POLICY BRIEF

Adoption and Impact of ICT on Labour Productivity in Africa: Evidence from Cross-Country Firm-Level Data

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Abstract

This paper uses a large cross-country firm-level database that contains information of about 6,300 firms from 19 sub-Saharan Africa (SSA) countries, collected by the United Nations Industrial Development Organization (UNIDO) in 2010 and 2011, to assess the determinants of adoption and use of Information and Communication Technologies (ICT) in SSA firms, while controlling for the problem of censoring that would exist in the modelling of ICT-capital adoption choice. The gain obtained from the adoption of ICT-capital investment has been examined by estimating the impact of ICT-capital on labour productivity in

adopters' firms, while considering the role of Organizational Changes (OC). Compared to the Cobb-Douglas production function the Translog production function has been tested to be more adequate with our data. Unlike previous work on the estimation of a production function and given the simultaneity between labour productivity and ICT-capital investments, the Instrumental Variables (IV) method, has been used to address this endogeneity problem. The descriptive analysis shows that East African firms, on average, adopt ICT-capital more than other African countries, while Southern African firms, on average, use ICT-capital more intensively than other sub-regions. Finally, we find that income, wages, and firms' size are significant determinants of ICT-capital adoption. Moreover, the study reveals that the impact of ICT-capital intensity on labour productivity in SSA countries is positive and statistically significant in the presence of OC, which is robust to several different specification tests.

Introduction

According to the OECD (2011), Information and Communication Technologies (ICT) investment covers the acquisition of equipment and computer software used in production for more than one year. ICT has three components: information technology equipment (computers and related hardware); communications equipment; and software.[1]

Measuring ICT at the aggregate level is a daunting task. However, several ICT proxies exist at the firm-level, and depending on the availability of data. Among other measures of ICT at the firm-level, there are, for example, ICT investment expenditure and the stock of a firm's computer hardware. The role of ICT for the development of productivity has been at the forefront of development strategies (UNCTAD, 2003; 2005). ICT, broadly, allows for a reduction in transaction costs, for example, in the acquisition of intermediate inputs by deleting or by reducing the number of intermediary actors in the supply chain between a firm and its suppliers, improved communications with markets and within the supply chain, and improved information about new opportunities. ICTs can also improve the internal information systems of enterprises.

Given that investment is widely acknowledged as essential to improving labour productivity, it is also recognized that investment in non-ICT-capital (machinery, equipment, and non-residential buildings) associated with adoption of ICT allow workers to improve their business processes and produce more and higher-quality goods and services. However, these investments have different uses, although they are all relevant for policy purposes since ICT and non-ICT-capital are driven by

1 Software includes acquisition of pre-packaged software, customized software and software developed in-house.

different forces. Firm-level empirical analysis reveals that both ICT and non-ICT-capital investment are strongly demand-driven, but ICT investment adjusts more rapidly to a given demand shock.

Empirical literature widely demonstrated that ICT investments are flexible inputs that allow firms to fundamentally reorganize the production and distribution of goods and services to improve efficiency. In the same vein, it is recognized that ICT investment generates higher returns to growth than the other physical capital thus producing higher level of Gross Domestic Product (GDP). Further, ICT has been the driving force behind the acceleration of productivity growth in Canada and the United States of America (USA) since 1996; also, in European countries, ICT is characterized by above normal returns.[2]

Several studies have shown that ICT-capital investments contribute to returns at the firm-level. In this regard, Dedrick et al. (2003), for example, showed that although there is a significant contribution of Information Technology (IT) to the returns of the firm, the magnitude of the contribution varies extensively across firms. This means that some firms with similar investment in IT have performed differently. Strong evidence that emerged from this observation revealed that the difference in performance was influenced by Organizational Changes (OC).[3]

Several developed countries have taken a huge benefit from the adoption and use of ICT, both socially and economically. The literature on the subject emphasizes that these benefits obtained depends on the existence of telecommunication infrastructures and of the economic development of these countries. Furthermore, despite the progress and outstanding efforts observed in the adoption and diffusion of ICT in developing countries, and particularly in Africa, some works including (International Telecommunication Union [ITU], 2014) argue that Africa still lags remarkably in the adoption and use of ICT.

Like R&D, acquisition, adoption and use of new technologies, embodied in capital investment, lead to innovation. In doing so, ICT are seen as enablers of innovation, productivity, and economic growth in all sectors of the economy.

