PREDICTING INNOVATION ACTIVITY IN EUROPEAN MANUFACTURING FIRMS: A MULTI-COUNTRY EMPIRICAL STUDY

Avraam Papastathopoulos, Technological Educational Institute of Ionian Islands
Christina C. Beneki, Technological Educational Institute of Ionian Islands

ABSTRACT

The purpose of this paper is to investigate the factors that influence the Internal Process Innovation (IPI) Activity of the European manufacturing firms. Moreover, a predictive model is developed that can be used to predict which manufacturing firms are more likely to introduce any new or significantly improve their internal processes. This survey is part of the "e-Business Watch," a service launched in 2007 and provided by "empirica GmbH" to the European Commission, Enterprise and Industry Directorate General, in co-operation with renowned international partners. In the present study, 914 European manufacturing small, medium and large enterprises were examined and a set of hypotheses, regarding their innovation activity, were developed. The results showed that the adoption of Enterprise Resource Planning (ERP), Customer Relationship Management (CRM) and the electronic information exchange between business partners are positively related to firm's process innovation activity. Moreover, the results revealed that the employment of ICT-qualified employees, investments in ICTs, firm size and long-term relationships with suppliers also played a major role for European manufacturing firms to conduct internal innovations. The paper highlights the fact that the innovation activity of the firms is deeply affected by a number of different factors, both internally and externally.

JEL: L6; M1; O32; O33

KEYWORDS: Innovation activity, Processes improvement, ICT, Manufacturing firms

INTRODUCTION

Innovation is crucial for ensuring competitiveness of companies and industries (Galia and Legros, 2004; Tourigny and Le, 2004; Storey, 2000). In our days, firm's survival is often dependent on the degree to which they incorporate innovation into their business strategy, especially because of increasing global competition (Cefis and Marsili, 2006). It is widely accepted that firms, which successfully satisfy market demands and customer preferences can develop and maintain a long-term competitive advantage (Panayides, 2006). The ability to introduce innovation often depends on the adoption and use of advanced technologies, such as Information and Communication Technologies (ICT). The last twenty years the value and the importance of ICT have become increasingly decisive and ubiquitous in all organizational processes. Technology exerts an important impact on social and financial innovation and development (of societies and economies) since a long time ago. The Global Information Technology Report 2006–2007 makes its appearance at a critical juncture as far as the impact of ICT on the world economy is concerned. There is growing evidence that ICT is driving innovation by allowing creative thinking and responsive problem-solving to provide the promise of unprecedented opportunities for all (Dutta and Mia, 2007). The rapid deployment of the internet, the corporate databases and information-enterprise systems accelerated this process of modifications to enterprises' internal and external environment. This new 'technology-driven' situation and its possible evolution provide abundant new challenges in all functional areas across the enterprise (Carneiro, 2006).

ICT has far-reaching properties. It is a so-called general purpose technology, or *"key enabling technology"*, with three basic characteristics: it is pervasive as it spreads to most sectors of the economy;

it improves over time and hence keeps lowering costs for users; and it spawns innovation, as it facilitates research, development and market introduction of new products, services or processes. This last property can be termed the "enabling role of ICT for innovation" (European Communities, 2010). From the early work of Barney (1991) through to studies by Lee (2000), Koellinger (2005, 2006), McAfee (2006) and to the more recent research by European Commission (2006, 2008), the successful innovation may be dependent on the presence of other organization specific skills and capabilities, like the implementation of ICT (Barney, 1991). ICT made a direct impact on process innovation in an organizational setting by facilitating inter-organizational integration and collaboration enhances the innovation capabilities of companies by providing opportunities for shared learning, transfer of technical knowledge and resource exchange (Koellinger 2005, 2006; Lee 2000). The most obvious benefit of information integration with the help of ICT is the optimization of the value chain in order to eliminate the so-called "bullwhip effect", that is to say how small variations in intermediate and final demand levels along a supply chain can add up to significant disturbances and disruptions (European Commission, 2008). Other, less obvious consequences for firms' innovativeness include the creation of communication infrastructures, which facilitate the production networks or enable partners to align the incentives of multiple players by creating joint business units or teams managing the same tasks (McAfee, 2006). Ultimately, ICT investments can enable process innovations if the implementation of new ICT succeeds, the routines are changed and the new system is actually utilized (European Commission, 2006).

