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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

Does firm size affect learning-by-exporting? Empirical evidence from Sub-Saharan Africa

Stephen Esaku*

Abstract: This study examines whether the relationship between exports and productivity growth differs across firm size. Using panel data from three Sub-Saharan African countries, I use propensity score matching procedure to examine this relationship. This study finds evidence of productivity differences between new exporters and non-exporters confirming the empirical regularity that new exporters are more productive than never exporters. The findings indicate that export participation effects vary across firm size, with both small and large firms experiencing immediate and significant productivity gains upon entry. However, the productivity gain for large firms is highly significant and more pronounced in the first two years after entry but declines drastically from the third year and tends towards negative in subsequent years. Learning effects might be important for large firms during the initial years of exporting, but these effects dissipate once learning avenues have been exhausted. Small firms display sustained learning effects that expand beyond the fourth year. Relative to the large firms, small new exporters display sustained and significant productivity growth for five year. This study finds no evidence of cumulative productivity growth beyond the third year for large firms. These results are robust to alternative measure of productivity. Any export-led growth should be directed at helping small new exporters access the export markets.

ABOUT THE AUTHOR

Stephen Esaku is adjunct faculty at Kyambogo University (Soroti Campus) in Uganda, where he lectures courses in Microeconomics. His research interests are in the areas of international economics (firms in international trade, regional integration, and foreign direct investment), development economics (focusing on economic growth and development, poverty dynamics, corruption and gender studies) and empirical industrial economics (learning, pricing and market strategies). Stephen has published papers on firm-level investment and Exporting; Export markets and productivity; employment dynamics in Sub-Saharan Africa; Job creation and destruction in an African economy, among others. His teaching experience spans 8 years.

PUBLIC INTEREST STATEMENT

Firm learning is important for productivity growth at both the firm-level and sector/industry level. In this study, learning means, firms acquiring new knowledge that helps them restructure and reorganize the production process to survive in the dynamic business environment. With entry into an additional market, new exporters will have to compete against other firms, sometimes well established and experienced ones. This puts a lot of pressure on the new exporters to adapt to new technologies of production and marketing to survive the stiff competition. Once they choose to adapt to new technologies of production, they will improve their productivity, so that output per input used is higher than before hence raising the odds for firm survival. International markets therefore become a source of knowledge acquisition, through learning mechanism. The question is, does knowledge acquisition through learning vary across firms of different sizes? This paper succinctly answers the above question and shows how learning varies between small and large firms.

Subjects: Industrial Economics; International Finance; International Trade;; incl; trade agreements & tariffs; Development Economics

Keywords: firm behavior; productivity; firm size; firm growth; learning-by-exporting; trade
JEL classification: D22; D25; L25; F10; F14; O55

1. Introduction

The literature on international trade has extensively examined the relationship between exports and productivity, reaching consensus on the nature and superiority of exporting firms. Following the novel work of Bernard and Jensen (1999), there is growing evidence showing that exporters are significantly more capital intensive, larger and more productive and pay higher wages than non-exporters. Consequently, trade policies that advance the growth of exports could be directed at promoting the creation and growth of firms with characteristics that facilitate entry into the export markets. Melitz's (2003) model provides theoretical predictions that support the view that exporters possess superior characteristics and self-select (potential exporters are already productive years before they start to export) into the export markets and learn-by-exporting (firms that start to export increase their productivity). While the self-selection hypothesis is generally viewed as valid, there is still debate on the learning-by-exporting (henceforth, LBE) hypothesis.

Recently, both theoretical and empirical research has started to focus on whether firms that start to export increase their productivity as a result of export market participation. Specifically, the focus of economic analysts is whether these new exporters experience LBE effects. Some papers find evidence of LBE hypothesis, either weak or non-existent (see, Bernard & Jensen, 1999; Clerides et al., 1998; Haidar, 2012). However, some studies find strong evidence of LBE. For example, De Loecker (2007) uses data from Slovenian firms and finds evidence of extra-productivity growth as a result of exporting. Van Biesebroack (2005) uses data from nine Sub-Saharan African countries and finds similar results. Correspondingly, Lileeva and Trefler (2010) use data from Canadian firms and find evidence of LBE effects among low productivity firms that started to export in response to a fall in trade tariffs between Canada and the U.S. In cases where LBE effects are present, exposure to international markets has been a source of new knowledge for entrants leading to learning.

Despite the presence of some evidence of LBE, a number of studies emphasize that it holds under specific conditions. For example, Silva et al. (2013) use data from Portugal to study the relationship between exports and productivity and find a positive LBE effects for new exporters that also engage in importing activities at the same time. Further, the authors show that LBE is pronounced for firms that start to export to markets in advanced economies, and those that have reached a particular threshold of export intensity and operate in a sector where a country has a comparative disadvantage. This implies that LBE is achieved when certain conditions hold. Further, Martins and Yang (2009) analyze more than 30 papers that study the relationship between exports and exporting and find that the evidence of LBE is more pronounced for developing than developed countries. This implies that LBE may be relevant for economies that are less developed than the developed ones. Moreover industries that are more exposed to international trade display pronounced LBE effects (Girma et al., 2004), implying that a country's trade policy stance is important for LBE effects. Similarly, Du et al. (2012) use Chinese data for 1998–2005 to examine whether LBE effects differ between domestic exporters and foreign affiliates and find stronger LBE effects among domestic exporters than foreign affiliates. This implies that LBE might require less familiarity with the export market since previous export market experience could be uncorrelated with LBE (see, Liu, 2017). In conclusion, LBE might be important for the growth of exports but requires certain conditions to be realized.

While a number of papers analyzed the relationship between exports and productivity, there are fewer studies that examine how LBE effects vary across firm size. Much of the previous analyses devote much effort into providing general evidence of LBE, with little focus on the various dimensions

of learning. The frameworks of Bernard and Jensen (1999) and Melitz (2003) are largely anchored on providing evidence on ex ante differences between non-exporters and exporters in general; so that exporters are taken as homogenous entity with little attention to the differences in firm size. Specifically, little work has been done in LBE effects across firm size (Máñez-Castillejo et al., 2010). This study examines whether productivity differs across firm size using panel data from three Sub-Saharan African countries (Tanzania, Kenya and Ghana). I consider two types of firms, the small and the large. I follow Máñez-Castillejo et al. (2010) classification of firms, according to size. I classify as small, firms that employ from 1–200 (≤ 200) workers; and large, firms with more than 200 (> 200) workers. The data I use to investigate this relationship is from manufacturing firms that operate in the above countries and span 12 years, from 1991–2002. I choose these countries for a number of reasons; (i) availability of longitudinal data spanning 12 years, from 1991–2002. Some studies show that LBE effects take some time to be experienced (Máñez-Castillejo et al., 2010), implying that the analysis of LBE should require long panel data. I find our dataset ideal for this purpose; (ii) the three countries represent economies that have carried out successful trade reforms from the 1980 s to early 1990 s. By 1993 trade reforms were concluded in most of these countries. Trade reforms are aimed at easing trade restrictions and spurring export-led growth. It is therefore reasonable that our choice of these economies provides ideal testing ground for LBE (see, Esaku, 2019).

