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INVESTMENTS IN ICT-CAPITAL AND ECONOMIC PERFORMANCE OF SMALL AND MEDIUM SCALE ENTERPRISES IN EAST AFRICA†

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Abstract: In this paper, we focused on whether investments in ICTs could cause any increases in a firm's performance. We constructed a data set for two East African countries—Kenya and Tanzania for small and medium scale enterprises and focused on three performance indicators—internal rate of return, labour productivity and domestic and export market expansion. Findings of this paper suggested that investments in ICT have a positive impact on general market expansion. However, it has a negative impact on labour productivity, and such investment does not have any significant impact on the firm's return nor does it determine the firm's exporter (non-exporter) status. Copyright © 2006 John Wiley & Sons, Ltd.

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1 INTRODUCTION

The questions of whether investments in information and communication technologies (henceforth, ICTs) can cause an increase in a firm's performance, and whether an increase in ICT stock can cause growth and development are some basic concerns for development economists during recent times.[1] In this paper, the first question, whether investments in

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[1]Impacts of ICT investment on firm's productivity was a major issue in the productivity debate in the USA and in other developed countries in the 1980s and 1990s. See, for instance, Gordon (2000) for a review. Similarly, the role of ICTs on development ranges from wild optimism to deep pessimism. See, for instance, Morales-Gomez and Melesse (1998) for a positive view, and Avgerou (1998) for a more skeptical view. Similarly, assistance for information and communication technology (ICT) has become a priority for policy makers in developing countries and donors alike. See, for instance, the Okinawa Charter on Global Information Society (2000) adopted in G8 Summit—Dot Force.

ICTs can cause any increase in a firm's performance, is dealt with in the context of two East African countries—Kenya and Tanzania. Three performance indicators considered were the internal rate of return, labour productivity and domestic and export market expansion. They are measured for small and medium-scale enterprises (henceforth, SMEs) in three sectors: food processing, textiles, and tourism.

SMEs in developing countries historically played important roles in job creation and income generation (ESCAP, 2003). In Kenya, the SME sector was estimated to employ 3.2 million people and contributed about 18 per cent of total GDP in 2003. In Tanzania, the share of SME in total enterprises is 85 per cent and they contribute about a third of GDP (AfDB/OECD, 2005). The three sectors chosen in this study—food processing, textiles and tourism—make important, though varying, contributions to employment and output. While in Kenya, food processing sector accounts for the highest share in manufacturing value added (32 per cent in 1995), textiles and wearing apparel play a relatively minor role. In Tanzania, textiles are the largest manufacturing sector with 18 per cent of the value added. The tourism sector however, is now the most important sector in Tanzania in terms of its contribution to GDP (Table A1 in Appendix).

In the 1990s, many SMEs operating in the three designated sectors in the two study countries have invested, albeit in a limited and varying scale, in ICT-capital (Table A2 in Appendix). Since SMEs can use ICTs both as an input in the production process, and during the transaction process while selling their products or acquiring inputs, there are various ways by which they can influence the performance of an enterprise. ICTs can enhance enterprise performance with indirect cost savings such as those in labour and increased labour productivity, and direct cost reductions of a firm's input such as those in information. In addition to these short run impacts of ICT adoption in the production process, the use of ICTs in the transaction process can also foster input and output market expansion. However, in the long run, ICTs might have an even bigger impact in terms of completely restructuring the production process, influencing transaction methods, increasing flexibility and improving outputs.

These predicted impacts are partly due to the fact that ICT is not only a new technology but it is also a vector of network externalities.[2] The key reason for the appearance of network externalities is the 'complementarity' between the components of the network. In this case, the components of the network are firms, suppliers and consumers and the complementarity refers to the spreading of information, for example prices. If all components have the same information then the use of ICT will not increase the availability of information for the individual firm. This network externality effect distinguishes ICT from a simple substitute for labour or other kinds of capital input (Creti, 2001).

The empirical evidence relating to the impact of ICTs on a firm's performance is at best mixed. In fact, in industrial countries, the growth of the total factor productivity associated with technical change has actually declined in parallel to the increased use of ICTs in the past 10 to 20 years (Jorgenson and Stiroh, 1999). It was only in the 1990s when empirical evidence appeared to show that ICTs have a substantial positive effect on firms' productivity levels (Brynjolfsson and Hitt, 2000). In the case of developing countries,

[2]A positive consumption or production externality signifies the fact that the value of a unit of the good increases with the number of units sold. In other words, the value of a network in which a decision maker participates increases with the number of total participants. In the case of ICT, this means, for example, buying a telephone is considerably more useful if not only the firm's potential suppliers and customers own telephone, but other firms in the same sector also possess a telephone. See Liebowitz and Margolis (1994), and Katz and Sharpio (1986), and Armstrong (1998) for an overview of network externalities in ICT.

the empirical evidence on the effects of investments on ICTs on small enterprises is limited, partly due to the unavailability of firm level data. Two recent studies on SMEs in India's manufacturing sector have reported a positive link between ICT-capital and productivity (Müller-Falcke, 2002), and between ICT capital and export performance (Lal, 1996). However, these studies are subject to severe endogeniety problems. To our knowledge, there is no study to date that analyses the impact of ICT capital on the performance of SMEs in East Africa. The present study is a contribution that fills this gap.[3]

Investment in ICT precedes a technology adoption process that might follow any of the models discussed in Geroski (2000). In addition, local conditions and peer groups can also influence ICT adoption decision. Such decisions could also be due to network externalities and learning from peer groups or due to unobserved traits. Network externalities can affect the adoption of technology and can lead to suboptimally slow adoption, fast adoption or even the adoption of an inferior technology (Katz and Shapiro, 1986). Similarly, learning from others can also influence technology adoption decision, as found by Griliches (1957) in his classic study on the diffusion of hybrid corn in the case of the USA. Individuals are more likely to do something when those around them are doing it because they share unobserved common traits, known as Tiebout bias (Tiebout, 1956). Literature on herd behaviour also shows how herding and learning from peer groups and neighbours can influence economic and social decisions (Banerjee, 1992). However, in this paper, we did not focus on the ICT adoption process; we have assumed that the adoption follows any of the models discussed in Geroski (2000) and we focused on the impact of such technologies once adopted.

