

# **The Effect of Information and Communication Technologies Investments and Strategic Alignment on Greek Firms' Performance**

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## **Abstract**

Firms all over the world make significant investments in information and communication technologies (ICT) aiming to increase their efficiency and effectiveness. It is of critical importance to investigate the impact of these investments on firms' performance in various contexts, and also identify 'soft factors' that can increase this impact. This paper presents the results of an empirical investigation of the effect of ICT investments on Greek firms' business performance, measured through value added and labor productivity. It also examines for first time in Greece whether and to what extent this effect can be increased if ICT investments are aligned with business strategy. The study is based on a unique research dataset, including data from 237 Greek firms about business performance, usage of ICT, adoption of modern organization forms and innovation, which has been collected through a questionnaire-based survey among Greek firms conducted in cooperation with ICAP, one of the largest business information and consulting companies of Greece. Using these data econometric models of output and labor productivity have been estimated based on the Cobb-Douglas production function. It has been concluded that ICT investments in Greece make a positive and statistically significant contribution to both firm output and labor productivity, so there is no 'ICT Productivity Paradox' in Greece. Additionally, it has been found that this contribution can be increased considerably, in the firms for which a very high degree of bilateral relationship between the ICT Plan and the Overall Business/Strategy Plan exists.

**Keywords:** Information and Communication Technologies Investment, Survey on Information and Communication Technologies Investment, Business Performance, Strategic Alignment, Cobb-Douglas Production Function.

**JEL Classification Codes:** O3, D24

## 1. Introduction

Firms all over the world have been making for long time considerable investment in information and communication technologies (ICT), aiming to increase the efficiency of both their internal processes (e.g. through the adoption of enterprise resource planning (ERP) systems) and their transactions with their customers, suppliers and business partners (e.g. through the adoption of e-business systems) (OECD 2003, 2004, 2008). The ICT investments in OECD countries rose from less than 15% of the total non-residential investment in the early 80s, to between 15% and 30% in 2001, and are trending upwards (OECD, 2004). With regard to the supply side, the ICT sector is one of the most dynamic sectors of the economy, with higher than average growth rates and research intensity; this results in ICT products and services becoming better and cheaper, leading to their wide adoption by the economy (European Commission, 2007). Therefore it is of critical importance to investigate the benefits and the value that ICT investments create for firms and their effect on firms' business performance, and also to identify 'soft factors' that can increase their business value. Previous research in this area has revealed that the benefits from ICT investment vary significantly among firms, depending to a large extent on the combination of 'hard' ICT investments (i.e. in computers' hardware, software and networks) with appropriate 'soft investments' in new organizational practices and skills, business process re-engineering, innovation, etc. (OECD, 2003; OECD, 2004; Melville et al 2004; Arvanitis & Loukis, 2009).

One of these 'soft factors', which has been extensively discussed in the relevant literature, is the strategic alignment of ICT. It is defined as the extent to which business strategies are enabled, supported and stimulated by ICT strategies (Broadbent & Weil, 1993). Luftman (2000) provides a more detailed definition stating that "Business-IT alignment refers to applying Information Technology in an appropriate and timely way, in harmony with business strategies, goals and needs. This definition of alignment addresses: 1. how IT is aligned with the business and 2. how the business should or could be aligned with IT". ICT strategic alignment has been ranked as the most important issue that IS managers face in several recent formal surveys conducted by the Society for Information Management (SIM) of USA ([www.simnet.org](http://www.simnet.org)) concerning the key IS management issues (Luftman & McLean, 2004; Luftman, 2005).

The contribution of ICT strategic alignment to ICT business value and to business performance has been investigated in some empirical previous studies, which are reviewed in the next section. However, most of them are based on managers' subjective perceptions of business performance or contribution of ICT to business performance, as their main dependent variables, and not on objective measures of them. Also, they lack sound theoretical foundations, so they do not include all the fundamental independent variables. Moreover, all these previous empirical studies of the impact of ICT strategic alignment on ICT business value and business performance have been conducted in the context of only a few countries with high levels of economic development and ICT diffusion, and large markets, such as USA and UK. Therefore the results of these studies are conditional on the characteristics of these particular national contexts, since the relevant literature emphasizes that the national context is affect all issues and dimensions of ICT business value (e.g. OECD 2003, OECD 2004, Melville et al 2004).

