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Entrepreneurship, Technology Development and Productivity Across Firms in Africa in the 1990s: Lessons for the Youth Post COVID-19 Era

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Abstract:
This paper seeks to assess the contribution of technological change over the 1990s to the enterprise development in Sub-Saharan Africa and how that may inform the youth-start-ups today. Applying the Multivariate Multilevel Statistical modeling tools, the study investigated variability in productivity growth across enterprises within and between countries in Africa due to technological change, and those due to firm and country- specific effects. The results indicate that, variability in productivity growth due to technological change over the period was not significant suggesting that, the changes in productivity growth across and within enterprises in Africa were not influenced greatly by technology. The results however show that variability in productivity growth across enterprises in Africa, specifically Ghana, Kenya, Zimbabwe, Zambia and Cameroon has been largely due to physical, human capital and labour inputs. These results are in line with findings by Lall in 2003 that suggest that technological development has not been prioritized in Africa. The lesson for the youth here is that, the bulk of the output growth across enterprises in Africa in the 1990s and even in 2000s was largely due to production inputs. Has that changed today and can that change in the post COVID-19 era? The answers require further studies.

Keywords: Technological Change, Physical Capital, Human Capital, Productivity Growth, Enterprise Development, Africa.

1. Introduction

Productivity growth or variation of output between firms within countries across Sub-Saharan Africa could be due to input-output mix within firms and between firm differences or firm-specific fixed effects, or country-specific policies, technological change or the interactive effects of these factors. For example, there is so much to gain when firms are localized thus, they are able to take advantage associated with the concentration of firms in one place. Those advantages include ready access to a pool of labour force, highly developed infrastructure and competitive environment to operate within. However, it is good to know for each country the differences in firms output resulting from its choice of technology and inputs and that resulting from elsewhere so as to know where to concentrate policy efforts.

Since governments have little or no influence on whatever firms choose to produce in whatever quantity and whatever time and place, it is politically expedient for every government to provide enabling environment especially in the wake of increasing globalization.

Bigstern and Collier (1998) sought to find answers to the rate of returns to physical capital and human capital and how different rate of return if any help explain differences in productivity growth across manufacturing sectors in various countries in Africa. Also, they tried to capture the role of technology in determining differences in productivity across these countries using Cobb-Douglas (1928) production function. Arrow et al (1961) have already explained that the rate of returns to labour and capital inputs basically determines which of the two to use more in the production process. The main assumption is that capital and labour can be substituted and so depending on which one gives higher returns, more of it would be used for optimum benefits. This study differs from the Big stern and Collier (1998)'s work in two settings. First, the choice of methodological (analytical) techniques in trying to answer similar questions on Africa's manufacturing over the period. In the multivariate multilevel context (Snijders, T. and Bosker, R.,1999), we extend the analysis to investigate not only the input-output relationships but the role that firm-specific and country-specific differences as well as technological change play in output growth. Second, in effect, various levels of hierarchy of the data structure are accounted for in the model specifications.

2. Theoretical underpinning

Wangwe (1995) identified changes in technology hardware and software especially in the last two decades of the 20th century as one of the major challenges in the world economy. These historic technological advances have become a blessing not only for so-called high-tech industries but even for low-tech ones as well. What is particularly interesting though is the transition from mass production in the 1950s and '60s to tailor-made production techniques and products.

This is what many writers including Lall (2000) believe should drive competitiveness of SMEs. Large firms would even have to think of ways to produce tailor-made products that meet the varying needs and users as SMEs by their nature tend to cater for specific needs of their customers. Madu (1992) wrote that productivity, quality and competitiveness of a firm are all related to technology but warned that simply adopting new technologies may not produce the competitiveness aimed at as one would have to effectively manage these technologies in order to exploit their full potential. Citing Japanese managers as the success case in utilizing their skills to manage such technologies effectively, Madu referred to managers in US as re-evaluating their management practices in order to meet such challenges. What is obvious however is that new technologies are as good as the managers can successfully deal with them?

Technological reasons have been assigned to the increasing desire of firms to become competitive internationally (Madu, 1992). The rising trend of innovation and its impact on productivity growth have left firms, no matter their place of location and stage of development without any choice but to improve. New technologies have full proof position of being beneficial to all firms and that they impact positively on both traded and non-traded products and services thereby serving as a vital determinant of peoples' welfare.