The remainder of the paper proceeds as follows, Section 2 describes the theoretical links between the investment in ICTs and the performance of SMEs from which follows the econometric specification. Section 3 presents an overview of the data collection methods, the firm level data used in this paper and descriptive statistics linked to ICT capital and performance indicators. Section 4 presents the results of the estimation of the impact of ICTs capital on the firm's performance, and Section 5 concludes with implications for the implementation of ICT programs.

2 ICTS AND FIRM PERFORMANCE—THEORETICAL BACKGROUND AND EMPIRICAL SPECIFICATION

In the majority of studies that have explored the productivity impacts of ICT at the firm level, a production function framework was used with ICT capital entering as a separate input (Hempell, 2002; Brynjolfsson and Hitt, 2003). The framework adopted here for the empirical specification relates the composition of capital and the intensity of capital to relative and absolute measures of economic performance of firms. The absolute performance of a firm is related to the composition of the capital stock and the relative performance of the firm with the intensity of capital. The basic assumption is that as a profit maximizer, a firm allocates its investment in ICT and non-ICT capital stocks and achieves a capital composition such that it ensures the highest return.

[3]One drawback that may be noted is that the data used for empirical analysis comes from a cross-section of countries and of sectors and therefore subject to standard evaluation problems. A large body of literature deals with the limitation of cross-sectional data. See, for instance, La Londe (1986) and the literature that follows.

To put it in a formal setting, following Stoneman and Kwon (1996), the performance of a firm can be decomposed into performance stemming from ICTs and performance due to other factors. More specifically, the performance of a firm i operating in industry k is decomposed into gross performance and performance due to the ICT capital. It follows that y_i is defined as the gross performance of firm i at time t, y_i^{ict} as the performance of the firm due to the investment in ICTs, and y_i^0 as the counter factual performance where no such technology has been invested.

Hence, it follows that,

$$y_i = y_i^0 + D_i y_i^{ict} \tag{1}$$

$$y_i^0 = y_i^0[Z_i, Z_k] \tag{2}$$

$$y_i^{ict} = y_i^{ict}\left[Z_i, Z_k, I_i^{ict}\right] \tag{3}$$

Here D_i is a bivariate state equal to 1 if firm i owns ICTs, and 0 otherwise; Z_i and Z_k are the respective firm and industry characteristics; I_i^{ict} is an index representing the extent of ICTs that the firm i has invested at time t. Summing up (2) and (3) into (1) gives the basic estimating equation:

$$y_i = y_i^0[Z_i, Z_k] + D_i y_i^{ict}\left[I_i^{ict}\right] \tag{4}$$

To assess the impact of the investment in ICTs on the economic performance of firms, the following three traditional indicators of performance are employed:

1. Internal rate of return
2. Labour intensity and labour productivity
3. Market expansion (domestic and foreign)

For tractability, the link between the investment in ICT and each of the indicators as well as the corresponding empirical formulations are discussed separately.

2.1 ICTs and Return on Investment

An important characteristic of ICTs is that they are mostly scale-neutral, and therefore, appropriate for large as well as small firms. Investments in ICT-capital can lead to a substitution of ICT equipment for other forms of capital and labour and may generate substantial returns for firms that invest in ICTs. In this case, it should be reflected in the firm's internal rate of return (IRR), and IRR differential among firms can be mapped to their ICT-capital differential.

However, a difference in return that is driven by a difference in ICT-capital can only occur in the short run in an out of equilibrium setting. This is where not all firms are fully aware of the benefits of ICT-capital due to information imperfections or not all firms have the same access to ICT due to credit or supply constraints. The reasoning is that if firms are aware of the benefits, they will allocate their investments between ICT and non-ICT capital

efficiently and it should be expected that the composition of capital should not affect the return on the investment. Furthermore, if firms make inappropriate investment decisions due to imperfect information, there may be sub-normal returns. In the latter case, the average returns for firms with high ICT-capital may not be higher than the firms with low ICT-capital.

To measure the return from the investment in ICTs, the internal rate of return (IRR) is defined here as the logarithm of revenue minus variable costs divided by the aggregate capital stock. IRR is an *ex post* measure of firm's profitability and is a flow measure of performance by construction.

To account for the impact of ICT on IRR, the whole capital stock of firm i denoted by K_i is divided into ICT-capital and non-ICT capital denoted by ICT_i, and EQ_i, respectively. IRR is regressed on a constant term, the aggregate capital intensity (K_i/Y_i), the ratio of ICT capital to total capital (ICT_i/K_i), and the ratio of non-ICT capital to total capital (EQ_i/K_i):[4]

$$IRR = \ln A + \ln(K/Y) + \ln(ICT/K) + \ln(EQ/K) \tag{5}$$

2.2 ICTs and Labour Productivity

The second performance indicator chosen in this paper was to map the link between investment in ICT-capital and labour productivity. In addition to high return potentials, ICTs as cheap input substitutes, particularly with respect to labour, are well recognized in the literature (Berndt and Morrison, 1995). As an input in the production process, ICTs can have both substitution and complementary effects; ICTs can be cheaper substitutes of other inputs and can have positive complementarities with other inputs. As a result, ICTs can increase the productivity of labour and other inputs.

