

**Information and Communication Technologies and Firms
Productivity in Cameroon**

By

Nketcha Nana Pierre Valère¹ & Choub Faha Christophe Péguy

University of Yaounde II

Cameroon

ICBE-RF Research Report No. 11/12

Investment Climate and Business Environment Research Fund
(ICBE-RF)

www.trustafrica.org/icbe

Dakar, April 2012

¹ Contact : vnketcha@yahoo.fr

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.

Acknowledgements

We acknowledge the grant support from ICBE through the joint project of TrustAfrica and IDRC that allowed us to achieve this research.

Table of Contents

Abstract	ii
Acknowledgements	ii
Table of Contents	iii
List of Tables	iv
List of Figures	iv
1. Introduction	5
2. Literature review.....	7
3. Methodology.....	9
4. Data.....	16
5. Estimation Results	17
6. Conclusion.....	19
References.....	21
Annexes.....	24

List of Tables

Table 1: Descriptive statistics of key variables (log).....	17
Table 2 : Estimation results for the Translog model.....	18
Table 3: Distribution of firms by size	24
Table 4: Statistics on the workforce, total investment, ICT investment and the value added for the full sample.....	24

List of Figures

Figure 1: Evolution of investments (in millions of francs).....	6
---	---

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 percent of local firms are still reluctant to use ICTs (RIA, 2006).

The role of ICT in improving business productivity is however at the forefront of development strategies (UNCTAD, 2003; 2005). 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. This impact stems from the role that ICTs play as an input and on other hand, from their ability to reduce transaction costs and improve the coordination of different activities, not only within the firm (Dedrick and al., 2002), but also externally with business partners (Kaplan and Norton, 1992).

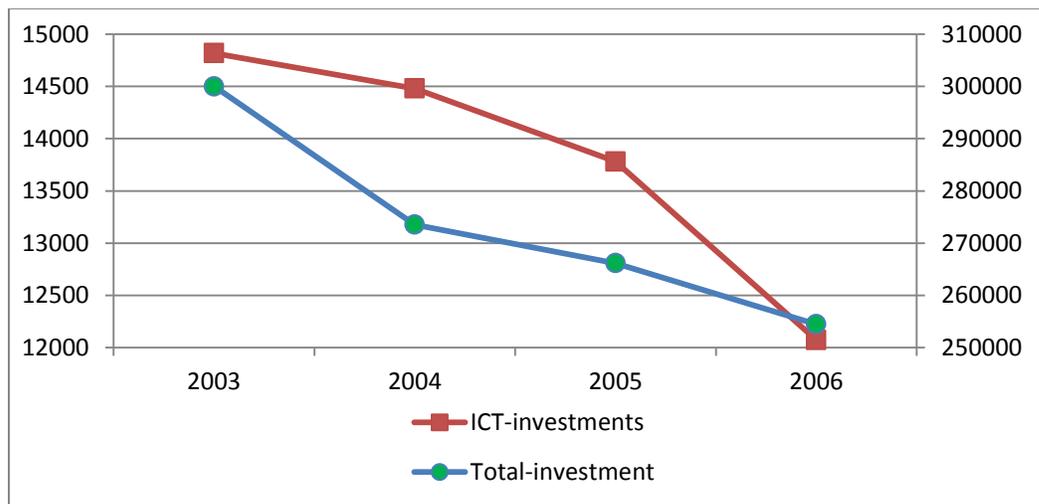
Yet, recent empirical evidence from developing countries suggests that increased investment in ICTs does not necessarily lead to higher productivity (Dewan and Kraemer, 2000; Lal, 2001; Chowdhury, 2006). This might reduce firms' incentives to use ICTs, especially when they are facing tight budgetary 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 (Brynjolfsson and Hitt, 2000, Bresnahan et al., 2002). 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 Figure 1, ICT-investments decreased by 12% during this period, while total investment felt by 3.6% only. This suggests a kind of distrust of the firms with regard to ICT.

Figure 1: Evolution of investments (in millions of francs)



Source: Conjuncture Survey, MINEFI

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:

- 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 (Brynjolfsson and Yang, 1996). 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 (Siegel's 1994, Lichtenberg 1995, Brynjolfsson and Hitt 1996, Lehr and Lichtenberg 1999), particularly because of improvements in the measurement of output so as to account for qualitative aspect of ICTs² impact. Measuring the value created by ICTs is still a challenge as Berndt and Morrison (1995) on the one hand, and Jorgenson and Stiroh (1995) on the other hand, obtained contradictory results after working on the same period. But generally, this type of inconsistency often common in the literature emphasizes the relevance of methodology, measurement of performance and quality of data in the results.