3. Objectives of the study

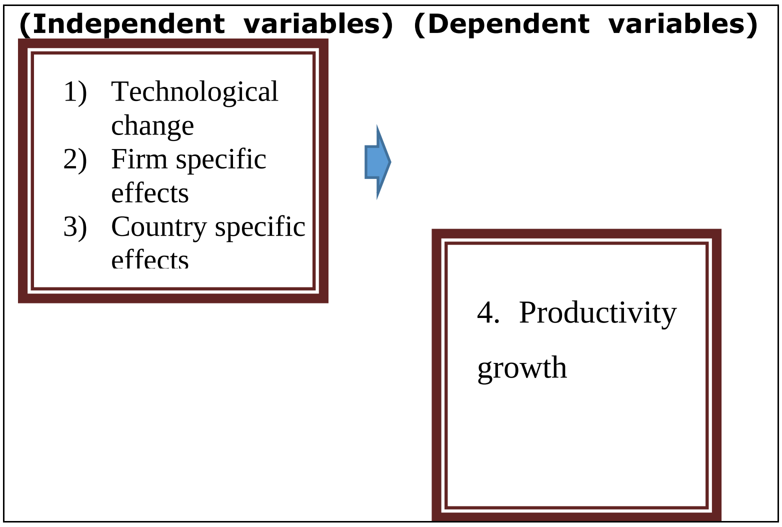
The main objective of this study is to establish the variability in productivity growth between firms within countries across Sub-Saharan Africa due to or technological change, input-output mix within firms or firm-specific fixed effects and country-specific policies.

4. Basic questions:

- How much of the variability of productivity growth across firms within-countries can be attributed to technological changes over time?
- How much of the variability in firms' output across firms within-countries can be attributed to firm-specific fixed effects? and
- How much of the variability in firms' output across firms within-countries can be attributed to country-specific fixed effects?

5. Empirical framework

This framework provides the sources of productivity growth as:



Definition of Variables and Parameters

- Technological change: This is captured as variability in productivity growth due to time-specific effects/variability across time periods or wave 1, wave 2 and wave 3 within which data was collected.
- Firm specific fixed effects: This is captured as variability in productivity growth due to input-output mix within firms and between firms.
- Country specific effects: This is captured as variability in productivity growth due to country-specific policy differences.

6. Methodology

A production function models the relationship between outputs and inputs. To accommodate more than two inputs namely labour L, physical capital K, human capital H and time T in a flexible function, we adopt a transcendental logarithmic (translog) production function expressed within the multivariate multilevel frame-work. It is called translog function because it involves taking the exponent of the log transformed variables (see Griliches and Ringstad, 1971), (Berndt and Christensen, 1973). The approach is just to capture the repeated response variables and repeated explanatory variables with a hierarchical structure. The translog function can be thought of as an approximation to second-order Taylor series and models the relationship between inputs and output as an exponential function. Incorporating our three inputs and accounted for time and hierarchical structure of the data, we devote the next section to our model specification. As the model assumes that technological change captured by time influences the choice of three inputs mix L, K and H, it follows the multilevel analysis as below.

7. The model

In fitting the models, we are interested in capturing the relationships between inputs and outputs across countries but above all, in the process of model selection, we are more interested in which random effect to retain and which to drop. We model the firm-specific random component and technology or time component for the five countries.

1) Model Selection: Checking for the existence of **random effects**:

$$ln(Y_{tik}) = \alpha_{0tk} + \alpha_{1tk}\tau_{tik} + f(L_{tik}, K_{tik}, H_{tik}) + \epsilon_{tk}.$$

Where Y is output

$$\begin{aligned} \alpha_{0tk} &= \alpha_0 + \mu_{0tk} \\ \alpha_{1tk} &= \alpha_1 + \mu_{1tk}. \end{aligned}$$

$$\begin{aligned} f(L_{tik},K_{tik},H_{tik}) &= \beta_0+\beta_L lnL_{tik}+\frac{\beta_{LL}}{2}(lnL_{tik})^2 \\ &+\beta_{LK}lnL_{tik}lnK_{tik}+\beta_{LH}lnL_{tik}lnH_{tik} \\ &+\beta_{KH}lnK_{itk}lnH_{tik}+\beta_K lnK_{tik}+\frac{\beta_{KK}}{2}(lnK_{tik})^2 \\ &+\beta_H lnH_{tik}+\frac{\beta_{HH}}{2}(lnH_{tik})^2. \end{aligned}$$