This paper contributes to filling the above research gaps. It presents an empirical investigation of the effect of ICT investments on business performance in the Greek national context. It is quite interesting to investigate the abovementioned research questions in Greece, taking into account its differences from the highly developed countries in which most of the empirical studies on this subject have been conducted. Greece does not belong to the highly developed countries, though it has made considerable economic progress in the last decade and has become a member of the European Economic and Monetary Union. It is characterised by smaller size of internal market, smaller average

firm size, lower intensity of competition and lower level of ICT penetration and Internet usage than the highly developed countries (High-level Committee for the Greek National ICT Strategy, 2005). According to Eurostat (<http://epp.eurostat.ec.europa.eu>) the expenditure for IT hardware, equipment, software and other services in Greece is at the level of 1.2% of the Gross Domestic Product (GDP), while in the whole European Union it is much higher at the level of 3.0% of GDP; also, concerning Internet electronic commerce, the sales that Greek firms conducted through the Internet are on average 1.1% of their total sales, while in the whole European Union they reach the level of 4% of total sales. Since most of the firms of the sample used in this study are listed at the Athens Stock Exchange (ASE), it should also be mentioned that several changes have occurred during the 90's in the legislative and regulatory framework regarding ASE and the listed firms towards harmonization with international standards (for details see for instance Alexakis and Xanthakis, 1995; Laopodis, 2004; Milionis and Papanagiotou 2008) as a result of these changes Morgan Stanley Capital International upgraded ASE to a developed market status, while previously ASE belonged to the so-called European Emerging Markets. However, despite these reforms, the Greek firms have still some idiosyncratic characteristics, mainly related to corporate governance, that are noteworthy, as they are not usually found in firms listed in other developed financial markets: in many firms, even in big ones, the majority of company ownership belongs to members of the same extended family. For the above reasons it is of much interest to investigate the effect of ICT investments and also their alignment with business strategy on business performance under such country specificities, which may affect firms' decisions concerning the use and the management of ICT, and therefore the generation of business value from them. However, the findings of this study will be interesting not only for Greece, but also for many other countries, which are not highly developed and have similar characteristics.

A second contribution of this paper is that it examines the effect of aligning ICT investment with business strategy, by using objective measures of business performance and ICT investment, and including such measures in econometric models, which are founded on the well-established and validated Cobb-Douglas production function (Nicholson, 2004).

Finally, a third contribution of this paper is that for investigating empirically the above research questions we created a unique research dataset, through a questionnaire-based survey among Greek firms, titled 'Usage of information and communication technologies, modern organization forms and innovation in the Greek companies', conducted in cooperation with ICAP, one of the largest business information and consulting companies of Greece. It includes data from 281 Greek firms concerning business performance, ICT investment, ICT management (including ICT strategic alignment), non-ICT investment, employment and management of human resources, adoption of new organisational practices, innovation and quality management. No similar database combining these data components exists in Greece. Our data allow the empirical investigation of many critical research questions concerning the contribution of ICT investments to business performance, and also their relations and complementarities with several 'soft factors' (such as adoption of new organisational practices, innovation, human resources management and quality management).

The structure of the paper is as follows: in section 2 the background of this study is presented, while in section 3 its research hypotheses, method and data are described. Then in section 4 the results are presented and discussed. Finally in section 5 the conclusions are summarised.

## **2. Background**

Considerable research has been conducted in order to investigate the relation between ICT investment and business performance, due to the big ICT investments made by firms all over the world, which pose the critical question of how productive these investments are. The first period of this research, from the mid 1980s until the mid 1990s, contrary to expectations, provided very little empirical evidence of a positive and statistically significant relation between ICT investment and business performance (e.g. Strassman, 1990; Strassman, 1997). These early results posed critical questions to managers and researchers concerning the productivity and the usefulness of ICT investments, usually

referred to as the 'ICT Productivity Paradox' (Brynjolfsson, 1993), which is summed up in R. Solow's statement that 'you can see the computer age everywhere but in the productivity statistics' (Solow 1987). However, the second period of this research, from the mid 1990s until today, has provided empirical evidence of positive and statistically significant relation between ICT investment and some measures of business performance (e.g. Brynjolfsson & Hitt, 1996; Stolarick, 1999; Gilchrist et al, 2001; OECD, 2003). Subsequent research in this area has revealed that the positive impact and the benefits from ICT investment vary significantly among firms, depending to a large extent on the combination of 'hard' ICT investments (e.g. in computers' hardware, software and networks) with appropriate 'soft investments' in new organizational practices and skills (organizational and human capital) (Arvanitis, 2005; Arvanitis & Loukis, 2009), business process re-engineering (Grover et al, 1998; Loukis et al, 2009).