This study contributes to the literature on firm heterogeneity (differences between exporters and non-exporters) by focusing on the LBE effects that underlie firms according to firm size. Understanding how LBE effects differ across firm size is important for policy formulation. Policy makers should know which firms are likely to increase their productivity once they start to export so that export incentives could be directed to these firms. Our empirical analysis fills the existing gap in the LBE literature, specifically, for Sub-Saharan Africa. Our paper is similar to the work of Máñez-Castillejo et al. (2010) but differs in two main areas. The above authors use stochastic dominance techniques to derive total factor productivity estimates from the production function. I use the approach proposed by Akerberg et al. (2006, 2015) for this purpose. Further, their paper investigates LBE effects in a developed economy where LBE is considered less likely to occur (Martins & Yang, 2009), but I focus on Sub-Saharan Africa with higher prospects of experiencing LBE effects.

This study finds evidence of productivity differences between new exporters and non-exporters confirming the empirical regularity that new exporters are more productive than never exporters. I also find that export participation affects firms differently. There are immediate and significant productivity gains for both small and large firms upon entry into the export markets. However, the productivity gain for large firms is highly significant and more pronounced in the first two years after entry but declines drastically from the third year and tends towards negative in the subsequent years. This study notes that LBE could be important for large firms, in the initial years of export participation, but dissipates with continued exposure to exporting. The scope for LBE narrows down for these firms as the export market becomes more familiar. While large firms experience a short spell in LBE, small firms display sustained LBE effects that expand beyond the fourth year, signaling the significance of LBE for small firms than for large firms.

The rest of the paper is organized as follow. Section 2 describes the data and presents the descriptive statistics. Section 3 presents the methodology and estimation of productivity (Total factor productivity, henceforth TFP). Section 4 presents the results and discusses how LBE effects differ between small and large firms. Section 5 concludes the paper.

2. Data and descriptive statistics

2.1. The data

The data I use for the empirical analysis are drawn from three Sub-Saharan African countries (Ghana, Kenya and Tanzania). The data were collected by the Center for the study of African Economies (CSAE)¹ in collaboration with the World Bank, under the Regional Program on Enterprise Development (RPED). The original dataset had 5 countries (Ghana, Kenya, Nigeria, South Africa and Tanzania) but I excluded

Table 1. Summary of firm characteristics (1991–2002)

	All	Small	Large
No. of firms (exporters)	1,087	688	399
Proportion of exporters %	100	63.7	36.3
Ln(Capital)	6.55	6.54	6.56
Ln(labor)	7.54	7.57	7.50
Ln(wages)	3.61	3.55	3.66
Employment	54.5	49	60

Source: Author's calculations from CSAE dataset.

Nigeria and South Africa from the analysis because they are large economies that could easily drive the results of LBE. This dataset is unique and has important information that facilitates our research objective. Moreover a number of other studies have used this dataset as well (see, Boermans, 2013; Esaku, 2019; Esaku & Krugell, 2020; Rankin et al., 2006).

2.2. Descriptive statistics

Table 1, reports the summary of firms, according to the size classification. The number of small firms is higher and accounts for 63.7%, while large firms account for only 36.3% of the sample. Relative to small firms, larger firms on average are more capital intensive (6.56%) and have comparable labor productivity (7.50%) with small firms. Further, this study also shows that larger firms, on average, pay higher wages (3.66%) and employ more workers (60) than small firms (49).

Previous research emphasized the productivity differences between exporters and non-exporting firms and documented that the former are large, more productive and pay more wages than the latter (see, Bernard & Jensen, 1999). I examine this evidence using Sub-Saharan African data, where I use feasible generalized least squares (FGLS) method and run the regression of the following form:

$$\ln y_{it} = \beta_0 + \beta_e \text{Exp}_{it} + \beta_s \text{size}_{i,t-1} + \beta_w \text{ownership}_{it} + \sum_{jt} X_{jt} + \mu_{it} \quad (1)$$

Where $\ln y_{it}$ is a measure of productivity (total factor productivity in logs), Exp_{it} is an indicator variable that denotes the export status of the firm, equal one if firm i is an exporter in period t , zero otherwise. Ownership_{it} is the ownership status of firm i in period t , equal one if firm has some foreign ownership, zero otherwise; X_{jt} denotes a vector of control variables; that is, firm age, year and industry dummies; and μ_{it} is the error term.

I report the results of the analysis of Equation (1) in Table 2. I find that, relative to non-exporters, exporting firms possess superior characteristics. Column 2, shows that exporters are large (in terms of employment), pay higher wages, operate with more capital than labor, and have high productivity than non-exporters. Accordingly, exporters are 45% more productive than non-exporters, 46.6% more capital intensive and have 35.3% labor productivity than non-exporters. In terms of

Table 2. Characteristics of exporters and non-exporters (1991–2002)

	All	Small	Large
Ln(TFP)	0.450***(0.088)	0.805***(0.077)	2.403**(0.303)
Ln(Labor productivity)	0.353***(0.117)	0.479***(0.075)	2.385***(0.287)
Ln(Capital intensity)	0.466***(0.113)	0.756***(0.093)	2.460***(0.339)
Ln(wages)	0.460***(0.065)	0.597***(0.059)	-0.074(0.128)
Employment	1.397***(0.060)	0.866**(0.052)	2.152***(0.181)

Notes: Regression includes size, industry and time effects, including firm ownership status. Standard errors are in parenthesis. Significance levels are: *p < .05; **p < .01; ***p < .001

employment, I observe that exporters significantly employ more workers than non-exporters (their employment level is 139.7% higher than non-exporters). These results hold regardless of the age of the firm. These findings seem to agree with previous studies that have studied differences between exporters and non-exporters. For example, Bernard and Jensen (1999) use data from the U.S. to document these differences. Correspondingly, De Loecker (2007) using Slovenian data finds similar results.