Taking advantage of the methodological improvements, the general trend that emerges from recent studies is that of a positive relationship between ICTs and firm performance in developed countries (OECD, 2003). In particular, Arvanitis (2004) shows that labor productivity in Swiss firms is closely correlated with the use of ICTs. Maliranta and Rouvinen (2004) have obtained similar results in the case of Finland.

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. The World Bank (2006) shows positive correlation between measures of ICTs and some indicators of

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

firms' performance. Matambalya and Wolf (2001) and Chowdhury (2006) 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. But these results do not clarify whether some firms are successful in finding productivity gains and if so, how they get there.

Studies carried out in developed countries have suggested that several factors may explain the "lack of informatics in statistics of productivity" in developing countries. Indeed, most results obtained in the case of developed countries confirm that relationships between ICTs and productivity of firms depend on particular circumstances in which the ICTs are used (Pilat, 2004). For example, Bresnahan et al. (2002) and Brynjolfsson, Hitt and Yang (2002) showed that firms with a decentralized organizational structure gained higher productivity from investments in ICTs than firms with a centralized structure.

These results are consistent with the thesis of strategic complementarities between ICTs and organizational changes originally highlighted by Milgrom and Roberts (1990). In addition, Gretton et al. (2004) have observed that the impacts of ICTs' use on the productivity growth in Australian firms were generally related to the level of human capital and skills within firms, as well as experience of these firms in innovation, adoption of advanced professional practices and intensity of organizational changes. Gera and Gu (2004) and Black and Lynch (2004) obtained similar results in the case of Canadian and U.S. firms respectively.

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 Matambalya and Wolf (2001) and Chowdhury (2006) 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, Basant et al. (2006) 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.

3. Methodology

As stated hereinbefore, this study aims at investigating the impacts of ICTs on firms' productivity in Cameroon, paying a special attention to the role of organizational changes.

The theoretical framework commonly used is the production function theory (Brynjolfsson and Hitt, 1996). 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 (Hempell, 2005; Sumit and Jung, 2007). Hence, we will use a Translog-based specification in this study. Following Hempell (2005a), our empirical model is specified as follows:

$$\begin{aligned}
 \ln Y_{it} = & \mu_{it} + \beta_1 \ln N_{it} + \beta_{11} (\ln N_{it})^2 + \beta_2 \ln TIC_{it} + \beta_{22} (\ln TIC_{it})^2 \\
 & + \beta_3 \ln K_{it} + \beta_{33} (\ln K_{it})^2 + \beta_{12} \ln N_{it} \ln TIC_{it} + \beta_{13} \ln N_{it} \ln K_{it} \\
 & + \beta_{23} \ln TIC_{it} \ln K_{it} + \beta_4 TIC_{it} ORG_i
 \end{aligned} \tag{1}$$

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

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, which allow for unobserved heterogeneity in the mean of the sales series across individuals. 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:

$$E(\varepsilon_{it})=0 \quad (3)$$

$$E(\varepsilon_{it}, \varepsilon_{is}) = \begin{cases} \sigma_\varepsilon^2 & t = s \\ 0 & \forall t \neq s \end{cases}, \text{ which implies that } E(\varepsilon_{it}, \varepsilon_{it'}) = \sigma_\varepsilon^2 I_T \text{ where } I_T$$

is identity matrix (T,T) (4)

$$E(\varepsilon_{it}, \varepsilon_{js}) = 0, \forall j \neq i, \forall (t,s) \quad (5)$$

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. Indeed, if ICTs improve the quality of output, consumers will be willing to pay a higher price to the firm, which increase the firm's value added.

