Enterprise Systems and Innovation – An Empirical Investigation

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Abstract

Information and communication technologies (ICT) have been initially used mainly for supporting or automating firms’ pre-existing business processes, in order to improve their efficiency. Subsequently it was realised that much more value can be generated from ICT if we exploit their great potential to drive innovations in firms’ products/services and processes. However, limited empirical research has been conducted concerning the effects of the many different types of enterprise systems (ES) that firms use on their innovation performance. This paper contributes in this direction. It investigates empirically and compares the effects of six important and widely used types of ES (ERP, CRM, e-sales, telework and collaboration support systems) on firms’ product/service and process innovation. Our study is based on a large dataset collected from 14,065 European firms through the e-Business Watch Survey of the European Commission, which has been used for estimating innovation models. We have been found that all examined types of ES have some positive effect on both product/service and process innovation; however, these effects differ in magnitude. Our results indicate that the e-sales are the strongest drivers of product/service innovation, followed by the CRM and external collaboration support systems; with respect to the process innovation the e-sales the strongest drivers of it as well, followed by the telework systems.

1. Introduction

Information and communication technologies (ICT) have been initially used mainly for supporting or automating firms’ pre-existing business processes, aiming to improve their efficiency. However, subsequently it was realised that higher levels of value can be generated from ICT if we exploit their great potential to drive innovations in firms’ products/services and processes. So there has been much more empirical research on the effects of ICT use on various measures of firm’s productivity (reviews of this empirical literature are provided by ([1], [16], [36], [52])) than on firms’ innovation performance (a brief review of the latter empirical literature is provided in section 2.2). Furthermore, most of the existing empirical research concerning the effects of ICT on innovation views the former as a single entity (usually using a single ICT variable as independent variable, such as firm’s total ICT investment per employee, or share of employees using computers in their work) and do not discriminate between different types of information systems (IS).

However, many different types of IS have been developed, and also new ones are continuously emerging, which differ significantly in the capabilities and functionalities they offer, and in the data they store and process. So we would expect that they might have different impacts on product/service and process innovation (some of them might be stronger drivers of innovation than the others); therefore, viewing all of them as a single entity – variable in ICT innovation empirical studies allows drawing only too general conclusions on this important relationship, but not the more detailed conclusions required for providing useful advice and guidance to practitioners (managers of various levels and consultants).

For the above reasons it is highly important to investigate empirically and compare the effects of various types of IS on product/service and process innovation, and identify the ones having the strongest impact on innovation. This is going to be quite useful to firms’ management in order i) to make optimal decisions concerning their investments in various types of IS, taking into account their impacts not only on efficiency but also on innovation as well, and ii) to proceed to a better more innovation-oriented exploitation of their ICT infrastructures (for making innovations in the processes, products and services). However, limited empirical research has been conducted in this direction concerning the effects of the many different types of enterprise systems (ES) that firms use on their innovation performance.

This paper makes a contribution in this direction. It examines empirically and compares the effects of six important and widely used types of enterprise systems (ES) (ERP, CRM, e-sales, telework and collaboration support systems) on product/service and process...
innovation. The theoretical foundation of our study is the extensive theoretical basis that has been developed concerning the potential of ICT to drive innovation in firms’ processes, products, and services (reviewed briefly in section 2.1). This study has been based on a large dataset collected from 14,065 European firms through the e-Business Watch Survey of the European Commission, from which product/service and process innovation models have been estimated.

This paper is organized in seven sections. In the following section 2 the relevant literature (both theoretical and empirical) is reviewed. Then in section 3 the research hypotheses are formulated. The data and method are described in sections 4 and 5 respectively, while the results are presented in section 6. Finally, in section 7 the conclusions are summarized.

2. Literature Review

Initially the existing both theoretical and empirical literature concerning the potential of ICT to drive innovation has been reviewed, following the directions provided by previous literature on the organization of research literature reviews ([8], [42], [67]).

2.1 Theoretical Literature

There has been considerable theoretical research concerning the great potential of ICT to facilitate and drive various types of innovations; it can be divided into three streams.

