

Information Systems and Innovation in Greek Firms – An Empirical Investigation

Spyros Arvanitis
KOF Swiss Economic Institute
ETH
Zurich, Switzerland
arvanitis@kof.ethz.ch

Euripidis Loukis
Dep. of Information and
Communication Syst. Engin.
University of the Aegean
Samos, Greece
eloukis@aegean.gr

Vasiliki Diamantopoulou
Dep. of Information and
Communication Syst. Engin.
University of the Aegean
Samos, Greece
vdiamant@aegean.gr

Abstract – There has been an extensive theoretical literature during the last 20 years supporting that information and communication technologies (ICT) have a huge potential to drive significant innovations in firms' processes, products and services, which can result in big performance improvements. However, limited empirical investigation of this innovation potential of ICT has been conducted. This paper presents an empirical investigation of the impact of two widely used types of information systems (IS) (internal and e-sales ones), and also of four important 'traditional' innovation determinants (demand expectation, price and non-price competition, market concentration) for comparison purposes, on innovation in Greek firms. It has been concluded that in the 'innovation averse' Greek national context both these IS types have a strong positive impact on innovation, whilst this does not hold for any of the examined 'traditional' innovation determinants.

Keywords – *information and communication technologies (ICT); information systems (IS); e-sales; innovation*

I. INTRODUCTION

There has been an extensive theoretical literature during the last 20 years supporting that the full potential of information and communication technologies (ICT) for firms can be exploited by using them not merely for supporting existing processes, products and services, but also for making innovations in all these dimensions; ICT have a huge potential to drive significant innovations in firms' processes, products and services, which can result in big performance improvements [1] – [20] (this theoretical literature is briefly reviewed in section II.A). Initially this literature focused on the innovation potential of the internal information systems (IS) used by firms for supporting their internal processes and functions [1] – [10]; subsequently the emergence of the Internet motivated a focus of it on the innovation potential of external environment oriented IS which support interaction with customers, prospects, suppliers and business partners [11] – [20] through the Internet.

Though considerable empirical investigation has been conducted for identifying and understanding the 'determinants of innovation' (= factors having a positive impact on innovation activity of firms) [21] – [27], limited empirical investigation of the impact of ICT on innovation has been conducted [28] – [31], despite the high expectations of the above theoretical literature (this limited empirical literature is briefly reviewed in section II.B). Furthermore,

this limited empirical research on the relation between ICT and innovation has been conducted in the national contexts of a few highly developed countries, which are characterized by extensive use of ICT and also strong innovation culture and activity. Taking into account that the national context influences both ICT adoption and use [32] – [33] and innovation [34] – [35], it is necessary to study the relation between ICT and innovation in other types of national contexts as well.

This paper contributes to filling the above research gaps by presenting an empirical investigation of the impact of two widely used types of information systems (IS) (internal and e-sales ones), and also of four important 'traditional' innovation determinants (demand expectation, price and non-price competition, market concentration) for comparison purposes, on innovation in Greek firms. Greece is characterized by lower levels of both ICT use and innovation, as Eurostat statistics show. For instance ICT expenditure in Greece is at the level of 1.23% of GDP (average 2004 – 2006), while for the Scandinavian and the Continental European countries it is on average much higher, at the levels of 3.22% and 2.85%; also, in Greece 35.8% of firms can be characterized as innovative, while for the Scandinavian and the Continental European countries the corresponding average percentages of innovative firms are much higher, at the levels of 45.60% and 47.90% respectively. Furthermore, with respect to culture, according to Geert Hofstede's studies (<http://www.geert-hofstede.com/>) for Greece the value of the 'uncertainty avoidance index' is 112, while the corresponding average values for the Scandinavian and the Continental European countries are at the much lower levels of 35.25 and 50.17 respectively. Therefore the Greek national context is characterized by lower levels of ICT and innovation, and also a culture negative to innovation and uncertainty. In this national context, which is quite different from the ones of the highly developed countries in which the few empirical studies of the relation between ICT and innovation have been conducted, it is quite interesting to investigate this crucial relation.

This paper is organized in six sections. The following section II reviews briefly relevant literature, while in section III the hypotheses of our study are formulated. In section IV data and method of the study are described, followed by a presentation of the results in section V. The final section VII summarizes the conclusions.