While there is an extensive body of literature on innovation activities of the firms, there is scant research on the relationship between internal process innovations and ICT-related factors. In addition, the existing studies are fragmented and provide incomplete explanations for the ICTs that enable the introduction of innovations which may significantly improve the firm's internal processes. The majority of innovation studies have been primarily focused on the stimulating effect of innovation to a firm's growth (Coad and Rao, 2008, Wolff and Pett, 2006; Motwani et al., 1999), the impact of innovation on a firm's performance (Dibrell et al., 2008, Verhees and Meulenberg, 2004), the effect of innovation on the survival of firms as a whole (Cefis and Marsili, 2006; Buddelmeyer et al., 2006) and the development of competitive advantages (Lewis et al., 2002).

This paper reports the results of a study that examined factors to Internal Process Innovation Activity among a sample of 914 manufacturing small, medium and large enterprises in seven selected EU countries (UK, France, Germany, Sweden, Spain, Italy and Poland). Specifically, the seven factors (independent variables) which take place in our study, concern *adoption of ERP and CRM systems, employment of ICT practitioners, investments in ICTs, electronic information exchange between business partners, type of relationships with suppliers* and, one further variable are included on the basis of research plausibility, *firm size.* The first objective of the study is to analyze the descriptive statistics of the above variables for each EU country and the second is to develop a predictive model that can be used to predict which firms are more likely to introduce any new or significantly improve their internal processes. The results will help develop a deeper understanding of the factors to and predictors of internal process improvements and will provide practitioners with useful guidelines for implementing appropriate practices to extend their innovation activities and to respond to enhanced competitiveness.

This study provides distinguishing contributions to the extant literature in the following ways. First, previous studies have investigated innovation activity in a specific country (Wolff and Pett, 2006; Madrid-Guijarro et al., 2009; Carol Yeh-Yun Lin and Mavis Yi-Ching Chen, 2007). This study examines the innovation activity in seven EU countries. A second distinguishing contribution of the current study from prior studies (Dibrell et al., 2008; Ru-Jen Lin et al., 2010) is that it broadens the number of ICT-related factors influencing firms' process innovation activities. Lastly, the major contribution of this study lies in that it brings scholars and practitioners closer to new factors influencing the process innovation activity of firms.

The paper is organized as follows. First, we underpin our formal hypotheses with a discussion stemming from the relevant theory and prior research conclusions. Secondly, we present a discussion of the methodological issues regarding survey development, sampling and data collection. Thirdly, the results of our research are followed not only by an analysis, but also by relevant interpretations. The last section contains a discussion on these findings as well as our conclusions, while a discussion on the limitations of our research and its implications for further future research is also included.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Innovation And Process Innovation: Innovation has been perceived as the cornerstone for achievement in the business sector of the 21st century, large and small organizations have begun to re-evaluate their products, their services and their operations in an attempt to develop a culture of innovation. This re-examination of organizational purpose is due to recognition that developing a culture of innovation within the organization is the best insurance that an organization can have of longevity in the new environment of fast-moving and competitive market (European Commission, 2004). The conception of innovation has evolved significantly over the last forty years. During the 1950s, innovation was considered as a discrete development resulting from studies carried out by isolated researchers. Nowadays, innovation as defined by the European Commission is «the renewal and enlargement of the range of products and services and the associated markets; the establishment of new methods of production, supply and distribution; the introduction of changes in management, work organization, and the working conditions and skills of the workforce» (Commission of the European Communities, 1995). According to Dibrell et al., (2008), innovations vary in complexity and can range from minor changes to existing products, processes, or services to breakthrough products, and processes or services that introduce first-time features or exceptional performance. Process innovation, in this research, refers to the changes made in the processes or technologies used by the organization to deliver products or services (Walker, 2005).