3. Methodology

This section describes TFP estimation and the method I use for empirical estimation of the LBE effects across firm size. I follow the method of Akerberg et al. (2006, 2015) in the estimation of TFP and use propensity score matching techniques to examine the LBE effects that take place.

3.1. Production function estimation

I assume that firms produce output using a Cobb-Douglas production technology:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \varepsilon_{it} \quad (2)$$

Where y_{it} represents the output of firm i at period t , k_{it} is capital, l_{it} is the labor units, m_{it} is intermediate materials, ω_{it} is the productivity that is observable to the firm at the beginning of period t but unobservable to the econometrician and ε_{it} is the error term.

Estimation of Equation (2) using popular methods like ordinary least squares (OLS) is untenable because it ignores possible correlation between input choices and productivity. Since firms can choose the use of variable inputs based on the observed productivity of the firm, which is unknown to the econometrician, it follows that productivity can be correlated with inputs. This leads to simultaneity issues in the estimation of the production function (Marschak & Andrews, 1944) as firms can increase the use of variable inputs in response to a positive productivity shock. Therefore, using OLS to derive estimates of the production function yields inconsistent and biased estimates. Recently, some authors have developed innovative approaches of overcoming this problem. They propose the use of some inputs to proxy unobservable productivity. For example, Olley and Pakes (1996, henceforth OP) propose estimating Equation (2) semiparametrically to obtain consistent estimates of the production function coefficients. They suggest using firm investments to proxy the unobservable productivity. One limitation of OP method is that some firms report zero investment. Accordingly, Levinsohn and Petrin (2003, henceforth LP) propose the use of intermediate materials to proxy unobserved productivity, a method suggested to circumvent OP technique. The advantage of LP method is that it avoids the problem of zero investment among firms since most firms report positive use of intermediate materials.

While OP and LP methods provide useful ways of dealing with biases arising from the use of Akerberg et al. (2006, 2015) note that these two methods suffer from functional dependence issues, especially in the estimation of labor inputs in the first stage of estimation. Consequently the authors propose an alternative method, (following the two approaches of OP and LP) that addresses the limitations of OP and LP. In this paper, I follow the method proposed in Akerberg et al. (2006, 2015) to estimate the estimates of the production function of Equation (2). I use the Stata command *prodest* to estimate a Cobb-Douglas production function. I give a brief explanation of their method in Appendix A3.

3.2. Econometric strategy

This section introduces the empirical method that I follow to investigate whether LBE effects vary across firm size. I apply propensity score matching procedures to examine the relationship between exports and productivity across firm size. Consequently, this study needs to compare the productivity trajectory of entrants² (across different firm size), when they start exporting, with non-exporters (of similar firm size). However, this comparison will be meaningful only if self-selection effects can be isolated from LBE, since productivity gains could result from either of the two or both. To isolate self-selection from LBE effects

needs comparing the actual productivity growth of new exporters when they start to export with that of the same firms had they not started to export. One challenge is that the productivity of firms that start to export can be observed but not their productivity had they not started to export, hence the counterfactual situation. Therefore, solving the counterfactual situation requires us to rely on matching methods to construct the counterfactual. Thus, I categorize our sample into two; (i) exporters and (ii) non-exporters. I then classify as exporters, firms that have not exported in the previous period prior to period t , and are observed in the sample for at least 5 years prior to period t . Correspondingly, I classify as non-exporters, firms that are observed in the sample for at least 5 years and have not exported during the whole sample period. With these samples in place, we can investigate the LBE effects across firm size.

Let Δy_{it} denote the productivity growth of firm i in period t , and $D_{it} \in \{0, 1\}$ denote an indicator variable equal one if firm i is a new exporter (selling to exports markets for the first time during the sample period). Similarly, let productivity growth of a new exporter between the two periods, period t and $t + u$ be $\Delta y_{i,t+u}^1$ (where $u > 0$); and let $\Delta y_{i,t+u}^0$ denote the productivity of firm i had it not started to export in period t . We can formally express the causal effect of exporting on productivity growth as:

$$\Delta y_{i,t+u}^1 - \Delta y_{i,t+u}^0 \tag{3}$$

In line with the evaluation literature (Heckman et al., 1997), I analyze the average treatment effect of exporting on the productivity growth of entrants as follows:

$$E(\Delta y_{i,t+u}^1 - \Delta y_{i,t+u}^0 | D_{it} = 1) = E(\Delta y_{i,t+u}^1 | D_{it} = 1) - E(\Delta y_{i,t+u}^0 | D_{it} = 1) \tag{4}$$

Using Equation (4) to infer causal inference is problematic since we can observe $\Delta y_{i,t+u}^1$ but not $\Delta y_{i,t+u}^0$ (the average productivity growth of entrants had they not started to export). Matching techniques help us identify and select non-exporters in period t with the same distribution of observable variables (that determine the productivity growth and probability of starting to export) in period $t-1$, similar in most respects to that of entrants. Conditional on X (observable variables), firms having similar characteristics are then randomly exposed to the treatment (exporting). We can write Equation (4) as:

$$E(\Delta y_{i,t+u}^1 - \Delta y_{i,t+u}^0 | D_{it} = 1) = E(\Delta y_{i,t+u}^1 | X_{i,t-1}, D_{it} = 1) - E(\Delta y_{i,t+u}^0 | X_{i,t-1}, D_{it} = 0) \tag{5}$$

Thus, I first estimate the probability of firm i starting to export to market j (the propensity score), before I implement the matching procedures. Our propensity score can thus be expressed as follows:

$$P(EXP_{it} = 1) = G(X_{i,t-1}, C_i) \tag{6}$$

Equation (6) implies that a firm starts to export conditioned on the arguments of G which denotes the cumulative distribution function and a set of observable characteristics $X_{i,t-1}$; which includes lagged capital, size, productivity, age, year and industry dummies.

I follow Becker and Ichino (2002) and use the nearest neighbors matching to construct the counterfactual. Using the *psmatch2* Stata command (Leuven & Sianesi, 2003) I examine how LBE effects vary across firm size over a period of 5 years. After the analysis of each specification, I then evaluate the quality of the matching process, and relying on indicators of the balancing properties within the matched samples (Rubin, 2001). The outcome of evaluation of the quality of matching shows that our procedure sufficiently balances the samples. I present our results in Tables 3 and 4.