The first stream focuses on the ‘direct’ ICT-based innovations in firms’ processes, products, and services, which can be directly driven and enabled by the capabilities offered by ICTs, through incorporating and using them in the internal processes, products and services of firms (9), [10], [11], [12], [13], [20], [27], [28], [33]). This literature argues that most of the existing work practices, business processes and products/services of firms have their roots in the pre-ICT era, so they have been critically influenced and shaped by the dominant at these times logics and limitations of the manual mode of work. For instance, the manual mode of work necessitates extensive human labor (since all tasks have to be performed by humans), colocation of cooperating persons and required documents, and synchronous human interaction; also it provides limited capabilities for tasks parallelism (since the required documents can be used only by one person at each specific time) and is characterised by high costs of information processing and transfer. However, ICT have dramatically changed these logics and assumptions, have reduced dramatically information processing and transfer costs, and enable overcoming the limitations of manual work; for instance, in order to co-operate and perform a joint activity it is not any more necessary all involved individuals to be in the same place at the same time, since they can have remote and asynchronous cooperation through electronic networks. Also, a higher degree of tasks parallelism can be achieved, since electronic documents and data can be accessed by many persons at the same time. For these reasons ICT can lead initially to new enhanced business processes and work practices, which result in big productivity increases; subsequently ICT can drive the design of new products/services, and also significant improvements of important intangible aspects of existing ones, such as convenience, timeliness, quality, personalization, etc. ICT can be enablers of new products and services, which were not feasible, or were too costly, previously.

The second stream of theoretical research focuses on the innovation potential of the ‘extrovert’ Internet-based e-business IS, concluding that they can be drivers and enablers of radical innovations of firms’ processes, products, services, and business models ([19], [32], [48], [50], [58], [59], [61], [69], [70], [73]). [61] and [58] describe several new and highly disruptive business models driven by the Internet, which can deeply transform many industries and markets. [73] identifies eleven categories of innovation opportunities provided by the ‘Web-Internet’ compound, which are associated with access to existing and new marketplaces, extension and reconfiguration of supply-chain linkages, networks of relationships and business ecologies, deeper collaboration with business partners concerning both operations and continuing innovation, communities of knowledge exchange, use of interactive media, digitization and delivery of goods and services, anytime-anywhere connectivity and location-sensitive products/services, intra- and inter-organizational development platforms, universal telecommunication networking and finally intelligent sharing, allocation and combination of computational capacity. [32] argue that Internet can reduce significantly transaction costs and lead to transformations of firms’ both horizontal and vertical boundaries, unbundling of the core functions of firms (product innovation, customer relationship management and infrastructure management) in many industries, deconstruction of existing value chains, and creation of ‘virtual value chains’ that exploit the information captured in physical value chains in order to create additional value for the customer. Furthermore, the Internet has been the driver for the development of a wide variety of electronic services (e-services) ([19], [48], [50]), in which the Internet is used in order to solve problems,
conduct transactions, or create value for current or potential customers.

The third theoretical research stream focuses on the potential of ICT to facilitate and drive ‘indirectly’ the development of innovations in firms’ processes, products and services, by supporting and increasing the productivity of research and development (R&D) and innovation creation processes, resulting finally in higher innovation performance ([18], [21], [24], [26], [35], [40], [41], [57], [60]). This research has identified the following three main mechanisms for this:

a) ICT can significantly support and improve the internal management, diffusion and exchange of innovation-related knowledge. Networking and database technologies enable a better communication and exchange of knowledge among firm’s employees from different functions and disciplines, and this facilitates the combination of scientific and operational knowledge from different domains, which is of critical importance for innovation.

b) ICT can also support and improve external research and innovation collaborations with other organizations, such as universities, research centers, other firms, etc. This is quite important due to the gradual shift from the ‘closed innovation’ paradigm to the ‘open innovation’ one ([18], [24]), in which both internal and external ideas, skills and knowledge, coming from both firm employees and also from suppliers, customers, partners, are combined in order to create innovations of higher customer value in shorter time and promote them in various markets.

c) Finally, all the stages of the innovation production process itself (idea and concept development, product design, product engineering (prototyping) and manufacturing) can be significantly supported and improved through appropriate ICT tools supporting advanced and complex simulation, problem solving, and also the design, prototyping and testing of new products. For instance, the analysis of the information provided by customer relationship management (CRM) systems enables firms to identify problems of current products and services, and also unmet needs, which helps in generating ideas for new products and services. Also, the computer-aided design and manufacturing (CAD/CAM) technologies can significantly support, accelerate and reduce the cost of developing and products new products.

