Information and Communication Technologies and Firms Productivity in Cameroon*

Pierre Valére Nketcha Nana[1] and Christophe Péguy Choub Faha[1,2,**]

[1] Department of Economics, Université Laval, Canada
{vnketcha,fpeguy}@yahoo.fr
[2] 2276, Place Versailles, G1V1S1, QC, Canada

Abstract. Using panel data from manufacturing firms in Cameroon, this study investigates the impact of Information and Communication Technologies (ICTs) on firms' productivity in Cameroon. The empirical model is derived from the flexible Translog production function. The strategic complementarities between ICT-capital and organizational changes are accounted for. We estimate our model using the System-Generalized Method of Moments (GMMS) estimator as it is adequate to deal with endogeneity issues. Our results reveal that the effects of ICT on productivity are catalyzed by the implementation of organizational changes. Moreover, we identified the specific organizational changes that deliver the highest benefits.

Keywords: ICT, Productivity, System-GMM Estimators, Organisational Changes.

1 Introduction

In 1995, Cameroon has launched a nationwide program to promote the adoption of Information and Communication Technologies (ICTs) by local firms. A recent survey, carried out by the National Institute of Statistics in 2006, reveals that 56% of companies have invested in at least a basic form of ICTs. However, it is unclear whether and to what extent these technologies have contributed to the growth of productivity. This issue is ever more important since about 40% of local firms are still reluctant to use ICTs [1].

The role of ICT in improving business productivity is however at the forefront of development strategies. Theoretically, ICTs can significantly contribute to firms' productivity through the improvement of production processes; especially by facilitating transactions and by stimulating labour productivity and multifactor productivity.

Yet, recent empirical evidence from developing countries suggests that increased investment in ICTs does not necessarily lead to higher productivity,

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** Corresponding author.

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[2,3]. This might reduce firms' incentives to use ICTs, especially when they are facing tight budgetary constraints. In addition, many firms are still using traditional methods and these firms can switch to use ICTs only if the benefits derived are higher than the investment and maintenance costs.

In the light of developed countries' experience, it appeared that the mere accumulation of ICT capital is not enough. How those technologies are used within the firm is determinant. For example, if firms introduce complementary organizational changes along with investments in ICT, the productivity gains will be more important, [5,6]. Note that these complementary investments require technical expertise and financial resources that might be limited in small and medium enterprises.

At the macroeconomic level, a set of conditions should also be ensured to allow productivity use of ICT at the firm level, namely, the availability of skilled labor, regular electricity supply, adequate telecommunication infrastructure, etc. Thus, in the absence of an enabling environment, it might not be very productive to invest in ICT; may be one reason why firms' investments in ICT are still very low in Cameroon.

In fact, between 2000 and 2006, investments in ICT represent an average of 7% of total firm's investments in our sample. As shown in Fig. 1, ICT-investments decreased by 12% during this period[1], while total investment felt by 3.6% only. This suggests a kind of distrust of the firms with regard to ICT.

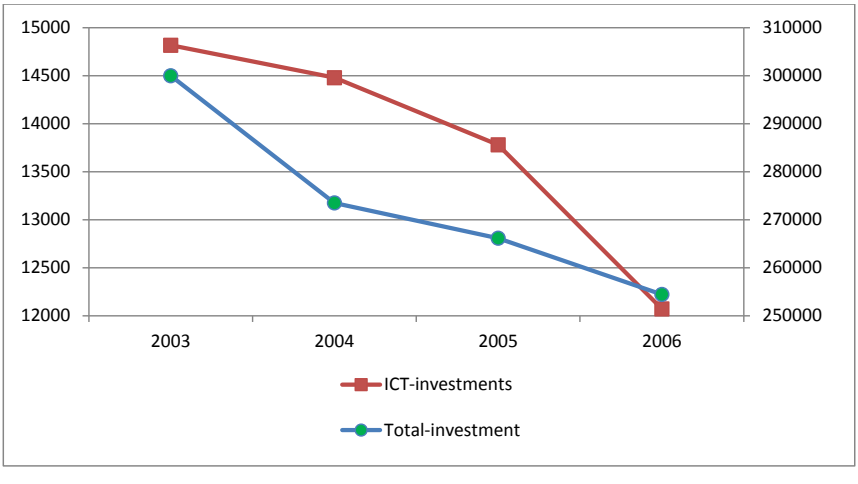

Fig. 1. Evolution of Investments (in Millions of Francs)

