical review: Productivity Growth and Poverty Reduction

Guibaud (2003) who tried to identify the relationship between productivity growth and poverty reduction in some developing countries identified how productivity[2] could be key to reducing by one half those confronted with extreme poverty by 2015. Whilst the literature on the relationship

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[1] Pro-Poor growth in the 1990s : Lessons and insights from 14 countries https://documents.worldbank.org/en/publication/documents-reports/documentdetail/421141468027836341/pro-poor-growth-in-the-1990s-lessons-and-insights-from-14-countries

[2] Which defines inputs-outputs relationship with some partial indicators as output labour ratio, output capital ratio and output raw material ratio among others

between economic growth and poverty reduction establishes unequivocally the poverty reducing effect of growth at the macro-level that has not been the case between productivity growth and poverty at the micro-level given the limited nature of the literature on the subject. The literature on the relationship between productivity and poverty especially in developing countries is limited even at the macro level and virtually non-available at micro level focusing on SMEs. Hayes et al. (1994) established a two-way relationship between poverty and productivity using output per unit of labour as a proxy. Other studies by Datt and Ravallion (1998) and Fluet and Lefebvre (1997) have attested to the positive impact that productivity gains can have on poverty both directly and indirectly. Productivity gains resulting either from using less physical inputs to produce more physical outputs or in value terms such as higher value for the same output produced should negatively impact on privation.

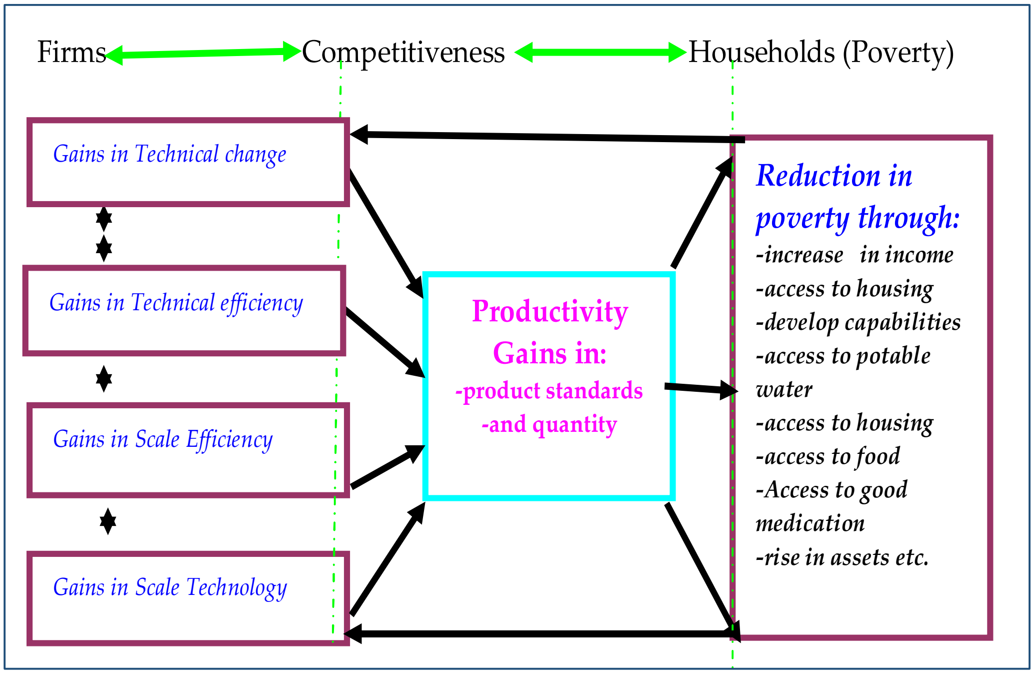
Earlier, there were parametric studies such as that of Farrell (1957) which was conducted contemporaneously with Solow (1957) neoclassical growth model but these works assumed exogenous technological change. The notion was that, same set of input combination and a better technology would cause an outward movement of the production possibility frontier. However, Malmquist (1953) developed a productivity index which was non-parametric technique, meaning it does not make any prior assumption about the distribution from which the data is drawn. Thw Malmquist index allows us to: 1) estimate total factor productivity (TFP) growth and 2) decompose TFP growth into technical change and technical efficiency change.

