# The IT Impact on the Productivity and the Organizational Performance of Firms in Romania. A model of Empirical Analysis

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**Abstract.** The paper propose an analysis based on an empirical model of IT impact on firms performances of Romania. There are presented the model, the equations of the model and the results of statistical processing. All these shown that the ICT impact on firm performance is greater and positive if the information technologies are accompanied by a proactive management policy and an organizational culture.

**Keywords:** impact IT, productivity, performance

## 1. Introduction

In the last years, Information technologies and their impact on society, hare been the subject and the object of many studies, not only for academics but also for business, because their implementation in a number of increasingly large companies. However, the results presented in the literature are contradictory.

Common, in theory there is a certain consensus regarding the existence of a positive relationship between information technology and performance. In particular, many authors argue that implementation of information technology provides higher productivity, better customer satisfaction, creates more value, etc. Others, by contrast, believe that IT effects are null or even negative on profits, efficiency and value share. These studies support the productivity paradox, which is still in debate.

According to Complementary Theory, we can consider that the benefits will be greater if information technologies will be used in conjunction with appropriate organizational resources and capabilities, especially skilled labor, proactive and innovative culture.

A study made by Gargallo-Castel & Galva-Gorriz (Gar 07) in Spain, shows that the improvement of firms'productivity due to IT used, is directly related to complementary resources of the company. In particular, it is the importance of skilled labour and proactive attitude that explains why firms with the same IT capital have different levels of productivity.

There are many studies, published over the time, which presenting the contradictory evidence and showing weak or no links between ICT (Information and Communication Technology) and performance [Ban 88], [Bry 93], [Dav 94], [Ket 94], [Lov 94], [Roa 87], [Str 85], [Str 90], [Wei 92], [Wil 93, 95], all called Paradox.

According to Solow's productivity paradox (1987), "we see computers everywhere except in productivity statistics". The main explanations for the paradox productivity are summarized in Table 1. Among other authors,

Brynjolfsson and Yang (1996) suggested several explanations for this apparent lack of relation between IT and productivity, such as: problems in productivity and investments quantification, delayed results, over-investments relative to the agent expanses, zero earnings. Though, for some firms there are positive effects, for others, negative, but in the industry case, there are no changes.

In the U.S., the years 1995-2000, were characterized by a new "golden period" of labor productivity growth. This growth is generally associated with investments and using of information and communication technology (ICT).

IT is considered a technology with an extremely wide potential of use, also called General-Purpose Technology (GPT) and it seems to explain the resurgence growth in the late '90s. Thus, IT is not reflected only in the leap in productivity of sectors that produce ICT goods, but also affects labor productivity, contributing on long-term growth of Solow Residual (called in Anglo-Saxon literature also Total Factor Productivity - TFP or Multifactor Productivity - MFP, especially BLS).

**Table 1. The main explanations for the paradox of productivity**

| Explanations | Authors |
|---|---|
| Measuring inputs and outputs: problems of measuring IT investments, problems of measuring productivity, problems of information technologies quantification in output of IT | Brynjolfson, 1993; Brynjolfson & Yang, 1996; Schreyer, 2001, Griliches 1992, 1994, 1995, Oliner & Sichel 1994. |
| Delays due to training and adjustments, delayed results. | Schreyer 2000; Cornella 1994, National Science Foundation and National Science Board 2000. |
| Problems caused by over-investments related to costs, which motivate managers to invest for their own interest. | Brynjolfsson & Yang, 1996. |
| Redistribution and dissipation of profits: although there is a positive effect in some companies, for others it is negative, and in the case of industry there are no changes. | Brynjolfsson & Yang, 1996. |
| Delays of immediate control factor and problems of an interference pattern. | Dos Santos and others 1993, Hitt & Brynjolfsson 1996, Lucas 1993. |

In agreement with Jorgenson and Stiroh (2000), [Jor 00], in the United States, there is a consensus on the correspondence between productivity growth and ICT production and especially, the use of information technology in non-producing sectors of industry, consensus, obviously not without challenges. The skeptics consider that information technologies have a spectacular contribution to growth only in the sectors producing IT.