2.2 Empirical Literature

However, there has been much less empirical investigation of this potential of ICT to drive innovation. [29] examined the relationship between IT investment and firm innovation outcome measured through patent counts, based on data for 450 US manufacturing firms; they found that IT investment did not have a direct effect on innovation outcomes, but the interaction between ICT investment and R&D expenditure positively affected innovation. [15], using data from 557 service firms from the region of Madrid, Spain, examine the effects of ICT investment (measured qualitatively) on the importance and contribution of firm’s innovations in the following five dimensions: productivity and costs, product or market expansion, employment and required skills, services quality and fulfillment of ecological standards. They found that ICT investment has a positive impact on all the above dimensions of innovations’ importance and contribution. [30], based on data from 4,500 German manufacturing and service firms, concluded that ICT investment per employee has a positive impact on product and process innovation, mainly by increasing internal work flexibility (=extent of teamwork adoption and resulting employees’ participation and horizontal communication), which affects positively both types of innovation. [40], analyzing data from 201 large U.S. manufacturing firms over the period 1987 to 1997 (a total of 1,829 observations), found that ICT capital has a positive effect on patents output (which is used as a measure of product innovation), and especially on the more ‘incremental’ (i.e. less radical) ones.

Also, there are two empirical studies focusing on the impact of ES on innovation. [22], using data from 1454 German firms coming from both manufacturing and service sectors, investigated the effect of using three different types of enterprise software, enterprise resource planning (ERP), supply chain management (SCM) systems and customer relationships management (CRM), on the innovation performance of firms. He found that CRM systems have positive effect on the likelihood of achieving product innovation, while SCM systems have a positive effect on the number of product innovations; also, CRM systems have positive effect on the likelihood of making process innovations, while ERP systems have a positive effect on the number of process innovations. [23] investigated the relationship between the use of sector-specific standardized/packaged enterprise software and customized enterprise software on service innovation (335 German firms; 2007-2009); the results showed that primarily customized enterprise software contributes to innovation.

We remark that most of the existing empirical research concerning the effects of ICT on innovation views the former as a single entity, using a single ICT variable, such as firm’s total ICT investment per employee, or share of employees using computers in their work, and do not discriminate between different types of IS. There is quite limited empirical investigation of the effects of different types of IS on
firm’s innovation performance. Our study contributes to filling this research gap, by investigating empirically and comparing the effects of six important and widely used types of ES on product/service and process innovation.