Also, in this paper, poverty measurement was not built on classical set theory and logic which deals with precise measures and poverty lines, of say, one either belongs to a set of poor people or rich people but built on Fuzzy set theory and logic (Zadeh, 1965) based on admitting membership values in their imprecise form. For example, with respect to poverty/deprivation, the multidimensional measurements accommodate the degree of deprivation from completely deprived through partially deprived to completely non-deprived. There are no categorical arguments of say haves and have-nots. This study therefore focused on the proposition that gains in output and productivity should lead to reduction in poverty.

3.0 Theoretical framework

Theoretically, it is believed that any changes that lead to gains in productivity should lead to reduction in poverty as suggested by Pineau (2004) and the Centre for the Study of Living Standards (2002 and 2003).

1. **Figure 1:** Simplifying Framework and Units of Analysis



Source: Authors

Following the framework in Figure 1, any gains in technical change given other components of productivity translates into overall gains in productivity and finally poverty reduction through increase in income, access to housing, develop capabilities, access to potable water, access to food, access to good medication and rise in durable and non-durable assets among others**.** Gains in technical efficiency given other factors lead to productivity gains and a positive effect on the welfare of the apparel related households. Gains in scale efficiency and scale technology should also lead to gains in productivity through product standards improvement or quantity expansion or both and these should affect overall poverty index.

Here, technical efficiency measures a firm's success in producing maximum outputs from a given set of inputs. Scale change appraises the changes in output in relation to percentage change in inputs. Technical change considers the shift in production frontier resulting from the application of new technologies or techniques using the same amount of inputs. These were derived for both standards corrected and non-standards corrected measures in this study.

4.0 The main Hypothesis:
The hypothesis is that, there should be some relationships between output growth, TFP growth and poverty reduction among apparel manufacturers where growth in output as well as TFP growth should lead to reduction in poverty.

Specifically:

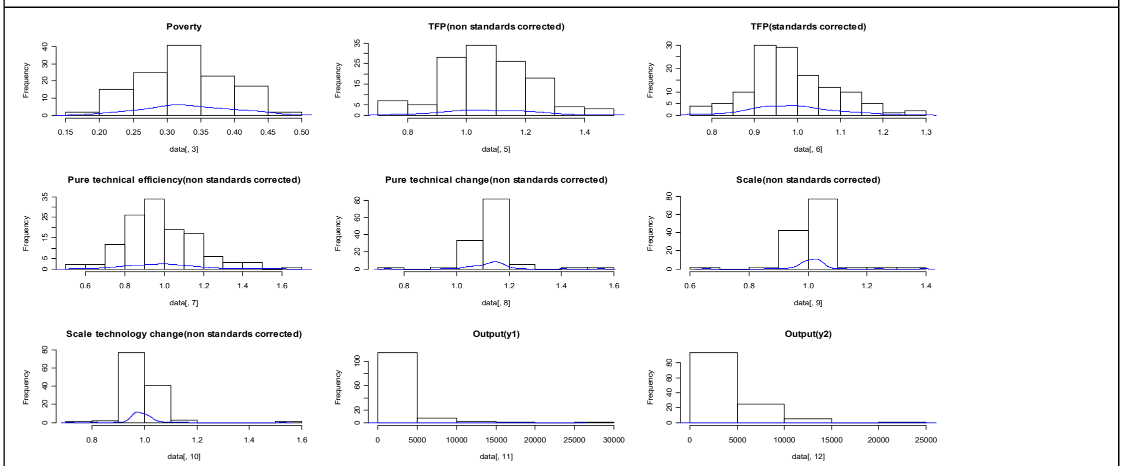
Output growth should lead to a reduction in poverty. TFP growth as well as its components should impact on poverty. The components of TFP growth comprised of pure efficiency change, pure technical change, scale change and scale technology change.