However, there are two problems with the substitutability and complementarities of ICTs in the study context. First, relative to capital, labour is already cheap in East African countries and hence the substitution of ICTs for labour may not be the profit maximizing option for SMEs. Second, ICTs invented in industrialized countries may not ensure complementarities due to technology-skill mismatch; since these technologies are primarily designed to be operated by skilled workers, the productivity of these technologies can be relatively low when operated by unskilled workers.[5]

To measure the impact of ICT capital on labour productivity, a similar relationship such as that of the IRR can be derived. First, a Cobb-Douglas production function is given by:

$$\ln Y = \ln A + \beta_1 \ln L + \beta_2 \ln K^* \tag{6}$$

Here, L stands for labour and K^* stands for quality-adjusted stock of aggregate capital defined as:

$$K^* = K(ICT/K)^{\delta}(EQ/K)^{\gamma} \tag{7}$$

[4]A similar formulation can be found in Berndt and Morrison (1995) for the US manufacturing sector. Note that we have avoided the subscript i in writing the equations.

[5]See Acemoglu and Zilibotti (2001). Their paper provides both theoretical explanation and empirical evidence on technology-skill mismatch as a possible reason for productivity difference between developing and industrialized countries.

This in logarithmic form can be written as:

$$\ln K^* = \ln K + \delta \ln(ICT/K) + \gamma \ln(EQ/K) \tag{8}$$

Combining (8) into (6), assuming constant returns to scale, and solving for $\ln(L/Y)$:

$$\ln(L/Y) = \alpha_1 + \alpha_2 \ln(K/Y) + \alpha_3 \ln(ICT/K) + \alpha_4 \ln(EQ/K) \tag{9}$$

Where $\alpha_1 \equiv -\ln A/\beta_1, \alpha_2 \equiv (1-\beta_1)/\beta_1$, $\alpha_3 \equiv -\delta(1-\beta_1)/\beta_1$, $\alpha_4 \equiv -\gamma(1-\beta_1)/\beta_1$. Equation (9) provides the basic estimation relationship between labour intensity and ICT-capital intensity. If $\alpha_3 < 0$, ICT-capital has a positive impact on labour productivity as labour intensity decreases. However, if $\alpha_3 = 0$, the effect of ICT-capital is not different from the effect of non-ICT capital.

2.3 ICTs and Market Expansion

The third performance indicator examined is the impact of the investment in ICTs on market expansion. Both input and output markets in developing countries are characterized by imperfect and asymmetric information. ICTs can cause the costs of input and output market interactions for an enterprise to decline. As a result, the costs for inputs might decrease as ICTs reduce information and search costs. Furthermore, the price of output might increase as ICTs reduce the search and information costs of trade. Consequently, ICTs, particularly the Internet, can change the way in which seller-buyer matches are made thus allowing for the integration of SMEs into the global market. In other words, the demand for a particular product produced by a SME may become less dependent solely on local market conditions.[6]

In the case of export market expansion, this usually starts with a SME searching for a foreign buyer. Here, the search process usually involves advertising, participation in international trade fairs or networking with brokers and other intermediaries. After a successful search process, the next step is to negotiate product specifications and prices and to engage in a contract. Once the contract is agreed upon, the export process then typically involves delivering, transporting, billing and acceptance of payment. ICTs can therefore reduce the costs of export before, during and after the export. This is particularly true for the Internet which can be used for electronic commerce (Lucking-Reiley and Spulber, 2001).

However, market expansion potential due to ICTs may work against SMEs, too. Availability of ICTs to SMEs as well as to large frims may expose SMEs to greater competition via market integration and erode market share and profitability as a result. In particular, SMEs located in rural areas, that serve the local niche market and are protected against competition from large firms because of high information and communication costs, are expected to face more competition and hence a reduction in oligopoly rents and profits.

[6]As Saxenian (1999) described, '... new transportation and communications technologies allow even the smallest firms to build partnerships with foreign producers to tap overseas expertise, cost savings, and markets'. In the case of labour market, see Autor (2001). See also Rauch (2001).

To examine the extent of ICT driven market expansion, two sub-indicators are adopted: output market expansion and export market expansion. Output market expansion includes general market expansion. To capture this, a market expansion index is constructed and the firms are ranked according to their local, regional and export market participation, named as their market expansion rank. The market expansion index is a weighted index in which weights are based on the proportion of output sold locally, regionally (within the country but outside the locality), and internationally (export). This index is standardized to 100. To test for the sensitivity of the index, two other indices with varying weights are constructed.[7]

The market expansion rank varies from 0 to 5. It is based on the market expansion index and defined as 0 for firms that sold their products only locally; 1 for firms that sold products both locally and regionally but where the regional sales did not exceed 40 per cent of total production; 2 for firms that sold more than 40 per cent of production to the regional market but did not export at all; 3 for firms that exported but the total export did not exceed 40 per cent of total production; 4 for firms that exported more than 40 per cent but less than 80 per cent of total production; and 5 for firms that exported 80 per cent or more of total production. To test for the sensitivity of these ranks, two other categories of ranks with varying cut-off points are constructed.[8]

Although it is possible to see the market expansion in a continuum, this choice of ranking is motivated by the fact that in such cases, each state of performance can be seen, for example local, regional and export, is affected, *ceteris paribus*, by the level of ICT investment. However, since cross-sectional data is all that is available,[9] it was not possible to examine the transition from one state of performance to another, for example from local to regional or regional to export and vice versa.