The use of ICTs is very widespread among firms of all sizes. Many firms are increasingly, adopting ICTs in both developed and developing countries. Firms are also driven to adopt appropriate ICTs for improving their internal processes, improving their

2 See, Jorgenson and Stiroh (1999), Baldwin and Sabourin (2002), Jorgenson and Vu (2007) and Van Reenen et al. (2010).

3 OC here refers to managerial practices carried out within the company such as innovation, decentralization of management levels, restructuring of business processes, and others.

product through faster communication with their customers, and better promoting and distributing their goods and services through online presence.

Yet, there is a striking lack of robust empirical evidence on the drivers of ICT adoption, on the impact of ICT on productivity, and on the factors underlying the positive impacts of ICT in the African context.[4] This study seeks to fill the gap.

The observations and discussions presented above help explain why the adoption of ICT-capital by firms is not made like any other investment in physical capital, and justify the interest and choice devoted to the analysis of ICT-capital in this research. Using a large cross-country firm-level data of about 6,300 firms in 19 SSA countries, namely, African Investors Survey (AIS) 2010 collected by the UNIDO in 2010-2011, this research aims at addressing the following two research questions:

i. What are the factors that impede or discourage some African firms from adopting and using ICT-capital to increase their productivity?

ii. What is the impact of ICT-capital on labour productivity for ICT adopters at the firm-level in SSA countries?

To highlight the importance and relevance of different research objectives, we formulate three main research hypotheses concerning the adoption of ICT as well as on the impact of these technologies on labour productivity of ICT adopting firms. Firms need capital to produce goods and services. When considering investments, such as ICT-capital investment, the firm's income is one of the most interesting determinants to watch, as an increase in the level of production is likely to stimulate capital demand and therefore to increase investments. Therefore, an increase in firm's income is likely to boost investment. In a precise manner, we postulate that:

a. The ICT-capital intensity increases with the firm's income.

b. The labour productivity of adopters increases with investments in ICT-capital intensity.

c. An increase in ICT-capital intensity is associated with an increase in labour productivity when firms have conducted a process of innovation.

The main policy relevance of this research is to contribute to a clearer understanding of what could be done to enable firms in SSA countries to take the best from ICT to improve their productivity. The results could be used as part of national strategies to

4 Asongu and Nwachukwu, (2018) argues that, Africa generally has the lowest ICT penetration rate in the world.

promote ICT adoption by local firms, since there are still many African firms that are reluctant to engage in the new economy: a recent AIS conducted by the UNIDO in 2010 and 2011 in 19 SSA did in fact reveal that there are about 27% of firms with zero United States Dollars (USD) invested in ICT assets. Also, this research will contribute to clarifying channels through which firms could harness substantial productivity gains from their ICT investments. Finally, policy makers would be made aware of some specific levies they could use to ensure greater uptake of the ICT productivity gains by individual firms.

Data sources

To address our research questions, we will exploit a large cross-country firm-level database that contains a wide array of information on 6,373 firms from 19 SSA countries (Burkina-Faso, Burundi, Cameroon, Cape Verde, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mali, Mozambique, Niger, Nigeria, Rwanda, Senegal, Tanzania, Uganda, and Zambia). This is the first time that such data will be used to study the impact of ICT on productivity in the African context.

The data has been collected and harmonized through AIS (2010) across 19 SSA countries. AIS (2010) was conducted by UNIDO over the period 2010-2011, and the survey method involved face-to-face interviews with top-level managers of foreign- and domestic-owned firms active in the following sectors: agriculture,[5] manufacturing, mining, utilities, construction, and services.

The survey was designed to cover a representative sample of all public and private sector, for-profit enterprises which were registered and employed more than ten people. Apart from each firm's contact details, the representative sample was built for each country by stratifying the sampling frames along the dimensions of size (number of employees, assets, or output),[6] ownership status (foreign- or domestic-owned),[7] and economic sub-sector.[8]

5 Agriculture in this survey represents all the companies that deal with fertilizers and pesticides, farm implements and inputs, and agricultural machinery.

6 Size groups (Small-Medium-Large) has been measured in terms of number of full-time employees, output and fixed assets. In the surveys notes, UNIDO has mentioned that size groups in terms of output and number of full-time employees depends on the country. However, assets have kept the same measure in all countries of the database.