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 I_{t-1} . Thus, if we consider K_{kt} the capital stock of the type k ($k = 1$ for non-ICTs capital stock and $k = 2$ for the stock of ICTs capital) in the period t , then we have:

$$K_{kt} = (1 - \delta_k)K_{k,t-1} + I_{k,t-1} \quad (6)$$

Where δ_k is the rate of depreciation for capital of type k . In the absence of information on capital stock, the initial volume is calculated using the method proposed by Hall and Mairesse (1995), and previously used by Hempell (2002; 2005a). Assuming a constant growth rate g_k for each type of capital investment k , the “Equation 6” above can be rewritten as follows for the period $t = 1$:

$$\begin{aligned}
K_{k1} &= I_{k0} + (1 - \delta_k)I_{k,-1} + (1 - \delta_k)^2 I_{k,-2} + \dots \\
&= \sum_{s=0}^{\infty} I_{k,-s} (1 - \delta_k)^s = I_{k,0} \sum_{s=0}^{\infty} \left[\frac{1 - \delta_k}{1 + g_k} \right]^s \\
&= \frac{I_{k,1}}{g_k + \delta_k} \tag{7}
\end{aligned}$$

Following Hempell (2002), we assume constant linear depreciation rate of 30% for ICT-capital; and 9% for conventional capital.

Investment in ICTs will be defined as the total investment of the firm minus the total ICT expenses as reported by the firm; total investment is all the capital expenditures incurred by the company that is to say expenditure in hardware and common equipment.

In general, ICTs refers to the means of acquiring, processing and disseminating information. Included are: computers and their peripherals, computer software and communication systems (telephones, videoconferencing systems, internet). However, under specific environmental Cameroon ICT which we refer in this study are: computers, software, intranet, extranet and internet.

$TIC_{it}ORG_{it}$ is a multiplicative dummy variable. It captures the indirect impact of ICTs on productivity resulting from the strategic complementarities between organizational changes³ (measured by ORG_i) and ICT (see Hempel, 2005; Basant et al., 2006). Thus, the elasticity of ICTs capital is stronger for firms involved in the restructuring of their organizational structure ($\alpha_4 > 0$).

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 (Vickery and Wurzburg, 1998, Black and Lynch, 2005). 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.

If the objective pursued through organizational change remains virtually the same from one firm to the other, the various organizational practices implemented, their combination or size vary depending on the firm's size, the sector of activity and even the country (Vickery and Wurzburg, 1998). In this context, it is difficult to state a general framework for measuring (and comparing the degree) of organizational changes in firms. A case study (by experts in organizational practices) would be more appropriate to evaluate the effectiveness of organizational changes within firms.

However, it is still possible in this study 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 (Gera and Gu, 2004, Bresnahan et al. 2002; Arvanitis, 2005). The focus here will be to question the relevance of these practices for Cameroonian firms that have invested in ICTs. A similar approach by Basant et al. (2006) has rightly questioned the relevance of some of these practices in the case of Indian firms. What about the case of Cameroon?

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; the “workplace reorganization”, which is a measure of whether firms have introduced performance compensation scheme; 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.

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 “Equation 1”. Next methodologies Basant et al. (2006), Black and Lynch (2004) and Arvanitis (2005), 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:

$$\bar{\alpha}_N = \frac{\partial Y_{it}}{\partial N_{it}} = \beta_1 + 2\beta_{11} \overline{\text{Ln}N_{it}} + \beta_{12} \overline{\text{LnTIC}_{it}} + \beta_{13} \overline{\text{Ln}K_{it}} \quad (8)$$

$$\bar{\alpha}_{TIC} = \frac{\partial Y_{it}}{\partial \text{TIC}_{it}} = \beta_2 + 2\beta_{22} \overline{\text{LnTIC}_{it}} + \beta_{12} \overline{\text{Ln}N_{it}} + \beta_{23} \overline{\text{Ln}K_{it}} \quad (9)$$

$$\bar{\alpha}_K = \frac{\partial Y_{it}}{\partial K_{it}} = \beta_3 + 2\beta_{33} \overline{\text{Ln}K_{it}} + \beta_{13} \overline{\text{Ln}N_{it}} + \beta_{23} \overline{\text{LnTIC}_{it}} \quad (10)$$

To estimate the parameters of the production function, several studies (Matambalya and Wolf, 2001; Chowdhury, 2006) 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 (Griliches and Mairesse, 1997).

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 main disadvantage of OLS estimates of “Equation 1” in this case is that explanatory variables are correlated with the error term μ_{it} due to the presence of individual specific term, and this correlation does not vanish as the number of individual units in the sample gets larger (see Bond, 2002).