This study proposes to examine closely the impact of ICTs on firm productivity in Cameroon, paying particular attention to the role of organizational change. Specifically, our aims are to:

[1] Conjuncture Survey, Ministry of Economy and Finance.

- estimate the elasticity of output with respect to ICT capital;
- determine if the implementation of organizational changes improve the productivity gains from the ICT-capital;
- identify the different types of organizational changes that are more likely to maximize the benefits of ICT investment in Cameroon.

The paper is organized as follows: The next section reviews the literature on the impacts of ICTs on firms' productivity. Section 3 presents the methodological framework. Section 4 describes the data. Section 5 presents and discusses the preliminary results, and Section 6 concludes.

2 Literature Review

In the early 1980s, most studies on the relationship between ICTs and productivity led to the statement of the paradox of productivity [7]. This "lack of ICTs in the productivity statistics" ultimately turns to be a problem of measurement of ICTs and the value they create, particularly in the sector of services where output is particularly difficult to identify.

Subsequent studies on manufacturing firms have in fact led to positive results [4,8], particularly because of improvements in the measurement of output so as to account for qualitative aspect of ICTs'[2] impact.

In developing countries on the contrary, the efficiency of ICTs as a factor in firm performance is still hampered by the lack of a solid empirical foundation. [9] and [6] on the contrary report a negative impact of ICTs on labour productivity in Small and Medium Scale Enterprises (SMEs) in Kenya and Tanzania. Such a result would indicate that on average the use of ICTs is not beneficial for firms in developing countries.

More generally, ICTs have higher impacts primarily where skills in ICT were improved, and where organizational changes were implemented. Therefore, the productivity paradox that have been highlighted by [9] and [2] for the case of Eastern African firms may be due to the fact that organizational changes or qualification of employees in using ICT were not accounted for in the underlying empirical models.

In a nutshell, if we have convincing evidence for developed countries that ICTs contribute to higher productivity in firms, the issue is still unresolved as far as developing countries are concerned. This may be due to the paucity of robust empirical analyses. In a study on Brazil and India, [10] have taken into consideration the impact of organizational changes while estimating the impact of ICTs on firms' productivity. Yet, their results may be biased because they do not deal with the potential issue of simultaneity in the input and output choices at the firm level. Clearly, for the purpose of effective policy making, we need robust evidence about the real economic impacts of ICTs on firms' productivity, as well as the necessary conditions to ensure the highest positive impacts.

[2] This is in particularly the improvement of the quality of output and labor input, the variety of products, quality customer service, reducing delays.

3 Methodology

The theoretical framework commonly used is the production function theory [8]. The underlying assumption is that the firm has a method for transforming various inputs into output, and the process can be represented by a production function. This requires a particular specification of the relationship between the inputs and the outputs.

The Cobb-Douglas specification is commonly used in previous studies, particularly because of its simplicity. It is however a very restrictive specification, compared to the Translog specification that offers the advantage of being more flexible [11,12]. Hence, we will use a Translog-based specification in this study. The resulting empirical model is specified as follows:

$$\begin{aligned} LnY_{it} = \mu_{it} + \beta_1 LnN_{it} + \beta_{11}(LnN_{it})^2 + \beta_2 LnTIC_{it} \\ +\beta_{22}(LnTIC_{it})^2 + \beta_3 LnK_{it} + \beta_{33}(LnK_{it})^2 + \beta_{12} LnN_{it} LnTIC_{it} \\ +\beta_{13} LnN_{it} LnK_{it} + \beta_{23} LnTIC_{it} LnK_{it} + \beta_4 TIC_{it} ORG_i \end{aligned} \tag{1}$$