Also, for more than two decades there has been a high level of interest of both researchers and practitioners in the alignment between ICT and business strategy, which is founded on the recognition that ICT have a significant strategic potential, i.e. if properly exploited they can have a significant strategic impact on the enterprise and provide valuable competitive advantages. The theoretical foundations of the strategic potential of ICT have been laid by the work of M. Porter (1980) on competitive strategy, which identifies three generic business strategies: differentiation, cost leadership and focus; also it concludes that organizations use these generic strategies in order to control five basic industry forces, which determine their competitive position and profitability: rivalry among existing competitors, bargaining power of suppliers, bargaining power of buyers, threat of substitute products/services and threat of new entrants. Concerning ICT he argues that each of the above strategies requires a different kind of ICT usage in order to be effectively implemented; also, the above five forces can be favorably affected by using ICT. McFarlan (1984) reinforced the above foundations of the strategic potential of ICT; he argues that ICT can have a strategic impact, if they are used in order to build barriers against new entrants, build switching costs, change the basis of the competition, generate new products and services and change the balance of power in supplier relationships. Important is the contribution of Porter & Millar (1985) on this topic, who identify three basic ways that ICT can affect competition: by altering industry structures, supporting differentiation and cost leadership strategies, and also by spawning entirely new businesses; they also argue that ICT have strategic potential if they can add value to a product or service in at least one of the primary activities (inbound logistics, operations, outbound logistics, marketing and sales, after-sales support and services) or one of the support activities (human resources management, technology development, infrastructure management, procurement) of the value chain.

These foundations gave rise to considerable research concerning various aspects of ICT strategic alignment. This research can be grouped into three basic streams:

- I. Conceptualization and basic understanding of ICT strategic alignment. The main objective of this research stream is to conceptualize and understand the strategic alignment of ICT, focusing on the identification of its basic processes, barriers, critical success factors and benefits (King, 1978; Lederer & Mendelow, 1988; Earl, 1989; Jarvenpaa & Ives, 1990; Zviran, 1990; Chan, 1992; Earl, 1993; Luftman, 1996; Reich & Benbasat, 1996; Armstrong & Sambamurthy, 1999; Luftman, Papp & Brier 1999; Luftman & Brier, 1999; Kearns & Lederer, 2000; Reich & Benbasat, 2000; Allen & Wilson, 2003; Campbell et al, 2005; Rantham et al, 2005). This research stream has provided a basic conceptualization and understanding of the strategic alignment of ICT, concerning mainly its basic processes, barriers, critical success factors and benefits. However, more in-depth research is required on these topics, in various types and sizes of enterprises, in various industries and national and cultural contexts, and for various types of ICT, in order to get a deeper and more complete understanding of them.

- II. Development of models/frameworks for directing/assessing ICT strategic alignment. This research stream aims to support the practical application in 'real-life' of the ICT strategic alignment concept by developing models/frameworks for assisting the technical and the business management in directing and assessing ICT strategic alignment. The most widely used of the models/frameworks that have been developed for directing strategic alignment is the 'Strategic Alignment Model' (SAM) developed by Henderson and Venkatraman (1999). Avison et al (2004) used successfully and validated this SAM in a financial services firm, and finally concluded that it has a good conceptual and practical value; also they developed a framework for its practical application, which enables the technology and business management to determine the current level of alignment and to monitor and change it in the future as required. Also, a number of models/frameworks have been developed for assisting technical and business management in assessing the level of ICT strategic alignment in their organization. The most widely used of them is the 'Strategic Alignment Maturity Model' (SAMM) developed by Luftman (2000). The research of this stream has produced some first 'high-level' models/frameworks for directing and assessing ICT strategic alignment, which offer some basic guidance, but in general they require further elaboration, evolution and adaptation to the new ICT that are continuously emerging and the new models of their exploitation by modern organizations.
- III. Impact of ICT strategic alignment on the business performance. This third research stream aims to investigate the impact of ICT strategic alignment on business performance or on the contribution of IS to business performance. In this stream, despite its significance, has been conducted less research work than in the other two. King & Teo examined empirically the impact of four types of integration between the business plan (BP) and the information systems plan (ISP) (administrative, sequential, reciprocal and full integration) on the perceived contribution of ICT to various measures of organizational performance and on the perceived extent of various types of ISP problems (organization problems, implementation problems, database problems, hardware problems and cost problems) (Teo and King, 1996; King and Teo, 2000); using data from 157 large USA firms from the Corporate 1000 Book and performing independent sample t-tests and calculating correlations they found that the extent of BP-ISP integration and also its proactive orientation has a statistically significant positive relation with the perceived ICT contribution to organizational performance, and also a statistically significant negative relation with the perceived extent of ISP problems. Chan et al (1997) investigated empirically the impact of ICT strategic alignment on perceived enterprise systems effectiveness and perceived business performance; using data from 164 North-American financial services and manufacturing firms (from USA and Canada) with more than 100 employees from the Dun and Bradstreet directories they constructed a structural equations model (SEM), from which it was concluded that ICT strategic alignment has statistically significant positive contributions to both perceived enterprise systems effectiveness and perceived business performance. Using the same data Sabherwal and Chan (2001) addressed the same research question, but in regard to the business strategy the enterprise follows; they considered three different business strategies: 'defenders', 'prospectors' and 'analyzers' and found that the strategic alignment of enterprise systems affects perceived business performance, only in enterprises following a 'prospector' or 'analyzer' business strategy, but not in the ones following a 'defender' business strategy. Cragg et al (2002) examined the link between ICT strategic alignment and four measures of perceived firm performance (long term profitability, sales growth, financial resources availability and public image & customer loyalty) in the context of small firms; using data from 250 small UK manufacturing firms and performing analysis of variance (ANOVA) they found that the subgroup of firms having higher levels of ICT alignment had also higher levels of all these four measures of perceived firm performance than the ones with lower levels of alignment.