Taking the “Equation 1” in first difference help remedy the problem of unobserved heterogeneity since it swept η_i from the model. In fact, given that $\eta_{i,t} - \eta_{i,t-1} = 0$, we obtain:

$$\Delta y_{it} = (\gamma_t - \gamma_{t-1}) + \tilde{\alpha} \Delta X_{it} + (\varepsilon_{it} - \varepsilon_{i,t-1}) \quad (11)$$

Where $\ln Y_{it}$ is replaced by y_{it} ; X is the matrix of all the explanatory variables; $\tilde{\alpha}$ is the parameter vector to estimate, and “ Δ ” denotes the changes from $t = 1$ to $t = 2$.

Now that the fixed-effects have been cancelled out, OLS can yield consistent estimates of $\tilde{\alpha}$ if the explanatory variables X_{it} are uncorrelated with ε_{it} . However, this is not the case since measurement errors, particularly in both types of capital are more likely, as argued by Brynjolfsson and Yang (1996).

Moreover, simultaneity in input and output decisions is also more likely and this introduces the simultaneity bias. 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 without taking into account the simultaneity bias does not always produce satisfactory results (Griliches and Mairesse, 1997).

In order to correct for these two potential sources of bias, the GMM estimation approach is applied for the “Equation 11” in first difference. This approach takes advantage of the panel structure of data by instrumenting contemporaneous inputs in first difference by their lagged values in the past. Specifically, Arellano and Bond (1991) proposed to use the corresponding levels of the lagged inputs X_{t-2} , X_{t-3} , X_{t-4} X_0 to instrument endogenous inputs at the right-hand side of “Equation 11”, leading to the following moment condition:

$$E[X_{i,t-s} \cdot (\varepsilon_{it} - \varepsilon_{i,t-1})] = 0 \text{ for } s = 1, 2, \dots, T. \quad (12)$$

“Equation 12” shows that there are more valid instruments than endogenous variable and this is the main advantage of GMM estimator over the standard Instrumental Variable⁴ estimator.

However, Blundell and Bond (1998) 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, lagged variables in levels are weakly correlated with the equations in first differences (weak instruments); and the problem of weak instruments may introduce some bias and imprecision in first difference GMM estimates.

Blundell and Bond (1998) also they argued that this poor performance could be counteracted by incorporating more informative moment conditions that are valid under the stationarity of the series. Basically, this results in the estimation of a system of two equations, the first being the differenced “Equation 11” and the second being the level equation in “Equation 1”. Suitable lagged levels of X_{it} are used as instruments in the first differenced equation while lagged-first differences are used as instruments in levels equations⁵.

Hence, 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 suitable initial conditions can significantly improve the quality of results. These results are confirmed by subsequent studies carried out by Alonso-Borrego and Sanchez-Mangas (2001), Heyer et al. (2004), etc.

Hempell (2002) 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.

⁴ See Anderson and Hsiao (1982).

⁵ See Arellano and Bover (1995).

GMMS estimations of parameters of production function will be obtained using the GAUSS DPD98 program developed by Arellano and Bond (1998).

Finally, the quality of the estimated coefficients of “Equation 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 residuals thus obtained are supposed to be correlated to the order 1, but not to order 2. The tests AR (1) and AR (2) Arellano and Bond (1991) 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 treatments⁶, 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. 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 years⁷. The main descriptive statistics of the panel are presented as follows:

We see from the Table 3 that “small firms” dominate our sample. They represent 42.8% of the total sample. This is a common feature in developing countries. “Medium firms”

⁶ 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. Finally, there was the post-stratification exercise to ensure that the resulting sample is representative of the population of interest. This is important to ensure the efficiency of the estimates to be obtained from the sample. Indeed, firms under the “régime de base” were over-represented in the sample, which might introduce a bias in the estimates. It was therefore decided to use post-stratification using the characteristics of all firms in the formal manufacturing sector of Cameroon. This method is based on a modification of the structure of the sample to make sure that it reflects the structure of the entire population of manufacturing firms of the formal sector in Cameroon.

⁷ Data for the more recent years are not included because the recent FSS are not officially released by the National Institute of Statistics yet.

represent 21.6% of the sample, while “big firms” represent 35.6 percent of the total sample.

Table 4 shows that the number of employees in Cameroonian firms varies between 10 and more than 12 000 persons. This gives an average around 250 persons per firms; with substantial disparities however, given that the standard deviation is 806.9.