$$\mu_{it} = \eta_i + \gamma_t + \epsilon_{it} \tag{2}$$

The index i refers to the individual units of firms, and index t the temporal observations. The variables η_i are time-invariant firm-specific effects. The variables γ_t are time-specific effects, strictly identical across individuals. ϵ_{it} is the component of the residual term which is orthogonal to η_i and γ_t . A key assumption we maintain throughout is that ϵ_{it} is a disturbance term independently and identically distributed, which satisfy the following assumptions:

$$E(\epsilon_{it}) = 0 \tag{3}$$

$$E(\epsilon_{it}, \epsilon_{js}) = 0, \ \ \forall j \neq i, \ \ \forall (t, s) \tag{4}$$

$$E(\epsilon_{it}, \epsilon_{is}) = \begin{cases} \sigma_\epsilon^2 \ si \ \ t=s \\ 0 \ \forall t \neq s \end{cases}, \quad which\ implies\ that\ E(\epsilon_i, \epsilon_i) = \sigma_\epsilon^2 I_T \tag{5}$$

Y is the output: This variable is defined by the value added calculated before tax. This definition takes into account improvements in the quality of output in relation to the use of ICTs.

N is employment: It is measured by the number of employees including staff employed full time, part time or seasonally.

K and TIC are respectively the stock of ICT-capital and ordinary capital : Capital stocks are calculated using a proportional downgrading model that will easily express the amount of capital of a period depending on the capital of the previous period and the volume of investment in the previous period.

$TIC_{it} ORG_i$ is a multiplicative dummy variable. It captures the indirect impact of ICTs on productivity resulting from the strategic complementarities between organizational changes[3] (measured by ORG_i) and ICT see [11] and [10].

[3] Detailed definition is presented below.

In general, taking into account the organizational changes in empirical studies is controversial and this is due to the absence of a universally accepted definition of the concept [13]. Indeed, the concept of organizational change refers to a complex set of changes affecting not only the internal organization of the firm but also its relationships with its customers or business partners. Concretely, it is when a firm redefines or restructures a number of factors such as the hierarchical structure, the political incentive to work, or the management of customer services.

In this study, it is still possible to evaluate the appropriateness of some practices identified in the literature as "best practices". In fact, these practices have effectiveness in obtaining high yields of investments in ICTs in the context of developed countries [14,15]. The focus here will be to question the relevance of these practices for Cameroonian firms that have invested in ICTs. Similar approach by [10] has rightly questioned the relevance of some of these practices in the case of Indian firms. What about the case of Cameroon?

To assess the impact of organizational practices on the marginal return of ICTs capital, the corresponding dummy variables are taken into account in estimating the following model (1). Following methodologies [10], [13] and [15], organizational variables will be taken into account individually.

The marginal contribution of an input to total output depends on the level of utilization of all factors of production. They are expressed as follows, respectively for employment, ICT capital and ordinary capital:

$$\overline{\alpha}_N = \frac{\partial Y_{it}}{\partial N_{it}} = \beta_1 + 2\beta_{11}\overline{LnN_{it}} + \beta_{12}\overline{LnTIC_{it}} + \beta_{13}\overline{LnK_{it}} \tag{6}$$

$$\overline{\alpha}_{TIC} = \frac{\partial Y_{it}}{\partial TIC_{it}} = \beta_2 + 2\beta_{22}\overline{LnTIC_{it}} + \beta_{12}\overline{LnN_{it}} + \beta_{23}\overline{LnK_{it}} \tag{7}$$

$$\overline{\alpha}_K = \frac{\partial Y_{it}}{\partial K_{it}} = \beta_3 + 2\beta_{33}\overline{LnK_{it}} + \beta_{13}\overline{LnTIC_{it}} + \beta_{23}\overline{LnK_{it}} \tag{8}$$

To estimate the parameters of the production function, several studies [9,2] have used the approach of Ordinary Least Squares (OLS). However, in the presence of simultaneity and/or unobserved heterogeneity, the standard OLS estimators generally turns to be unsatisfactory and the resulting estimates are less efficient in terms of statistical properties [16].