Non-agricultural business sectors, non-producing IT, recorded actually a deceleration in productivity, estimated somewhere at 0.28% for 1995-1999 period [Gor 00]. Thus, the productivity paradox of Solow seems to be confirmed.

Moreover, Europe's experience in IT is less spectacular, and in any case, uneven (for instance, discrepancies between investment and use of ICT in Netherlands and Ireland relative to France, Germany and Italy) and therefore different from that of U.S.' experience.

Summarily, the main question that crosses the entire theoretical debate in the New Economy is whether Solow's productivity paradox is still valid or has been exceeded. We will remember some theoretical answers given to this issue.

Information technology together with complementary innovations, offers solutions for sustainable growth. Reformulating, IT is considered input, acts as General-Purpose Technology (GPT), obviously maintained by a high elastic demand for semi-conductors / microprocessors [DELL 2001], and generates spillovers effects, or effects which can be called training, in economic sectors that have invested in IT and have developed complementary innovations to capture all the benefits of IT. Thus, IT is part of an endogenous-exogenous logic of productivity.

In their work, Basu and others (2003) [Bass 03] exhibit a favorable position to a higher TFP in industrial sectors non-producing ICT. Without going into details, they considered the experience in IT of U.S. and U.K., for the second half of the '90s, and concede that although U.S. and the UK reported a different increase in TFP, it is not less explained by investments and contributions in IT. The authors consider that Solow's paradox was passed in the U.S. U.K. has experienced a boom in ICT investment over the same period, but TFP growth decline.

If the investments in ICT in U.K. are associated with a lower level of TFP, this is because the resources are allocated to reorganization and learning more than for the production of output.

However, both the U.S. and the U.K. have strong correlation between the use of IT and TFP growth. In short, the authors expose an argument that includes on the one hand, the General-Purpose Technology nature of ICT and, on the other hand, the hypothesis of "adoption costs" of complementary innovations (usually poorly measured and considered "immeasurable input"). Thus, TFP growth is positively correlated with the use of ICT, and negatively associated with investment in ICT boom.

In conclusion, the common opinion on the U.S. economic recovery in the second half of the '90s is that ICT has fundamentally contributed to economic growth. The divergence on TFP does not reduce the importance of investments and the contribution of ICT. Jorgenson and Stiroh [Jor 00] believes that the

huge investment in ICT, particularly stimulated by the decline in prices, allowed the substitution of existing capital and labor with IT capital. Thus IT explains the increase in productivity.

Other authors [Wal 89], [Bel 98], [Pow 97], [Bre 02], [Ram 01], consider that it is necessary to find a close relationship between the ICT management and the additional resources such as strategy, organizational structure, human resources and organizational resources.

Bresnahan and others in 2002, [Bre 02] made an empirical analysis of how can be positively influenced firm productivity by combining information technology with an organizational project.

In the case of Spain, DMR Consulting-Aetic (2005) found a positive relationship between information technologies and productivity in various sectors, together with decreasing marginal returns, which indicates that improvements in productivity are reduced over time.

As a general conclusion of representative works in the field, it can be stated and argued that the more investment in ICT does not lead to improvements on performance.

In their paper, Gargallo-Castel and Galva-Gorriz, [Gar 07] enunciated four hypotheses about the impact of IT on the firm performance:

**The first hypothesis (Hypothesis 1)** states that: "Information technologies could be a weak predictor of productivity, not generating significant improvement of the results by themselves"

In this context, it takes complementary resources and capabilities to achieve effective implementation and expected benefits by investing in IT. How these technologies will combine in the company, will determine the level of efficiency achieved. Among the factors analyzed, one of the most important is human resource, usually studied as a determinant of productivity, and not as a complementary element of ICT [ODE 01A]. The skills of employees allow companies to more effectively integrate the information technologies in the business process planning, in the designing and developing application, which reduces costs and accelerate the production more than the the competition [Bha 00].