Econometrically it follows that the performance of the firms is ranked, where ranks are ordinal and rank 0< rank 1 $\ldots$ < rank 5, and follow a latent regression model (Greene 2000):

$$y^* = \beta' x + \varepsilon \tag{10}$$

Where y^* is performance which is unobserved. What we observe is:

$$\begin{aligned} y &= 0 \ \textit{if} \ y^* \leq 0 \\ &= 1 \ \textit{if} \ 0 < y^* \leq \mu_1 \\ &= 2 \ \textit{if} \ \mu_1 < y^* \leq \mu_2 \\ &= 3 \ \textit{if} \ \mu_2 < y^* \leq \mu_3 \\ &= 4 \ \textit{if} \ \mu_3 < y^* \leq \mu_4 \\ &= 5 \ \textit{if} \ \mu_4 \leq y^* \end{aligned} \tag{11}$$

[7]MKT_INDEX_2 is a weighted average of the percentage of output sold to different locations. It includes per cent of output sold in other regions but within the same country (weight 1/3), per cent of output sold to other East African countries (weight 1/2), and per cent of output exported elsewhere (weight 1).
MKT_INDEX_3 consists only of per cent of output exported (within and out of East Africa).

[8]MKT_RANK_2 is defined as 0 for SMEs that sold their products locally only, 1 for SMEs that sold products both locally and regionally but where the regional sell did not exceed 20 per cent of total production, 2 for SMEs that sold more than 20 per cent of production to the regional market but did not export, 3 for SMEs that were involved in export, but where this did not exceed 20 per cent of total production, 4 for SMEs that exported more than 20 per cent but less than 50 per cent of total production, and 5 for SMEs that exported 50 per cent or more of total production. MKT_RANK_3 is defined as 0 for SMEs that sold their products locally only, 1 for SMEs that sold regionally but not internationally, 2 for SMEs that exported to other East African countries, 3 for SMEs that exported also to other countries, and 4 for SMEs that exported 50 per cent or more of their products outside the region.

[9]For data description, see Section 3.

Where μs are unknown parameters to be estimated with β, and x are observable firm characteristics that include ICT-capital and non-ICT capital. In line with the basic estimating framework given by equation (4). In addition, x includes country, sector and regional dummies, as well as size and education of firm management. Here, ε are unobservable factors. Assuming that ε follows a logit distribution, we have estimated the probabilities and corresponding marginal effects utilizing the ordered logit method.

Export market expansion examines the impact of ICTs on export market participation where firms are categorized as exporters and non-exporters. Econometrically, the specification problem is very similar to (10), and follows a latent regression model:

$$y^* = \beta' x + \varepsilon \tag{12}$$

Where y^* is the unobserved latent variable. The observed dummy variable $y$is defined by

$$\begin{array}{ll} y = 1 & \textit{if } y^* > 0 \\ y = 0 & \text{otherwise} \end{array} \tag{13}$$

The Probit method is used to estimate this equation. Here x includes similar observable characteristics described in general market expansion.

3 DATA AND SUMMARY STATISTICS

Data is used from a firm survey conducted in Kenya and Tanzania between November 1999 and May 2000. The survey included small-scale enterprises from three sectors, food processing, textiles and tourism, where the firm size of up to 50 employees was the selection criteria for an SME to be included in the sample. A structured firm survey questionnaire was conducted that gathered information on input, capital, labour, output and markets. Firms were also asked about investments in different types of ICTs (telephone, fax, computer etc.), in recent years to get the actual value of ICT equipment. The total sample size was 300 firms, 150 from Kenya and Tanzania each, distributed equally amongst the three sectors. In selecting firms, the survey followed a simple random sampling procedure where the sample firms were selected randomly from major commercial corridors in the countries under study.[10]

Table 1 provides summary statistics pertaining to the performance of SMEs and Table 2 provides summary statistics pertaining to regressors. The internal rate of return (IRR) and labour intensity (L_Y) are measured using a nominal scale, and the market expansion index (MKT_IND) is measured using a logarithmic scale. The two other measures of market expansion, market expansion rank (MKT_RANK) and export market expansion (EXP) are ordered (0 to 5), and binary variables (0, 1), respectively.

Turning to the regressors and their measurement scales, total stock of capital (K), ICT-capital (ICT), and non-ICT capital (EQ) are measured in US dollars. The average years of schooling of management (SIM) is measured in years. The size of enterprise (L) is the total number of employees. Total capital-output ratio (K/Y), ICT-capital to total capital stock

[10]The two key considerations in the determination of the sample regions were their economic significance and their representativeness for the SME sector. The selected commercial corridors are the Lake Zone, the Coastal Zone, and the Arusha Region in Tanzania and the Coastal Zone and Lake Zone in Kenya.

Table 1. Summary statistics of performance of SMEs (Mean and standard deviation)

Performance Indicators	Name	Food	Textile	Tourism
Internal Rate of Return	IRR	13.39 (35.01)	23.91 (74.76)	6.56 (19.26)
Labor Intensity in log	L_Y	0.033 (0.075)	0.037 (0.106)	0.025 (0.057)
Market Expansion Index[(1)]	MKT_INDEX	1.44 (2.13)	1.74 (1.90)	3.70 (1.23)
Market Expansion Rank	MKT_RANK	2.39 (1.54)	2.42 (1.25)	4.65 (1.40)
Export Market Expansion	EXP	0.24 (0.43)	0.25 (0.43)	0.84 (0.37)

Note: [(1)]Expressed in logarithmic scale.
Source: own calculations from SME survey.