The unobserved heterogeneity bias is possible because the strategies of highly productive firms are usually different from the strategies of firms that are not in such a way that if highly productive firms, invest more in ICTs, the results will be overestimated. The simultaneity bias arises because the choice of inputs is often a function of the level of output that the company wants to achieve and therefore the capital stock and productivity are correlated.

The estimation of a production function on individual data by taking into account the simultaneity bias and/or heterogeneity does not always produce satisfactory results [16]. In this context, the estimator of the Generalized Method of Moments in first Differences (GMMD) is generally used. However, [17] show that the properties of the estimator are weak when the variables are highly

persistent, as it is usually the case with series of sales, added value, capital and employment. In this case, delayed variables in levels are weakly correlated with the equations in first differences (weak instruments).

[17] also show that the implementation of the Generalised Method of Moments in System (GMMS), by combining information from first-difference equations (standard instruments) and level (instruments in first differences) and by imposing initial conditions can significantly improve the quality of results.

[18] applied the GMMS method to assess the impact of ICTs on firms' productivity in Europe and discovered that GMMS estimators are more efficient than OLS estimators and GMMD. In the context of this work, we will use the GMMS method. From what we know, this estimation approach has not yet been used in previous studies assessing the impact of ICT on productivity in the context of developing countries. GMMS estimations of parameters of production function will be obtained using the GAUSS DPD98 program developed by [19].

Finally, the quality of the estimated coefficients of the model (1) depends on the validity of instruments that should not be correlated with the disturbance in order to correct the regression. This hypothesis will be tested using a Sargan test. In addition, since the equation of reference is passed in first difference, the residues thus obtained are supposed to be correlated to the order 1, but not to order 2. The tests AR (1) and AR (2) [20] can be used to verify this.

4 Data

To implement our empirical methodology, we used data obtained from a field survey in addition to the data already available from the Fiscal and Statistics Statements (FSS) at the National Institute of Statistics. From the FSS, we collect all the necessary quantitative information. After all the statistical treatments[4] , we came out with an unbalanced panel of 344 firms with annual observations from 2003 to 2007.

From the survey, we collect the necessary qualitative variables to complete our database. The treatment of qualitative variables consists in attributing the value one to the variable measuring organizational change when a change is made in the company organization and zero otherwise. At the time of the survey, 320 of the 344 firms of our first database have been identified, and 261 were able to provide qualitative information necessary to measure the organizational changes. Finally, we merged the two databases and obtain an unbalanced panel of 261 firms over 5 years[5] . The main descriptive statistics of the panel are presented as follows:

[4] Firstly, from the raw dataset, firms with inconsistent information in the FSS have been removed. Secondly, to account for the entry-exit in the population of firms, only firms that produced their FSS for at least two consecutive years between 2003 and 2007 have been considered.

[5] Data for the more recent years are not included because the recent FSS are not officially released by the National Institute of Statistics yet.

Table 1. Descriptive Statistics of Key Variables (Log)

Variables	Obs.	Firms	Mean	Med.	S.d.	Min	Max
value added	1238	261	2.313	1.497	6.693	0.003	5.560
Employment	1238	261	6.001	5.540	6.693	2.303	9.327
ICT-Capital	1238	261	1.908	3.009	4.067	0.001	6.778
Non ICT-Capital	1238	261	6.777	5.743	4.250	3.196	13.749

Source: Authors' Calculations

5 Estimation Results

Table 2 presents in a concise manner the estimation results of our empirical Translog model by GMMS on the entire sample.