II. LITERATURE REVIEW

A. Theoretical Background

An extensive theoretical literature concerning the innovation potential of ICT has been developed in the last 20 years [1] – [10]. It develops a wide range of arguments supporting the potential of ICT to enable and drive innovations of both processes and products/services of firms, which can enhance significantly business performance. This literature argues that most of the existing work practices, business processes and products/services of firms have been developed in the past, and have been critically influenced and shaped by high costs of and information processing and transfer at that time and the logic of the manual mode of work. These assumptions are not valid any more, since ICT have dramatically reduced information processing and transfer costs, and have removed many of the limitations that the manual mode of work imposes with respect to time and place. Co-operation between individuals is now possible from a distance and asynchronously through digital networks. These can lead initially to new enhanced business processes and work practices, which result in big productivity increases, initially by reducing costs and increasing output quality; subsequently they can drive the design of new products/services and improvements of important intangible aspects of existing products/services, such as convenience, timeliness, quality, personalization, etc. Another strong argument of this literature is that ICT have a unique characteristic in comparison to the other technologies that firms use: they are ‘general purpose technologies’, having high flexibility and adaptability, so they can be used in numerous different ways and for many different purposes, and therefore enable important innovations in business processes, products and services of firms. ICT enable significant restructuring of the work practices, through allocation of well-defined routine tasks associated with symbols processing to computers, and transformations of the tasks that require human skills.

The emergence of the Internet motivated a shift of this theoretical literature from the internal IS to the new types of IS which are developed based on the Internet for supporting interaction with firm’s external environment [11] – [20]. This literature argues that Internet changes the ways and costs of firms’ communication, collaboration and transaction with their customers, prospects, suppliers and business partners, and for this reason can be enablers and drivers of radical performance-enhancing innovations in the business processes, products, services, and even business models and value propositions of firms. There is an interesting research stream describing new business models that will be driven by the Internet (such as e-auction, e-mall, third party marketplace, virtual community, value chain service provider, value chain integrator, etc.) [11] – [13], and even methodologies for designing them [19]; they envision that these new business models will create totally new value propositions by mobilizing and combining people and resources in much more efficient ways than in the past, and will transform the markets and the bases of competition. So, theoretical literature expects that these Internet-based

external environment oriented IS will be much more disruptive than the internal IS, driving much more dramatic innovations.

B. Empirical Literature

Numerous empirical studies have been conducted concerning the ‘determinants of innovation’ at firm level, in order to identify and understand which factors affect innovativeness of firms (reviews of them are provided in [21] – [27]). From these studies it has been concluded that demand prospects, type and intensity of competition, market structure, factors affecting the production of knowledge (such as technological opportunities and appropriability) and firm size are the main determinants of firm’s innovation activity.

On the contrary, limited empirical research has been conducted on the impact of ICT on innovation based on large datasets, despite the above extensive theoretical background on it, in order to find out to what extent the high expectations of this theoretical literature are realized. Three empirical studies in this direction have been conducted in Germany. Licht and Moch [28] conclude that the level of investment in information technologies per employee impacted positively some product quality dimensions which they interpreted by the authors as indicators of product innovation. Hempell & Zwick [29] found that ICT investment and share of employees working mainly on a computer have a positive impact on functional flexibility and through it on product and process innovation, while ICT has a direct effect on both types of innovation as well. Engelstätter and Sarbu [30] conclude that there is no relationship between widely used enterprise software packages and innovation activity, and it is primarily the customized software that contributes significantly to innovation. Another study in this direction has been conducted in USA by Bartel et al [31] that new IT promotes increased production of customized products leading to product innovation, and that new IT embedded machines influenced and improved considerably production processes.

Summarizing, there are only a limited number of empirical studies that have investigated the impact of ICT on innovation based on large datasets (though numerous case studies have been published [36] – [39] investigating successful or failed ICT-based innovations, e.g.). This limited empirical literature has some important deficiencies i) it does not discriminate between different types of IS, which might have different impacts on innovation, ii) it does not make comparisons of ICT with the ‘traditional’ innovation determinants as to the impact on firm’s innovation activity, iii) it has been conducted in a few highly developed countries (Germany and USA), which are characterized by extensive use of ICT and also strong innovation culture and activity. This paper contributes to filling these research gaps by presenting an empirical investigation of the impact of two widely used types of information systems (IS) (internal and e-sales ones), and also of four important ‘traditional’ innovation determinants (demand expectation, price and non-price competition, market concentration) for comparison purposes, on firms’ innovation activity; it is conducted in the

Greek national context, which is characterized by lower levels of ICT and innovation, and also a culture negative to innovation and uncertainty.