Table 2. Summary statistics of regressors (Mean and standard deviation)

Regressors	Name	Food	Textile	Tourism
Stock of Capital (in 1000 US$)	K	124.8 (567.3)	19.6 (52.3)	63.1 (119.6)
Stock of Non-ICT Capital (in 1000 US$)	EQ	127.1 (574.7)	18.9 (51.2)	61.3 (120.2)
Stock of ICT Capital (in 1000 US$)	ICT	2.0 (6.7)	1.5 (8.6)	5.7 (16.2)
Schooling Intensity of Mgt[(1)]	SIM	2.466 (0.240)	2.476 (0.185)	2.613 (0.206)
Size of the enterprise[(1)]	L	2.703 (0.835)	2.290 (0.632)	2.572 (0.686)
Capital-Output ratio[(1)]	K/Y	2.07 (1.60)	2.64 (1.40)	0.92 (1.48)
ICT capital to Total capital[(1)]	ICT/K	−3.82 (2.25)	−3.43 (1.99)	−2.67 (2.27)
Non-ICT capital to Total capital[(1)]	EQ/K	−0.081 (0.139)	−0.130 (0.398)	−0.211 (0.349)
ICT Index[(1)]	ICT_IND	2.633 (0.838)	2.509 (0.584)	2.833 (0.490)
Non-ICT Index[(1)]	EQ_IND	−0.736 (2.150)	−1.966 (2.020)	0.085 (1.583)

Note: [(1)]Expressed in logarithmic scale.
Source: own calculations from SME survey.

(ICT/K), and non-ICT capital to total capital stock (EQ/K) are expressed in logarithmic scale. The ICT index (ICT_IND) is based on the intensity of the use of different information and communication technologies namely number of fixed phone lines, number of mobile phones, number of faxes, use of email and the Internet. These intensities are weighed by the average investment that is necessary to purchase the devices and the index is normalized to 100.[11] Similar to ICT_IND, an index for non-ICT capital (EQ_IND) based on the value of non-ICT capital stock is constructed and normalized to 100.

As determined from the summary statistics, the SMEs in the different sectors differ markedly with respect to performance indicators as well as with respect to firm's characteristics. The IRR and labour intensity indicators are the lowest in the tourism sector but the market expansion is the highest for all three indicators. In the tourism sector, the management also has the highest education level and the absolute stock of ICT capital is the highest. As it is a service sector, the capital output ratio is the lowest. The differences between the two manufacturing sectors are not as marked, although, all performance indicators are higher for the textiles sector. The similar size of firms across the three sectors and the low variance is due to the fact that a firm size of up to 50 employees was the selection criteria for an SME to be included in the sample. Finally, the dummy for location controls whether a firm is located in the capital city or not. Because of the network externalities, it is expected that the impact of ICT is non-neutral with respect to firm's characteristics. For firms in different sectors and in different countries the impact of ICT

[11]As more advanced ICTs are more expansive the weighting ensures that the focus is on more advanced technologies.

will therefore differ (Creti, 2001). However we could not include network externalities directly into the empirical analysis due to a lack of appropriate data.[12]

Before proceeding further, some econometric issues should be noted. First, an assumption is made that the difference in firm performance comes from the difference in ICT-capital. However, if firms that invest in ICTs are the firms that perform better, then this measure is subject to an omitted variable bias since it does not take firm heterogeneity into account. To correct this, firm size, which should control for firm heterogeneity, is included in the analysis. Second, the three sectors from two different countries are aggregated, and to control for heterogeneity, country as well as sector dummies are included. However, there is no guarantee that these dummies are going to capture heterogeneity adequately. Finally, since this analysis consisted of a cross-section of firms where controlling for time is not possible, the causal reference is somewhat limited. Therefore, any results should be interpreted with caution.

4 ESTIMATION AND RESULTS

We have estimated equation (5) that measures IRR and equation (9) that measures labour productivity with the ordinary least square (OLS) method. For equation (4) and its variants given by (10) that measures market expansion, both OLS, ordered logit, and binary probit are utilized. Table 3 through Table 7 describe the estimation results. In order to be more tractable, the results are discussed under three categories of performance indicators.

Table 3. Dependent variable: Internal Rate of Return; method: OLS

Regressors	Coefficients	
ln(K/Y)	1.0073	1.0840
	(0.0640)**	(0.0721)**
ln(ICT/K)	0.0235	0.0257
	(0.0528)	(0.0597)
ln(EQ/K)	−0.2111	−0.1332
	(0.3027)	(0.3034)
Dummy for textile sector		−0.2528
		(0.2449)
Dummy for Tourism sector		0.5664
		(0.2843)*
Dummy for Kenya		−0.0123
		(0.1040)
Dummy for Location		−0.0572
		(0.2628)
Constant	−1.2458	−1.3989
	(0.2651)**	(0.4182)**
Observations	163	163
R-squared	0.615	0.634
D-W	2.104	1.917

*Significant at 5 per cent level; **significant at 1 per cent level.

[12]The empirical literature that deals with firm performance incorporating the effect of ICTs usually do not include network externalities as a separate variable in the estimation. For instance, see Berndt and Morrison (1995), and Brynjolfsson and Hitt (2000). One exception is perhaps Koski (1999). He used the proportion of a firm's business partners connected with it by the advanced communications technology and finds a positive and significant relationship with firm output. However, the sample he used was very small.

4.1 Impact of ICT on IRR

The second column in Table 3 provides the estimated results for the equation (5), and the third column provides a variant of equation (5) that controls for industry and other characteristics. The estimated coefficients are stable across both equations. The internal rate of return is predominantly determined by the capital output ratio with a coefficient close to 1 in both cases. As determined in Table 3, the impact of ICT-capital as a proportion of total capital on IRR is not significant which suggests that investment in ICTs does not lead to higher returns. IRR is furthermore influenced by industry characteristics and is positively affected if an enterprise belongs to the tourism sector. As both capital-output ratio and labour intensity are relatively low in the tourist sector, the IRR is mainly determined by the costs of other inputs.