4. Results and discussion

4.1. Effect of exports on productivity according to firm size

This section presents the results of the analysis of the effect of exports on the productivity levels of new exporters for the sample period, 1991–2002. Our research objective is to evaluate how the

Table 3. The effect of exporting on productivity according to firm size (1991–2002)

	Nearest Neighbor			Kernel Matching	
		Outcome: Total factor productivity (TFP)	Outcome: Labor productivity	Outcome: Total Factor Productivity (TFP)	Outcome: Labor Productivity
	Obs.	Matched	Matched	Matched	Matched
Panel (a) Small firms					
Year0	162 (2,540)	0.491** (0.201)	0.146* (0.093)	0.891*** (0.149)	0.390** (0.171)
Year 1	223 (2,479)	0.561*** (0.187)	0.272* (0.187)	0.810*** (0.135)	0.427** (0.156)
Year 2	170 (2,532)	0.641** (0.217)	0.271* (0.125)	0.808*** (0.157)	0.390** (0.176)
Year 3	115 (2,587)	0.545** (0.247)	0.198* (0.063)	0.874*** (0.180)	0.157* (0.014)
Year 4	77 (2,625)	0.500* (0.320)	0.396** (0.119)	0.962*** (0.254)	0.233* (0.116)
Year 5	57 (2,645)	0.434* (0.163)	-0.405 (0.363)	0.857*** (0.255)	0.161 (0.306)
Panel (b) Large firms					
Year0	75(581)	1.700** (0.731)	1.815** (0.757)	3.170*** (0.492)	3.229*** (0.518)
Year 1	114(542)	2.377*** (0.634)	2.358*** (0.675)	2.849*** (0.422)	3.009*** (0.452)
Year 2	110(546)	1.350** (0.644)	0.311 (0.686)	1.255** (0.459)	1.318** (0.495)
Year 3	82(574)	-1.682** (0.731)	-2.044** (0.780)	-0.346 (0.511)	-0.560 (0.546)
Year 4	80(576)	-2.276*** (0.709)	-2.411*** (0.751)	-1.546*** (0.493)	-1.769*** (0.527)
Year 5	68(588)	-0.891 (0.791)	-1.175 (0.848)	-0.542 (0.554)	-0.725 (0.598)

Note: Reported are results for matched samples. Obs. denotes observations, untreated is in parenthesis. Estimation of results is by psmatch2 command of Leuven and Sianesi (2003) and common support is imposed. S.E denotes standard errors. Significance levels are: *p < .1; **p < .05; ***p < .01.

productivity trajectory of new exporters varies according to firm size. The results of the nearest neighbor matching and kernel estimation approach for both matched sample are shown in Table 3. I focus our discussion on the results of the matched sample. Panel (a) denotes small firms (employees = <200) while panel (b) is for large firms (Employees >200). Our outcome of interest is TFP and labor productivity.

Table 3 shows remarkable differences between the treated (entrants) and the untreated (non-exporters) firms. Exports lead to a rise in productivity level among exporter starters compared to never export starters. In panel (a) column 3, we can observe that productivity is positive both for TFP and labor productivity, statistically significant in the year of entry (Year0). There is evidence of variation in productivity gains between small and large firms, implying that the potential impact of exporting activity differs across firm size. This study observes that there is immediate productivity gains for both the small and large firms upon entry into the export market compared to never export starters. Small firms experience high productivity gains for up to five years of exporting. Similarly, large firms experience intense and more pronounced productivity gains up to the second year of exporting. After the second year, productivity gains start to decline and tend towards negative.

Table 4. The effect of exporting on productivity growth according to firm size (1991–2002)

	Nearest Neighbor Matching			Kernel Matching	
	Obs.	Outcome: ΔTotal factor productivity (TFP) Matched	Outcome: ΔLabor productivity Matched	Outcome: ΔTotal Factor Productivity Matched	Outcome: ΔLabor Productivity Matched
Panel (a) Small firms					
Year0	70(1,701)	0.049** (0.020)	0.053** (0.023)	0.040** (0.019)	0.047** (0.021)
Year 1	141 (1,630)	0.020* (0.012)	0.029** (0.014)	0.023** (0.010)	0.030** (0.013)
Year 2	122 (1,649)	0.019* (0.012)	0.022* (0.014)	0.018* (0.010)	0.023* (0.014)
Year 3	92(1,679)	0.028* (0.015)	0.033* (0.018)	0.033** (0.015)	0.033* (0.018)
Year 4	65(1,706)	0.041** (0.020)	0.036* (0.021)	0.040** (0.020)	0.039* (0.024)
Year 5	52(1,719)	0.065** (0.029)	0.060* (0.031)	0.073** (0.027)	0.071** (0.029)
Panel (b) Large firms					
Year0	34(193)	0.189** (0.077)	0.190** (0.077)	0.144*** (0.045)	0.148*** (0.045)
Year 1	44(165)	0.084** (0.038)	0.098** (0.040)	0.126*** (0.023)	0.127*** (0.024)
Year 2	45(164)	0.118** (0.042)	0.102** (0.044)	0.124*** (0.023)	0.111*** (0.026)
Year 3	28(181)	0.110** (0.053)	0.076 (0.062)	0.114*** (0.037)	0.094** (0.042)
Year 4	21(188)	0.087 (0.086)	0.098 (0.086)	0.072 (0.052)	0.056 (0.057)
Year 5	26(183)	0.078 (0.069)	0.060 (0.071)	0.061 (0.048)	0.038 (0.050)

Note: Reported results are for matched samples. Obs. denotes observations, untreated is in parenthesis. Estimation of results is by psmatch2 command of Leuven and Sianesi (2003) and common support is imposed. S.E denotes standard errors. Significance levels are: *p < .1; **p < .05; ***p < .01.

These findings are robust to the alternative measure of productivity, that is, labor productivity. Labor productivity gains set in immediately in the year of entry and continue to expand as firms continue exporting. For example, in column 4, the effect of exporting on the matched sample confirms that small export starters experience 14.6% labor productivity gains compared to small never export starters. This productivity gain expands up to 39.6% in the fourth year and declines thereafter. Similarly, our findings show that a 10% increase in export participation among large export starters leads to 31.7% gain in labor productivity, significant at 1% level, than never export starters that are large. This labor productivity gain increases up to year two and declines in subsequent years.