Table 2. Estimation Results for the Translog by GMMS

Dependent variable: lnY			
	ORG= Decentralization	**ORG= Workplace organization**	**ORG= Human resources practices**
LnN	$1,258^{***}$	$1,385^{***}$	$1,238^{***}$
	(0,157)	(0,156)	(0,153)
$LnICT$	-0,042	-0,019	-0,027
	(0,061)	(0,063)	(0.059)
LnK	$0,153^{***}$	$0,198^{***}$	$0,111^{***}$
	(0,083)	(0,088)	(0,08)
$(LnN)^2$	$-0,033^{***}$	$0,011^{***}$	$0,028^{***}$
	(0,017)	(0,016)	(0,014)
$(LnICT)^2$	$0,002^{**}$	$0,001^{***}$	$0,005^{**}$
	(0,007)	(0,004)	(0,006)
$(LnK)^2$	0,011	0,014	0,018
	(0,006)	(0,007)	(0,003)
$LnN * LnICT$	$0,034^{***}$	$0,042^{**}$	$0,024^{***}$
	(0,017)	(0,015)	(0,021)
$LnN * LnK$	-0,009	-0,005	$-0,008^{*}$
	(0,006)	(0,001)	(0,007)
$LnICT * LnK$	-0,007	-0,003	-0,004
	(0,005)	(0,008)	(0,007)
$ICT * ORG$	0,017	$0,019^{**}$	0,018
	(0,012)	(0,02)	(0,014)
R^2	0,831	0,798	0,856
Dif. Sargan (p-values)	0,56	0,572	0,479
AR(1)	0,008	0,006	0,009
AR(2)	0,033	0,037	0,041

Source: Authors' estimation from the DPD98 program running in GAUSS.
$***$, $**$ *and* $*$ denote significance at 1, 5 and 10% level, respectively.
Values in parentheses represent standard deviations. The results are those of the two-step GMMS estimator.

As discussed in the "methodology" section, the GMMS estimator is robust to potential endogeneity issues, which allows us to interpret the results in terms of causality; the results presented in Table 2 show that the direct impact of ICT-capital depends on the level of investment in ICT. In fact, the coefficient of the quadratic term for the ICT-capital is positive and significant; while the coefficient of the simple ICT-capital is negative. Thus, the higher the amount firms invest in ICT, the more the input "ICT-capital" is productive.

Based on a Cobb-Douglas model, [4] had revealed that the direct impact of ICT-capital is negative in the case of firms in the East Africa. Our analysis enables to understand that their result depends crucially on the level of investment in ICT. We see the advantage of using flexible Translog based empirical model that the more restrictive Cobb-Douglas-based models as in previous studies.

As we indicated earlier, another approach to better understand the impact of ICTs on firm's productivity is to consider the role of organizational changes. Three specific measures of organizational changes are considered, namely the "decentralization of competences", which is a measure of whether the number of hierarchical or reporting levels has decreased, and if employees have autonomy of decision in the company; the "workplace reorganization", which is a measure of whether firms have introduced performance compensation scheme, or a flexibility in programming and management of working hours; and the "human resources practices", which is a measure of whether firms have put more emphasis on the monitoring of individual workers or teams of workers.

The results presented in Table 2 show that the coefficient on the interaction term between ICT capital and organizational changes is positive for all measures of organizational changes that we used. This confirms the view that the productivity of ICT is improved when complementary organizational changes are implemented within the firm. However, only the effect of the "workplace organization" is significant. This suggests that if the organizational changes are important for improving the productivity of ICT, the impacts are not the same for all types of changes. "Workplace organization" seems to be the best type of complementary organizational changes.

6 Conclusion

At the end of this analysis, a number of important results have been established. First, the direct impact of ICT on productivity depends on how much firms spent in these technologies. This can be easily understood when we know that to take advantage of the basic ICT equipment such as computers, it is necessary to invest in the purchase of software, network hardware and other technical means necessary to process and share information. All those other components of the ICT-capital are relatively more expensive than basic computers, but they are important otherwise, investments in computers will not be productive.