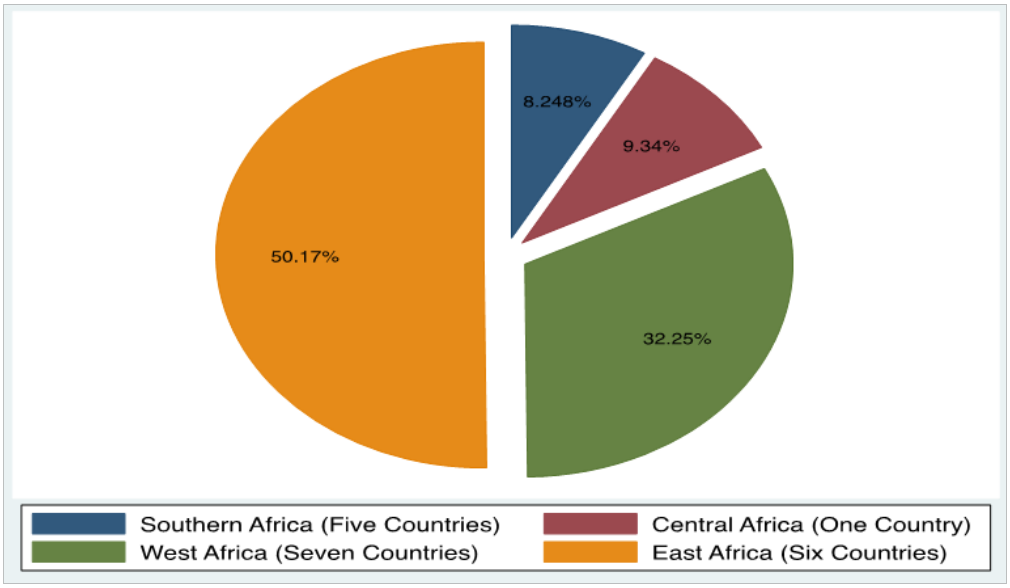
7 OECD in 2008 recommended the 10% threshold to define the ownership. The AIS (2010) survey follows the OECD definition of ownership which considers all Foreign Direct Investment (FDI) that gives the foreign investor ownership of 10% or more of the shares of a firm as FDI.

8 A full description of the design and implementation of the survey is available in UNIDO (2011).

Unfortunately, UNIDO did not publish in its reports the response rate of the companies interviewed in this rich survey. This information could have provided information on investors' interest in having a credible and reliable database for investment analysis in Africa, both by firms that participated in the surveys and by government authorities, development organizations, private sector associations and financial institutions. Also, there are no sampling weights available, despite all the efforts made to UNIDO to obtain this information; we will carefully interpret any of the descriptive statistics, as they may reflect the oversampling of large firms. We will test whether any observed differences remain when controlling for size.

To assure that data collected by the enumerators was reliable, several levels of quality checks were instituted before, during and after the data collection phase. These involved human checking in the field by enumerators and supervisors and at UNIDO headquarters. Several algorithms were employed at the data collection point, as well as in subsequent stages for consistency checking. The reviews of questionnaires involved frequent re-visits and re-call of interviewees to ensure replies were accurately recorded. We filtered the data to focus on our subject of interest. The wide array of information contained in UNIDO data set is described in the figures and tables below.[9]

Figure 1: Distribution of ICT-capital investments by sub-region



Source: AIS 2010, UNIDO.

9 The distribution by sub-region is presented as follows. Southern Africa: Lesotho, Madagascar, Malawi, Mozambique and Zambia; Central Africa: Cameroon; East Africa: Burundi, Ethiopia, Kenya, Uganda, Tanzania and Rwanda; West Africa: Burkina Faso, Cape Verde, Ghana, Mali, Niger, Nigeria and Senegal.

The distribution of firms by sub-region, shown in Figure 1, was inspired from the proposed distribution by the African Development Bank (AfDB) in 2014 in its report on trade financing in Africa. In the light of Figure 1, it appears that Southern Africa and Central Africa are poorly represented in terms of investment in ICT-capital, compared to East Africa and West Africa which account, respectively, for 50.17% and 32.25% of ICT-capital investments in our database.

This result suggests that there are factors that encourage or impede some firms to adopt ICT-capital. These factors will be analyzed with appropriate methods, later in the paper.

Table 1: Repartition of firms by sub-region

Sub-Region	Firms	Percent
Central Africa	270	4.24
East Africa	2,766	43.40
Southern Africa		
West Africa	1,130	
2,207	17.73	
34.63		
Total	6,373	100

Source: AIS 2010, UNIDO.

Table 1 provides a distribution of the number of firms (6,373 in total) by sub-region. This distribution follows practically the same pattern as that shown at Figure 1, on the amount of investment in ICT-capital, for East Africa and West Africa. Central Africa, on the other hand, has fewer companies than Southern Africa but, moreover, has much more invested than Southern Africa in terms of ICT-capital.