4.1 Data Set

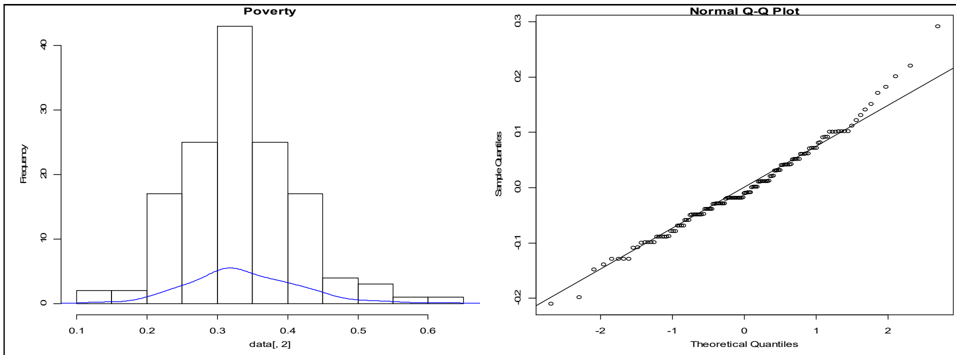
The data set comprised of the response variable namely the rate of deprivation (Poverty) for 140 households, and independent variable, the observed apparel output (y) for 2002 and 2007. Other independent variables include TFP growth defined as output growth not accounted for by the growth in inputs, pure technical change(*ptech*) which reffers to technological progress, pure technical efficiency(*peff*) which is expressed as obtaining optimum amount of output from a given set of inputs, scale efficiency(scale) expressed as attaining optimal size of a firm and scale technology(*sctech*) defined as operating towards constant returns to scale (non-standards corrected and standards corrected estimates) for 140 firms.

As we can see in Figure 2, the variables including our dependent variable (poverty) are not normally distributed. All the variables except our observed outputs (y1 and y2) were derived from previous from the data. Thus we have the first stage where we derived some of our variables including poverty and second stage where we try to predict poverty using outputs growth, TFP growth and its components as explanatory variables. The variables appear skewed and not normally distributed.

Figure 2: Distribution of our dependent variable(poverty) and independent variables



Test for Normality of the Response variable(Poverty)



<u>Hypothesis</u>	
H_0 : *Distribution of data same as normal distribution* H_1 : *Distribution of data not same as normal one*	ks.test(gy2$residuals,'pnorm') One-sample Kolmogorov-Smirnov test data: gy2$residuals D = 0.4268, p-value < 2.2e-16 ***Since p-value is below 0.05, we reject H0***

5.0 The Methodology

As we are predicting the rates of deprivation among apparel manufacturers and given that productivity growth namely pure technical efficiency change, pure technical change, scale change and scale technology change are also rates, we modeled our rates of deprivation specifically persistent poverty on explanatory variables as defined over the interval (0, 1). Functions define over the interval (0, 1) could be nonlinear and exhibit flexible characteristics which must be captured for accurate predictions.

5.1 The Beta Regression Approach and Parameter Estimation

We have already seen that our variables comprised of estimations on the rate of poverty, total factor productivity growth (TFP growth),pure technical efficiency, pure technical change, scale change and scale technology change). These derived variables exhibit some shapes that cannot be ignored. As seen in Figure 2, they are skewed and not normally distributed. Predicting poverty derived from fuzzy models requires distributions that model the exact nature of the data and accounts for possible violations of the assumptions of the Normal theory and the Central Limit Theorem. The normal theory requires that we have *independent* and *identically* distributed random variables but when the variables are derived, they may not be independent. The Central Limit Theorem holds when for large enough samples, the mean of *independent* and *identically* distributed random variables are approximately normally distributed.

Based on the nature of our variables, we know that Ordinary Least Squares (OLS) may not be suitable because it assumes that the dependent variable should be unbounded and normally distributed which our response variable (poverty) and other variables violate. The Beta regression is viewed as a generalization of the logistic regression and particularly suitable for modeling dependent variables that violate the assumption of normality. This is the case when the response variable is bounded between 0 and 1(0% to 100%). The level of deprivation among households range from fully non deprived (skewed towards 0) to fully deprived (skewed towards 1).