3. Research Model and Hypotheses

The most important type of ES is definitely the enterprise resource planning (ERP) systems, which are increasingly becoming the backbone of the ICT infrastructure of numerous firms of all sectors and sizes. They are integrated software packages, consisting of modules, which support and link various business units of an organization, such as financial, accounting, manufacturing, and human resources ones, having a common shared database ([4], [7], [44]). So our first research hypothesis concerns the effect of ERP systems on innovation. ERP systems enable and facilitate various kinds of innovation in firms’ business processes, such as simplification, improvement, integration, standardization (for all units of the firm), and also automated execution of some parts of them (e.g. automation of accounting entries in various transactions), and creation of new horizontal inter-departmental processes. Also, ERP enable high levels of visibility of firm’s operations (both ‘vertical’ and ‘horizontal’), and store big amounts of data about them; these allow identifying bottlenecks and weaknesses of existing processes, and required modifications of them. Furthermore, in modern ERP systems there are built-in best practices and processes for important tasks (based on the experiences of many successful firms), which can be easily adopted by the ERP user firm (though appropriate configuration of the system). At the same time ERP systems support and facilitate the introduction of new or improved products and services, and also the low cost customization – personalization of the existing ones, providing an ICT infrastructure for managing all aspects of their production and logistics; many of them would not be feasible (operationally or economically) without the high levels of electronic support provided by the ERP system. Also, ERP systems collect and analyze large amounts of data about the sales of firm’s products and services, which allow the identification of weaknesses of them and needs for improvements, and also for development of new ones. However, in the relevant literature there are arguments in the opposite direction as well ([53], [55], [62]): it is argued that ERP systems in some cases may inhibit innovation in the firm’s processes, products and services, if the required electronic support of a specific innovation is not included in the range of capabilities (e.g. best practices and processes) of the system (which can be easily activated through configuration – parameters’ setup). In such cases customization of the ERP code is required, which can be difficult and costly, due to the complexity of the code, the tight coupling between the ERP modules (and therefore the corresponding processes), and the need to redo all code modifications for each new upgrade of the ERP. For these reasons we have formulated two alternative research hypotheses concerning the effects of ERP systems on product/service innovation and on process innovation:

**Hypothesis 1a:** ERP systems have a positive effect on product/service innovation.

**Hypothesis 1b:** ERP systems have a negative effect on product/service innovation.

**Hypothesis 2a:** ERP systems have a positive effect on process innovation.

**Hypothesis 2b:** ERP systems have a positive effect on process innovation.

The growing competition has increased the importance of firm’s relationships with its customers, and this has lead to the development of the most important complement of the ERP systems: the customer relationship management (CRM) systems ([17], [34], [37], [39]). So our next two research hypotheses concern the effect of CRM systems on innovation. CRM systems aim to support firms to attract and retain customers, and achieve high levels of sales to them, by fulfilling their needs to the highest possible extent and increasing their satisfaction and loyalty. They provide extensive functionality for supporting the sales and customer service processes and also the collection, integration, analysis and internal dissemination (e.g. to the sales, marketing and customer service departments) of customer data (e.g. communications, transactions, needs, preferences). So CRM systems enable and facilitate innovations in all ‘customer-facing’ processes and practices of the firm, which make them more customer-centric and efficient. Furthermore, CRM systems collect large amount of customers related data; their analysis leads to the creation of valuable knowledge about the needs, wants, preferences, complaints and buying habits of customers, which can be quite useful for the improvement of new products and services, and the development of new ones [34]. In general, CRM systems enable the exchange and sharing customers related data and knowledge among all departments dealing with the customer (such as sales, marketing and customer service ones); this promotes innovation, since according to previous innovation research ([47], [63], [64]) the exchange and combination of knowledge among different functional units of the firm can be a highly productive source of innovation ideas.
For these reasons our next two research hypotheses are:

**Hypothesis 3:** CRM systems have a positive effect on product/service innovation.

**Hypothesis 4:** CRM systems have a positive effect on process innovation.

The emergence of the Internet lead to the rapid development of Internet-based electronic commerce ([43], [65]), with the on-line sales of numerous products and services increasing exponentially. This has resulted in the development of another important complement of the ERP systems, the e-sales IS, which enable firms to receive electronic orders for products and services from customers through the Internet. Our next two research hypotheses concern the effect of e-sales IS on innovation. These systems initially lead to innovations in firm’s business processes, especially in the ‘customer facing’ ones, in order to fulfill the needs of this new electronic sales channel: receive orders and payments electronically on a 24hours/7days basis, deliver products to more geographically dispersed customers, and offer them after-sales support. Furthermore, e-sales IS enable and facilitate selling bigger numbers of products (in comparison with ‘traditional’ physical shops), which can be either variants of the existing ones, or totally new products; also they enable low cost customization – personalization of products according to customers needs and preferences. Additionally, these systems allow the introduction of new complementary electronic services (see section 2), which can significantly increase the value offered to customers. Latter, e-business systems can drive more radical innovations in value propositions, products, services and even business models (see section 2). For the above reasons our next two research hypotheses are:

**Hypothesis 5:** e-sales systems have a positive effect on product/service innovation.

**Hypothesis 6:** e-sales systems have a positive effect on process innovation.

Another important type of ES are the collaboration support IS, which are increasingly used by firms, providing electronic support of internal collaboration (among different units of the firm) as well as external collaboration (with business partners, suppliers and customers) ([2], [25], [56]). So our next two research hypotheses concern the effect of collaboration support systems on innovation. These systems offer extensive collaboration support functionalities, such as centralized content storage, forum, instant messaging and other interaction and productivity applications, social media type applications, project management, etc. These capabilities enable a more intensive and rapid exchange of data and knowledge amongst firm’s employees working in different functional units, which as mentioned above promotes innovation ([47], [63], [64]). Furthermore, in the modern economy innovation becomes increasingly ‘open’ (=not limited within firm’s boundaries) ([31], [51], [71], [72]): firms are increasingly collaborating with other firms, which possess complementary resources (e.g. equipment and production facilities, human skills, knowledge), in order to design, produce and promote innovative products, services, or even production and business processes. Collaboration support IS can be quite useful and supportive in this direction as well: they enable a more intensive and rapid exchange of data and knowledge with external innovation partners (e.g. suppliers, customers, other cooperating firms), which according to previous innovation research ([46], [49], [72]) promotes and facilitates innovation. For these reasons, the next two research hypotheses are:

**Hypothesis 7:** Collaboration support systems have a positive effect on product/service innovation.

**Hypothesis 8:** Collaboration support systems have a positive effect on process innovation.

Another important trend in the modern economy is teleworking. The development of the communication networks (higher speeds at lower costs with high levels of availability) gave rise to development of teleworking, defined as the engagement in work activities from places other than firm’s offices (e.g. from home, customers’ or suppliers’ offices, or from the field, while travelling, etc.) through the use of ICT ([3], [5], [6], [38], [54]). In this direction firms are increasingly developing a new type of ES, the telework ones, which enable employees to work remotely, away from firm’s offices, by accessing the other types of firm’s ES (through the Internet or mobile wireless networks) based on pre-defined access authorizations. Our final two research hypotheses concern the effect of telework systems on innovation. These systems lead to new geographic distributions of work, extending earlier temporal and spatial boundaries of work, and to important transformations of firm’s work practices and business processes, with employees having more autonomy in how to organize their work, and also of employees’ supervision and management practices, and of collaboration and teamwork practices. Furthermore, as telework systems enable employees to work in the “source of the problem” (e.g. in the field, or in the premises of customers or suppliers), they can give rise to important service and product innovations. Also, this extensive exposure to the problems or interaction with customers or suppliers can give to the firm new knowledge, which can lead to product/service and process innovations. For these reasons, the next two research hypotheses are:

**Hypothesis 9:** Telework systems have a positive effect on product/service innovation.
Hypothesis 10: Telework systems have a positive effect on process innovation.

4. Data

For this empirical study we used data collected through the “e-Business Survey” conducted by the European e-Business Market Watch (www.ebusiness-watch.org) under the auspices of the General Directorate for Enterprise and Industry of the European Commission. The main objective of this survey was to collect data concerning the adoption and use of several ICTs by firms of the European Union member states, countries of the European Economic Area and EU candidates (29 countries in total), and also their innovation activities. The data were collected using computer-aided telephone interview (CATI) technology from 14,065 companies from ten sectors, both manufacturing and services ones (Food and Beverages, Footwear, Pulp and Paper, ICT Manufacturing, Consumer electronics, Shipbuilding and Repair, Construction, Tourism, Telecommunications and Hospital activities). The sample including 8.5% of large enterprises (250+ employees), 22.6% of medium-sized firms (50 to 249 employees), 31.1% of small enterprises (10 to 49 employees), while the remaining 37.8% were micro-businesses (fewer than 10 employees).