The productivity gains of entrants could be a true reflection of LBE effects or a better utilization of existing inputs in response to the demand shock that firms might face. It could also be the result of self-selection of more productivity firms into the export market so that their productivity still continues to bear effect once they start exporting. Damijan and Kostevc (2006) find that entry into international markets leads to increased demand requiring firms to adjust inputs to cope with the surge in demand arising from entry into an additional market. If this is the case, LBE effects should dissipate immediately after entry since productivity gains are only transitory. This study

finds that this might be the case for large exporting firms. However, for this to hold, then productivity gains should disappear immediately after the year of entry. Analyzing firms that start to export from the year of entry (Year0) helps us to assess the evolution of productivity gains through to fifth year (Year5) and eliminate the possibility of self-selection effects and helps us to identify the true LBE effects at work. These results indicate the presence of LBE effects since productivity gains stretch for at least two years for large firms and five years for small firms. Further, these findings suggest sustained LBE effects among small firms than large ones.

I posit that small firms have sustained LBE effects because they are more likely to experience hurdles in the export entry (Máñez-Castillejo et al., 2010) and could still have issues once they start to export. If this is the case, then small firms are likely to experience stimulus situations during export market participation than large firms. For large firms, learning could be necessary only during the initial years of exporting, beyond which export markets become more familiar and induce no further LBE effects. Indeed some studies show that as export markets become more familiar, LBE effects start declining until diminishing returns set in (Fernandes & Isgut, 2015). This would imply that entry into the export market induces restructuring process among new exporters as a response to the export market dynamics. The required changes could be in the form of adapting to new technologies of production, marketing strategies, new firm-level investments or innovations (product and process).

Our findings are consistent with the view that exporting begets success as shown by a number of studies. For example, De Loecker (2007) finds that firms that start to export experience high productivity gains, up to four years. Augier and DAVIS (2013) study the relationship between exports and productivity and find evidence of LBE effects in small and younger firms. Cruz et al. (2016) examines the relationship between exports and productivity and find similar results for manufacturing firms in Mozambique. Similar results are found for a sample of Spanish manufacturing firms (Manjón et al., 2013), and for Portuguese firms (Silva et al., 2013). However, the above studies did not explicitly examine the relationship between exports and productivity across firm size; which makes our findings unique and informative on this relationship.

The unique message in this paper is that exports are important for productivity improvement among new exporters. The effect of exports is more pronounced among large entrants than small ones, but it is the small new exporters who have sustained productivity gain, stretching to five years. This study shows that, for new exporters that are large, learning may only be important during the early stages of internationalization on account of important structural adjustments associated with export market entry and participation.

4.2. The relationship between exports and productivity growth

This section examines the relationship between exports and productivity growth in manufacturing firms from Sub-Saharan Africa. In particular, I compare the productivity growth of entrants and matched non-exporters for five years. Panels (a) and (b) are labeled as before. Table 4 presents the results of the analysis and comparisons, both for small and large firms. Regardless of the matching procedure used, new exporters realize immediate productivity growth upon entry. Both small and large firms experience immediate and significant productivity growth in the year of entry (Year0), which varies from 4.0% to 18.9%, depending on the matching procedure. When I take a closer look at the matched results of kernel estimation, the following emerge: First, there is immediate productivity growth upon entry to the export markets, implying that exporters enjoy higher productivity growth compared to non-exporters. Productivity growth is more pronounced for new exporters that are large firms compared to those that are small. Second, the productivity growth of new exporters that are small is significant and sustained for a period of five years compared to small non-exporters. For small firms, the productivity growth upon entry is 4% and rises to 7.3%, significant at 5% level, in the fifth year. While there is significant and sustained productivity growth for small firms, large firms enter the export market with high enough productivity which is positive and statistically significant for a period of three years. After the third year, productivity growth of

large firms is still positive but statistically insignificant. To note pronounced results, this study finds that productivity growth upon entry to the export markets is positive and statistically significant at 5%. During entry, productivity growth is at 14.4%, which drops to 12.6% one year after entry, and continues to decline until it settles at 11.4%, three year after entry. However, in the fourth year, the productivity growth of large firms drops to 7.2%, declining further to 6.1% in the fifth year.

Our findings reveal significant LBE effects, which start upon entry into the export markets and lasting for five years, for small new exporters and three years for large ones. However, as noted by Pisu (2008) it would be erroneous to consider LBE in the year of entry as productivity growth cannot be attributed to LBE effects. According to the above author, LBE effects take time to be noticed, and require longitudinal data since the restructuring or reorganization processes³ that follow entry into the export markets take time to cause effect in the organization of the production process. As shown by AW et al. (2005) the productivity growth upon entry might be attributable to the scale effects induced by entry into the international markets that have the size advantage- that is, larger (Damijan & Kostevc, 2006) or ex ante productivity that induced export market entry, in the first place. Either way, new exporters are more productive than firms that decide not to enter the export markets, and experience increased productivity growth as a result of export market participation. The productivity pattern for the new exporters continues to expand which points to the LBE effects, especially among small firms.

To explain the LBE differences between small and large firms, I turn to the work of Arrow (1962) who suggests that experience breeds learning, and learning is facilitated when there is an attempt to solve a bottleneck to success. There is a possibility that our results offer a plausible explanation to the fact that small firms might find exporting a challenging activity when they start to export, hence they have to acquire the knowledge and requisite experience to succeed in the export market. Correspondingly, our results could also suggest that learning is important for large firms as well but only during the initial years of exporting, after which, the diminishing returns to exporting start to set in (Fernandes & Isgut, 2015). Moreover, these findings could also imply that small firms might be using higher quality inputs to produce products at lower per unit costs generating LBE effects in the process, as shown by Manova and Zhang (2012). Overall, our findings are consistent with Fernandes and Isgut (2005) who suggest that successful learning processes might be important during the initial years of export participation as entry exposes firms to intense competition from international market. Given that the scope of the market is now large, competitors (who may be more established exporters) are drawn to these markets to reap the benefits of scale economies. Consequently export market participation exerts pressure on the new exporters to improve the quality of their products to survive in the export market. As firms improve their learning process, the scope of continued LBE diminishes and firms have to expand their learning processes elsewhere.

