DBA Africa Management Review
2012, Vol 3 No 1 pp. 50-72

# Determinants Of Manufactured Exports In Kenya: An Application Of Control Function Approach

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**This paper uses firm level survey panel data to estimate parameters of export propensity and intensity in Kenyan manufacturing. The effects of unobservable factors that would otherwise bias the estimated parameters are removed using a control function regression procedure. The key finding of the study is that export propensity and intensity are strongly responsive to total factor productivity. In particularly a 10% increase in total factor productivity increases export propensity by 54%, but export intensity rises less steeply by 18%. We also find that ownership structure of the firm and unobserved factors specific to firms strongly influence exports. Taken together, the estimation results provide insights into the policies needed to promote entry and stay of firms in export markets. The findings suggest that policy measures to improve export performance of Kenyan firms should focus on improving total factor productivity, encouraging foreign direct investment and stimulating modernization of manufacturing capital.**

**Keywords**: Exports, manufacturing firms, total factor productivity, control function approach, Kenya.

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## Introduction

The export-led growth hypothesis postulates that exports growth leads to economic growth (World Bank, 1993). Total factor productivity is the main channel through which countries increase their export earnings. Since growth performance in most developing countries is constrained by shortage of foreign exchange, economies of these countries can grow faster with more exports. This paper assesses the role of enhanced total factor productivity in increasing manufactured exports in Kenya. Despite numerous studies around the world (see below), controversy rages as to the effect total factor productivity on a firm's ability to export. Knowledge of what determines export propensity and intensity is crucial in designing policies that can promote manufactured exports in a country. Application of the control function approach on panel data from manufacturing firms reveals that when effects of unobservable factors are controlled for, improvement in total factor productivity is positively and strongly associated with export propensity and intensity

Beyond demonstrating the strong relationship between total factor productivity and manufactured exports, the paper makes an important contribution to the applied econometrics literature. As far as we know, this is the first time that export propensity and intensity functions are estimated while simultaneously addressing the commonly encountered econometric problems of endogeneity, heterogeneity and sample selectivity in Kenya. Section 2 reviews the relevant literature on export propensity and intensity. Sections 3 and 4 respectively present and discuss data and empirical results, and Section 5 concludes the paper.

## Related Literature

The literature on firm exports is enormous, but very few of these studies relate to sub-Saharan Africa. Bernard and Jensen (1997) argued that exporters are better than non-exporters on a large range of performance indicators which include being larger in size, being more productive and more capital intensive, being more technology-intensive and being able to pay higher wages. A large and growing body of empirical work has documented the superior characteristics of exporting firms relative to those producing purely for the domestic market (e.g. Bernard and Jensen (1995, 1997), Bernard and Wagner (1997), Bernard *et al* (2000), Aw and Hwang (1995), Clerides *et al* (1998), Kraay (1999), Aw *et al* (2000), Bigsten *et al* (2002b), Van Biesebroeck (2005), among others). However Fernandes and Isgut (2005) argue that these desired characteristics of exporters might be a cause rather than a consequence of firms' participation in the export market. Exporters may be exceptional because good firms become exporters or because exporting is good for firms or both. Therefore disentangling these effects becomes crucial for understanding firm level responses to aggregate shocks and for designing appropriate policy.

For low-income countries, the important policy issue is not to understand the role of trade in the performance of an economy but to understand what factors motivate firms to become exporters in the first place. Bernard and Jensen (1997) argue that if firms increase innovative and productive activity in order to enter foreign markets, that is, they become good at exporting, policy should reward exporting ex-post since this could increase such activity and increase economic growth.

The main conclusion of the Bernard and Jensen (1997) study is that firms that become exporters are successful before they start exporting. Their analysis shows that several years prior to entry into the foreign market, exporters are larger, more productive and pay higher wages. These firms have also been shown to grow faster in the years leading up to exporting. Their results confirm that firm success leads to exporting leaving little doubt that good firms become exporters. Bernard and Jensen (2001) present a dynamic model of export-decision by a profit-maximizing firm using a sample of US manufacturing firms and conclude that firm heterogeneity is substantial and important in export decisions. Their results suggest that firms of different sizes, located in different regimes producing different product mixes are likely to make different decisions with respect, to entering the export market. This result also concurs with Bigsten *et al* (2000a), Soderbom (2001, 2004).

Exporters can also improve their productivity after entering foreign markets via learning-by-doing. This view is however disputed by some studies like Bernard and Jensen (1997) among others. This is because the international markets are more likely to acquire and transfer new technology. The broader international market could also enable them to exploit economies of scale. According to Bigsten *et al* (2008), the two hypotheses are by no means mutually exclusive; they argue that highly productive firms that can afford the sunk cost of entry into the export markets may improve their productivity as a result of their exposure to export markets which is a tougher screen; a view also shared by Fernandes and Isgut (2005).

Interest in testing the causality relation between productivity and export activity has been growing following the influential studies by Bernard and Jensen (1995, 1997 and 1999b) and Clerides *et al* (1998). Most of the evidence supports self-selection hypothesis but not learning-by-exporting (for example, Bernard and Jensen, 1999a for USA; Clerides *et al*, 1998 for Colombia, Mexico and Morocco; Aw *et al*, 2000 for Taiwan). However, there is evidence of both self-selection and learning-by-exporting (Hahn, 2004 for Korea; Fernandes and Isgut, 2005 for Colombia; Kraay, 1999 for China; Girma *et al*, 2005 for the U.K., Bigsten *et al*, 2002b and Van Biesebroeck, 2005 for sub-Saharan Africa).