III. RESEARCH HYPOTHESES FORMULATION

Our first two research hypotheses concern the impact of internal and e-sales IS on firms' innovation activity. Internal IS create numerous opportunities initially to transform processes and then to improve existing products and services and to develop new ones that were not feasible before. The potential of internal IS to drive innovation is supported by a rich theoretical literature [1] – [10], which has been briefly reviewed previously in section IIA. The internal IS greatly reduce information processing and transfer costs, so they can pervade all firm's processes, products and services and improve or transform them improving their efficiency; also, internal IS provide an infrastructure for designing, producing and delivering improved or new products and services in an efficient manner, which would not be feasible without ICT support. Furthermore, IS can support the communication and exchange of ideas among firm's employees, which is recognized by previous literature [40] – [42] to be of critical importance for the generation and adoption of innovations. For the above reasons our first research hypothesis is:

Hypothesis 1: Internal IS has a positive impact on innovation activity

As mentioned in section IIA an extensive theoretical literature has been developed concerning the huge innovation potential the new types of IS developed based on the Internet for supporting interaction with firm's external environment (e.g. customers, prospects, suppliers, business partners) [11] – [20]. This literature places particular emphasis on the potential of e-sales IS to drive radical innovations. E-sales change radically the way firms communicate and transact with their customers and prospects, and also reduce dramatically the corresponding costs, so they can lead to significant changes initially of some of firm's processes and later of its products and services; it can also lead to disruptive transformations of business models, establishment of new value propositions to the customers (including new products and services), and also new value creation models through cooperation of many different firms. Therefore our next research hypothesis is:

Hypothesis 2: E-Sales IS have a positive impact on innovation activity

Our next five research hypotheses concern the impact of the four most important 'traditional' innovation determinants (i.e. the main factors identified by previous literature as affecting firms' innovation) and also size on firms' innovation activity. It is widely accepted that demand growth potential has a positive impact on innovation performance of firms ("demand pull" hypothesis [43]). The larger the (anticipated) demand potential is, the higher are a firm's incentives for fostering product innovation and for using new cost-saving production techniques. There have been several empirical studies providing conformation of this in several highly developed countries [44] – [45]. So our third research hypothesis is:

Hypothesis 3: Demand expectation has a positive impact on innovation activity

The market conditions, and particularly the competitive pressures, are also regarded as highly important of firm's innovation activity. Market concentration (usually measured by the market share of the largest four firms in the industry) is a basic determinant of competition intensity: the more evenly market power is distributed among the competitors in the market (i.e. lower market concentration), the stronger will be the competition pressure for each single firm. Competitive pressures can be measured also directly, separately for different dimensions of competition (price, quality, etc.). So we have examined three aspects of market conditions: (a) market concentrations as reflected by the number of main competitors in firm's specific market; (b) the intensity of price competition in firm's specific market; and (c) the intensity of non-price competition in firm's specific market.

Concerning the effect of competition on innovation there are two opposing viewpoints. Industrial organization models of product differentiation and monopolistic competition typically argue that more intense product market competition, measured by an increase in the substitutability between differentiated products, will reduce post-entry rents, i.e. the profits to be gained from the innovation after entering the respective market, and therefore reduces the incentives for product innovation [46] – [47]; this is the so-called 'Schumpeterian' point of view. Another line of thought argues on the contrary that it is the price elasticity of demand (i.e. the relative change of demand caused by a relative change of price divided by the causing relative change of price faced by a firm in its specific market that induces innovative activity [48]. In those markets where competition pressure is greater, demand elasticities can be expected to be higher because of the existence of close substitutes, thus driving firms to innovative activity. This is the so-called "free competition" point of view. Aghion et al. [47] developed a model that predicts an inverted-U relationship between product market competition and innovation: for lower level of competition it has a positive impact on innovation, however if the competition exceeds a threshold its effect on innovation becomes negative; they also found strong evidence for this model using UK data.