Table 4 also shows a decline of total investments and investment in ICT during the period 2003 – 2007. The total employment has not changed substantially. But the average value added has increased during the period; which may be an indication of an increase in productivity.

Table 1 show a summary of our main variables presented in table 1 and Table 3, but this time the variables are taken in logarithm.

Table 1: Descriptive statistics of key variables (log)

Variables	Obs.	Firms	Mean	Median	Std. dev	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 the estimation results of our empirical model by GMM-system (GMMS) on the entire sample.

Table 2 : Estimation results for the Translog model

Estimations by GMMS	Dependent variable: log(value added)		
	ORG= Decentralization	ORG= Workplace organization	ORG= Human resources practices
<i>LnN</i>	1,258*** (0,157)	1,385*** (0,156)	1,238*** (0,153)
<i>LnICT</i>	-0,042 (0,061)	-0,019 (0,063)	-0,027 (0,059)
<i>LnK</i>	0,153*** (0,083)	0,198*** (0,088)	0,111*** (0,080)
$(LnN)^2$	-0,033*** (0,017)	0,011*** (0,016)	0,028*** (0,014)
$(LnICT)^2$	0,002** (0,007)	0,001*** (0,004)	0,005** (0,006)
$(LnK)^2$	0,011 (0,006)	0,014 (0,007)	0,018 (0,003)
<i>LnN * LnICT</i>	0,034*** (0,017)	0,042** (0,015)	0,024*** (0,021)
<i>LnN * LnK</i>	-0,009 (0,006)	-0,005 (0,001)	-0,008* (0,007)
<i>LnICT * LnK</i>	-0,007 (0,005)	-0,003 (0,008)	-0,004 (0,007)
<i>ICT * ORG</i>	0,017 (0,012)	0,019** (0,020)	0,018 (0,014)
R^2	0,831	0,798	0,856
Dif. Sargan (p-values)	0,560	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. ***, ** denote significance at the 1 and 5% level. Values in parentheses represent standard deviations. The results are those of the two-step System –GMM 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, Chowdyury and Wolf (2006) 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; yet their restrictive empirical model was unable to detect. Hence we see clearly the advantage of using the flexible and rich Translog based empirical model that the more restrictive Cobb-Douglas-based models as in previous studies.

In addition, the results in Table 2 show that the coefficient on the interaction term between ICT-capital and employment is positive and significant; while the coefficient on the interaction term between ICT-capital and conventional-capital is negative. This confirms the view that ICT also contributes indirectly to the firms' productivity through the improvement of labor productivity.

On other hand, 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.

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

- Alonso-Borrego, C. and R. Sanchez-Mangas. (2001). "GMM estimation of a production function with Panel Data: An application to Spanish manufacturing firms". Working Paper 27, Universidad Carlos III, Madrid.
- Arellano, M. and S. Bond. (1991). "Some tests of specification for Panel Data: Monte Carlo evidence and an application to employment equations". *Review of Economic Studies*, 58(2). 277–97.
- Arellano, M. and S. Bond. (1998). "Dynamic panel data estimation using DPD98 for GAUSS: a guide for users".
www.american.edu/academic.depts/cas/econ/gaussres/regress/dpd/dpd98.pdf
- Arjun, S.B. (1999). "The role of information and communication technologies in economic development". *Discussion Paper on Development Policy*, Center for Development Research, Bonn.
- Arvanitis, S. (2004). "Information technology, workplace organization, human capital and firm productivity: evidence for the Swiss economy". In OECD (2004) *The Economic Impact of ICT – Measurement, Evidence and Implications*, OECD, Paris.
- Arvanitis, S. (2005). "Computerization, workplace organization, skilled Labour and firm productivity: evidence for the Swiss business sector". *Economics of Innovation and New Technology*, 14(4). 225–49.
- Basant, R., S. Commander, R. Harrisson and N. Menezes-Filho. (2006). "ICT adoption and productivity in developing countries: New firm level evidence from Brazil and India". *Discussion Paper*, (2294). IZA.
- Berndt, E.R. and C.J. Morrisson. (1995). "High-tech capital formation and economic performance in US manufacturing industries: an exploratory analysis". *Journal of Econometrics*, 65. 9–43.
- Black, S.E. and L.M. Lynch. (2004). "What's driving the new economy? The benefits of workplace innovation". *Economic Journal*, 114(493). 97–116.
- Black, S.E. and L.M. Lynch. (2005). "Measuring organizational capital in the new economy". *Discussion Paper*, (1524). IZA.
- Blundell, R. and S. Bond. (2000). "GMM estimation with persistent panel data: an application to production functions". *Econometric Reviews*, 19(3). 321–340.
- Bresnahan, T., E. Brynjolfsson and L. Hitt. (2002). "Information technology, workplace organization and the demand for skilled labour: Firm-level evidence". *Quarterly Journal of Economics*, 117(1). 339–76.
- Bresnahan, T. and M. Trajtenberg. (1995). "General purpose technologies: Engine of growth? ". *Journal of Econometrics*, 65. 83–108.
- Brynjolfsson, E. and L. Hitt. (1996). "Paradox lost? Firm-level evidence on the returns to information systems spending". *Management Science*, 42(4). 541–58.
- Brynjolfsson, E. and S. Yang. (1996). "Information technology and productivity: A review of the literature". *Advances in Computers*, 43. 179–214.
- Brynjolfsson, E. and L. Hitt. (2000). "Beyond computation: information technology, organisational transformation and business performance". *Journal of Economic Perspectives*, 14. 23–48.
- Brynjolfsson, E., L. Hitt and S. Yang. (2002). "Intangible assets: computers and organizational capital". *Brooking Papers on Economic Activity*, 1. 137–99.