5. Method

In order to test the hypotheses of this study, the following regression model was estimated:

\[
\text{INNOV} = b_0 + b_1 \* \text{COMP ICT} + b_2 \* \text{R&D} + b_3 \* \text{HQUAL} + b_4 \* \text{ERP} + b_5 \* \text{CRM} + b_6 \* \text{e-SALES} + b_7 \* \text{COLLAB_INTRAFIRM} + b_8 \* \text{COLLAB_INTERFIRM} + b_9 \* \text{TELEWORK} + b_{10} \* \text{D_MEDIUM} + b_{11} \* \text{D_LARGE} + e_i
\]

Initially with product/service innovation (INNOVPD) and then with process innovation (INNOVPC) as dependent variable. In particular, variable INNOVPD measures whether, during the last year, the company has launched a new product or service (Y/N), while variable INNOVPC measures whether the company in the last year has improved or has developed a new internal procedure (Y/N).

A first set of independent variables measure the use by the firm of the abovementioned fundamental types of ES (Y/N): ERP, CRM, e-SALES, COLLAB_INTRAFIRM, COLLAB_INTERFIRM, and TELEWORK.

Also, we have included a second set of independent variables, which correspond to “traditional” innovation promoting factors, which have been identified by previous innovation literature ([14], [45], [64], [66]): competition (COMP ICT variable – it focuses on the ICT driven competition –it has been recoded as a binary 0/1 variable, with 1 representing significantly or somewhat increased competition), human resources (HQUAL variable) and R&D (recoded into the binary 0/1 R&D variable).

Furthermore, we have also included 9 sectoral dummy control variables (corresponding to 9 out of the above 10 sectors covered in this survey, while the 10th sector was used as a reference); 28 country dummy control variables (corresponding to 28 out of the above 29 countries covered in this survey, while the 29th country was used as a reference); and also two dummy control variables for firm size (corresponding to medium (D_MEDIUM) firms and the large firms (D_LARGE), using the small ones as a reference).

The corresponding questions from the “e-Business Survey” used in this survey (= definitions of the above variables) are shown in the Appendix.

6. Results

The regression model (1) has been estimated for product/service innovation and process innovation, using LOGIT estimation, as the dependent variable is binary, and in the following Table 1 we can see the results; for each independent variable is shown the exp(bi), which is the increase of the odds of having innovation (= probability of having innovation/ probability of not having innovation) if the independent variable increases by one unit. The ones with significance less than 5% are indicated by asterisk.

We remark that for all six independent variables representing the use of different types of ES their effects on both product/service and process innovation is statistically significant and positive (as we have exp(bi) > 1 for all). This indicates that all the examined types of ES promote product/service innovation and process innovation. Therefore all our research hypotheses 1-10 are supported; for the research hypotheses 1 and 2 the alternative a (positive effects) is supported). However, by comparing the corresponding exp(bi) values we can see that the magnitudes of the positive impacts of these different ES types on innovation are different (this comparison is straightforward, since all these six independent variables have the same scale, being all binary (0/1)).

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Table 1. Estimated models of product/service and process innovation

<table>
<thead>
<tr>
<th>Variables</th>
<th>Product-/Service Innovation</th>
<th>Process Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Traditional factors:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R&amp;D</td>
<td>2.309*</td>
<td>1.692*</td>
</tr>
<tr>
<td>HQUAL</td>
<td>1.452*</td>
<td>1.106</td>
</tr>
<tr>
<td>COMP_ICT</td>
<td>1.613*</td>
<td>1.601*</td>
</tr>
<tr>
<td><strong>Enterprise Systems:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERP</td>
<td>1.190*</td>
<td>1.508*</td>
</tr>
<tr>
<td>CRM</td>
<td>1.610*</td>
<td>1.512*</td>
</tr>
<tr>
<td>e-SALES</td>
<td>1.854*</td>
<td>1.776*</td>
</tr>
<tr>
<td>COLLAB_INTERFIRM</td>
<td>1.570*</td>
<td>1.526*</td>
</tr>
<tr>
<td>COLLAB_INTRAFFIRM</td>
<td>1.305*</td>
<td>1.568*</td>
</tr>
<tr>
<td>TELEWORK</td>
<td>1.319*</td>
<td>1.596*</td>
</tr>
<tr>
<td><strong>Controls:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D_MEDIUM</td>
<td>0.931</td>
<td>1.286*</td>
</tr>
<tr>
<td>D_LARGE</td>
<td>0.893</td>
<td>1.184*</td>
</tr>
<tr>
<td>Industry dummies (9)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Country dummies (28)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>N</td>
<td>12916</td>
<td>12916</td>
</tr>
<tr>
<td>Cox &amp; Snell R²</td>
<td>0.177</td>
<td>0.166</td>
</tr>
<tr>
<td>Nagelkerke R²</td>
<td>0.239</td>
<td>0.230</td>
</tr>
<tr>
<td>Wald Test Chi square</td>
<td>474.0*</td>
<td>1389.2*</td>
</tr>
</tbody>
</table>