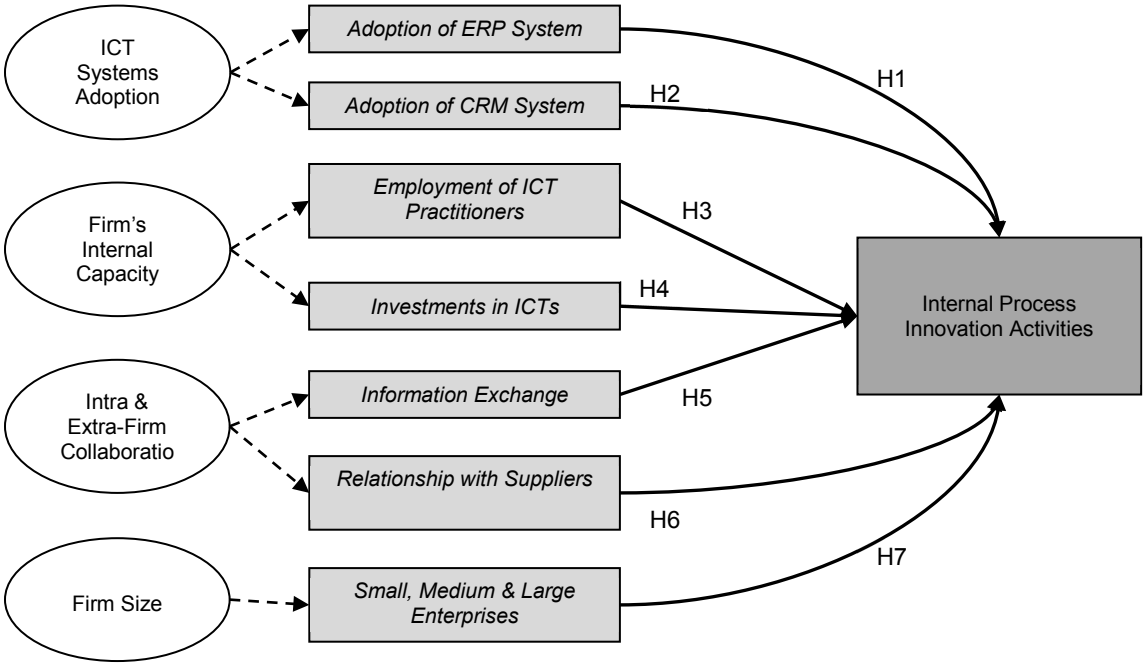
Innovation Activity & ICT: Innovative activity by firms is thought to be an important way to gain competitive advantage and outperform other firms. Firms that introduce new products or process will have an advantage in the market, as each innovation can provide a growth opportunity for an existing firm or a new firm (Frenken and Boschma, 2007). Basic and applied technological knowledge can yield high payoffs and act as a source of competitive advantage for private firms (Spencer, 2001). Based on the literature, the initiatives of innovation and ICT are complementary (Dibrell et al., 2008). ICTs transform the process of replicating business innovations across organizations (Brynjolfsson et al., 2006). Traditionally, deploying business innovation on a larger scale proved to be time-consuming and required considerable involvement of resources and employees. In our times, ICTs allow companies to embed business innovations and then implement them across the organization at a much smaller cost than before without compromising on quality. Every location or unit implements and follows all steps of the new process in a way specified in the software design (European Commission, 2008).

In the following section, we explain our conceptualization of the relationship between process-related innovations/improvements (independent variable) and related factors (dependent variables) that are under investigation in this research. All the dependent variables may be perceived as too great of a challenge to overcome in order to expand firms' process innovation activities. The dependent variables are grouped into the following four categories:

i. ICT Systems Adoption
ii. Firm's Internal Capacity
iii. Inter and Extra-Firm Collaboration-Relationships
iv. Firm Size

From the above independent and dependent variables, we develop our model in forward order, left to right in Figure 1, proposing testable hypotheses for predicting process innovation activities in EU manufacturing firms.