The Beta Regression Model

Following Ferrari and Cribari-Neto (2004), we let the response variable **Y**=($y_1,..., y_n$) be defined over an open interval such that $y_i \in [0,1]$ follows a beta distribution in equation 1a :

$$1a \qquad \pi(y;\mu,\phi) = \frac{\Gamma(\phi)}{\Gamma(\mu\phi)\Gamma((1-\mu)\phi)} y^{\mu\phi-1}(1-y)^{(1-\mu)\phi-1}, \quad 0 < y < 1,$$

where $E(y) = \mu$ is the mean of the response variable and ϕ is the dispersion parameter modeled by the gamma function $\Gamma(.)$. The mean μ and dispersion parameter ϕ are both positive and provide the shape that y assumes. Taking the log-likelihood of equation 1a for the t-*th* observation, we have 1b:

$$1b \quad \ln(y_t;\mu_t,\phi) = \log\Gamma(\phi) - \log\Gamma(\mu_t\phi) - \log\Gamma((1-\mu_t)\phi) \\ + (\mu_t\phi - 1)\log y_t + \{(1-\mu_t)\phi - 1\}\log(1-y_t)$$

Maximizing the sum of the log-likelihoods over y_t yields the maximum likelihood estimators. The beta regression model which accommodates heteroscedasticity (variance of the dependent variable varies across the data) and twice differentiable follows a generalised linear model (GLM) which uses the link function $g(.)$ to map $\mu \in [0,1]$ into observation as:

$$1c \quad g(\mu_t) = \sum_{i=1}^{k} x_{ti}\alpha_i = \eta_t = \ln[\mu/(1-\mu)],$$

$$t = 1,........,n \;\; and \quad i = 1,........,k \,, \quad k < n$$

where our choice of the link function $g(\mu_t)$ is the logit function expressed as $\mu_t = \dfrac{e^{x_t^T\alpha}}{1+e^{x_t^T\alpha}}$ for $x_t^T = (x_{t1},....,x_{tk})$. A row vector of unknown regression parameters are $\alpha = (\alpha_1,.....,\alpha_k)$ and the observations on k covariates are $x_1,.....,x_k$ where k<n. The estimates of $\alpha's$ as well as the standard errors and p-values are obtained through the maximum likelihood procedure using R software package.

From equation 1c, we can predict poverty using the predictors [i.e. output growth ($\hat{Y}$)] by estimating: $\ln[(\mu/(1-\mu)] = \alpha_0 + \alpha_1\hat{Y}$. For TFP growth, we estimate: $\ln[(\mu/(1-\mu)] = \alpha_0 + \alpha_1 TF\hat{P}$ (Also see Smithson and Verkuilen, 2006).

The statistical significance of the regression parameters α_i are tested by dividing parameter estimates ($\hat{\alpha}_i$) $i= 1,.., k$ by their respective standard errors $se(\hat{\alpha}_i)$ to get $[\hat{\alpha}_i / se(\hat{\alpha}_i)]$.

6.0 Presentation and analysis of results

We now proceed to analyse the effects of our covariates on poverty and the strength of the association. We modeled the main effects of output growth, TFP growth and their respective components on poverty.

From Table 1, we can see that, there is evidence of statistically significant relationship between the response variable (poverty) and output growth albeit small. The results show negative relationship between output growth and poverty in all estimates (OLS and Beta Regression models). An increase in output growth by one unit holding other factors constant induces a nominal change in poverty by -0.002 units (see Non Standards Corrected Beta Regression model). In the standards corrected estimates, output growth is not statistically significant (see OLS and Beta Regression models in Table 1). This is understandable as accounting for product standards may have reduced the growth effects on poverty.

Table 1: Results:

Modeling the effects of output growth on Poverty

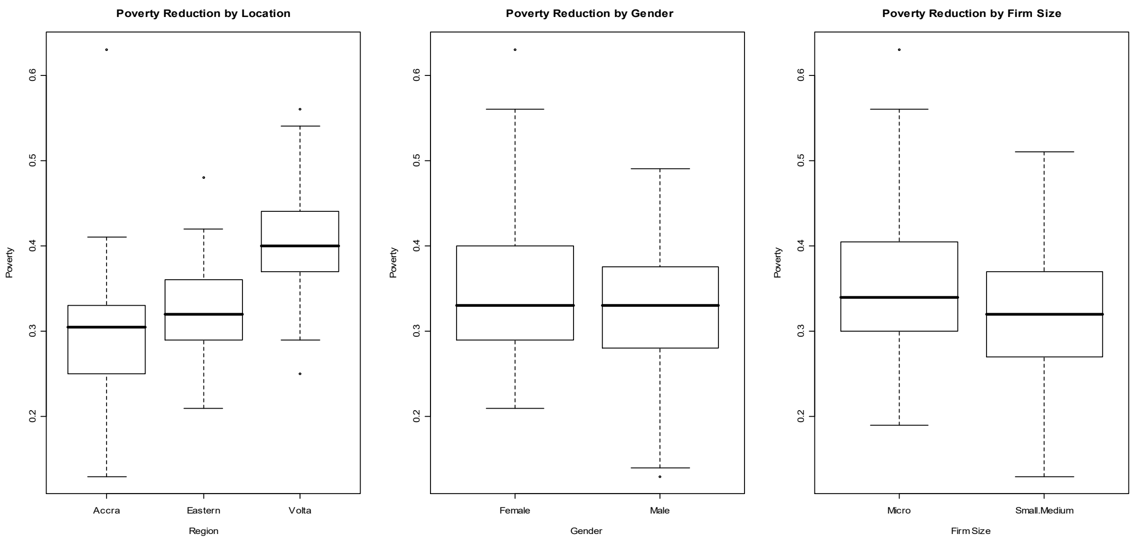
(response variable is persistent poverty)

	OLS		Beta Regression	
	Non-Standards Corrected Model	Standards Corrected Model	Non-Standards Corrected Model	Standards Corrected Model
α0	0.324*** (0.011)	0.322*** (0.011)	-0.740*** (0.048)	-0.750*** (0.048)
αOutput Growth	-0.0004* (0.0002)	-0.0001 (0.0001)	-0.002** (0.0008)	-0.0002 (0.0004)
αGender-Male	-0.0241** (0.011)	-0.022** (0.011)	-0.109*** (0.047)	-0.104** (0.048)
αRegion-Eastern	0.037*** (0.037)	0.032** (0.013)	0.175*** (0.061)	0.153** (0.061)

αRegion-Volta	0.105*** (0.013)	0.105*** (0.013)	0.468*** (0.055)	0.468*** (0.056)
αSize-small.medium.	-0.031*** (0.011)	-0.033*** (0.011)	-0.144*** (0.049)	-0.151*** (0.050)
R^2	0.40	0.39	Pseudo R^2: 0.37	Pseudo R^2: 0.36
φ			56.022	54.923
Standard Errors in brackets ****=significant at 1%* ***=significant at 5%* **=significant at 10%*			*Residual Deviance: 123.9503 on 119 degrees of freedom*	*Residual Deviance: 123.9474 on 119 degrees of freedom*

The estimates of the R^2 in the OLS models are 0.40 and 0.39 compared with the pseudo R^2 of 0.37 and 0.36 in Beta Regression respectively. The gender, location and size relationships with poverty which are all statistically significant are summarized in Figure 3. The dispersion parameters φ's in the Beta Regression are 56.022 and 54.923 respectively and the residual deviance of 123.95 on 119 degrees of freedom and 123.95 on 119 degrees of freedom(for Non-standards corrected and Standards corrected models) indicate that the models are quite adequate. Diagnostic analysis of residuals, checking for independence of errors and that errors are not correlated with output, back up the adequacy of the model specification and eschew concerns about the problem of endogeneity.

Figure 3: Effects of output growth on poverty by location, gender and firm size(Beta Regression)



	Model
α_0	-0.740*** (0.048)
αOutput Growth	-0.002** (0.0008)
αGender-Male	-0.109*** (0.047)
αRegion-Eastern	0.175*** (0.061)
αRegion-Volta	0.468*** (0.055)
αSize-small.med..	-0.144*** (0.049)
φ	56.022

Since our results indicate that output growth has been the significant source of poverty reduction among apparel manufacturers over the 2002 and 2007 period, Figure 3 depicts the results by location, gender and firm size (results in left-panel).

By location, the boxplots (upper-panel) show that Greater Accra region experienced the lowest rate of poverty with the median of about 0.3 (30%---see thick line in the boxes) compared to the Eastern region (32%) and Volta region (39%) with the highest rate of deprivation.

Among gender groups, rate of deprivation appear to be higher among women than men (both have same median of about 0.33).