It should be mentioned that all the above empirical studies have used subjective (perceived) measures of business performance and/or ICT contribution to business performance. The only empirical investigation of the impact of ICT alignment on business performance that uses objective measures of business performance has been the one conducted by Byrd et al (2006); using on data from 275 fabricated metal products manufacturing companies from South-eastern USA they constructed econometric models with sales revenue per employee and profit per employee as dependent variables, while as independent variables they used the IT expenditure per employee, a measure of ICT strategic alignment and an interaction term equal to the product of the above two variables. In these econometric models the coefficient of this interaction term was found to be positive and statistically significant, so it is concluded that there is a synergistic coupling (positive interaction) between ICT strategic alignment and ICT investment with respect to both these measures of firm performance. However, the econometric models constructed in this study did not include some fundamental independent variables, such as non-IT capital and labour, which constitute basic determinants of firm output according to production economics (Nicholson, 2004).

In conclusion, from the research of this stream has been produced some first evidence of a positive contribution of ICT strategic alignment to business performance. However, further research is required in order to understand better the contribution of different types of ICT strategic alignment to various dimensions of business performance, in various sectoral, national and cultural contexts, based on objective business performance measures and also on sound theoretical foundations from the area of economics.

### **3. Research Hypotheses, Method and Data**

Our research aims to overcome the deficiencies of the previous research on this issue, which have been mentioned in the previous section, by the use of objective measures of business performance and/or ICT contribution to business performance, and by estimating single equation econometric models. Such models are simple in nature, but are based on sound theoretical foundations, such as the Cobb-Douglas production function (Nicholson, 2004), and include all fundamental explanatory variables.

Our first research objective is to investigate, the effect of ICT investments on Greek firms' business performance. We expect that ICT investment make a positive and statistically significant contribution to business performance, since they increase the efficiency of both internal processes and transactions with customers, suppliers and business partners, and also improve decision making and coordination. Therefore our first null hypothesis is:

**H<sub>0</sub>(1):** ICT investment makes no contribution to business performance and we expect that it will be rejected.

Our second research hypothesis concerns ICT strategic alignment. The bilateral co-ordination between ICT plans/strategies and business plans/strategies results in the selection of the most appropriate ICT investments, which support to the highest possible extent the selected business strategy and action plan of the firm. The analysis of its internal environment, which is a critical pillar business plans/strategies formulation, constitutes a very good foundation for determining the most appropriate internal systems that should be built, in order to support its internal business functions, reinforce its strengths and reduce its weaknesses; also it allows to use ICT in combination with unique resources of the firm, in order to reinforce their potential for providing sustainable competitive advantage. The analysis of the external environment of the firm, which is another critical pillar business plans/strategies formulation, constitutes a very good foundation for determining the most appropriate inter-organizational and 'outward-looking' (e.g. Internet-based) systems that should be developed, for connecting the company with customers, suppliers and business partners. Furthermore, the whole process followed for achieving a bilateral relationship between the ICT Plan and the Business/Strategy Plan increases ICT managers' business awareness and knowledge on one hand, and executives' awareness and knowledge about the capabilities and opportunities offered by ICT on the other; also it builds mutual understanding and communication between executives and ICT managers

and facilitates a fruitful knowledge sharing among them, which can produce ICT-based competitive advantages. For the above reasons we expect that ICT strategic alignment results in a statistically significant increase of the contribution of ICT investments to business performance. Therefore our second null hypothesis is:

$H_0(2)$ : *ICT strategic alignment will not increase the contribution of ICT investment to business performance*

and we expect that it will be rejected.