4.3. Quality of the matching analysis

To check the reliability of the matching outcome I evaluate whether the matching procedure balances the relevant variables for both new exporters and matched never exporters. I use balancing tests (*p*-test) proposed by Abadie et al. (2004). I report the summary of the balancing tests for different specifications in Appendix, Tables A1 and A2. The summary results of the balancing tests show significant differences between new exporters and never exporters. Moreover, the results indicate that matching on our variables of interest reduces the mean and median bias remarkably. The absolute standardized difference in means of the propensity scores between the treated and matched untreated groups, Rubin's B is below 25 and the ratio of treated to matched untreated variances of the propensity score, the Rubin's R range between 0.5 and 2 as recommended (Rubin, 2001).

5. Conclusion

The expansive literature examining the relationship between exports and productivity growth finds remarkable results that are positive and robust to alternative specifications and measures of productivity. Findings from previous research show that exporters are generally more productive

than firms that never export, and confirm the presence of self-selection and learning-by exporting hypotheses. However, higher productivity growth for exporting firms might arise due to self-selection of more productive firms into the export markets. To examine this, research has isolated new exporters and analyzed whether they experience higher productivity growth as a result of exporting- LBE. However, previous studies have assumed that LBE is homogenous across firms, which is not necessarily the case since some studies show that the LBE effects vary according to firm age, destination market of products, firm size and ownership status of the firm.

Using a unique dataset from Sub-Saharan African countries, this study addresses the existing gaps in the literature by investigating how LBE varies across firm size. I conduct our analysis by first, assuming that firms produce using a Cobb-Douglas production technology, which I then use to derive firm productivity estimates. Second, I use propensity score matching methods to match exporters (treated) and non-exporters (control) and then test for LBE effects across firm size. There is evidence that new firms that start to export are different from non-exporters. For both TFP and labor productivity, small firms experience sustained productivity growth for a period of five years compared to the large ones whose productivity growth disappears after the third year. Moreover, for both small and large firms, productivity gains are realized immediately upon entry into the export markets. These results indicate that firm size does matter in the learning process which follows export market participation. I note that learning is crucial during the initial years of export entry, especially for small firms. For large firms, the evidence shows that learning effects disappear after two to three years of export entry.

I make an important contribution relevant for policy and the literature on LBE. First, previous research examined LBE using data from developed and developing countries with the assumption that firms are homogenous when they start to export. Our findings show clearly the heterogeneous nature of the learning mechanism across firm size. I have systematically isolated LBE effects across firm size and shown how learning is more sustained for small firms than for large ones. Second, our findings show that there is a limit to learning among large firms as these firms master the “export terrain”. However, the learning process is continuous for small firms, as these firms are more likely to experience challenges when they start to export, which induces them to make adjustments in form of adapting to new production technologies and marketing strategies) to survive in the export market. Any policy to promote exports should help small firms to access the export markets. Further, export promotion policies should provide export incentives, like tax waivers for new exporters, with special focus to small exporters to achieve productivity improvements among resource constrained exporters who start to export.

In conclusion, I show that these findings shed light on importance of learning to small firms and how LBE effects vary across firm size. These findings suggest that theories and empirical work that could shed more light on the mechanisms that drive learning processes in small firms might be promising areas for further research. One limitation of these findings is that data used for the analysis is old and might have omitted some key changes that could have taken place in manufacturing firms in the countries under consideration. This study proposes testing whether LBE effects vary among firms of different sizes using recent data.

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Notes

1. We would like than CSAE for making the data available. The cleaned dataset was downloaded from CSAE website at <https://www.csae.ox.ac.uk/data>.
2. We use entrants to mean new exporters and vice versa.
3. This may involve research and development initiatives, firm-level investments, innovations or adoption of new technologies do take time to case fundamental effect in the production process.