**A second hypothesis (Hypothesis 2)** says: "The ICT impact on the results will be higher for the organizations that combine the computer technology with a higher level of qualification of employees".

In order to take the full advantage of IT, is necessary that the information technology to become part of the strategic business decision and not just the technology itself. A factor to be quickly aligned is the managers' attitude towards technology. The research confirms that the sustaining of senior-level manager is in positive relationship with the success in adopting and implementing the information systems. This support will enable the IT to be reflected in the strategy which will provide the necessary funds for implementation and integration, as a future funding guarantee.

A firm with a proactive attitude at higher management levels means more than having a specialized group of people working with new requirements and innovations. This will allow reaching the maximum performance of the computer technology adopted by the firm.

Finally, the fact that IT is part of the effective management can lead to maximum efficiency.

In this regard is stated **the third hypothesis (Hypothesis 3),** which sets out the following: "The impact of information technology on the results will be higher for the organizations that combine ICT with the proactive attitude of management towards new technologies."

Many authors have considered the importance of the coordination of corporate organizational changes, in order to achieve an appropriate match between the organizational and technological elements. The technological strategy refers to the degree in which a firm, gradually move to technological changes in terms of the innovation process (updating equipment and production technology), product innovation or technological forecasting activities. In this regard, Ramirez [Ram 01] has discovered that adopting models of employee involvement, TQM (Total Quality Management) and re-engineering, have positive influence on ICT impact in the results.

Thus, **the fourth hypothesis (Hypothesis 4)** states that: "The impact of ICT on the results will be higher for organizations that combine the information technologies with the innovation process."

To verify these assumptions the authors [Gar 07] have used the data published in The Business Strategies Study coordinated by the Spanish Ministry of Science and Technology. Thus, were selected the statistically representative samples of the "manufacturing" production companies from Spain. The total number of companies in that report was in 1998, 3072. After filtering the data, in the sample remained 1225 firms.

We believe that a similar empirical analysis for Romania can be proposed and developed, in order to verify the four hypotheses formulated above. In this regard, we must define the following types of variables: dependent variables, independent variables, instrumental variables (dummy) and control variables.

## 2. Dependent variables

Among the metrics of performance, one of the most popular is productivity, measured using various samples, sectors and methodologies. In this analysis we will use three different metrics of productivity:

a. Productivity _1 (PD1): is measured using the value added per employee, in the company.
b. Productivity_2 (PD2): is a measure of company goods and services produced per employee.
c. Productivity_3 (PD3): is a measure of the value added by each employee per work hour.

**Independent variables**

In agreement with other papers and previous research, the company's independent variables are:

a. ***IT capital intensity IT (KIT/L):*** This variable defines the „amount" of IT capital per initial labour unit. It can be measured by reporting the IT stock in the number of employees of the company. The IT stock is estimated using the „perpetual inventory" that accumulates investments made by the company, in time, equipment (computers) and data processing equipment and requiring a depreciation rate of 20% (The depreciation rate of 20% was used by Kafouros in 2006 and he estimeted a depreciation rate for intangible technological resources).
b. ***The intensity of the remaining capital (KNIT / L):*** This variable includes non-IT capital. It is measured by conventional capital, calculated as the difference between net assets/total assets (derived from balance sheets) and the corresponding fixed assets net of IT, the total number of employees of the company.

**Instrumental variables (dummy)**

There are three variables that reflect the multiplicative interaction between IT and complement each respectively qualified employees, proactive direction and process innovation.

a. ***A qualified IT employees (ITCal):*** A dummy variable that captures the interaction between this IT in business and qualified staff, as measured by the existence of a greater number of qualified employees than average number of skilled workers in the industry. The variable has the value 1 if the company has a number of qualified employees higher than average number of employees qualified branch with a positive stock of IT, and 0 otherwise. It approximates the level of educational qualification variable distinguishes employee.
b. ***IT and managerial attitude (ITMan):*** reflect variable involvement of senior management in implementing the new technology, ie: there is a technology company group or a plan for innovation activities, or if the company uses indicators to measure results of innovation. Dummy variable takes the value 1 if a practice of the activities listed above and has ICT capital, or 0, otherwise.
c. ***IT and process innovation (ITI):*** The innovation process is measured as long as the company is considering a process of innovation during the study. The variable has value 1 if the firm has process innovation and IT capital and 0 otherwise.