Our study is based on two objective measures of business performance as basic dependent variables, the value added (=yearly sales revenue minus yearly expenses for buying materials and services) and the labour productivity (=value added per employee), and also on an objective measure of enterprise systems investment. Simple econometric models will use these objective measures as the dependent variable. The corresponding economic models are based on the theory developed in the area of production economics, and in particular on the Cobb-Douglas production function (Nicholson, 2004), and include all fundamental variables. The Cobb-Douglas production function has been successfully used in the past for estimating the contribution to firm output of various firm inputs, including ICT investment (e.g. Brynjolfsson & Hitt, 1996; Stolarick, 1999; OECD, 2003; OECD, 2004). As recommended by this literature at first an extended form of the Cobb-Douglas production function, will be used, in which the capital is divided into ICT capital and non-ICT capital:

$$VA = e^{\beta_0} L^{\beta_1} K^{\beta_2} ICK^{\beta_3} \quad (1)$$

where VA is the yearly firm value added, and  $L$ ,  $K$  and  $ICK$  are the yearly labour expenses, the non-ICT capital and the ICT capital respectively, while the parameters  $\beta_1 - \beta_3$  are the corresponding output elasticities with respect to these inputs. By log-transforming equation (1) and including the disturbance term  $u_i$  we obtain the following log-linear econometric model:

$$\ln VA = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(ICK) + u_i \quad (2)$$

Further, in order to investigate the effect of enterprise systems strategic alignment on the contribution of the ICT capital to firm value added an 'interaction term' (Greene, 2003; Gujarati, 2003), which is equal to the product of a 'strategic alignment factor'  $STR\_AL$ , a variable measuring the extent of bilateral relationship between the ICT Plan and the Overall Business/Strategy Plan, and the  $\ln(ICK)$  is added to model (2):

$$\ln VA = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(ICK) + \beta_4 \ln(ICK) \cdot STR\_AL + u_i \quad (3)$$

Similar models will also be estimated for the second business performance measure (dependent variable), the value added per employee, but with all the above independent variables ( $L$ ,  $K$ ,  $ICK$ ) standardised (divided by the number of firm employees  $N$ ).

The data used for the estimation of the above econometric models were collected through a survey among Greek companies, titled 'Usage of information and communication technologies, modern organization forms and innovation in the Greek companies', conducted in cooperation with ICAP, one of the largest business information and consulting companies of Greece. This survey was based on a structured questionnaire, which included questions about: i) the basic financial data of the company for the year 2004 (sales revenue, expenses for materials and services, labour expenses, value of capital, value of computer capital, etc.), ii) its innovative activity, iii) the degree of adoption of new forms of work organization, new forms of human resources management, quality management and redesign of processes and structures, iv) usage of various kinds of ICT, v) IS management practices and processes (including ICT strategic alignment). This is a unique database, since a similar one, combining all these data components, had never been collected before in Greece; it can be quite useful for future research, since it allows the empirical investigation of many critical research questions concerning the contribution of ICT investments to business performance, and also their relations and complementarities with several 'soft factors' (such as adoption of new organisational practices, innovation, human resources management and quality management). The questions about the financial data of the firm and ICT alignment we used in this study are given in the Appendix. The sample of the

survey was randomly selected from the database of ICAP and consisted of 304 Greek companies from the 27 most important sectors of Greek economy. In this sample there was equal representation of the small, the medium and the large companies: in particular, 103 of these companies were small (with more than 10 and less than 50 employees), 103 were medium (with more than or equal to 50 and less than 250 employees) and 98 were large (with more than or equal to 250 employees). Additionally two similar samples were also created (with the same percentages of small, medium and large firms, and the same percentages of companies from the above 27 sectors). The questionnaire was sent by mail to the Managing Directors of the 304 companies of the first sample, and the recipients were asked to fill in the questionnaire and return it by fax or mail within one month. After one month the recipients who had not responded were contacted by phone again and reminded of the questionnaire; for most of the companies of this first sample several phone calls were required, in order to have the questionnaire filled in completely and correctly. Some companies declined participation, regarding such data as confidential, or being too busy; each of these companies was replaced by a 'similar' company (i.e. from the same size group and industry) from the second sample; in cases that the similar companies of the second group were exhausted, we were using the third sample. In this way questionnaires from 281 companies (99 small, 98 medium and 84 large ones), 237 of which were complete, were received. Their average number of employees was 492 and the median number of employees 84, while their average and median sales revenue in 2004 was 183.7 and 9.5 million euro respectively.