There is little empirical evidence for Africa mainly because of the absence of longer panel data. Bigsten *et al* (2004) and Biesebroeck (2005) use the same data source, firms' surveys conducted by Regional Programme for Enterprise Development (RPED) of the World Bank in the 1990's, but differ in the number of countries included; 4 and 7 respectively. They found evidence for self-selection and learning-by-exporting. However, the two studies analyze a very short panel data of 3 years. Longer panel could potentially provide stronger basis for testing the competing hypotheses.

A large number of studies including Bernard and Jensen (1995, 1997), Bernard and Wagner (1998), Aw and Hwang (1995), Das *et al* (2001), Clerides, Lach and Tybout (1998), Aw, Chung and Roberts (2000), Bigsten *et al* (2000a, 2002b), Fafchamps *et al* (2002), Rankin *et al* (2005), Rankin (2001), Shiferaw (2007), Biggs and Raturi (1999), Teal (1999) among others, have come to the conclusion that sunk costs along with a range of firm characteristics such as size, labor composition, productivity, product mix, ownership structures among other factors, are key to the decision of firms to enter the export market . Das *et al* (2001), for example conclude that sunk costs and cross-firm heterogeneity significantly affect export dynamics. They develop a dynamic structural model that characterizes firm decisions concerning whether to export and the volume of foreign sales among those firms who do export.

One of the possible explanations for such divergent results is the use of binary variable to measure export behavior in the first case and censored variable to measure export intensity (share of export sales in total sales) in the second case. The interpretation of the dependent variables and the obtained results differ as follows: just entering the export market (described by binary 0-1 variables) is not likely to have a high impact on productivity changes, thus suggesting no learning-by-exporting effects. At the same time, maintaining a high intensity of exports (measured as a ratio – using a censored variable), presumably above some threshold level, would positively affect productivity changes.

The literature indicates that a complex set of factors determine export activity by firms both in developed and developing countries. There is general agreement as documented by a number of studies that exporters and non-exporters are different in terms of performance indicators, with exporters being larger in size, more capital intensive, paying higher wages and being more productive than non-exporters (Bernard and Jensen, 1997; Clerides *et al*, 1998 and Aw *et al*, 2000 among others). It is however still controversial as to the direction of causality in this relationship, i.e. do good firms (high productivity firms) become exporters or do exporters become good firms. This translates into two competing hypotheses with regard to the causal relationship between exporting and

productivity as explained above, i.e., self-selection versus learning-by-exporting. These two hypotheses would lead to different policy prescriptions as argued by various authors cited above.

Though there is as yet no general consensus on the direction of causation between exports and firm productivity, Bigsten *et al* (2008) suggest that it may well be that the direction of causality between productivity and export activity may vary by the economic environment of the firm. They argue that one may presume that the exposure to international export markets has less of an effect in a highly industrialized country where we would expect the difference between exporting and non-exporting firms to be small. On the contrary they argue that in the case of African economies like Kenya, causality may flow both from productivity to exporting as well as from exporting experience to improvements in performance.

**Data**

We use data from Kenyan manufacturing sector from three related sources, namely, firm-level panel data obtained from RPED surveys conducted by the World Bank and the Economics Departments of both the University of Nairobi (Kenya) and the University of Gothenburg (Sweden) in 1993, 1994 and 1995. The other subset of data comes from the Kenya Manufacturing Enterprise Survey (KMES) fielded in October-November 2000 by UNIDO and Centre for The Study of African Economies, which was a follow-up to the last Kenyan RPED survey conducted in 1995. The last subset of the Kenyan manufacturing data comes from the 2002/2003 firm survey conducted through the partnership between the Kenya Institute of Public Policy Research and Analysis (KIPPRA) and the World Bank.

These surveys used more or less the same survey instrument and to the extent possible covered virtually the same firms. The unit of observation is the firm and focused on firms in four main Kenyan cities, namely, Nairobi, Mombasa, Nakuru and Eldoret, and were restricted to four main subsectors, namely, food, textiles and garments, woodworking and metalworking firms. These subsectors accounted for about 73% of manufacturing firms at the time and were considered by the RPED survey to represent a fairly comprehensive picture of the manufacturing sector in Kenya. The data are from stratified random samples considered to be more efficient than simple random sampling since firms within each stratum are relatively homogenous with respect to the measurements of interest while firms between strata are relatively heterogeneous. The surveys collected information on firm sizes, firm age, firm ownership, replacement value of capital, firm location, firm industry sector, firm's wage bill, firm exports participation, and quantity of exports among other variables. The summary statistics of the merged datasets (1993-2002) are reported in appendix 1 which

includes generated variables used in this paper.

A total of 2343 observations were made by all the surveys (1993-2003) with different number of firms in each survey wave. The data for 1996, 1997, 1998 and 1999 are based on responses to the KMES (2000) survey which requested respondents to give information for the period 1996-1999, while the data for 2001 and 2002 are responses from the KIPPRA/RPED 2003 survey which similarly sought information for the years 2001 and 2002.

The proportions of the firms which participated in any exporting varied between 21% of all firms to 47%. The average export participation rate for the full sample was about 25% of all firms. These figures are at variance with other studies (Soderbom 2001b) which put the average export participation of Kenyan firms at between 46% and 52%. The percentage of any foreign ownership of Kenyan firms is very consistent and stable in all years with the proportion for most years being 18%. Export intensity varied from 9% (percentage of total output/sales exported in 1993 to a high of 52% for the 2002 sample). The mean export intensity is reported to be 18%, meaning that on average Kenyan firms exported 18% of their total output value.