These results are in line with the literature. Particularly as the share of ICT equipment in total capital is still very small, it might be difficult to estimate the effects of ICT empirically (Hempell, 2005). We have estimated similar equations at country and industry level. However, results remain generally the same. When we restrict data to the textile sector only, the coefficient of ln(K/Y) changes from 1.0847 to 1.1081. However, there is no change in the level of significance and ln(ICT/K) remains insignificant. Similarly, if we restrict the data to the tourism only or to Kenya or to Tanzania only, the coefficient of ln(K/Y) changes to 1.1247, 1.2314 and 1.0779 respectively, keeping the level of significance unchanged in all cases.

4.2 Impact of ICT on Labour Intensity and Labour Productivity

The first column of Table 4 provides the estimated results of equation (9), and the second column provides a variant that controls for industry and other characteristics that have

Table 4. Labor intensity and productivity; Dep. variable: ln(L/Y); Method: OLS

Regressors	Coefficients	
ln(K/Y)	−0.5864	−0.3945
	(0.1170)**	(0.0576)**
ln(ICT/K)	0.2743	0.0814
	(0.0948)**	(0.0470)∼
ln(EQ/K)	1.1413	0.2276
	(0.5534)*	(0.2416)
Dummy for textile sector		0.4852
		(0.1955)*
Dummy for tourism sector		−0.9244
		(0.2252)**
Dummy for Kenya		19.203
		(0.0822)**
Dummy for location		0.2821
		(0.2099)
Constant	−4.8946	−7.2067
	(0.4811)**	(0.3333)**
Observations	165	165
R-squared	0.192	0.854
Adjusted R-squared	0.177	0.8477

∼Significant at 10 per cent level; *Significant at 5 per cent level; **significant at 1 per cent level.

been included in estimating the IRR. Here the stock of ICT-capital as a proportion of total capital has a significant positive impact on labour intensity. This implies that the stock of ICT-capital has a negative impact on labour productivity, as the respective coefficient δ is negative. The negative coefficient for the tourism sector corresponds with the expectation that the relatively high capital intensity of this sector has a positive impact on labour productivity.

The negative effect of the share of ICT capital in total capital is in line with the findings of Berndt and Morrison (1995) 'High-Tech Capital Formation' for US data. The accumulation of ICT devices has not been labour saving, but to the contrary, expanded the labour force and therefore is associated with decreasing average labour productivity.

4.3 Impact of ICT on Market Expansion

This stage of the analysis starts with the general form of market expansion. For this, the basic estimating equation (4) is estimated by OLS, where the dependent variable market expansion, MKT_IND, is measured in a continuum. Table 5 reports the estimated coefficients along with their standard errors and level of significance. As shown in the table, a firm's relative stock of ICT-capital has a positive impact on market expansion.[13]

Table 5. Market Expansion; Dependent variable: MKT_IND; Method: OLS

Regressors	Coefficients
ln(ICT_IND)[a]	0.5627
	(0.2412)*
ln(EQ_IND)[a]	0.2802
	(0.0746)**
Dummy for Kenya	0.0380
	(0.0944)
Dummy for textile sector	10.665
	(0.3096)**
Dummy for tourism sector	23.675
	(0.3090)**
Dummy for location	0.0407
	(0.2481)
ln(L)	0.3306
	(0.2207)
ln(SIM)	0.0055
	(0.6621)
Constant	−0.9899
	−16.000
Observations	187
R-squared	0.502
Adjusted R-squared	0.479
D-W	1.984

Note: [a]Instrumentalized to correct for possible endogeneity bias; *Significant at 5 per cent level; **significant at 1 per cent level.

[13]We have explored the role of modern ICTs such as Internet and email separately. However, they do not have any significant impact while putting them alone in the regression.

Other factors that also have a positive impact are the relative stock of non-ICT capital and industry characteristics. As the tourism sector is more oriented towards foreign customers, the coefficient for the tourism dummy is relatively high. It is somewhat surprising that the size of the firm expressed in number of employees is not significant, contrary to other findings that conclude that bigger African enterprises are more likely to export.[14] To some extent this might be due to the limited size range of the sample, but it may also give a hint that the use of ICTs could somehow reduce advantages of bigger size. The fact that the educational attainment of the management is also not significant might also be due to the ICT effect as the usage of more advanced ICTs is already linked with higher education.

To see the discrete change in market expansion performance, equation (10) is estimated with ordered logit. Table 6 reports the marginal effects. Table A3 in the Appendix reports the estimated coefficients along with other statistics. Similar to MKT_IND, MKT_RANK is also influenced by the firm's relative stock of ICT-capital. A firm with a higher stock of ICT-capital is more likely to have a higher rank. With the exception of the country dummy, which was not significant in the OLS regression, the significance of other factors remains unchanged when using the ordered logit method.

To test for the sensitivity of the market expansion index and market expansion ranks, two other variants of each of the indices were estimated. The constructions of these variants are discussed in Section 3. Table A4 and Table A5 in the appendix report the estimation results of the market expansion indices, and Table A6 and Table A7 report the market ranks. It appears from the tables that the effects of relative investment in ICT capital and non-ICT capital on market expansion remains the same as before.

Table 7 reports the coefficients related to export market performance where SMEs are classified in dichotomous form, either as exporters or not. The relative stock of ICTs does not have any significant impact on the export performance indicator. Although weak, it is rather the non-ICT stock of capital that has a positive impact on export performance. Other factors that have a significant impact include industry characteristics and the country dummy.