#### **4. Results**

Initially for the firm value added (VA) we estimated model (2). However, although the variables are expressed in logarithms and the problem of heteroscedasticity, usually encountered in cross-sectional data, was expected to be reduced, White's (White 1980) test for heteroscedasticity revealed the existence of heteroscedasticity in model residuals. One way to overcome this problem is to use the so-called White's heteroscedasticity consistent estimators, instead of the OLS estimators (White, 1980). However, further examination of the data revealed that the presence of heteroscedasticity in model residuals is attributed to some aberrant observations. Such observations, which may be due to an error at some stage of the data collection procedure, may introduce artificial heteroscedasticity as well as autocorrelation (see Milionis, 2004). In addition to heteroscedasticity tests statistics, the values of other model statistics, such as the partial regression coefficients and the coefficient of determination, are also affected by the presence of aberrant observations. Therefore, the model was estimated again, by using OLS and excluding ten aberrant observations. The results are shown in Table 1. In addition to the partial regression coefficients, the corresponding standardised regression coefficients are also reported in Table 1. The later (coefficients) can be used in order to compare the relative strength of the effect of each explanatory variable on the dependent variable.

From the results on heteroscedasticity test, as reported in Table 1, it is evident that the hypothesis of no heteroscedasticity in model residuals cannot be rejected. It is also evident that the coefficients of labour, non-ICT capital and ICT capital, which are equal to the elasticities of the corresponding inputs, are all positive and statistically significant, so we conclude that all these three inputs make a positive contribution to firm value added, a result similar to those of other studies referring to larger and more developed economies (Brynjolfsson & Hitt, 1996). Moreover, the standardised coefficient of the ICT capital (0.138) is somewhat higher than the one of the non-ICT capital (0.107), so we can conclude that the ICT investment contributes to value added more than the investment in 'traditional capital' (regular assets); however, both these coefficients are substantially lower than the one of the labour (0.710), reflecting the high importance of the labour input in the Greek economy.

The results regarding the estimation of model (3) are shown in Table 2.



**Table 1:** Estimation results and statistics for model (1).  
White's statistic stands for the value of the statistic in White's test for heteroscedasticity.

Dependent variable: $\ln(VA)$				
Explanatory Variable	Partial regression coefficient	Standardized Coefficient	t-value	Significance
Constant	1.012		2.106	0.036
$\ln(K)$	0.089	0.107	2.835	0.005
$\ln(ICK)$	0.155	0.158	3.660	0.000
$\ln(L)$	0.793	0.710	16.038	0.000
<b>R square=0.815</b>	<b>Adjusted R square= 0.813</b>			
White's statistic=4.09	Degrees of freedom=6	Critical value (95%)=12,59		

**Table 2:** Estimation results and statistics for model (2).

Dependent variable: $\ln(VA)$				
Explanatory Variable	Partial regression coefficient	Standardized Coefficient	t-value	Significance
Constant	1.334		2.608	0.010
$\ln(K)$	0.086	0.104	2.759	0.006
$\ln(ICK)$	0.129	0.131	2.891	0.004
$\ln(L)$	0.787	0.706	15.984	0.000
$\ln(ICK)*STR-AL$	0.004	0.060	1.958	0.051
<b>R square=0.819</b>	<b>Adjusted R square= 0.816</b>			

From the results of Table 2 it is evident that the coefficients of labour, non-ICT capital and ICT capital remain all positive and statistically significant, as expected. The coefficient of the interaction term between ICT investment and strategic alignment is positive and marginally significant at the 5% significance level. Hence, strategic alignment of ICT investment increases its contribution to firm value added.

However, more insight regarding the effect of strategic alignment may be gained by modifying model (3) as follows:

$$\ln VA = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(ICK) + \gamma_1 \ln(ICK) \cdot d_1 + \gamma_2 \ln(ICK) \cdot d_2 + \gamma_3 \ln(ICK) \cdot d_3 + \gamma_4 \ln(ICK) \cdot d_4 + u_i \quad (4)$$

In model (4) the strategic alignment, which is a 5-valued variable, has been represented with four binary dummy variables  $d_1, d_2, d_3, d_4$ , which correspond to a "small degree", "moderate degree", "high degree", and "very high degree" of bilateral relationship between the ICT Plan and the Overall Business/Strategy Plan of a firm respectively. The advantage of model specification (4) over model specification (3) is that although in (3) it is implicitly assumed that the differential effect corresponding to different "values" of strategic alignment is identical, in specification (4) this differential effect may be different and may be assessed from the values of the coefficients  $\gamma_1, \gamma_2, \gamma_3$  and  $\gamma_4$ . The results regarding the estimation of model (4) are presented in Table 3.