We finally have more compact form where *Y* is output and *Xs* are inputs

$$\begin{aligned} \ln(Y_{tik}) &= \alpha_0+\alpha_{1k}\tau_{tik}+\sum_i \alpha_i lnX_{tik} \\ &+\frac{1}{2}\sum_i \gamma_{ii}(lnX_{tik})^2+\sum_i\sum_{j\neq i}\gamma_{ij}lnX_{tik}lnX_{tjk} \\ &+\mu_{0tk}+\epsilon_{tk}. \end{aligned}$$

Again we assume that:

$$\mu_{0i} \sim N(0,\sigma^2\Sigma),\ \epsilon_{ti} \sim N(0,\sigma_\epsilon^2\mathbf{I}).$$

Specifically, in a compact form, there are three parameters that we need to check for the existence of random effects: Technology- specific effects, firm-specific and country-specific random effects

2) Checking for the presence of the technology-specific effects captured by τ_{01} (time-specific effects)

$$\begin{aligned} ln(Y_{ti}) &= \alpha_0+\sum_i \alpha_i lnX_{ti} \\ &+\frac{1}{2}\sum_i \gamma_{ii}(lnX_{ti})^2+\sum_i\sum_{j\neq i}\gamma_{ij}lnX_{ti}lnX_{tj} \\ &+\tau_{0i}+\epsilon_{ti}. \end{aligned}$$

$$\text{where } \tau_{0i} \sim N(0,\sigma_\tau^2),\ \epsilon_{ti} \sim N(0,\sigma_\epsilon^2)$$

3) Checking for the presence of the firm-specific effects captured by μ_{01}

$$\begin{aligned} ln(Y_{ti}) &= \alpha_0+\sum_i \alpha_i lnX_{ti} \\ &+\frac{1}{2}\sum_i \gamma_{ii}(lnX_{ti})^2+\sum_i\sum_{j\neq i}\gamma_{ij}lnX_{ti}lnX_{tj} \\ &+\mu_{0i}+\epsilon_{ti}. \end{aligned}$$

$$\text{where } \tau_{0j} \sim N(0,\sigma_\tau^2), u_{0i} \sim N(0,\sigma_\mu^2),\ \epsilon_{ti} \sim N(0,\sigma_\epsilon^2)$$

4) Checking for the presence of the country-specific effects captured by μ_{0tk}

$$
\begin{aligned}
ln(Y_{tik}) &= \alpha_0 + \alpha_{1k}\tau_{tik} + \sum_i \alpha_i lnX_{tik} \\
&+\frac{1}{2}\sum_i \gamma_{ii}(lnX_{tik})^2 + \sum_i \sum_{j\neq i} \gamma_{ij} lnX_{tik} lnX_{tjk} \\
&+\mu_{0tk} + \epsilon_{tk}.
\end{aligned}
$$

where $\mu_{0tk} \sim N(0, \sigma_k^2)$, $\epsilon_{tk} \sim N(0, \sigma_\epsilon^2)$

8. Data description

This data set was collected across manufacturing firms between 1992 and 1998 in five countries with the support of the World Bank, carried out by a team of researchers from the Centre for the Study of African Economies, Oxford (CSAE), University of Ghana, and Ghana Statistical Service among others as part of the Africa Regional Program on Enterprise Development (RPED) initiative (CSAE, 1995). They are longitudinal data (with repeated measures) in three rounds referred to as wave 1, wave 2 and wave 3. The variables are firm output measured as manufacturing value added (LVADPPP) in purchasing power parity (equal value across countries). Labour input measured as number of employees (LEMP) in a firm and physical capital stock (LCAPPPP) measured in US dollars purchasing power parity. Another variable of interest is human capital (EDUWGT) measured as years of education in the firm. The rest of the variables include time measured as wave 1, wave 2 and wave 3. The variables were collected across five countries namely, Cameroon, Ghana, Kenya, Zambia and Zimbabwe. In Table 1 at the appendix, some descriptive statistics for the variables are presented