Small firms (1-10 workers) are the least likely to export. Their mean export propensity is only 5% and they exported about 4% of their output. This conforms to the findings of numerous studies on African manufactured exports, such as Bigsten *et al* (1999a, 2001) and Söderbom *et al* (2001). Medium-sized firms (11-99 workers) have a mean export propensity of about 32% and an export intensity of 19%. Large firms (100-500 workers) are more likely to enter the export market as they have a mean export propensity of 56%. The export intensity of these firms is correspondingly high at about 25%. The mega firms, (more than 500 workers) have a high export propensity of about 55% with an export intensity of about 35%. It should however be noted that these firms are relatively few; there are only 121 mega firms in the sample compared to 650 small firms, 808 medium-sized firms and 384 large firms.

**Theory and empirical model**

Numerous papers on the decision to export by firms both in developed and developing countries, for example, Bernard and Jensen (1995, 1999, 2001), Bigsten *et al* (2001, 2002b), Bernard and Wagner (1997), Clerides *et al (1998)* among others, model export decision as a function of firm level variables such as sunk entry costs, location, firm ownership structure, government interventions among others. Theoretically, the decision to enter the export market (export-propensity) is usually determined by employment (size), productivity (total factor productivity), average wage, sales, firm ownership structure, the proportion of production to non-production workers, capital intensity, firm age, past success of the firm, sunk costs usually proxied by lagged export status, industry and

location dummies among other variables.

A finding across virtually all micro-level studies is that exporting and productivity are positively correlated. Most of the work focuses on how this correlation can be interpreted. Studies on most non-African countries have found more evidence that causation runs from exporting to productivity, that would imply learning from exporting, these studies include Bernard and Jensen (1995, 1999a, b) for the USA, Tybout and Westbrook (1995) on Mexico, Clerides *et al* (1998) on Mexico, Colombia and Morocco, Kraay (1999) on China, Aw *et al* (2000) on South Korea and Taiwan, Isgut (2001) on Colombia and Fafchamps *et al* (2002) on Morocco, among others. The case of sub-Saharan Africa presented in Bigsten *et al* (2004, 2008) show little evidence of self-selection into exporting. Indeed they argue that both effects seem present and that the learning from exporting may be important due to the nature of these economies. However, they note that their finding may be due to colinearity between some of the regressors in their export probit. The panel they use is also short, three years, and so it may be difficult to convincingly assess the importance of productivity as a determinant of exporting while allowing for firm heterogeneity and the presence of sunk costs with a dynamic setting.

Much of the literature has tended to focus on distinguishing learning from exporting and self-selection into exporting, but a common finding across all the work on African data sets has been a strong correlation between firm size and exporting (see for example Söderbom and Teal, 2000, 2003; Bigsten *et al*, 2004; Van Biesebroeck, 2005 and Rankin, 2001). Bigsten *et al* (2002b) find that firm size is a robust determinant of export participation across specifications which allow for certain forms of firm heterogeneity and dynamics. One interpretation of the size effect is that size is really a disguised element of productivity in that larger firms benefit from increasing returns to scale. Another interpretation of the size effect is that it can be explained by the presence of fixed costs. This latter interpretation may however be hard to reconcile with the robust significance of the size variable when there are controls for sunk costs in the form of lagged dependent variable as in Bigsten *et al* (2002b). Size may also be capturing sectoral differences in technology as size remains highly significant with sectoral controls in the Bigsten (2004) equation.

Other factors affecting firm participation in exporting include productivity (total factor productivity). It is expected that firms with higher productivity tend to self-select into the export market as is documented in numerous studies cited earlier.

Another externality may come about if the presence of other exporters lowers the cost of production possibly by increasing the availability of specialized capital and labor inputs. These spillovers can be location or industry specific. These are exogenous variables since in

general they are exogenously determined. They are measured in our case by industry and location dummies. We use the panel dimension of the data to assess in particular the potential importance of firm level heterogeneity in determining export participation among firms. Moreover, we can determine which factors are of importance in understanding how time-invariant factors such as ownership, industry and location may impact on export performance.

**4.1 The model**

A Heckman selection model is applied to investigate exporting behavior of Kenyan manufacturing firms.

Another aspect of export activity is the export intensity, the ratio of exports volume to the total volume of sales. In modeling export intensity it should be recognized that the factors that determine pre-selection of the firms into the export market might be different from those that affect the share of exports in total sales. Using the Heckman two-step model (Heckman 1979), export propensity and intensity functions can be can be written as:

$$Exportpropensity = \gamma + \delta_1 z + \delta_2 X + \mu \qquad \mu \sim N(0,1)$$

$$ExportIntensity = \alpha + \beta_1 \hat{E} + \beta_2 X + \varepsilon \qquad \varepsilon \sim N(0,\sigma)$$

.....(1)

Where

$z$ are the exclusion restrictions

$\hat{E}$ is the Inverse of Mills ratio

$\gamma$, $\delta_1, \delta_2$, $\beta_1$ and $\beta_2$ are parameters to be estimated

$X$ are exogenous covariates, including control-function regressors

$\mu$ and $\varepsilon$ are disturbance terms, for export propensity and export intensity equations, respectively.