**Table 3:** Estimation results and statistics for model (4).

Dependent variable: $\ln(VA)$				
Explanatory Variable	Partial regression coefficient	Standardized Coefficient	t-value	Significance
Constant	1.244		2.433	0.016
$\ln(L)$	0.085	0.102	2.738	0.007
$\ln(K)$	0.128	0.131	2.915	0.004
$\ln(ICK)$	0.798	0.715	16.281	0.000
$\ln(ICK)*d_1$	-0.043	-0.043	-1.483	0.139
$\ln(ICK)*d_2$	-0.020	-0.034	-1.140	0.256
$\ln(ICK)*d_3$	0.016	0.049	1.407	0.161
$\ln(ICK)*d_4$	0.034	0.061	2.002	0.047
<b>R square=0.824</b>	<b>Adjusted R square= 0.819</b>			

From these results it is evident that only in the case of very high degree of bilateral relationship between the ICT Plan and the Overall Business/Strategy Plan of a firm there is a statistically significant effect. For the other three cases the corresponding  $\gamma$  coefficient is not statistically significant. To certify that the non-significance of  $\gamma_1, \gamma_2, \gamma_3$  is not a result of inflated standard errors owing to the existence of multicollinearity some further analysis was undertaken. This includes estimation of the so-called variance inflation factors (VIF) for the coefficient of each explanatory variable as well of the so-called condition index. VIF for the  $j$ th coefficient is defined as:  $VIF = \frac{1}{1 - R_j^2}$  where  $R_j^2$  represents the

coefficient of determination in the regression with dependent variable the variable corresponding to coefficient  $j$  on the remaining of the explanatory variables. Values of VIF greater than about 8 to 10 are an indication that the corresponding variable is highly collinear. On the other hand the condition index is given by the square root of the ratio of the maximum over the minimum eigenvalue of the data matrix and it is a measure of collinearity in the whole data matrix. As a practical rule for values of the condition index up to about 30-35 multicollinearity is considered to be modest (see for instance Gujarati, 2003).

The results of this auxiliary collinearity analysis are shown in Table 4.

**Table 4:** Colinearity statistics

Coefficient	VIF
$B_2$	1,725
$\beta_3$	2,519
$B_4$	2,405
$\Gamma_1$	1,039
$\Gamma_2$	1,117
$\Gamma_3$	1,489
$\gamma_4$	1,156
Condition Index	30.6

From the results of Table 4 it is evident that there is no indication of severe collinearity in the data matrix so the results of Table 3 regarding the statistical significance of the coefficients are not due to collinearity. This leads us to the conclusion that strategic alignment contributes only in the firms for which a very high degree of bilateral relationship between the ICT Plan and the Overall Business/Strategy Plan exists. As a matter of fact for such firms the effect of ICT investment on VA can be increased substantially as the values of the corresponding standardised coefficients for  $\ln(ICK)$  and  $\ln(ICK)*d_4$  in Table 3 indicate (0.131 and 0.060) respectively).

**Table 5:** Regression model for the impact of standardised labour, non-ICT capital and ICT capital on labour productivity.

Dependent variable: $\ln(VA/N)$				
Explanatory Variable	Partial regression coefficient	Standardized Coefficient	t-value	Significance
Constant	1.153		1.856	0.065
$\ln(K/N)$	0.091	0.129	2.779	0.006
$\ln(ICK/N)$	0.154	0.172	3.531	0.001
$\ln(L/N)$	0.794	0.625	12.982	0.000
<b>R square=0.540</b>	<b>Adjusted R square= 0.534</b>			

Next we estimated similar models for the labour productivity ( $=VA/N$ ). All the explanatory variables are divided (standardized) by the number of firm employees  $N$ , and the results are shown in Tables 5 (basic model) and 6 (model with interaction) respectively.

**Table 6:** Regression model for the impact of standardised labour, non-ICT capital, ICT capital and interaction between standardised ICT capital and strategic alignment factor on labour productivity

Dependent variable: $\ln(VA/N)$				
Explanatory Variable	Partial regression coefficient	Standardized Coefficient	t-value	Significance
Constant	1.357		2.193	0.029
$\ln(K/N)$	0.085	0.121	2.633	0.009
$\ln(ICK/N)$	0.120	0.134	2.631	0.009
$\ln(L/N)$	0.796	0.627	13.207	0.000
$\ln(ICK/N)*d_1$	-0.065	-0.060	-1.321	0.188
$\ln(ICK/N)*d_2$	-0.031	-0.048	-1.037	0.301
$\ln(ICK/N)*d_3$	0.032	0.088	1.778	0.077
$\ln(ICK/N)*d_4$	0.061	0.106	2.240	0.026
<b>R square=0.564</b>	<b>Adjusted R square= 0.550</b>			

From the results of Table 5 it is apparent that the coefficients of standardised labour, non-ICT capital and ICT capital are all positive and statistically significant, so all these three inputs make a positive contribution to labour productivity, as was the case with value added (Table 1). Further the comparison of their standardised coefficient also leads to a conclusion similar to the one drawn for value added. Finally from the model of Table 6 it is concluded the strategic alignment of ICT investment increases its contribution to labour productivity.