By firm size, households linked to small and medium sized firms experienced lower rates of poverty (median=0.32) compared to households linked to micro firms (median=0.33).

Standard Errors in brackets ****=significant at 1%* ***=significant at 5%*	The results in the estimated model (left column) show significant differences among location, gender and firm size groups.

In Table 2, we modeled the main effects of TFP growth and it components on poverty. Thus continuing from our results in Table 1, where we modeled the effects of output growth on poverty among apparel manufacturers. In Table 2, we isolate that part of output not accounted for by inputs which is TFP. It is obvious that TFP growth did not have any significant effect on poverty reduction among apparel manufacturers over the 2002 and 2007 period (Models 2a and 2b).

By modeling the main effects of the components of TFP growth namely pure efficiency (peff), pure technical change (ptech), scale change (scale) and scale technology change (sctech) on poverty, we established that all the four components did not reveal any statistically significant relationships (Models 2a and 2b in Table 2). The signs are right as exposed by the results but pure efficiency (peff), pure technical change (ptech), scale change and scale technology change (sctech) have not been enough to affect poverty significantly over the period. Our estimated residual deviance in Models 1a, 1b, 2a and 2b in Table 2 all indicate acceptable results and adequacy of the models estimated.

Finally, the hypothesis that TFP growth has had any significant effect on poverty over the period was not borne out by the results. This holds true for all the components of TFP growth as well. The results make sense as the output growth by some firms in the apparel sub-sector over the 2002 and 2007 period was completely offset by the negative growth rates in other firms. Inefficiency has dragged down modest gains in technological change rendering TFP growth effects weak.

Table 2: Modeling the effects of (TFP) growth on Poverty(Beta Regression)

Model 1a	Coefficient	Std. Errors	Pr(>|z|)
α_0	-0.664	0.1729	0.0001
$\alpha_{TFP(non\ stand.\ corrected)}$	-0.005	0.1548	0.9738
φ	33.5944		
Residual Deviance: 137.0889 on 138 degrees of freedom			

Model 1b	Coefficient	Std. Errors	Pr(>|z|)
α_0	-0.722	0.2886	0.0123
$\alpha_{TFP(\ stand.\ corrected)}$	0.053	0.2919	0.8554
φ	33.59249		
Residual Deviance: 137.0861 on 138 degrees of freedom			

Model 2a: Non Standards Corrected	Coefficient	Std. Errors	Pr(>|z|)
α_0	1.348	3.482	0.699
α_{peff}	-0.011	0.1713	0.947
α_{ptech}	1.907	1.185	0.107
α_{scale}	-3.044	2.328	0.191
α_{sctech}	-1.087	1.695	0.521
φ	34.38767		
Residual Deviance: 137.1150 on 135 degrees of freedom			

Model 2b: Standards Corrected	Coefficient	Std. Errors	Pr(>|z|)
α_0	1.36	3.482	0.696
α_{peff}	-0.011	0.1713	0.947
α_{ptech}	1.907	1.185	0.108
α_{scale}	-3.05	2.328	0.19
α_{sctech}	-1.093	1.696	0.519
φ	34.38826		

7.0 Summary and Conclusion

In this paper, we attempt to answer the research question on whether we can establish any connection between poverty reduction and output growth on one hand and poverty reduction and TFP growth on the other hand, over the 2002 and 2007 period. Our results indicate that output growth had some effect on poverty reduction and that pure technical efficiency change, pure technical change, scale change and scale technology change did not significantly reduce poverty. Pure technical change as a component of TFP growth was expected to have some significant effect on poverty but the expectation was not borne out by the results indicating that not enough progress has been made.

Correcting for product standards (the standards corrected models) appeared to have diminished the effect of output growth on poverty reduction (as the main effects of output growth on poverty reduction were not statistically significant). In the non-standards corrected estimates, the effect of output growth on poverty was obvious with statistically significant relationship clearly established. The main effects of the components of TFP growth supported the hypothesis that TFP growth did not have any significant effect on poverty reduction over the period (in both *non standards corrected* and *standards corrected* models). The paper concluded that, lack of TFP growth can only lead to loss of firm competitiveness and deeper deprivation among apparel manufacturers.

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