The export intensity is observed conditional on a firm entering an export market. The estimated specification are shown in equations (2) and (3).

$$Export\ propensity = f\left(\begin{array}{l} total\ factor\ productivity, replacement\ value\ of\ capital, foreign\ ownership, firmage, firmage^2, \\ deviation\ from\ the\ mean\ of\ replacement\ value\ of\ capital, sectordummies, locationdummies..... \end{array}\right) ...(2)$$

$$Export\ Intensity = f(Total\ factor\ productivity, foreign\ ownership, Inverse\ Mills\ Ratio, sectordummies, location\ dummies, firmage, firmage^2)$$

...(3)

Estimation of the export intensity function (equation 3), without the export propensity function equation (2), could lead to a sample selection bias since only a subset of firms do in fact export. The replacement value of capital and the deviation from the mean of replacement value of capital in equation (2) are the exclusion restrictions that are imposed to identify parameters of equation (3).

**4.2 Estimation issues**

In estimating the propensity of a firm entering the export market and the intensity of the firm's export given that it has entered the foreign market, it is important to note a number of econometric issues that arise. The main issue is that it is difficult to find variables that determine the export propensity but theoretically do not exert

an independent influence on export intensity. The second issue is the endogeneity of total factor productivity in the two export equations. The third problem is the heterogeneity of export propensity and intensity. A control function approach is used to model unobserved factors in the error terms of the export equations permitting unbiased estimations of the relevant parameters (see Heckman (1976, 1979; Xuepeng Liu *et al*, forthcoming; Garen, 1984; Wooldridge, 1997; Card, 2001; Söderbom *et al*, 2006.

**Results and Discussion**

The estimation results improve progressively as the various estimation problems are addressed using OLS/LPM, IV-2SLS and the control function approach respectively.

**Export propensity**

The results from the linear probability model (LPM) are reported in column 1 of appendix 2. Total factor productivity has a positive and statistically significant effect on export propensity. Firms with foreign participation are more likely to enter the export market than those that are fully locally owned. The replacement value of capital, the proxy for capital stock of the firm has a small positive but highly statistically significant effect on the firm's propensity to export. On the other hand, the deviation from the mean of capital enters the propensity equation with a negative sign and its coefficient is highly statistically significant. This implies that firms with below average capital investments tend to reduce their export propensity while those with above average capital investment increase their export propensity.

Our results in appendix 2 below indicate quite strongly that firms that have a high probability of entering the export market have more workers, employ proportionally more non-production workers (skilled workers), have higher productivity, tend to have greater amounts of capital and more likely to be partly foreign owned. These findings support the conclusions of earlier studies with regard to firms' export propensity in both developed and developing countries. For example, our findings corroborate those of Bernard and Jensen (1995, 1997, 2001) for U.S. firms, Aw and Hwang (1995), Clerides *et al* (1998) for Colombian and Moroccan firms, Bigsten *et al* (2000a, 2002b, 2008) for African firms, Söderbom (2004), Teal (1999) and Fafchamps (2002) for Moroccan firms.

Appendix 3 reports a random effects probit regression estimates for propensity to export, with controls for endogeneity and heterogeneity. Total factor productivity has a sizeable coefficient and is statistically significant at the 1% level. Similarly, foreign ownership bears a positive coefficient which is also highly significant. The firms' capital investments and firm age are also highly significant determinants of export propensity.

However, in an OLS regression total factor productivity is potentially endogenous since unobserved characteristics such as product attributes

or managerial ability which affect the decision to export by the firm are omitted. Since these characteristics are potentially permanent or at least highly serially correlated and unobserved they might bias our results. It means that our error term could be thought of as comprising two components, a permanent firm-specific element, and a transitory component. This implies that this dynamic binary choice model with endogenous and heterogeneity features is best estimated using probit with random or fixed effects. The random effects models require that the unobserved firm attributes be uncorrelated with the regressors. It is also known (Wooldridge, 1997) that most fixed effects models tend to produce biased and inconsistent parameter estimates, particularly for the coefficient on the lagged dependent variables such as our proxy for sunk costs. The required assumption for random effects will be quite likely violated in our export propensity model since firm characteristics such as size and ownership structure are likely correlated with managerial ability, technology and other unobserved firm level effects. Thus random effects estimation strategy only partially solves the problem of unobserved heterogeneity.

These concerns imply that we are facing the problems of endogeneity as well as heterogeneity which we must control for if our estimates are to be reliable and consistent. For example, firm size is correlated to worker skills. We also note that firms with otherwise similar characteristics may react differently in certain situations. We need to control for unobserved heterogeneity due to possible omitted variables such as managerial ability and product attributes, which affect the propensity to export. We therefore estimated an export propensity model using two stage least square method in which total factor productivity is instrumented with worker's education. The reason is that total factor productivity is a proxy for firm size and large firms employ skilled workers who would not directly influence export propensity. Firms employ workers whom it uses to produce output. It is only after output has been produced that a firm decides whether or not to enter export markets. It is the management which makes this decision. Since there is a strong correlation between total factor productivity and education of workers, but workers' education does not affect the decision to export, education can be considered a good instrument for total factor productivity. Workers' education is a significant determinant of total factor productivity. The coefficient on workers' education in the productivity equation is statistically significant (*t*-value=2.63) (not reported). Since we have only one endogenous regressor and one instrument, our estimating equation is exactly identified, so that the issue of over-identification does not arise.