Figure 1: Distribution of Interviews by Firm Size and Sector



This figure provides a graphic illustration of all hypothesized associative influences.

ERP And Internal Process Innovation Activity: ERP system is a packaged business software system that allows a company to automate & integrate the majority of its business processes, and share common data and practices within and beyond a firm's boundary (Hitt et al., 2002). Following a literature review, we were able to identify a multitude of ERP benefits to businesses such as inventory reduction, data integration and cost reduction (Holsapple and Sena, 2005, Gefen and Ragowsky, 2005, Buonanno et al., 2005), and inventory reduction (Sumner, 2000).

Last years the researches emphasize on the ERP technology as an enabler of business process reengineering (BPR); it deals with issues of process orientation and the organizational change – both internally and as a second phase in the supply chain (Papastathopoulos and Beneki, 2010; Davenport et al., 2004; Davenport and Brooks, 2004; Willis and Willis-Brown, 2002; Al-Mashari, 2001). Within this context, a study conducted by Buonanno et al., (2005) argues that the large companies, making use of an ERP system expect a wider extent of business transformation (business process reengineering and business network redesign), while SMEs always schedule a limited organizational change in the case of ERP adoption; thus, they seem not to consider ERP systems as a keystone for organizational innovation. These findings were generally supported by the study of Raymond and Uwizeyemungu (2007), although the latter study also identified that only the SMEs with a greater production and innovation capacity are more likely to adopt ERP systems.

Taking into account the arguments stated above, we formulate the first hypothesis:

H1: Manufacturing firms implementing an ERP system are more likely to introduce any new or significantly improve their internal processes, in comparison with their peer-group.

CRM and Internal Process Innovation Activity: CRM is a tool designed to integrate and automate management of all client-facing tasks in order to help build and retain their loyalty. CRM refers to the utilization of extensive strategies and engineering to find, obtain, cultivate advantaged customers, and hence maintain long-term partnerships (Sin et al., 2005). It is based on the recognition that not all customers should be treated the same way. In practice, companies adopting CRM technology have the ability to sustain significant competitive advantages by delivering value added services that respond to their customer's changing needs and preferences (Peltier et al., 2006; Zahay et al., 2004).

Recently, the literature has begun to link the practice of CRM with the development of innovation activity. Ramani and Kumar (2008) suggested that using CRM to engage in creating, maintaining, and fostering useful customer relationships along with maintaining long-term partnerships are important strategic elements for developing innovation capability. Intensive interaction between manufacturers and customers encourage customers to provide valuable suggestions for product development (Droge et al., 2004). Therefore, manufacturers who receive important information from customers are able to increase their innovation capability by meeting the needs of a targeted market (Ottum and Moore, 1997).

Finally, there is a growing consensus in the literature that the adoption of CRM technology is likely to be crucial when market conditions are characterized by high uncertainty and firms are attempting to gain competitive advantages through innovation (Papastathopoulou et al., 2007; Wang and Ang, 2004; McGee and Sawyerr, 2003).

In view of the foregoing studies, H2 is formulated as follows:

H2: Manufacturing firms implementing a CRM system are more likely to introduce any new or significantly improve their internal processes, , in comparison with their peer-group.

ICT Practitioners and Internal Process Innovation Activity: It is well known that adoption of innovation requires employee commitment and effort (Acemoglu and Pishke, 1999). In case of ICT, empirical studies have shown ICT is most productive when combined with complementary investments in working practices, human capital, and firm restructuring (Brynjolfsson and Hitt, 2000). In fact, knowledge stock and skills were found to be positively associated with a firm's absorptive capacity to adopt new technologies (Cohen and Levinthal, 1989). This, in turn, has positive impact on a firm's innovation performance. Thus, in order to develop marketable products or feasible production processes based on ICT, a firm needs to build up the relevant complementary assets such as knowledge stock and expertise. The most obvious example of investments in complementary assets includes investments in training and organizational transformations to accompany ICT investments.

Consequently, these points yield the following hypothesis:

H3: Manufacturing firms characterized by a higher share of employees with ICT qualifications are more likely to realize internal process innovations, compared with their peer-group.