- Chowdhury, S.K. (2006). "Investments in ICT-capital and economic performance of small and medium scale enterprises in East Africa". *Journal of International Development*, 18. 533–52.
- Dedrick, J., V. Gurbaxani and K.L. Kraemer. (2002). "Information technology and economic performance: firm and country evidence" *Working Paper August 2002, Center for Research on Information Technology and Organizations*, University of California, Irvine.
- Dewan, S. and K.L. Kraemer. (2000). "Information technology and productivity: preliminary evidence from country-level data". *Management Science*, 46(4). 548–62.
- Gera, S. And W. Gu. (2004). "The effect of organizational innovation and information and communications technology on firm performance". *International Productivity Monitor*, 4. 37–51.
- Gordon, R.J. (2000). "Does the new economy measures up to the great inventions of the past? ". *Journal of Economic Perspectives*, 14(4). 49–74.
- Gretton, P., J. Gali and D. Parham . (2004). "The Effects of ICTs and Complementary Innovations on Australian Productivity Growth". In OECD (2004) *The Economic Impact of ICT – Measurement, Evidence and Implications*, OECD, Paris.
- Griliches, Z. and J. Mairesse. (1997). "Production functions: the search for identification", in Strom, S. (ed.), *Essays in Honour of Ragnar Frisch*, Econometric Society Monograph Series, Cambridge University Press, Cambridge.
- Hempell, T. (2002). "What's spurious, what's real? Measuring the productivity impacts of ICT at the firm-level". Centre for European Economic Research, *Discussion Paper*, Zew.
- Hempell, T. (2004). "ICT, Innovation and Business Performance in Services: Evidence for Germany and the Netherlands". In OECD (ed.) *The Economic Impact of ICT: Measurement, Evidence and Implications*, OECD, Paris.
- Hempell, T. (2005a). "What's Spurious? What's Real? Measuring the Productivity Impacts of ICT at the Firm Level". *Empirical Economics* 30(2), 427- 464.
- Hempell, T. (2005b). "Does experience matter? Innovation and the productivity of ICT in German services". *Economics of Innovation and New Technology*, 14(4). 277–303.
- Heyer, E., F. Pelgrin and S. Arnaud. (2004). "Durée d'utilisation des facteurs et fonction de production : une estimation par la méthode des moments généralisés en système". *Document de Travail*, Banque du Canada.
- Jorgenson, D.W. (1972). "Investment behaviour and the production function". *Bell Journal of Economics and Management Science*, 3. 220–51.
- Jorgenson, D.W. and K. Stiroh. (1995). "Computers and growth". *Economics of Innovation and New Technology*, 3(34). 295–316.
- Kaplan, R. and D. Norton. (1992). "The balanced scorecard: Measures that drive performance". *Harvard Business Review*, 70(1). 71–79.
- Lal, K. (2001). "The determinants of the adoption of information technology: a case study of the Indian garments industry". In Pohjola, M. (ed) *Information Technology, Productivity and Economic Growth: International Evidence and Implication for Economic Development*, Oxford: Oxford university press, New York, 221–41.
- Lehr, B. and F. Lichtenberg. (1999). "Information technology and its impact on productivity: Firm-level evidence from government and private data source, 1977-1993". *Canadian Journal of Economics*, 32. 335–62.