Note: Statistical significance at the 5% test level is indicated by an asterisk.

In particular, from the product/service innovation model (second column of Table 1) we can see that the e-sales systems have the strongest effect (1.854). This indicates that e-sales systems are the strongest product/service innovation driver among the examined types of ES, enabling and facilitate selling more of products (in comparison with ‘traditional’ physical shops), and also low cost customization–personalization of these products accordingly, and provision of new complementary electronic services. They are followed by CRM and external collaboration systems (1.610 and 1.570 respectively). Therefore, CRM seem to be strong drivers of innovation in firm’s products/services, as they enable the collection, analysis of customers related data (on their needs, preferences, complaints), and also the exchange and sharing of them among all firm’s departments dealing with the customer (such as sales, marketing and customer service ones). The same happens with the external collaboration support systems, due to the support they provide for intensive and rapid exchange of data and knowledge with external innovation partners (e.g. suppliers, customers, other cooperating firms, etc.), promoting the ‘open innovation’ model ([18], [31], [72]), which becomes increasing important for the development of product/service innovation in the modern economy. Then follow the telework and the internal collaboration support systems (1.319 and 1.305 respectively); the weakest (though still statistically significant and positive) effect among all the examined types of ES have the ERP systems (probably because, as mentioned in the research hypotheses formulation in section 3, they can promote innovation, but also in some cases inhibit it as well).

A comparison with the effects of the ‘traditional’ innovation factors we have examined leads to the conclusion that the existence of R&D has the strongest statistically significant positive effect on product/service innovation among all the examined independent variables (2.309), stronger than the effects of all examined types of ES; the other two factors (ICT driven competition and human capital) have similar levels of effects (1.613 and 1.452 respectively) with the ones of the examined types of ES. Finally, we have not found statistically significant effect of the firms of our sample on product/service innovation.

With respect to the process innovation model (third column of Table 1) we can see that the e-sales systems have again the strongest effect (1.776). Therefore, e-sales systems are the strongest process innovation driver among the examined types of ES, as they lead to innovations in firm’s ‘customer facing’ business processes (in order to fulfill the needs of this new electronic sales channel: receive orders and payments electronically on a 24hours/7days basis, deliver products to more geographically dispersed customers, and offer them after-sales support), and then to other business processes as well. They are followed by the telework and the internal collaboration support systems (1.596 and 1.568 respectively). This indicates that telework systems are strong drivers of process innovation, as they lead to new geographic distributions of work, and to significant transformations of firm’s work practices and business processes, of supervision and management practices, and also collaboration and teamwork practices; the same happens with the internal collaboration support systems, as they enable more extensive, easy and rapid exchange of data and knowledge among firm’s employees working in different functional departments, which promotes innovation ([47], [63], [64]). Then follow the external collaboration support, the CRM and the ERP systems, having similar effects (1.526, 1.512 and 1.508).

With respect to the ‘traditional’ innovation factors we have examined, we can see that two of them, the existence of R&D and the ICT driven competition, have similar statistically significant positive effects on process innovation with the examined types of IS (1.692 and 1.601 respectively). Also, firm size has a weaker statistically significant positive effect on
process innovation. On the contrary, we have not found for the firms of our sample a statistically significant effect of human capital on process innovation.