Therefore whether positive "free competition effects" are stronger than negative effects according to the tradition of Schumpeter has to be resolved at the empirical level. As a consequence, two alternative research hypotheses have to be formulated for market concentration and price competition. Further, we expect a positive effect of the intensity of non-price competition (reflecting the influence of non-price factors such as quality, technical content, etc.) on innovation. This expectation is in accordance with models of product differentiation, in which product quality is the main dimension of competition among firms, and which are interpreted as models of incremental innovation [48]. Thus, our next three research hypotheses with respect to the influence of market conditions on innovation are:

Hypothesis 4: Non-price competition has a positive impact on innovation activity

Hypothesis 5a: Price competition has a positive impact on innovation activity

Hypothesis 5b: Price competition has a negative impact on innovation activity

Hypothesis 6a: Market concentration has a positive impact on innovation activity

Hypothesis 6b: Market concentration has a negative impact on innovation activity

Finally, firm size is a further important determinant of innovation performance. In general, larger firms have more resources for the design and implementation of innovations, a higher level of management capabilities and also the possibility to exploit economies of scale and scope [49]. So our next research hypothesis is:

Hypothesis 7: Size has a positive impact on innovation activity

IV. DATA AND METHOD

For this study we have used data we collected through a survey among Greek firms, which has been conducted in cooperation with ICAP S.A. (www.icap.gr), one of the largest business information and consulting companies of Greece. Initially from the database of ICAP a first sample of firms was randomly selected, which included 304 Greek firms (103 small, 103 medium and 98 large ones) from the 27 most important sectors of Greek economy. Furthermore, two similar samples were also created with the same proportions of small, medium and large firms, and also firm from the above 27 sectors. A questionnaire was developed, reviewed by three highly experienced experts from ICAP S.A., and based on their remarks the final version of it was formulated. The questionnaire was sent by mail to the managing directors of the 304 firms of the first sample; the ones refusing to participate were replaced by ‘similar’ firms (i.e. from the same size and industry class) from the second sample, and if the second sample was exhausted we proceeded to the third sample. This procedure allowed us to have a balanced sample concerning company size and industry. Finally, we received complete questionnaires from 271 firms (88 small, 105 medium and 78 large ones).

For testing our research hypotheses we used the above data for estimating the following innovation model:

$$\text{INNOV} = b_0 + b_1 \cdot \text{INT_IS} + b_2 \cdot \text{ES_IS} + b_3 \cdot \text{DEM} + b_4 \cdot \text{INPC} + b_5 \cdot \text{IPC} + b_6 \cdot \text{NCOMP} + b_7 \cdot \text{D_MED} + b_8 \cdot \text{D_LARGE} + b_9 \cdot \text{D_SECT} \quad (1)$$

Innovation activity (dependent variable) is a complex and multi-dimensional phenomenon, so for measuring it a composite index was formed (INNOV) as the sum of the standardized values (having zero average and unity standard deviation) of four variables: research and development (Y/N – this variable measures innovation input), product innovation (Y/N), process innovation (Y/N) (both these variables measure innovation output), percentage of firm revenue from new products/services (this variable measures innovation impact).

With respect to the independent variables, we have used as a measure of use of internal IS a composite index variable

(INT_IS), which is equal to the sum of the standardized values of two variables measuring the intensity of internal use (i.e. the percentage of firm employees using) two basic ICT, Internet and Intranet (both in a six levels scale: 0: 0%; 1: 1-20%; 2: 21-40%; 3: 41-60%; 4: 61-80%; 5: 81-100%). For measuring the extent of using e-sales IS we used one variable (ES_IS) equal to the percentage of firm’s sales conducted through the Internet. We have also included a demand expectations variable (DEM) measuring to what extent the firm expects an increase of demand on the relevant product markets in the next three years (Y/N). With respect to market conditions we have used three variables: a measure of the intensity of price competition on a firm’s specific market (variable IPC), a measure of the intensity of non-price competition (variable INPC) (both of them measured in an 1-5 scale, with 1 = very weak, and 5 = very strong) and a measure of the market structure/concentration as reflected by the number of main competitors on a firm’s most important product market (variable NCOMP). For measuring firm size has been used the number of employees, and from it two dummy variables have been formed: one for medium-sized firms (D_MED: taking value 1 for medium size firms with 50 to 249 employees, and 0 for all other firms) and a second one for large firms (D_LARGE: taking value 1 for large firms with more than 250 employees, and 0 for all other firms). Also, we have additionally included a sector dummy (D_SECT) taking value 0 for manufacturing sector firms and 1 for service sector firms.

V. RESULTS

The results from the estimation of the innovation model of equation (1) are shown below in Table 1 (the statistically significant independent variables, with significance levels lower than 5%, are shown in bold).