9. Analysis of results

The random estimates of models 1 to 4 for the five countries can be visualized in Figure 1 at the appendix. The results indicate that between firm variability would be what to investigate more closely as between technology variability overtime is almost nonexistent. In Ghana, the between-technology or time variability is 0.003 compared to 0.000 for Kenya, 0.006 for Zimbabwe, 0.038 for Cameroon and 0.000 for Zambia. The implication here is that changes in productivity have not being influenced greatly overtime by technology and that it would be more useful to investigate firm specific characteristics.

Focusing on firm specific effects

In Table 2 at the appendix, the results for Ghana indicate that there were only two significant sources of productivity growth over the period. Physical capital (α_K) and labour (α_L) were the inputs with coefficients of 0.2508 and 0.8139 respectively. Output (*Y*) tends to be more responsive to changes in labour input than to physical capital input by a margin of over 3:1 reported in column 1 of the Table 2. The estimated p-values of both the *pMCMC* and *Pr(>|t|)* together with the 95 percent highest probability density interval (HPD) all indicate that both capital and labour are significantly different from zero at 5 percent. The *pMCMC* is however, known to be more 'conservative' in both large and small samples than the Pr(>|t|) and their respective values of 0.0001 for the former and 0.0000 for the latter indicate that. The maximum likelihood estimates of mean output across firms in Ghana denoted by the intercept coefficient α_0 is 5.7987 and also compares well with its corresponding Markov-chain Monte Carlo (MCMC)_mean of 5.4013. The mean output is also significantly different from zero at 5 percent.

In Kenya, the results are similar to that of Ghana with the main effects of physical capital and labour being the only significant sources of growth recording values of 0.1759 and 1.0023 respectively in column 1 of Table 2 at the appendix. The mean output for Kenya α_0 of 6.8012 is however higher than that of Ghana. In Zimbabwe, the results indicate same sources of growth. Of the five countries, it was only in Cameroon and Zambia that we find some interaction terms being significantly different from zero at 5 percent. The coefficients of interaction terms labour and physical capital (LK), labour and human capital (LH) and physical and human capital (KH) help in identifying whether the inputs are substitutes where an increase in the use of one input leads to a reduction in the use for the other and vice versa or complements where an increase in the use of one leads to increase in the use for the other. In all the countries excerpt Kenya and Cameroon where we find evidence of coefficients of labour (α_L) significantly different from zero and greater than 1, the rest of the countries report values less than unity. Coefficients that are significantly different from zero at 5 percent with values higher than unity indicate the process of increasing returns where per one unit increase in input leads proportionately to more than one unit increase in output. Coefficients equal to unity indicate a constant rate of return whilst those less than unity reveal decreasing rates of return.

Table 3 at the appendix presents the results of random effects for the five countries. In Ghana, the estimates of level 2 variance, Var (μ_{0i}) is 0.71 and that of level 1, Var(ϵ_{ti}) is 0.63. Both the p-values of pMCMC and Pr(>|t|) just confirm that firm-specific fixed effects have been significant in determining output growth in over the period. Intra-class correlation which captures the proportion of variance due to firm specific fixed effects defined as $\sigma_\mu^2/(\sigma_\mu^2 + \sigma_\epsilon^2)$ is 0.53 or 53 percent (Figure 2 at the appendix). In Kenya, the estimates of level 2 variance is 0.58 and that of the residual is 1.13. Both the p-values of pMCMC and Pr(>|t|) confirm that firm-specific fixed effects HPD interval contains zero. The intra-class correlation is 0.34 or 34 percent (Figure 3 at the appendix).
In Zimbabwe, the estimate of level 2 firm-specific variance is 0.29 and that of the residual is 0.54. Intra-class correlation is 0.35 or 35 percent. This shows that the proportion of variation due to firm-specific fixed effects is not too high. In Cameroon, the level 2 variance is estimated as 0.55 and that of the residual term is 0.79. The estimated highest probability density interval for the firm random effects suggests no significant differences among firms in relation to productivity growth in Cameroon. The intra-class correlation is 0.41 or 41 percent (Figure 2 at the appendix).