Appendix 2 indicates the improvement in our estimates as we move from the OLS estimates which are biased due to the existence of endogeneity of total

factor productivity to export propensity and due to heterogeneity of firms. Column 2 of appendix 2 shows that the coefficient of tfp increases from 0.0190 to 0.4623 when endogeneity is controlled for using workers' education as an instrumental variable. This is a huge change (0.3433) or an increase in the coefficient by a factor of 24 (=0.4623/0.0190). This means that the OLS underestimates this coefficient due to endogeneity of tfp in the export propensity function. Column 4 of appendix 2 reports the probit marginal effects, where we control for both endogeneity and firm unobserved heterogeneity, by which we mean that there are some unobserved factors like managerial ability or product attributes which could make firms which otherwise face the same environment to behave differently. The marginal effect for total factor productivity is 0.1761. Thus a 10% increase in total factor productivity would lead to the probability of exporting increasing by around 18%.

The probit estimates in column 5 of appendix 2 measures the impact of various variables on the probit index. The probit index measures the perceived profits from exporting (the perceived benefit of exporting or entering the export market). The coefficient on total factor productivity in that column is 1.088. In column 6 of appendix 2 we take into account firm fixed effects, and the coefficient on total factor productivity rises to 4.3979 and is statistically significant. This probit random effects regression is the preferred specification because apart from controlling for endogeneity and heterogeneity, it also controls for firm-specific fixed effects. It shows that heterogeneity was indeed present as is indicated by the significant coefficient on the interaction term between total factor productivity and its fitted residual.

Using the two-step control function approach we estimated the model for export propensity controlling for both endogeneity and firm heterogeneity. We note that failure to control for unobserved heterogeneity results in an overstatement of the effects of total factor productivity on export propensity. For example, all location dummies have positive and insignificant coefficients, while the sectoral dummies show positive and insignificant coefficients, except for the metalworking sector. However, in appendix 2 column3, when heterogeneity is controlled for, all the sectoral dummies have positive coefficient and are statistically significant. The location dummies have positive coefficients which are however not statistically significant.

Appendix 2 column 5 gives the results of the probit model using the control function approach. The results confirm that a firm's total factor productivity, foreign ownership and replacement value of capital are strong determinants of export propensity. The coefficients of these variables are positive and statistically significant, mostly at the 1% level.

To take into account the panel data dimension of our sample, we estimated a random-effects probit for the export propensity equation. Column 6 of appendix 2 shows the random effects probit estimation results. From this table we note that total factor productivity has a large and statistically significant coefficient. The sectoral results show that all sectors have positive coefficients and the coefficient on metalworking is large and statistically significant, suggesting that firms in this sector have high export propensities relative to those in the food sector. It is also notable that the textile sector has a large coefficient (1.7) and is statistically significant at the 5% level (z = 1.93). This indicates that the sector is relatively export oriented, which probably reflects the effect of African Growth and Opportunity Act, a facility which has had a major impact on this sector as documented in other export studies (see for example Söderbom, 2001a).

From our results we note that firm level variables enter significantly into the export propensity equation and confirm the hypothesis about the role of firm characteristics in the export participation of firms. In particular, large firms, with higher total factor productivity and some measure of foreign ownership have a higher probability of exporting compared to small firms. Our control function estimates confirm that increases in total factor productivity will significantly raise export propensity nonlinearly. The results further confirm that firm heterogeneity is substantial and important in the decision to enter the export market. The role of firm heterogeneity is less surprising but means that only a subset of Kenyan manufacturing firms may have the characteristics necessary to become exporters. The results are also less clear as to the role of location and industry type in export activity of firms. There seems to be no major role in export promotion for geographical location of firms; similarly, there is weak evidence as to the importance of a firm belonging to a particular industry in so far as its likelihood to participate in export market is concerned.

**Export intensity**

Appendix 4 reports various estimates of the export intensity function. The first column reports the results for the ordinary least squares (OLS) with no controls for endogeneity, heterogeneity or sample selection bias. The coefficient on total factor productivity is 0.0281 and is statistically significant at the 1% level with a *t*-value = 4.07. The coefficient hardly changes with controls for endogeneity and heterogeneity (see columns 2 and 3 of appendix 4). However, when we control for sample selection bias using the inverse of Mills ratio (calculated as probability density divided by cumulative density), the change in the coefficient is dramatic. The coefficient increases nearly four-fold from 0.0281 with no controls to 0.1032 when we account for endogeneity, heterogeneity and sample selection bias. The inverse of Mills ratio coefficient is -0.1091 and is statistically

significant with a *t*-value of -3.11. This implies that if we do not control for sample selection bias, the coefficient would be under-estimated, i.e. the impact of total factor productivity would be understated.

Column 2 of appendix 4 reports an instrumental variable two stage least squares estimation which controls for endogeneity but does not control for heterogeneity of firms nor for sample selection bias. The third column is the estimation which controls for both endogeneity and firm heterogeneity but not for sample selection bias. Our preferred specification for the export intensity function is found in column 4 since it controls for endogeneity, heterogeneity as well as sample selection bias using the Heckman two-step estimation technique and the two-step control function method. The findings in this paper corroborate those of earlier studies in both developed and developing countries. These include Bernard ad Jensen (1995, 1997, 1999, 2001), Bigsten *et al* (1999a, b, 2000, 2001a, b and 2008), Clerides *et al* (1998), Fafchamps (2002, 2004), Tybout *et al* (1995) among others.

The total factor productivity has the expected positive and statistically significant coefficient in our preferred specification indicating that total factor productivity increases export intensity of firms. The finding also supports the branch of literature that argues that firms with higher productivity self-select into the export market and once there, they export a larger proportion of their total output (Bernard and Jensen, 1995, 1999, 2001; Roberts and Tybout, 1997; Clerides *et al*, 1998; Aw and Hwang, 1995; Bigsten *et al*, 2002b; Aw *et al*, 2000, and Hahn, 2004 among others).