**Control variables**

a. ***Sector, domain of activity (Sa):*** is defined by two numbers according to the EU classification of economic activities - NACE or a letter and two digits according to NACE 2010.
b. ***Legal structure of the firm (FL):*** This variable allows you to control the effects of various corporate structures that appear in the sample (limited liability companies, limited liability public companies, cooperatives, etc.).
c. ***Company size (D):*** Company size is measured in total number of employees.

## 3. The proposed methodology of analysis

To test the assumptions made will use a model to include the effects of ICT with proper organization and human resources. It will use a standard production function that models the production process, considering the IT as a production factor [Bry 96], [Ram 01]. He used a Cobb-Douglas production function. The formula was shown to be consistent in this context [Dew 97].

Different variables are included to represent the interaction of the IT with complementary resources. These variables were included as statistical models in terms of the inter-relationships is significant provides a more accurate estimate than those who do not take into account the interrelationship between the exploratory variables.

The coefficient of these variables will indicate directly the common representation of these components. (Sign positive / negative shows that both variables combined will have positive / negative impact on productivity). The study was conducted for 20 representative companies from Romania. In

order to increase confidence and evidence that the four hypotheses will be accepted or rejected three models were specified.

**Modelul 1:** $ln(PD1)_i = \alpha + \beta_1 ln(K_{IT}/L) + \beta_2 ln(K_{NIT}/L) + \beta_3 lnD + \gamma_1 ITCal + \gamma_2 ITMan + +\gamma_3 ITI + \Sigma\delta_{FL}F_L + \Sigma\delta_{Sa}Sa + \varepsilon$
**Modelul 2:** $ln(PD2)_i = \alpha + \beta_1 ln(K_{IT}/L) + \beta_2 ln(K_{NIT}/L) + \beta_3 D + \gamma_1 ITCal + \gamma_2 ITMan + +\gamma_3 ITI + \Sigma\delta_{FL}F_L + \Sigma\delta_{Sa}Sa + \varepsilon$
**Modelul 3:** $ln(PD3)_i = \alpha + \beta_1 ln(K_{IT}/L) + \beta_2 ln(K_{NIT}/L) + \beta_3 D + \gamma_1 ITCal + \gamma_2 ITMan + +\gamma_3 ITI + \Sigma\delta_{FL}F_L + \Sigma\delta_{Sa}Sa + \varepsilon$
where $\beta_i$ is the output elasticity of ICT capital, non-ICT capital and labor and will be different for the three models. Correlation matrix is built as shown in Table 2.

**Table2. Correlation matrix**

| Correlation coefficient | $ln(K_{IT}/L)$ | $ln(K_{NIT}/L)$ | $lnD$ | $ln(PDM1)$ | $ln(PDM2)$ | $ln(PDM3)$ |
|---|---|---|---|---|---|---|
| $ln(K_{IT}/L)$ | 1 | 0,302* | 0,316* | 0,378* | 0,340* | 0,381* |
| $ln(K_{NIT}/L)$ | 0,302* | 1 | 0,354* | 0,452* | 0,464* | 0,452* |
| $lnD$ | 0,316* | 0,354* | 1 | 0,367* | 0,334* | 0,381* |
| $ln(PDM1)$ | 0,378* | 0,452* | 0,367* | 1 | 0,578* | 0,988* |
| $ln(PDM2)$ | 0,340* | 0,464* | 0,334* | 0,578* | 1 | 0,588* |
| $ln(PDM3)$ | 0,381* | 0,452* | 0,381* | 0,988* | 0,588* | 1 |

Correlation is significant at a threshold of 0,001 (two-tailed)

In Romania's case as in the case of Spain, the correlation matrix showed no correlation between any of the independent variables, suggesting that there are no multicollinearity problems in the estimation model. The regression results for the productivity analysis are presented in Table 3.