TABLE I. ESTIMATED MODEL

Independent Variable	<i>b</i>	<i>St.error</i>	<i>Stand. Coeffic.</i>	<i>t</i>	<i>Sign.</i>
Int_IS	.290	.093	.189	3.161	.002
ES-IS	.044	.017	.148	2.535	.012
DEM	.371	.340	.064	1.091	.276
IPC	.120	.160	.046	.750	.454
INPC	.012	.148	.005	.083	.934
NCOMP	-.001	.000	-.061	-1.061	.290
D_SECT	-.526	.320	-.096	-1.645	.101
D_LARGE	1.865	.414	.306	4.507	.000
D_MED	.908	.380	.162	2.390	.018
Constant	-1.473	.791		-1.864	.064

We remark that both internal and e-sales IS have a statistically significant positive impact on innovation, so hypotheses 1 and 2 are supported. Taking into account the corresponding standardized coefficients we can conclude that internal IS have a stronger impact on innovation than the e-sales IS.

These results indicate that Greek firms exploit the great innovation potential of the internal IS, which pervade and

influence all firm's processes, products and services, for making innovations. They have realized that their existing processes, products and services have been designed in the pre-ICT era, so they have been shaped by the dominant logic and constraints of the manual mode of work, and the high costs of information processing and transfer at that time; therefore using capabilities offered by the internal IS allow highly beneficial transformations of their processes, products and services. These are in agreement with the conclusions of the few previous empirical studies of the relationship between ICT and innovation (briefly reviewed in II.B).

The results also indicate that Greek firms exploit the innovation potential of the e-sales IS as well. They have realized that these IS offer a new Internet-based channel of communication and transaction with their customers and prospects, reducing dramatically the corresponding costs, which requires significant changes of their processes, and also allows highly beneficial improvements and transformations of their products and services.

Taking into account the standardized coefficients of INT_IS and ES_IS (shown in the third column of Table I), which are 0.189 and 0.148 respectively, it can be concluded that internal IS have a stronger impact on innovation than the e-sales IS. This is not agreement with the relevant theoretical literature on the innovation potential of ICT (briefly reviewed in II.A), which expects that external environment oriented IS will be much more disruptive than the internal IS, driving much more dramatic innovations. It seems that Greek firms have not yet exploited the most advanced innovation capabilities that e-sales IS provide (e.g. for new business, models, value propositions, value creation networks, etc.), which however require extensive and risky coordinated transformations in several firms.

Furthermore, we remark that all four 'traditional' innovation determinants we examined (demand expectation, price competition, non-price competition, number of competitors) do not have a statistically significant impact on firms' innovation in the Greek national context. Therefore hypotheses 3, 4, 5 and 6 are not supported. This is not in agreement with the results of previous relevant empirical studies conducted in other highly developed countries (e.g. [50]), which have found that the above factors have a positive impact on innovation. These results indicate that in the Greek national context, which is innovation averse as mentioned in the Introduction, characterized by lower innovation activity and uncertainty avoidance culture, firms do not respond to high competition or demand expectations with innovations in their processes, products and services, as the firms of developed countries do. Finally, we can see that size that has a positive impact on innovation, as both D_LARGE and D_MED variables have statistically significant coefficients, so hypothesis 7 is supported.

VI. CONCLUSIONS

In the previous sections has been presented an empirical investigation of the impact of two widely used types of IS, internal and e-sales IS, and also of four important 'traditional' innovation determinants (demand expectation, price and non-price competition, market concentration) for

comparison purposes, on innovation in Greek firms. Even though an extensive theoretical background has been developed on the innovation potential of ICT, limited empirical investigation of it has been conducted, in national contexts of highly developed countries characterized by extensive use of ICT and strong innovation culture and activity. Our study has been conducted in a very different national context, the one of Greece, which is characterized by lower levels of ICT and innovation, and also a culture negative to innovation and uncertainty. Our results indicate that even in such an innovation averse national context, in which the traditional innovation determinants identified by previous research in highly developed countries do not drive innovation, the ICT can be a strong drive of innovation. Although Greece is characterized by lower use of ICT, and therefore lower experience in its effective exploitation, we can see that ICT is an important innovation drive. Further empirical research is required on the relation between ICT and innovation, in various national contexts, investigating the effects of different types of IS on different types of innovation.

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