We note that the model we estimate is exactly identified, i.e. It has one endogenous regressor (total factor productivity) and one instrument , worker education, which is a valid instrument because its effect on the endogenous explanatory variable is statistically significant (*t*-value=2.63, not reported) (see also Shea, 1997). The strength of the instrument was tested using the F-statistic and this gave an F-statistic of 8.30 with *p*-value of 0.0041. This implies that it can be considered a slightly weak instrument. However, it is close to the cut-off point of 10 and the *p*-value suggests that our margin of error in estimating this statistic is only 0.4% (see Bound *et al*, 1995; Stock *et al*, 2002).

To take into account the panel data feature of our sample, we estimate the random-effects model using the GLS regression method. This is reported in column 6 of appendix 4. The results indicate that the total factor productivity has a significant effect on export intensity. The coefficient is 0.06 and is statistically significant at 1% level (*t*-value = 2.02). One highlight of our results is that although foreign ownership was found to be important in influencing a firm's export propensity, it has no statistically significant impact on a firm's export intensity.

The coefficient on inverse of Mills ratio is statistically significant when heterogeneity of firms is taken into account through inclusion of interaction terms of the residuals with the endogenous total factor productivity. The interaction of total factor productivity with its residual is the main source of heterogeneity in the export intensity across firms.

This suggests that firms with managers of better ability are more likely to adopt action that increase export intensity. In this estimation, the coefficient on inverse of Mills ratio is statistically significant with a negative coefficient. This means that there is evidence that the unobservable variables, like managerial abilities are associated with the selection of firms into the estimation sample and are not separable from unobservables that are correlated with export intensity. These inseparable unobservables are controlled for through the introduction of the interaction of total factor productivity with its residual in the export intensity equation

The estimated coefficients of the inverse of the Mills ratio (-0.088, column 5, table 5) is statistically significant and thus can be said to correct for the sample selection bias present in the selected sample. We note that in order to properly interpret the estimated parameters of the models in appendix 4 it is important that the sample selection rule be clarified. We have one endogenous variable (total factor productivity) but two equations to estimate; identification requires at least two exclusion restrictions, because there are two equations that need to be solved simultaneously. We need one instrument for the endogenous variable and another exogenous variable that determines selection of firms into the estimation sample. All the two instruments should be excluded from the export intensity equation. In our case, the replacement value of capital and the deviation from the mean of the replacement value of capital are the exclusion restrictions imposed when estimating the export intensity equation, thus permitting the identification of the parameters of this equation. Identification here means being able to connect a change in export intensity to a change in a particular variable, e.g. total factor productivity.

In our sample, firms self-select into the export market, and this compounds the problem of identifying the causal effect of an endogenous regressor. In this case, our variable of interest, export intensity, may or may not be observed for some of the firms. In cases where firm exports are missing for some of the firms, the selected sample is said to be censored (see Heckman, 1979).

## Conclusion

The total factor productivity has been shown to have important implications for both export propensity and export intensity of Kenyan firms.

Policy makers need to know the parameters of both export propensity and the associated export intensity to be able to predict the effects of changes in

export policy. To generate this information, we have simultaneously estimated the parameters of export propensity and export intensity while taking care of the various estimation problems of endogeneity, heterogeneity and sample selection bias of the dependent variable with some explanatory variables. This approach has led to unbiased and consistent estimates in contrast to earlier studies in which some of these problems were not taken into account. We have done this using relatively recent econometric techniques. Another strength of the paper is the use of longer panel data (1993-2003) unlike earlier studies which used much shorter panels. This has led to more robust estimates. The paper finds that the data supports the self-selection hypothesis, such that firms with higher total factor productivity tend to self-select into exporting.

The main contribution of this paper is that we use existing econometric techniques in a novel way to show how the common problems of endogeneity, heterogeneity, fixed effects and sample selection can be simultaneously dealt with when estimating export propensity and intensity models. In this regard the two-step control function approach has been used to consistently estimate structural models of export propensity and intensity with panel data.

The findings suggest that policy measures to improve export performance of Kenyan firms should focus on improving total factor productivity, and encouraging foreign direct investment ad partnerships with Kenyan firms. Stimulating and modernization of manufacturing capital should also be a major priority of Kenyan policy makers. The results also suggest that improvements in total factor productivity would lead to higher competitiveness of Kenyan manufactured goods and hence higher export propensity and intensity

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**Appendix 1: Descriptive statistics**