5 CONCLUDING REMARKS

A descriptive and quantitative analysis of SMEs in Kenya and Tanzania shows that the investment in ICTs has an important correlative relationship with market expansion, if not a direct cause of market expansion. However, it is not only the relative stock of ICT-capital that is important, but also the relative stock of other capital that brings competitive advantages, and thus, market expansion. It seems that in the case of market expansion the benefits from better access to information through more use of ICTs may be relatively easy to realize.

However, an investment in ICTs in this study does not have any significant impact on enterprise return and export performance and perhaps even a negative impact on labour productivity. One plausible explanation is that for the internal rate of return, the share of ICT-capital does not seem to play a role due to the existence of network externalities. In particular, since more advanced ICTs are not very widespread in East Africa and since the majority of firms tend to operate locally or regionally, the benefit of a firm's own ICT capital is limited. Having said that, if investments in different types of capital is allocated

[14]See, for instance, Söderbom and Teal (2000).

Table 6. Marginal Effects for Ordered Logit

Variable	MKT_RANK = 0	MKT_RANK = 1	MKT_RANK = 2	MKT_RANK = 3	MKT_RANK = 4	MKT_RANK = 5
ln(ICT_IND)[a]	−0.2192805	0.1003429	0.0494821	0.0504306	0.0134987	0.0055262
	(0.07318)**	(0.03349)**	(0.01651)**	(0.01683)**	(0.0045)**	(0.00184)**
ln(EQ_IND)[a]	−0.0712096	0.0325856	0.0160689	0.0163769	0.0043836	0.0017946
	(0.01869)**	(0.00855)**	(0.00422)**	(0.0043)**	(0.00115)**	(0.00047)**
KENYA	0.0528307	−0.0241754	−0.0119216	−0.0121501	−0.0032522	−0.0013314
	(0.02203)∼	(0.01008)∼	(0.00497)∼	(0.00507)*	(0.00136)∼	(0.00056)*
ln(L)	0.000087	−0.0000398	−0.0000196	−0.00002	−5.36e-06	−2.19e-06
	(0.05286)	(0.02419)**	(0.01193)	(0.01216)	(0.00325)	(0.00133)
ln(SIM)	−0.0088117	0.0040323	0.0019884	0.0020265	0.0005424	0.0002221
	(0.17019)	(0.07788)*	(0.0384)	(0.03914)	(0.01048)	(0.00429)

Note: Textile, Tourism and regional dummies do not have any effect and have been excluded as a result.
[a]Instrumentalized to correct for possible endogenity bias.
∼Significant at 10 per cent level; *significant at 5 per cent level; **significant at 1 per cent level.

Table 7. Export performance; Dep. variable: EXP; Method: binary bivariate probit

Regressors	Coefficients	Marginal Effects
ln(ICT_IND)[a]	0.4285	0.1683
	(0.2827)	(0.1108)
ln(EQ_IND)[a]	0.1311	0.0515
	(0.0738)∼	(0.0290)∼
Dummy for Kenya	−0.1033	−0.0406
	(0.0917)	(0.0360)
Dummy for textile	0.3569	0.1406
	(0.2936)	(0.0865)
Dummy for tourism	1.7715	0.6129
	(0.3129)**	(.)
Dummy for location	0.1466	0.0576
	(0.2449)	(0.0509)
ln(L)	0.2857	0.1122
	(0.2202)	(0.0865)
ln(SIM)	0.0600	0.0236
	(0.6966)	(0.2736)
Constant	−2.5371	
	(−1.6817)	
Observations	188	188
Prob > chi2	0.0000	0.0000
Pseudo R2	0.3398	0.3398
Observed Probability		0.4361702
Predicted Probability		0.4300391

Note: [a]Instrumentalized to correct for possible endogeneity bias.
[+] Significant at 10 per cent level; *significant at 5 per cent level; **significant at 1 per cent level.

efficiently then it should be expected that the composition of capital should not affect performance.

The negative impact of ICT investment on labour productivity could be interpreted either as over investment in ICT or due to technology-skill mismatch mentioned in Section 1. This could also be partly a result of the relatively high costs of ICTs in East Africa and the non-divisibility of equipment in the case of small firms. Furthermore, the fact that in the initial phase there tends to be a substantial learning period of how to deal with the new technology, this could lead to an increase in labour intensity. One must keep in mind that in the early studies of the effects of ICT usage on productivity in developed countries found no positive effects of what was then termed as 'productivity paradox'.[15] In the case of exports, there are many complementary factors such as infrastructure and the functioning of the banking system that are crucial for effecting an increase in exports, and the investment in ICTs is perhaps not the sufficient condition, at least in the short-run.

One factor that limits the above analysis is that there may be a substantial time lag between ICT investments and their effects particularly when the learning effect is taken into account. Thus it is possible that a lack of an ICT effect may simply reflect the time lag before any investment in these technologies begins to payoff. Additionally, the approach

[15]As famously put by Robert Solow, 'We see computers everywhere except in the productivity statistics'. See Brynjolfsson and Hitt (2000).

with a sole focus on productivity may be too narrow. Information and communication technologies may exert their influence through product-quality improvements, through improved services and especially through improved networks, which may have external effects, too. Further investigations are needed to reveal the complementary factors that impact on the links between ICTs and SME performance and possible provision for additional impetus for investments.