The estimates of level 2 variance in Zambia is 0.61 and that of the residual is 1.37. The highest posterior probability interval of HPD95L with the value of 0.00 and HPD95U with the value of 0.21 contains zero and so some of the firms have been at least similar in productivity practices in Zambia over the period. The intra-class correlation which captures the proportion of variance due to firm specific fixed effects is 0.31 or 31 percent. Of the five countries analyzed, only in Ghana did we find the intra-class correlation in the 0.5s specifically 0.53 and significantly different from zero.

10. Conclusion

In conclusion therefore, the study accounted for variability in productivity growth due to technological change, firm and country-specific fixed effects across Ghana, Kenya, Zambia, Zimbabwe and Cameroon in Sub-Saharan Africa.
The results established that variability in productivity growth due to technological change over the 1990s was not significant. Analysis also indicated that firm-specific fixed effects including its physical capital stock and human capital were more important than country- specific fixed effects.
In all, the proportion of variability in output growth due to firm-specific fixed effects (physical capital stock and human capital) was estimated to be 53 percent for Ghana, 34 percent for Kenya, 35 percent for Zimbabwe, 41 percent for Cameroon and 31 percent for Zambia. The study established that, except for firm-specific differences, the effects of country differences on output growth across Sub-Sahara Africa were insignificant and the contribution of technological change was not significant either in the 1990s.

The paper concluded that, even though the bulk of the output growth in the 1990s was due to production inputs, technology could have played a significant role and Technology Startup Enterprises of today need not miss the opportunity to harness technology for productivity growth in Ghana, Kenya, Zimbabwe, Zambia and Cameroon for national development.

List of abbreviations

CSAE: Centre for the Study of African Economies, Oxford
EDUWGT: Human capital measured as years of education in the firm
HPD95L: 95 % Highest Posterior Density intervals- lower limit
HPD95U: 95 % Highest Posterior Density intervals- upper limit
LCAPPPP: Physical capital stock measured in US dollars purchasing power parity

LEMP: Labour input measured as number of employees LVADPPP: Manufacturing value added in purchasing power parity
pMCMC: particle Markov-chain Monte Carlo
RPED: Regional Program on Enterprise Development
SMEs: Small and Medium sized enterprises

Availability of data and materials

As explained in sub-section 8, the data set used for the analysis is made available by the Centre for the Study of African Economies at the University of Oxford and can be accessed free of charge through the following link: https://www.csae.ox.ac.uk/data

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11. Appendix

Table 1: The table shows summary statistics of inputs-output variables in the study. Countries and the number of repeated measures are also presented. The number of non-available (NA’s) for each variable are also presented

Variable	LVADPPP	LEMP	LCAPPPP	EDUWGT	COUNTRY
Min	3.4	0.0	0.9	0.0	Cameroon:724
Median	11.8	3.2	12.0	8.3	Ghana:645
Mean	11.7	3.3	11.7	7.4	Kenya:659
Max.	19.0	8.7	20.1	17.5	Zambia:654
NA’s	913	531	758	203	Zimbabwe:609

Source: Created by author for Oxford dissertation in Statistics

Table 2: Estimates: Fixed effects (Dependent Variable is log (output))