The above results lead us to the rejection of both our research hypotheses  $H_0(1)$  and  $H_0(2)$  for both examined measures of business performance, firm value added and productivity. In conclusion, this empirical investigation leads to the conclusion that in Greece the ICT investment makes a statistically significant positive contribution to business performance, so there is no 'ICT Productivity Paradox'; also, this empirical investigation contributes the third of the ICT alignment research streams mentioned in section 3 and provides sound evidence that the strategic alignment of ICT investment increases considerably its contribution to both these objective measures of business performance (value added and labour productivity), but only for those firms for which a very high degree of bilateral relationship between the ICT Plan and the Overall Business/Strategy Plan exists.

## 5. Summary and Conclusions

In the previous sections of this paper, an empirical investigation of the effect of ICT investments on Greek firms' business performance was presented. It has also been examined for first time in Greece whether and to what extent this effect increases if ICT investments are aligned with business strategy. It has been concluded that the ICT investment has a statistically significant positive effect on Greek

firms' value added and labour productivity. Its output elasticity is somewhat higher than the one of the non-computer investment, reflecting the important role that ICT capital plays in Greek firms; however, it is lower than the one of the labour, reflecting the 'labour intensive' nature of Greek economy. Also, it has been concluded that the strategic alignment of ICT investment increases considerably its contribution to firm value added and labour productivity, but only for firms of very high degree of bilateral relationship between the ICT Plan and the Overall Business/Strategy Plan.

The above conclusions enable a better understanding of the impact of ICT investment on business performance, and also the role of ICT strategic alignment in this relation, in a national context different from the ones of the highly developed countries, in which most empirical research on the issues has been conducted. Greece has a lower economic and technological development than these countries. It is characterised by smaller average firm size, smaller size of internal market, lower intensity of competition and lower level of ICT usage, and also limited history and experience in this domain, in comparison with the highly developed countries. Also, Greek firms have still some 'idiosyncratic' characteristics, mainly related to corporate governance, that are noteworthy, as they are not usually found in firms listed in other developed financial markets: in many firms, even in the larger ones, the majority of company ownership belongs to members of the same extended family; also in many firms there is no distinction between ownership and management with big shareholders being also the members of the board of directors. The above characteristics of the Greek national context affect negatively the capability of Greek firms to manage their ICT investments and generate business value from them. We believe that the findings of this study are interesting not only for Greece, but also for many other countries, which are not highly developed and have similar characteristics.

Another contribution of this research is the creation of a unique research dataset, through a questionnaire-based survey among Greek firms, titled 'Usage of information and communication technologies, modern organization forms and innovation in the Greek companies', conducted in cooperation with ICAP, one of the largest business information and consulting companies of Greece. It includes data from 281 Greek firms concerning business performance, ICT investment, ICT management (including ICT strategic alignment), non-ICT investment, employment and management of human resources, adoption of new organisational practices, innovation and quality management. This is a unique database, since a similar one, combining all these data components, had never been collected before in Greece, and can be very useful for future empirical research in this domain.

Our findings provide additional evidence on the variability of the benefits and impact of the 'hard' ICT investments, due to their dependence on additional 'soft ICT actions'. In this sense the present study has interesting implications for management. Firms should combine their 'hard' ICT investments (i.e. acquisition of new hardware, software and networks), with appropriate 'soft actions', in order to achieve higher levels of benefits and impact on business performance from them. One of these necessary 'soft actions' is the alignment of ICT investment to business strategy, which results in the selection of the most appropriate ICT investments that support to the highest possible extent the selected business strategy and action plan of the firm, and therefore leads to a higher level of ICT benefits and business impact.

Further research is in progress by the authors for investigating the impact of various mechanisms of ICT strategic alignment at different hierarchical levels on the contribution of various types of ICT investments to business performance. Also, this research will be extended to other ICT-related 'soft actions' as well, such as the creation of new processes for ICT service level management.

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## Appendix:

Survey questions (used in this study)

- Yearly total sales revenue (without VAT): \_\_\_\_\_ Euro
- Yearly total expenses for buying materials and services (without VAT): \_\_\_\_\_ Euro
- Yearly total labour (personnel) expenses (without VAT): \_\_\_\_\_ Euro
- Value of assets at the end of the year (without VAT): \_\_\_\_\_ Euro
- Value of computer equipment (hardware, software and networks) at the end of the year (without VAT): \_\_\_\_\_ Euro

To what extent there is bilateral relationship between the ICT Plan and the Overall Business/Strategy Plan of your firm?

not at all    to a small degree    to a moderate degree    to a high degree    to a very high degree