Second, our results showed that in addition to contributing directly to firms' productivity, ICT also contributes indirectly through the improvement of labor productivity. In fact, our results have revealed that the elasticity of output with respect to employment increases with the level of investment in ICT.

Finally, our results showed that the implementation of organizational changes can improve the impact of ICT. Furthermore, it appeared that among all types of organizational changes we considered, the introduction of performance compensation is the best.

References

1. Research ICT Africa: Towards an African E-Index: SME E-Access and Usage in 14 African Countries, Johannesburg: The Link Centre, http://www.researchictafrica.net/images/upload/SMEbook-Web.pdf
2. Chowdhury, S.K.: Investments in ICT-Capital and Economic Performance of Mmall and Medium Scale Enterprises in East Africa. Journal of International Development 18, 533–552 (2006)
3. Dewan, S., Kraemer, K.L.: The Grid: Information Technology and Productivity: Preliminary Evidence from Country-Level Data. Management Science 46(4), 548–562 (2000)
4. Lichtenberg, F.: The output contributions of computer equipment and personal: A firm-level analysis. Economics of Innovation and New Technology 3, 201–217 (1995)
5. Bryjolfsson, E., Hitt, L.: Beyond computation: information technology, organisational transformation and business performance. Journal of Economic Perspectives 14, 23–48 (2000)
6. Brynjolfsson, E., Hitt, L., Yang, S.: Intangible assets: computers and organizational capital. Brooking Papers on Economic Activity 1, 137–199 (2002)
7. Bryjolfsson, E., Yang, S.: Information technology and productivity: A review of the literature. Advances in Computers 43, 179–214 (1996)
8. Bryjolfsson, E., Hitt, L.: Paradox lost? Firm-level evidence on the returns to information systems spending. Management Science 42(4), 541–558 (1996)
9. Matambalya, F., Wolf, S.: The role of ICT for the performance of SMEs in East Africa. Discussion Paper on Development Policy No. 42, ZEF (2001)
10. Basant, R., Commander, S., Harrisson, R., Menezes-Filho, N.: ICT adoption and productivity in developing countries: New firm level evidence from Brazil and India. Discussion Paper No. 2294, IZA (2006)
11. Hempell, T.: Does experience matter? Innovation and the productivity of ICT in German services. Economics of Innovation and New Technology 14(4), 277–303 (2005)
12. Sumit, S., Jung, C.: A study of the impact of information technology on firm performance: a flexible production function approach. Information System Journal 19(3), 313–339 (2007)
13. Black, S.E., Lynch, L.M.: Measuring organizational capital in the new economy. Discussion Paper No. 1524, IZA (2005)
14. Gera, S., Gu, W.: The effect of organizational innovation and information and communications technology on firm performance. International Productivity Monitor 4, 37–51 (2004)
15. Arvanitis, S.: Computerization, workplace organization, skilled Labour and firm productivity: evidence for the Swiss business sector. Economics of Innovation and New Technology 14(4), 225–249 (2005)
16. Griliches, Z., Mairesse, J.: Production functions: the search for identification. In: Strom, S. (ed.) Essays in Honour of Ragnar Frisch. Econometric Society Monograph Series. Cambridge University Press, Cambridge (1997)

17. Blundell, R., Bond, S.: GMM estimation with persistent panel data: an application to production functions. Econometric Reviews 19(3), 321–340 (2000)
18. Hempell, T.: What's spurious, what's real? Measuring the productivity impacts of ICT at the firm-level. Centre for European Economic Research, Discussion Paper, No. 02–42, Zew (2002)
19. Arellano, M., Bond, S.: Dynamic panel data estimation using DPD98 for GAUSS: a guide for users (1998), http://www.american.edu/academic.depts/cas/econ/gaussres/regress/dpd/dpd98.pdf
20. Arellano, M., Bond, S.: Some tests of specification for Panel Data: Monte Carlo evidence and an application to employment equations. Review of Economic Studies 58(2), 277–297 (1991)