**Table 3. Regression results**

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| $ln(K_{IT}/L)$ | 0,052** | 0,068*** | 0,054** |
| $ln(K_{NIT}/L)$ | 0,362*** | 0,421*** | 0,351*** |
| $lnD$ | 0,088*** | 0,019 | 0,101*** |
| *ITCal* | 0,122*** | 0,112*** | 0,124*** |
| *ITMan* | 0,060** | 0,028 | 0,060** |
| *ITI* | 0,000 | 0,031 | 0,002 |
| *Sa* | Yes | Yes | Yes |
| $R^2$ | 47,80% | 49,22% | 49,02% |
| The coefficient of determination $R^2$ | 48,00% | 48,39% | 48,20% |
| Total number of firms | 20 | 20 | 20 |

*p<0,1 **p<0,05 ***p<0,01

In terms of business sector firms can not draw any conclusion even though the significance varies among the three models. Positive coefficients were obtained for variable ***KIT / L*** (IT capital intensity) for all three models. However, if the coefficient of this variable is compared with the corresponding conventional capital, its value is lower, indicating that the impact on each of the three metrics is considerably weaker than the rest of the capital. This allows acceptance of a hypothesis that postulates a weak effect on the results.

While the information technologies have rarely a direct impact, the variables representing ICT qualifications are positive, confirming the importance of qualifications. This allows corroboration with the hypothesis 2. These results are consistent with the studies showing that use of data processing equipment is more important when there are competent workers with medium and high [Bor 07], [Bor 06], [Bre 02].
If the variable measuring proactive IT management (ITMan), positive coefficients are obtained in all three models, although without statistical significance for the goods and services measured productivity per employee. Therefore, it can be concluded that the Hypothesis 3 is accepted for two of the three models.

Finally, the multiplicative variables that capture the relationship between IT and the innovation process is not significant in any model of the three, which leads to the conclusion that you have revised the definition of this variable, partly because it can capture management position. Thus, these results allow us to accept and the Hypothesis 4. Regarding the legal structure of the firm (***FL***) can not draw any

conclusions because of the significant differences between the three models. The three models show similar levels of explanatory power with a correlation coefficient around 48% which confirms the importance of the relationship of IT and human resources (IT and human resource management is positive and statistically significant coefficient in all three models).

## 4. Conclusions

The estimation results allow to conclude that in order to receive the information and communication technologies need to be taken into account the different elements. The difference between countries may be relevant to determine the impact IT otherwise as the organizational policies.

One of the problems that the public authorities must take into account is the need to increase capacity and improve the employee education and to ensure that the companies will have their full advantage as a result of implementing information technologies [OCD 01].

This analysis has obvious and limitations. A limitation derives from the types of technology need not be complete to allow an adequate analysis. In addition, it is difficult to measure the organizational characteristics, such as the presence of a culture open to innovation, or the ability to specify levels of employees as investments in IT.

The proposed study model for Romania in addition to these assumptions can add another one, called Hypothesis 5 is formulated as follows: „The impact of information and communication technologies in a firm is not independent of the implementation of ICT in the economic sector, and to national level".

***To verify this hypothesis but also because of limitations in this study that would be necessary first to introduce in the annual statistical reports and thus firms in the Statistical Yearbook of Romania, a special chapter dedicated to information and communication technologies existing in this companies. Obviously, this should be preceded by a careful watch metrics and indicators so they can be conclusive, and then allow their use in economic analysis.***

Currently Romanian Statistical Yearbook does not contain any information related to ICT and in Chapter Science, Technology and Innovation data are generated.

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