	Estimate	MCMCmean	HPD95lower	HPD95upper	pMCMC	Pr(>|t|)
Ghana						
α_0	5.7987	5.4013	5.0241	5.8043	0.0001	0.0000
α_L	0.8139	0.7492	0.6118	0.8844	0.0001	0.0000
α_K	0.2508	0.3093	0.2497	0.3664	0.0001	0.0000
Kenya						
α_0	6.8012	6.6506	6.0634	7.2035	0.0001	0.0000
α_L	1.0023	1.0053	0.8651	1.1400	0.0001	0.0000
α_K	0.1759	0.1883	0.1158	0.2652	0.0001	0.0000
Zimbabwe						
α_0	5.0975	4.8108	4.3500	5.2744	0.0001	0.0000
α_L	0.7751	0.7345	0.6367	0.8315	0.0001	0.0000
α_K	0.3606	0.3957	0.3378	0.4537	0.0001	0.0000
Camaroon						
α_0	6.2628	4.7784	2.0136	7.4014	0.0006	0.0000
α_L	2.3167	2.2560	1.6583	2.8931	0.0001	0.0000
α_K	0.1955	0.0392	-0.4798	0.5861	0.8858	0.4938
γ_{KK}	0.0288	0.0199	-0.0088	0.0454	0.1622	0.0483
γ_{LK}	-0.0761	-0.0865	-0.1224	-0.0515	0.0001	0.0002
Zambia						
α_0	4.4429	4.4317	2.0814	6.5492	0.0001	0.0001
α_L	0.0345	0.1949	-0.3565	0.7237	0.4832	0.9016
α_K	0.4035	0.3730	0.1129	0.6153	0.0046	0.0016
α_H	0.2447	0.2222	-0.0824	0.4996	0.1368	0.0888
γ_{LK}	0.0428	0.0386	0.0031	0.0700	0.0220	0.0169
γ_{LH}	0.0563	0.0454	-0.0002	0.0904	0.0490	0.0130
γ_{KH}	-0.0387	-0.0332	-0.0628	-0.0023	0.0366	0.0102

Source: Created by author for Oxford dissertation in Statistics

Table 3: Estimates: Random effects (Dependent Variable is log (output))

Groups	Name	Variance	MCMCmed.	MCMCmean	HPD95L	HPD95U
Ghana						
	μ_{0i}	0.71	0.39	0.39	0.26	0.51
	ϵ_{ti}	0.63	1.05	1.05	0.96	1.15
Kenya						
	μ_{0i}	0.58	0.10	0.11	0.00	0.28
	ϵ_{ti}	1.13	1.30	1.30	1.22	1.39
Zimbabwe						
	μ_{0i}	0.29	0.14	0.14	0.00	0.27
	ϵ_{ti}	0.54	0.89	0.89	0.82	0.96
Camaroon						
	μ_{0i}	0.55	0.14	0.14	0.00	0.32
	ϵ_{ti}	0.79	1.14	1.14	1.05	1.24
Zambia						
	μ_{0i}	0.61	0.05	0.07	0.00	0.21
	ϵ_{ti}	1.37	1.41	1.42	1.32	1.52

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Figure 1: firm-Firm specific fixed effects and technology-Firm specific fixed effects across countries