One important aspect of the use of ICTs that is frequently mentioned in enterprise surveys is the high cost of devices and services in many African countries. In this respect, liberalization and privatization that ensures competition and thereby increases quality and reduces prices will be the most important step in increasing the use of ICTs by all possible users.[16]

Most African countries have ICT development plans or even e-commerce programs in place or at least have the intention to develop them initially. Additionally, the donor community is enthusiastic about the role of ICT for development as it has the potential to facilitate participation of otherwise excluded people in all kinds of interaction, from democratic processes to markets. However, as these empirical results and other considerations show, the use of ICTs is at best one factor amongst others that improves firm performance. Therefore, ICTs should not be regarded in isolation as other factors are at least equally as important as ICTs.

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[16]Similar recommendations are made in Mattoo (2000).

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APPENDIX

Table A1. Food, Textiles and Tourism sectors in East Africa

Value added	Kenya	Tanzania
Manufacturing, value added (% of GDP, 1999)	10.7	7.4
Food products (% of value added in manufacturing, 1995)	32.0	11.0
Textiles and wearing (% of value added in manufacturing, 1995)	7.0	18.0
Tourism receipts (% of GDP, 1999)	2.7	8.2

Source: UN (1997), and World Bank (2001).

Table A2. Use of ICTs by country and sector

Percentage of Enterprise that:	Tanzania			Kenya		
	Food	Textile	Tourism	Food	Textile	Tourism
Don't have any ICT	22.4	31.9	2.6	18.4	52.8	0.0
Have phone (fixed + mobile)	76.3	64.0	97.4	81.6	45.3	100.0
Have fax	13.6	2.0	74.4	30.6	11.5	66.0
Have computer	3.4	4.0	35.9	2.0	1.9	10.0

Source: own calculations from SME survey.

Table A3. Market expansion; Dep. variable: MKT_RANK; Method: Ordered Logit

Regressors	Coefficients
ln(ICT_IND)[a]	1.1262
	(0.3758)**
ln(EQ_IND)[a]	0.3657
	(0.0960)**
Dummy for Kenya	−0.2713
	(0.1132)*
Dummy for Textile sector	1.0175
	(0.3803)**
Dummy for tourism sector	2.9698
	(0.4297)**
Dummy for location	0.0457
	(0.3038)
ln(L)	−0.0004
	(0.2715)
ln(SIM)	0.0453
	(0.8741)
Observations	188
Chi-squared	139.67
Significance level	0.0000
Pseudo R2	0.2180

Note: [a]Instrumentalized to correct for possible endogenity bias.
*Significant at 5 per cent level; **significant at 1 per cent level.

Table A4. Market Expansion; Dependent variable: MKT_IND; Method: OLS

Regressors	Coefficients
ln(ICT_IND)[a]	0.5415
	(0.2283)*
ln(EQ_IND)[a]	0.2852
	(0.0710)**
Dummy for Kenya	−0.0727
	(0.2694)
Dummy for textile sector	0.9940
	(0.2948)**
Dummy for tourism sector	2.3663
	(0.2942)*
Dummy for location	0.0538
	(0.2359)
ln(L)	0.2897
	(0.2090)
ln(SIM)	0.0552
	(0.6318)
Constant	−1.0523
	(1.5253)
Observations	187
R-squared	0.5170
Adjusted R-squared	0.4953

Note: [a]Instrumentalized to correct for possible endogeneity bias.
*Significant at 5 per cent level; **significant at 1 per cent level.

Table A5. Market Expansion; Dependent variable: MKT_IND; Method: OLS

Regressors	Coefficients
ln(ICT_IND)[a]	0.4016
	(0.2531)
ln(EQ_IND)[a]	0.2375
	(0.0788)**
Dummy for Kenya	−0.6779
	(0.2987)*
Dummy for textile sector	0.3683
	(0.3269)
Dummy for tourism sector	2.9224
	(0.3261)**
Dummy for location	0.1447
	(0.2615)
ln(L)	0.4001
	(0.2317)∼
ln(SIM)	0.0640
	(0.7004)
Constant	−1.5643
	(1.6912)
Observations	187
R-squared	0.5203
Adjusted R-squared	0.4987

Note: [a]Instrumentalized to correct for possible endogeneity bias.
*Significant at 5 per cent level; **significant at 1 per cent level.

Table A6. Market expansion; Dep. variable: MKT_RANK; Method: Ordered Logit

Regressors	Coefficients
ln(ICT_IND)[a]	0.9064
	(0.3695)*
ln(EQ_IND)[a]	0.3612
	(0.0976)**
Dummy for Kenya	−0.6553
	(0.3445)∼
Dummy for Textile sector	1.0882
	(0.3843)**
Dummy for tourism sector	3.0999
	(0.4413)**
Dummy for location	0.0316
	(0.3106)
ln(L)	0.2288
	(0.2732)
ln(SIM)	−0.0271
	(0.9463)
Observations	190
Chi-squared	137.02
Significance level	0.0000
Pseudo R2	0.2202

Note: [a]Instrumentalized to correct for possible endogenity bias.
*Significant at 5 per cent level; **significant at 1 per cent level.

Table A7. Market expansion; Dep. variable: MKT_RANK; Method: Ordered Logit

Regressors	Coefficients
ln(ICT_IND)[a]	0.8588
	(0.3642)*
ln(EQ_IND)[a]	0.3978
	(0.0975)**
Dummy for Kenya	−0.7714
	(0.3445)*
Dummy for Textile sector	1.1083
	(0.3909)**
Dummy for tourism sector	3.0463
	(0.4425)*
Dummy for location	−0.0128
	(0.3064)
ln(L)	0.1172
	(0.2706)
ln(SIM)	0.1715
	(0.9019)
Observations	190
Chi-squared	136.87
Significance level	0.0000
Pseudo R2	0.2403

Note: [a]Instrumentalized to correct for possible endogenity bias.
*Significant at 5 per cent level; **significant at 1 per cent level.