- Lichtenberg, F. (1995). "The output contributions of computer equipment and personal: A firm-level analysis". *Economics of innovation and new technology*, 3. 201–217.
- Maliranta, M. and P. Rouvinen. (2004). "ICT and Business Productivity: Finnish Micro-level Evidence". In OECD (2004) *The Economic Impact of ICT – Measurement, Evidence and Implications*, OECD, Paris. 213–40.
- Matambalya, F. and S. Wolf (2001). "The role of ICT for the performance of SMEs in East Africa". *Discussion Paper on Development Policy* (42), ZEF.
- Milgrom, P. and J. Roberts. (1990). "The economics of modern manufacturing: Technology, strategy and organization". *American Economic Review*, 80(3). 511–28.
- OCDE. (2003). "*Les TIC et la Croissance Économique*". OCDE.
- Pilat, D. (2004). "The ICT productivity paradox: Insights from micro data". *OECD Economic Studies*, 38. 37–65.
- RIA - Research ICT Africa! - (2006). "*Towards an African e-Index: SME e-access and usage in 14 African countries*". Johannesburg: The Link Centre.
http://www.researchictafrica.net/images/upload/SME_book-Web.pdf
- Siegel, D. (1994). "The impact of computers on manufacturing productivity growth: a multiple-indicators, multiple-causes approach". *SUNY at Stony Brook Working Paper*, may.
- Sumit, S. and C. Jung. (2007). "A study of the impact of information technology on firm performance: a flexible production function approach". *Information System Journal*, 19(3). 313–39.
- Vickery, G. and G. Wurzburg (1998). "The challenge of measuring and evaluating organisational changes in enterprises". In *Measuring Intangible Investments*, OECD, Paris.
- World Bank Group. (2006). "*2006 Information and communications for development. Global trends and policies*" Washington DC: World Bank.

Annexes

Table 3: Distribution of firms by size⁸

Tax system	Structure of all firms	Structure of the sample before post-stratification	Structure of the sample after post-stratification
	2003-2007	2003-2007	2003-2007
Big firms	35,6	28,3	35,5
Medium firms	21,6	24,2	21,7
Small firms	42,8	47,5	42,8
Total	100,0	100,0	100,0

Source: NIS and our calculations

Table 4: Statistics on the workforce, total investment, ICT investment and the value added for the full sample⁹

	Year														
	2003					2005					2007				
	Max	Mean	±	σ	Min	Max	Mean	±	Σ	Min	Max	Mean	±	σ	Min
Workforce	11239,0	254,6	±	806,9	10,0	11400,0	252,2	±	813,7	10,0	12712,0	253,9	±	875,0	10,0
Total	1052,3	9,6	±	70,1	0,0	765,2	8,6	±	53,9	0,0	598,1	7,8	±	44,6	0,0
Investissement	878,4	6,7	±	58,4	0,0	467,8	4,5	±	54,1	0,0	351,2	4,3	±	51,6	0,0
ICT	287,2	10,1	±	26,3	0,0	348,4	11,3	±	33,6	0,1	508,3	12,3	±	42,2	0,0
Investissement Value added															
σ= Standard deviation <u>N.B</u> Investment and value added are in billions of FCFA. Workforce is the total number of employees.															

Source: NIS and our calculations

⁸ Truly, this is a distribution of firms by the tax system, and the choice of the tax is justified by the correlation between it and the value added. However, the definition of “tax systems” which is presented below can be viewed as a classification of firms according to the size:

- **“Régime de base”** for firms with a value added of less than 15 million FCFA: Firms in this category can be called “small firms”.
- **“Régime réel simplifié”** for firms with value added greater than or equal to 15 million FCFA and less than 50 million FCFA: Firms in this category can be called “medium firms”.
- **“Régime réel”** for firms with value added greater than 50 million and 100 million FCFA: Firms in this category can be called “big firms”.

⁹ For space reasons, we have presented the statistics every two years instead of every year of the period covered by the study.