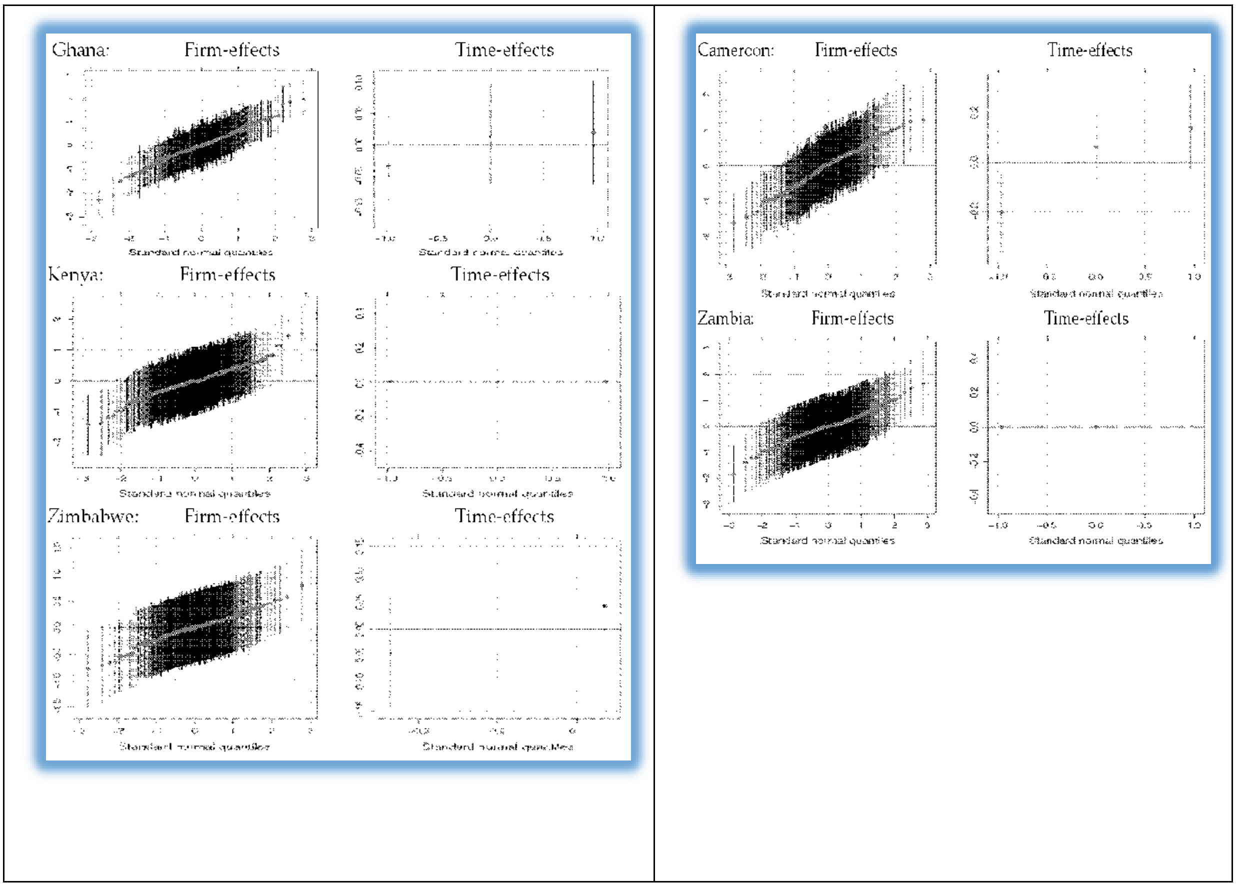

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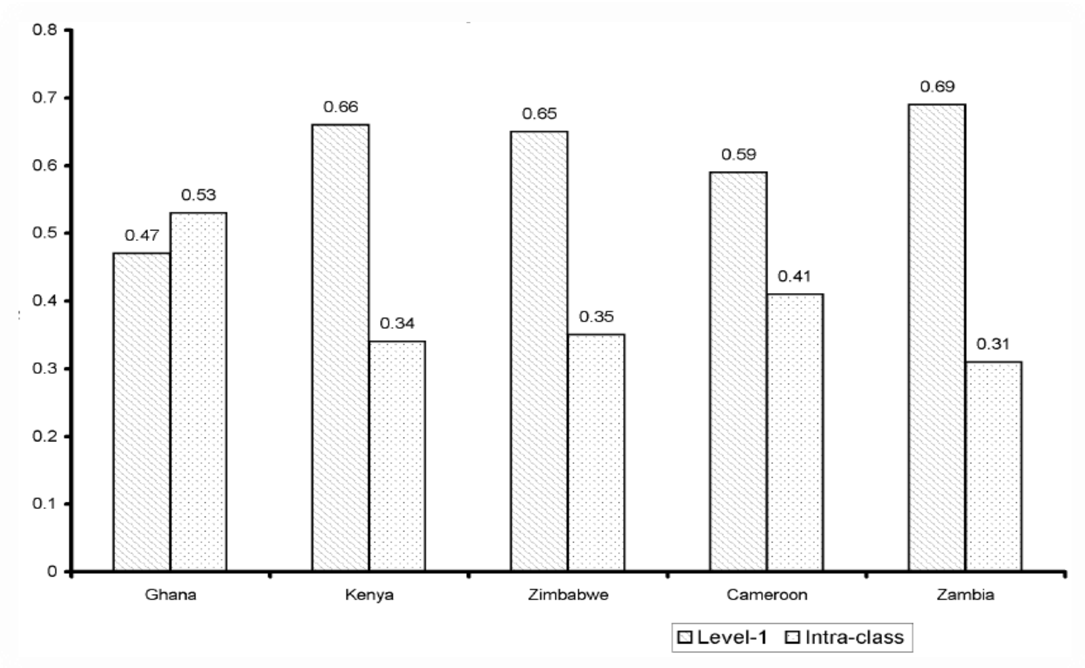
Figure 2: Proportion of variance due to the residual (level 1) and firm-Firm specific fixed effects (level 2)



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