| Variable | Observations | Mean | Standard deviation |
|---|---|---|---|
| Total factor productivity | 2343 | 3.306066 | 2.501502 |
| Predicted total factor productivity | 889 | 2.930492 | .74946 |
| Total factor productivity residual | 889 | -3.27e-09 | 1.427382 |
| Total factor productivity interacted with its residual | 889 | 2.035128 | 3.695536 |
| Nairobi = 1 if firm located in Nairobi, 0 otherwise | 2337 | .580659 | .4935569 |
| Mombasa = 1 if firm located in Mombasa, 0 otherwise | 2337 | .2062473 | .4046967 |
| Nakuru = 1 if firm located in Nakuru, 0 otherwise | 2337 | .1026958 | .3036261 |
| Eldoret = 1 if firm located in Eldoret, 0 otherwise | 2337 | .0967052 | .2956191 |
| Food = 1 if firm is in the food industry, 0 otherwise | 2343 | .1895006 | .3919894 |
| Textile = 1 if firm is in the textile industry, 0 otherwise | 2343 | .2338882 | .4233923 |
| Wood = 1 if firm is in the wood industry, 0 otherwise | 2343 | .1895006 | .3919894 |
| Metal = 1 if firm is in the metal industry, 0 otherwise | 2343 | .2505335 | .4334128 |
| Foreign ownership (1 = foreign) | 2343 | .1754161 | .3804038 |
| Export propensity =1 if firm exports | 2343 | .2471191 | .4314287 |
| Firm age | 2343 | 21.23773 | 15.89462 |
| Square of firm age | 2328 | 708.1057 | 1139.44 |
| Replacement value of capital | 2343 | 5.84e+09 | 1.55e+11 |
| Square of replacement value of capital | 2343 | 2.40e+22 | 8.21e+23 |
| Deviation from mean of replacement value of capital | 2343 | 206.3431 | 1.55e+11 |
| Total number of workers | 2343 | 163.0352 | 291.3816 |
| Firm size - small = 1 if number of workers is between 1 and 10, 0 otherwise | 1965 | .3307888 | .4706169 |
| Firm size - medium = 1 if number of workers is between 11 and 99, 0 otherwise | 1965 | .4111959 | .4921759 |
| Firm size - large = 1 if number of workers is between 100 and 500, 0 otherwise | 1965 | .1954198 | .3966245 |
| Firm size - very large = 1 if number of workers is over 500, 0 otherwise | 1965 | .0615776 | .240448 |
| Export intensity | 1293 | .1807682 | .3389313 |
| Ratio of non-production workers in total workforce | 1334 | .5525619 | .3508445 |
| Ratio of production workers in total workforce | 868 | .6719844 | .2339086 |
| One year lagged value of export propensity | 2333 | .2460351 | .4307916 |
| Worker education | 895 | 5.743017 | 2.750004 |
| Squared value of worker education | 895 | 40.53631 | 32.9365 |
| Inverse of Mills ratio | 889 | 1.879482 | .7296908 |
| Total factor productivity residual | 889 | -3.27e-09 | 1.427382 |
| Total factor productivity interacted with total factor productivity residual | 889 | 2.035128 | 3.695536 |
| Squared value of total factor productivity | 2343 | 17.18491 | 23.34663 |
| Deviation from the mean of foreign ownership | 2343 | 8.93e-09 | .3804038 |
| Predicted total factor productivity interacted with foreign ownership | 889 | 0.0121427 | 1.186305 |
| Predicted total factor productivity interacted with the deviation of firm age from its mean | 889 | -1.594719 | 44.70145 |

**Appendix 2: Determinants of Export Propensity (*t*-statistics in parentheses)**

| Variables | Estimation methods | | | | | |
|---|---|---|---|---|---|---|
| | Ordinary least squares and two-stage least squares | | Control function approach (accounts for endogeneity and unobserved heterogeneity) | | | |
| | **OLS/LPM (without controls for endogeneity and heterogeneity) (1)** | **IV-2SLS (with controls for endogeneity only) (2)** | **LPM (with controls for unobservables) (3)** | **Probit Marginal effects (with controls for heteroscedasticity and unobservables) (4)** | **Probit Parameter Estimates (5)** | **Probit Random Effects Estimates (6)** |
| Total factor productivity (tfp) | 0.0190 **(2.46)** | 0.4623 **(2.66)** | 0.2208 **(2.79)** | 0.1761 **(2.34)** | 1.088 **(2.31)** | 4.3979 **(2.43)** |
| Mombasa | -0.0375 **(-1.37)** | 0.0280 **(0.43)** | 0.0221 **(0.79)** | -0.0017 **(-0.06)** | -0.0108 **(-0.06)** | 0.3970**(0.63)** |
| Nakuru | -0.0181**(-0.47)** | 0.0373**(0.43)** | 0.0080**(0.21)** | 0.0085**(0.22)** | 0.0513**(0.23)** | -0.0148**(-0.02)** |
| Eldoret | -0.0250**(-0.70)** | 0.1656**(1.54)** | 0.0835**(1.77)** | 0.0956**(1.38)** | 0.4712**(1.66)** | 1.4064**(1.30)** |
| Textile | 0.0082**(0.26)** | 0.1611**(1.76)** | 0.1124**(2.84)** | 0.1025**(2.05)** | 0.5389**(2.35)** | 1.7000**(1.93)** |
| Wood | -0.0471**(-1.37)** | 0.1184**(1.19)** | 0.0946**(2.21)** | 0.0772**(1.37)** | 0.4051**(1.59)** | 1.4131**(1.46)** |
| Metal | 0.0288**(0.93)** | 0.1851**(2.03)** | 0.1592**(4.05)** | 0.1634**(2.97)** | 0.8128**(3.53)** | 2.4429**(2.75)** |
| Foreign ownership (1 = foreign) | 0.1633**(5.38)** | 0.1230**(1.80)** | 0.1118**(3.81)** | 0.1143**(2.90)** | 0.5581**(3.53)** | 1.5006**(2.43)** |
| Replacement value of capital ( x $10^{-9}$) | 1.28**(12.23)** | 3.03**(3.71)** | 2.98**(6.37)** | 2.31**(5.02)** | 14.3**(5.02)** | 44.0**(3.86)** |
| Deviation from mean of replacement value ( x $10^{-9}$) | -1.20**(-11.14)** | -3.91**(-3.60)** | -2.94**(-6.14)** | -2.18**(-4.64)** | -13.5**(-4.59)** | -42.8**(-3.69)** |
| tfp residual | … | … | -0.1869(-2.33) | -0.1525(-1.97) | -0.9420(-1.95) | -4.2225(-2.29) |
| tfp × tf p residual | … | … | -0.0334(-9.10) | -0.0257(-6.05) | -0.1586(-6.61) | -2.7912(-5.20) |
| Constant | -0.1016(-2.30) | -1.952(-2.68) | -0.9936(-3.01) | … | -6.9650(-3.52) | -24.3019(-3.12) |
| LR (chi-square) | … | … | … | 275(0.000) | 275(0.000) | … |
| Pseudo R2 | … | … | … | 0.351 | 0.351 | … |
| Wald Statistic (p-value) | … | … | … | … | … | 78.78(0.000) |
| R2 | 0.209 | … | 0.303 | … | … | … |
| F - Statistic (p-value) | 23.24(0.00) | 3.59(0.00) | 31.79(0.00) | … | … | … |
| Root MSE | 0.3287 | 0.719 | 0.309 | … | … | … |
| Observations | 889 | 889 | 889 | 889 | 889 | 889 |