References

- Abadie, A., Drukker, D., Herr, J., & Imbens, G. W. (2004). "Implementing matching estimators for average treatment effects in Stata. *The Stata Journal*, 4(3), 290–311. <https://doi.org/10.1177/1536867X0400400307>
- Akerberg, D. A., Caves, K., & Frazer, G. (2006). *Structural Identification of production functions*. University of California.
- Akerberg, D. A., Caves, K., & Frazer, G. (2015). Identification properties of recent production function estimators. *Econometrica*, 83(6), 2411–2451. <https://doi.org/10.3982/ECTA13408>
- Arrow, K. J. (1962). The economic implication of learning by doing. *The Review of Economic Studies*, 29(3), 155–173. <https://doi.org/10.2307/2295952>
- Augier, P., & DAVIS, M. (2013). Does export-market participation improve productivity? *Evidence from Spanish Manufacturing Firms*, 22(7), 1059–1087. <https://doi.org/http://dx.doi.10.1080/09638199.2011.637116>
- Aw, B. Y., Roberts, M. J., & Winston, T. (2005). The complementary role of exports and R&D investments as sources of productivity growth. NBER Working Paper No.11774.
- Becker, S., & Ichino, A. (2002). Estimation of average treatment effects based on propensity scores. *The Stata Journal*, 2(4), 358–377. <https://doi.org/10.1177/1536867X0200200403>
- Bernard, A. B., & Jensen, J. B. (1999). Exceptional exporter performance: Cause, effects or both? *Journal of International Economics*, 47(1), 1–25. [https://doi.org/http://dx-doi.10.1016/S0022-1999\(98\)00027-0](https://doi.org/http://dx-doi.10.1016/S0022-1999(98)00027-0)
- Boermans, M. A. (2013). Learning-by-exporting and destination effects: Evidence from African SMEs. *Applied Econometrics and International Development*, 13(2), 155–173. Available <http://www.usc.es/economet/reviews/aeid13211.pdf>
- Clerides, S. K., Lach, S., & Tybout, J. R. (1998). Is learning by exporting important? Micro-dynamic evidence from Colombia, Mexico, and Morocco. *The Quarterly Journal of Economics*, 113(3), 903–947. <https://doi.org/10.1162/003355398555784>
- Damijan, J. P., & Kostevc, Č. (2006). Learning-by-exporting: Continuous productivity improvements or capacity utilization effects? Evidence from Slovenian firms. *Review of World Economics*, 142(3), 599–614. <https://doi.org/10.1007/s10290-006-0083-7>
- De Loecker, J. (2007). Do exports generate higher productivity? Evidence from Slovenia. *Journal of International Economics*, 73(1), 69–98. <https://doi.org/10.1016/j.jinteco.2007.03.003>
- Du, J., Lu, Y., Tao, Z., & Yu, L. (2012). Do domestic and foreign exporters differ in learning by exporting? Evidence from China. *China Economic Review*, 23(2), 296–315. <https://doi.org/10.1016/j.chieco.2011.12.003>
- Esaku, S. (2019). Export markets and firm productivity in Sub-Saharan Africa. *Journal of African Business*, 4, Dec.2019. <https://doi.org/10.1080/15228916.2019.1695190>
- Esaku, S., & Krugell, W. (2020). Firm-level investment and exporting: new empirical evidence from Ghana and Tanzania. *International Economic*, 34(1), 125–143. <https://doi.org/Journal.10.1080/10168737.2019.1663440>
- Fernandes, A. M., & Isgut, A. E. (2005). *Learning-by-doing, learning-exporting, and productivity: Evidence from Colombia* (Policy Research Working Paper no. 3544). Washington, DC: World Bank.
- Fernandes, A. M., & Isgut, A. E. (2015). Learning-by-exporting effects: Are they for real? *Emerging Markets Finance and Trade*, 51(1), 65–89. <https://doi.org/10.1080/1540496X.2015.998073>
- Girma, S., Greenaway, D., & Kneller, R. (2004). Does exporting increase productivity? A microeconomic analysis of matched firms. *Review of International Economics*, 12(5), 855–866. <https://doi.org/10.1111/j.1467-9396.2004.00486.x>
- Haidar, J. I. (2012). Trade and productivity: Self-selection or learning-by-exporting in India. *Economic Modelling*, 29(5), 1766–1773. <https://doi.org/10.1016/j.econmod.2012.05.005>
- Heckman, J. J., Ichimura, H., & Todd, P. E. (1997). Matching as an econometric evaluation estimator. Evidence from evaluating a job training programme. *Review of Economic Studies*, 64(4), 605–654. <https://doi.org/10.2307/2971733>
- Leuven, E., & Sianesi, B. (2003). PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing. <http://ideas.repec.org/c/boc/bocode/s432001.html>. version 4. 0. 1230jan2016
- Levinsohn, J., & Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *Review of Economic Studies*, 70(2), 317–342. <https://doi.org/10.1111/1467-937X.00246>
- Lileeva, A., & Trefler, D. (2010). Improved access to foreign markets raises plant-level productivity ... for some plants. *The Quarterly Journal of Economics*, 125(3), 1051–1099. <https://doi.org/10.1162/qjec.2010.125.3.1051>
- Liu, J. (2017). Do bigger and older firms learn more from exporting? Evidence from China. *China Economic Review*, 45, 89–102. <https://doi.org/10.1016/j.chieco.2017.06.005>
- Máñez-Castillejo, J. A., Rochina-Barrachina, M. E., & Sanchis-Llopis, J. A. (2010). Does firm size affect self-selection and learning-by-exporting? *The World Economy*, 33(3), 315–346. <https://doi.org/10.1111/j.1467-9701.2010.01258.x>
- Manjón, M., Máñez, J. A., Rochina-Barrachina, M. E., & Sanchis-Llopis, J. A. (2013). Reconsidering learning by exporting. *Review of World Economics*, 149(1), 5–22. <https://doi.org/10.1007/s10290-012-0140-3>
- Manova, K., & Zhang, Z. (2012). Export prices across firms and destinations. *The Quarterly Journal of Economics*, 127(1), 379–436. <https://doi.org/10.1093/qje/qjr051>
- Marschak, J., & Andrews, W. (1944). Random simultaneous equations and the theory of production. *Econometrica*, 12(3/4), 143–205. <https://doi.org/10.2307/1905432>
- Martins, P. S., & Yang, Y. (2009). The impact of exporting on firm productivity: A meta-analysis of the learning-by-exporting hypothesis. *Review of World Economics*, 145(3), 431–445. <https://doi.org/10.1007/s10290-009-0021-6>
- Melitz, M. (2003). The impact of trade on intra-industry reallocations and aggregate industry production. *Econometrica*, 71(6), 1695–1725. <https://doi.org/10.1111/1468-0262.00467>
- Olley, G. S., & Pakes, A. (1996). The dynamics of productivity in the telecommunications equipment industry". *Econometrica*, 64(6), 1263–1297. <https://doi.org/10.2307/2171831>
- Pisu, M. (2008). *Export destinations and learning-by-exporting: Evidence from Belgium*. National Bank of Belgium working paper no.140, SSRN. <http://ssrn.com/abstract=1685184>.

Rankin, N., Söderbom, M., & Teal, F. (2006). Exporting from manufacturing firms in Sub-Saharan Africa. *Journal of African Economies*, 15(4), 671–687. <https://doi.org/10.1093/jae/ejk014>

Rubin, D. B. (2001). Using propensity scores to help design observational studies: Application to the tobacco litigation. *Health Services and Outcomes Research Methodology*, 2(3/4), 169–188. <https://doi.org/10.1023/A:1020363010465>

Silva, A., Afonso, O., & Africano, A. P. (2013). Which manufacturing firms learn by exporting? *The Journal of International Trade & Economic Development*, 21(6), 773–805. <https://doi.org/10.1080/09638199.2010.534811>

Van Biesebroock, J. (2005). Exporting raises productivity in sub-Saharan African manufacturing firms. *Journal of International Economics*, 67(2), 373–391. <https://doi.org/10.1016/j.jinteco.2004.12.002>

Appendix A3. Estimation of total factor productivity (TFP) using Akerberg et al. (2006, 2015) method.

Assuming a Cobb-Douglas production technology:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \varepsilon_{it} \tag{A3.1}$$

Where y_{it} represents the output of firm i at period t , k_{it} is capital, l_{it} is the labor units, m_{it} is intermediate materials, ω_{it} is the productivity that is observable to the firm at the beginning of period t but unobservable to the econometrician and ε_{it} is the error term.