In contrast, the trend is reversed for Southern Africa and Central Africa because, in terms of the distribution of the number of firms, we note that Central Africa has far fewer firms (4%) than Southern Africa that represents 18% of firms, while in respect of the volume of ICT-capital investment as highlighted in Figure 1, Central Africa has 9.34% of investments against 8.24% for Southern Africa. This interpretation justifies, once again, the interest to wonder about the various factors which could influence the adoption or not of ICT-capital in firms in SSA countries.

Conclusion and policy recommendations

There is extensive literature in the industrialized countries both on the determinants of the adoption of ICT- capital and on the impact of ICT- capital intensity on labour productivity. By contrast, in developing countries, and in SSA countries particularly, very few studies have focused on these issues. This study had set a goal to contribute

to the literature and to fill this gap. To be more precise, the main idea of this paper was structured around two main objectives. The first research question conducted on our analysis was to identify and analyse the major determinants of the ICT-capital adoption in SSA countries. Our second concern was to estimate the impact of ICT-capital intensity on firms' labour productivity in SSA countries.

To answer these research questions, we postulated three hypotheses as follow. Firstly, the likelihood of ICT-capital adoption increases with the firm's income; secondly, the labour productivity of adopters increases with investments in ICT-capital intensity; and finally an increase in ICT-capital intensity is associated with an increase in labour productivity when OC is present.

The necessary data to this analysis were collected and harmonized by UNIDO in the AIS (2010), carried out in Africa over the period 2010-2011. The descriptive analysis of the data has revealed several information and among other things that, on average, ICT-capital investment varies according to firms' size while labour productivity varies according to the firms' age and that Southern African firms, on average, adopt and use ICT-capital more intensively than other African countries. Several lessons can be learned from this situation. In this regard, public authorities and development partners in this sub-region must work together to firstly strengthen connectivity by focusing on cost reduction of regional and national Internet backbones and secondly promote access to the Internet and make the bandwidth available while integrating ICT in the delivery of public services and sectorial projects to facilitate the application of ICT.

To carry out these investigations, the research methodology was inspired, on the one hand, by the Tobit model to correct the existing censoring problem in the available data and, on the other hand, by IV method required to address the endogeneity problem of ICT-capital intensity in the model. On completion of the various analyses of sensitivity and robustness checks, it is noted that the results obtained are very insensitive to sample subdivisions. Also, it emerges that the model is identified and that, the selected instruments are not weak and are valid. Furthermore, it appears from this study that income, wages, and firms' size are significant determinants of the ICT-capital adoption.

In view of the results obtained, we can see that the companies which have a high income and paying high wages have a high propensity to adopt ICT. Also, large, and medium-sized enterprises as well as companies that export adopt ICT much more. However, at the policy level, government and policy makers must provide support through programmes designed to facilitate the adoption of ICT by all firms in general, but particularly small business unable to export their goods and services and firms paying low wages.

Compared to the Cobb-Douglas production function, the Translog production function has been tested to be more adequate with our data set. Moreover, using the Translog model, the study reveals that the impact of ICT-capital intensity on labour productivity in SSA countries is positive and significant in the presence of OC. This means that firms investing in ICTs significantly improve their productivity and hence their performance. This would allow these firms to become more competitive, more offensive and, ultimately, this could logically allow them to increase their market share.

Also, the estimated coefficient of ordinary capital squared, firms' size and firms' age are positive and significant, after correction the endogeneity problem in the model using IV method. The share of women is negative and significant at 5% level of significance. This suggests several ideas related to gender issues. It highlights the need for adequate training of women directed towards firms; it also shows women's unequal access to have jobs in the firms.

The OC and the interaction term between OC and ICT-capital are non-significant. This result is remarkable and requires more advanced investigations in future work. Maybe there could be a study on the impact of OC, but not for all types of firms, that deserves special attention in a future paper.

It is therefore important, not only to improve access to ICTs by government and public authorities, but also to generate the policies necessary to advancing the ICT skills, knowledge and capacities of workers at the firm level. Also, firms' owners must put their hands in the dough to develop skills and training of employees and managers in the firm so that they can effectively use available and existing resources and infrastructure.

Given that some firms cannot afford to pay for training for their workers, policy actions such as developing a flexible design for ICT training, electronical learning courses and exchange mechanisms for ICT skills training resources, as well as fostering ICT education at all levels should be followed more intensively. This will lead to more adequately trained ICT practitioners and users to meet the growing needs of firms. Firms' managers should be encouraged to implement OC within their firms, because OC are very complementary investments in ICT-capital, and this could allow firms to significantly increase their productivity.

In addition, policy makers and development community interested in promoting ICT as tools for improving business could use the results of this study to better develop their strategies. Finally, we expect that through dissemination activities, African firms will be sensitized and informed on the ways they can use the most of ICT-capital to improve their productivity.

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