**Appendix 3: Random effects probit regression estimates for propensity to export with controls for endogeneity and heterogeneity, dependent variable is Export Propensity (=1 if firm exports, otherwise 0)**

| **Variables** | **Coefficient** | **z-statistic** |
|---|---|---|
| Total factor productivity (tfp) | 3.9067 | 2.16 |
| tfp residual | -3.7504 | -2.05 |
| tfp × tfp residual | -0.2670 | -4.99 |
| Mombasa | 0.3818 | 0.61 |
| Nakuru | 0.0281 | 0.03 |
| Eldoret | 1.1074 | 1.03 |
| Textile | 1.3059 | 1.49 |
| Wood | 0.8543 | 0.88 |
| Metal | 2.0023 | 2.28 |
| Foreign ownership (1 = foreign) | 1.2374 | 1.99 |
| Replacement value of capital | 4.10e-08 | 3.61 |
| Deviation from the mean of the replacement value of capital | -3.99e-08 | -3.44 |
| Firm age | 0.1520 | 2.26 |
| Firm age squared | -0.0029 | -2.34 |
| Constant | -23.3969 | 3.00 |
| Wald Chi square statistic<br>*p*-value | 76.90<br>(0.000) | |
| Observations | 882 | |

**Appendix 4: Determinants of Export intensity (*t*-statistics in parentheses)**

| | **Estimation methods** | | | | |
|---|---|---|---|---|---|
| **Variables** | **OLS (without controls for endogeneity, heterogeneity and sample selection bias)** | **IV-2SLS (with controls for endogeneity only)** | **IV-2SLS (with controls for endogeneity and heterogeneity)** | **Heckit/Control function approach (with controls for endogeneity, heterogeneity, and sample selection bias)** | **Random Effects (control function estimates)** |
| Total factor productivity | 0.0281(4.07) | 0.0207(1.07) | 0.0291(1.27) | 0.1032(3.14) | 0.0583(1.98) |
| Mombasa | 0.0665(2.31) | 0.0641(2.18) | 0.0624(2.11) | 0.0665(2.28) | 0.0540(1.30) |
| Nakuru | 0.1525(3.91) | 0.1527(3.91) | 0.1554(3.95) | 0.1609(4.14) | 0.0829(1.37) |
| Eldoret | 0.0084(0.24) | 0.0051(0.14) | 0.0093(0.25) | 0.0399(1.06) | 0.0046(0.08) |
| Textile | 0.0135(0.43) | 0.0114(0.36) | 0.0137(0.42) | 0.0184(0.57) | 0.0092(0.19) |
| Wood | -0.0867(-2.38) | -0.0879(-2.40) | -0.0883(-2.41) | -0.0627(-1.69) | -0.0478(-0.84) |
| Metal | -0.0633(-1.95) | -0.0653(-1.98) | -0.0653(-1.98) | -0.0858(-2.58) | -0.0853(-1.78) |
| Foreign ownership (1 = foreign) | 0.0143(0.470) | 0.0148(0.48) | 0.0161(0.52) | -0.0379(-1.09) | -0.0134(-0.27) |
| Firm age | 0.0010(0.38) | 0.0010(0.39) | 0.0010(0.37) | 0.0001(0.05) | 0.0007(0.20) |
| Firm age squared | -0.0000(-1.16) | -0.0000(-1.18) | -0.0000(-1.15) | -0.0000(-0.81) | -0.0000(-0.70) |
| tfp residual | … | 0.0082(0.41) | 0.0014(0.06) | -0.0932(-2.48) | -0.0465(-1.42) |
| tfp × tfp residual | … | … | 0.0026(0.69) | 0.0152(2.76) | 0.0101(2.19) |
| Inverse Mills ratio | … | … | … | -0.1091(-3.11) | -0.0877(-3.06) |
| Constant | 0.0615(1.46) | 0.0822(1.25) | 0.0573(0.76) | -0.0029(-0.04) | 0.0963(1.29) |
| R2 | 0.1290 | 0.1294 | 0.1305 | 0.1530 | 0.1391 |
| Adjusted R2 | 0.1053 | 0.1033 | 0.1020 | 0.1228 | … |
| F – Statistic (p-value) | 5.44(0.000) | 4.95(0.000) | 4.57(0.000) | 5.06(0.000) | … |
| Censored Observations | 378 | 378 | 378 | 378 | 378 |
| Uncensored observations | 511 | 511 | 511 | 511 | 511 |
| Root MSE | 0.2180 | 0.2183 | 0.2184 | 0.2159 | … |