First, using LP method to derive the demand for intermediate materials, one can write the demand for materials as:

$$m_{it} = m_t(k_{it}, l_{it}, \omega_{it}) \tag{A3.2}$$

And assuming the demand of intermediate materials is monotonic in productivity, it can be inverted to get an inverse demand function for materials as follows:

$$\omega_{it} = h_t^{-1}(k_{it}, l_{it}, m_{it}) \tag{A3.3}$$

Where h_t^{-1} is a function of $k_{it}l_{it}m_{it}$ which is unknown and will be proxied by third degree polynomials in their respective arguments. Therefore, substituting Equation (A3.3) into the production function in Equation (A3.1) to obtain:

Table A1. The effect of exporting on productivity growth: Summary of results of the matching								
	R2	LR	P-value	Mean Bias	Median Bias	Rubin's B	Robin's R	% Variance
Small firms (<250 workers)								
Year0	0.000	0.04	0.982	1.4	1.4	2.1	1.08	0
Year1	0.000	0.00	0.999	0.2	0.2	0.4	1.06	0
Year2	0.002	1.08	0.582	7.1	7.1	11.3	0.87	0
Year3	0.001	0.44	0.801	4.8	4.8	8.7	0.86	0
Year4	0.004	0.85	0.654	7.4	7.4	14.8	1.28	0
Year5	0.001	0.09	0.957	3.0	3.0	5.5	0.85	0
Large firms (>250 workers)								
Year0	0.000	0.00	1.00	0.0	0.0	0.1	1.00	0
Year1	0.003	0.34	0.843	7.7	7.7	12.3	1.01	0
Year2	0.004	0.54	0.762	10.6	10.6	15.4	0.86	0
Year3	0.011	0.82	0.663	17.1	17.1	23.9	0.75	0
Year4	0.000	0.00	0.999	0.5	0.5	1.4	1.06	0
Year5	0.000	0.00	1.00	0.3	0.3	0.7	0.99	0

Note: This is the balancing summary statistics of the matching based on *pstest.ado* in Stata. Rubin's B is recommended to be below 25 while Rubin's R should fall between 0.5 and 2 for the samples to be regarded as sufficiently balanced. As we can see, all these fall within the recommended figures.

Table A2. The effect of exporting on productivity growth: Summary of results of the matching

	R2	LR	P-value	Mean Bias	Median Bias	Rubin's B	Robin's R	% Variance
Small firms (<250 workers)								
Year0	0.007	0.26	0.968	9.3	8.7	19.2	1.17	0
Year1	0.006	0.49	0.921	8.9	5.6	17.6	1.31	0
Year2	0.010	0.80	0.849	11.1	9.6	23.2	1.81	50
Year3	0.010	0.82	0.664	14.7	14.7	23.4	0.57	0
Year4	0.005	0.40	0.940	6.4	7.6	16.9	1.44	50
Year5	0.000	0.00	1.000	0.0	0.0	0.0	1.00	0
Large firms (>250 workers)								
Year0	0.001	0.22	0.896	4.1	4.1	7.9	1.14	0
Year1	0.001	0.25	0.881	3.8	3.8	6.0	0.97	0
Year2	0.001	0.48	0.786	6.0	6.0	8.9	0.69	0
Year3	0.005	1.16	0.561	9.4	9.4	15.8	0.78	0
Year4	0.000	0.00	1.000	0.0	0.0	0.0	0.94	0
Year5	0.001	0.07	0.964	2.7	2.7	5.2	0.69	0

Note: This is the balancing summary statistics of the matching based on *pstest.ado* in Stata. Rubin's B is recommended to be below 25 while Rubin's R should fall between 0.5 and 2 for the samples to be regarded as sufficiently balanced. As we can see, all these fall within the recommended figures.

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + h_t^{-1}(k_{it}, l_{it}, m_{it}) + \varepsilon_{it} = \hat{\phi}_t(k_{it}, l_{it}, m_{it}) + \varepsilon_{it} \tag{A3.4}$$

As shown by Akerberg et al. (2015), treating h_t^{-1} nonparametrically implies that β_k, β_l and β_m are not identified and are subsumed into $\hat{\phi}_t(k_{it}, l_{it}, m_{it}) = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \omega_{it}$ thereby giving the first stage moment condition as follows:

$$E[\varepsilon_{it} | I_{it}] = E[y_{it} - \hat{\phi}_t(m_{it}, l_{it}, k_{it}) | I_{it}] = 0 \tag{A3.5}$$

Akerberg et al. (2015) propose estimation of β_l together with other production function parameters in stage two of the estimation using the second stage conditional moment given as:

$$\begin{aligned} E[\zeta_{it} + \varepsilon_{it} | I_{it-1}] \\ = E[y_{it} - \beta_0 - \beta_k k_{it} - \beta_l l_{it} \\ - g(\hat{\phi}_{t-1}(m_{it-1}, l_{it-1}, k_{it-1}) - \beta_0 - \beta_k k_{it-1} - \beta_l l_{it-1}) | I_{it}] \\ = 0 \end{aligned} \tag{A3.6}$$

Where I_{it-1} is the firm's information at period t-1 and with $\hat{\phi}_{t-1}$ replaced by its estimate from stage one. In the first stage, ACF (2015) present trial values of parameters β_l and β_k by first constructing an estimate for $\beta_0 + \omega_{it}$ as follows:

$$\beta_0 + \hat{\omega}_{it}(\beta_l, \beta_k) = \hat{\phi}_t(m_{it}, l_{it}, k_{it}) - \beta_l l_{it} - \beta_k k_{it} \tag{A3.7}$$

Where $\hat{\phi}_t(m_{it}, l_{it}, k_{it})$ is derived in the first stage. Then in the second stage, ACF (2015) estimate the AR (1) process by regressing $\beta_0 + \hat{\omega}_{it}(\beta_l, \beta_k)$ on its lagged variable $\beta_0 + \hat{\omega}_{it-1}(\beta_l, \beta_k)$ to get the regression residuals $\hat{\omega}_{it}(\beta_l, \beta_k)$. Then as a final stage, ACF (2015) estimate β_l and β_k applying the following concentrated moment condition:

$$E \left[\hat{\zeta}_{it}(\beta_l, \beta_k) X \begin{pmatrix} l_{it-1} \\ k_{it-1} \end{pmatrix} \right] = 0 \tag{A3.8}$$

I rely on ACF (2015) procedure and use the Stata command *prodest* to estimate a Cobb-Douglas production function of the form:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \varepsilon_{it} \quad (\text{A3.9})$$

Where all variables are in logs; y_{it} denotes the value added, l_{it} is the labor input, m_{it} is the materials, and k_{it} is the capital input, ω_{it} represents the productivity shock that impacts the firm's input decisions, and ε_{it} denotes the error term.

Consequently, Equation (A3.9) gives a valid process of estimating TFP, where the residual is the TFP of the firm retrieved from the coefficients. Thus:

$$TFP_{it} = y_{it} - \tilde{\beta}_k k_{it} - \tilde{\beta}_l l_{it} - \tilde{\beta}_m m_{it} \quad (\text{A3.10})$$



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