7. Conclusions

7.1 Lessons Learned

Many different types of ES have been developed in order to support various tasks of firms. Most of the empirical research on their business impact has focused on their effects on firms’ productivity, while much less research has been conducted on their effect on firms’ innovation activity. This paper contributes to filling this research gap. It investigates empirically and compares the effects of six important and widely used types of ES (ERP, CRM, e-sales, telework and collaboration support systems) on product/service and process innovation. From our results the following interesting and practically useful lessons have been learned:

- We have found that all the abovementioned types of ES we have examined are to some extent drivers of innovation in both firms’ products/services and processes.
- However, their positive effects are of different magnitudes.
- The e-sales systems have the strongest positive impact on product/service innovation among the examined types of ES, followed by the CRM and external collaboration support systems; a common feature of them is that they all support communication and interaction of the firm with its external environment, which seems to be a possible source of their strong product/service innovation drive potential.
- From the examined ‘traditional’ innovation factors only the existence of R&D in a firm has much stronger positive impact on product/service innovation than the examined types of ES; on the contrary all the latter have similar or stronger positive impact in comparison with the other two examined ‘traditional’ innovation factors (ICT driven competition and human capital). These results indicate the strength of ES as drivers of firms’ products/services innovation.
- The e-sales have the strongest positive impact on process innovation, followed by the telework systems.
- The positive impacts of the examined types of ES on process innovation are of similar levels with, or even stronger than, the ones of the examined ‘traditional’ innovation factors. These results indicate the strength of ES as drivers of firms’ process innovation as well.
- In total, the e-sales systems seem to be the strongest drivers of innovation, having similar positive effects on both product/service and process innovation (so they are equally strong drivers of these two kinds of innovation),
  - followed by the CRM systems, which are also equally strong drivers of product/service and of process innovation,
  - and then by the external collaboration systems, which have slightly stronger effect on product/service innovation than on process innovation.
  - Then come the telework, the internal collaboration systems, and finally the ERP systems; all these three types of ES are stronger drivers of process innovation than of product/process innovation.

7.2 Implications

Our study has interesting implications for research and practice. With respect to research, it opens up new directions of more advanced empirical research on the impact of ICT on innovation, which does not view ICT as a single entity, but discriminates between different types of IS; such research can increase our understanding of the existing differences among different types of IS in driving innovations. With respect to practice, the conclusions of our study are useful to firms’ management, as they provide a basis for optimizing their ICT investment mix in various types of IS, taking into account their impacts not only on efficiency but also on innovation as well; also, they provide guidance to firms in order to exploit better their ES for promoting innovation.

Further empirical research is required concerning the effects of the examined types of ES, and also other types as well that are continuously emerging (such as business analytics, social media, etc.), on various kinds of innovation (both incremental and radical), in order to enrich our understanding of the highly important relationship between ICT and innovation.

8. References


Appendix: Questions Used

INNOVPD: During the past 12 months, has your company launched any new of substantially improved products or services?

INNOVPC: During the past 12 months, has your company introduced any new or significantly improved internal processes, for example for producing or supplying goods and services?

COMP_ICT: To what extent do you think that competition in your sector has increased or decreased due to ICT? Has competition significantly increased, somewhat increased, or rather decreased?

HQUAL: Please estimate the percentage share of employees with a college or university degree in your company. If you do not know it exactly, can you give me an estimate?

R&D: How many employees are primarily conducting research and development in your company?

ERP: Does your company use an ERP system for managing information in the company?

CRM: Does your company use a CRM system, that is a specific software suite for customer relationship management?

e-SALES: Do you use IT solutions for receiving orders from customers?

COLLAB_INTRAFIRM: Do you use online applications other than e-mail to share documents between colleagues or to perform collaborative work in an online environment?

COLLAB_INTERFIRM: Do you use online applications other than e-mail to collaborate with business partners in the design of new products or services?

TELEWORK: Can employees of your computer system remotely from outside the company, for instance from home, from a hotel or while travelling