ICT Investments and Internal Process Innovation Activity: With ICT's increasing sophistication and usage, managers now consider the use of ICT as a competitive tool used for the implementation of strategic plans and the support of firm core competencies (e.g., Aral and Weill, 2007; Oh and Pinsonneault, 2007). Therefore, investment in ICT by firms has dramatically escalated in recent times (Devaraj and Kohli, 2003).

Using survey data, Dibrell et al. (2008) found that managers who are able to integrate either a product or a process-oriented innovation strategy with investments in ICT enhance their firms' relative performance along two essential dimensions: profitability and growth. In contrast, a failure to invest in ICT can cause

a firm to be unable to support its innovation initiatives. Perhaps, a lack of investment in ICT over time may render the firm incapable of meeting customer requirements. Lastly, Brynjolfsson and Hitt (2000) have found parallel results, where they have been shown that ICT investment has a significant effect on productivity levels, productivity growth, and stock market value of firms.

In view of the foregoing arguments, H4 is formulated as follows:

H4: Manufacturing firms that make investments in ICTs (e.g. for new hardware, software or networks) are more likely to conduct internal process innovations, compared with their peer-group.

Intra-Organizational Information Exchange and Internal Process Innovation Activity: Intra-organizational information exchange is important for the creation and diffusion of innovations within complex multiunit organizations. ICT has a direct impact on process innovation in an organizational setting by facilitating inter-organizational links (Lee, 2000). ICT-enabled inter-organizational integration and collaboration enhances the innovation capabilities of companies by providing opportunities for shared learning, transfer of technical knowledge and resource exchange. Carr and Pearson (1999) pointed out that information sharing between manufacturers and their clients about markets, designs, and processes enables manufacturers to adopt technologies that can improve design and process innovative capabilities. A recent discussion of Ru-Jen Lin et al. (2010) also verified that using information sharing has positive and significant effects on process innovation. This leads to the following hypothesis:

H5: Manufacturing firms that use ICT applications to exchange information on their inventory levels or production plans with their business partners are more likely to introduce internal process innovations, compared with their peer-group.

Relationships with Suppliers and Internal Process Innovation Activity: Supplier relations are important value chain characteristics, which are likely to influence the innovation activity of companies. The benefits of inter-firm cooperation are subject to learning effects. In order to benefit fully from integration, both parties need time to comprehend and adapt to the new organization of activities. In other words, when relationship investments are indispensable or specific assets are procured firms will create networks in which suppliers form closed business relationships. This helps to overcome hold-up problems and allows firms to create relations, which are additionally strengthened by ICT (European Commission, 2008). According to Helper and MacDuffie (2003), ICT facilitating B2B interactions continues to be used in a way that enhances, not replaces individual companies' business strategies. Companies develop e-business tools that reinforce old paradigms for purchasing and supplier relations. This happens because there are patterns of social interaction that are deeply imbedded in systems of procurement. We thus postulate:

H6: Manufacturing firms maintaining long-term relationships with suppliers are more likely to conduct internal process innovations, compared with their peer-group.

Firm Size and Internal Process Innovation Activity

The literature offers contradictory findings about the direction and the intensity of the relation between size and innovation. On the one hand, there are studies that found significant relationships between the size of a firm and innovation (Camison-Zornoza and Lapiedra-Alcami, 2004; Sullivan and Kang, 1999; Damanpour, 1992). On the other hand, however, other researchers declared that firm size had no apparent effect on either product or process improvement (Wolff and Pett, 2006). Lastly, still other work claims that no relation exists between the core variables (Aiken et al., 1980).

Against this background, our next hypothesis is:

H7: The larger the size of the business, the more likely process innovations activities will be conducted by small, medium and large enterprises.

In the next section, we discuss the methodology employed to test the theoretical model.

RESEARCH METHODOLOGY

Research Design

In order to address the preceding research questions, we used data from the 'Sectoral e-Business Survey (SeBW) 2007'. This global survey is part of the "e-Business Watch", a service launched in 2007 and provided by "empirica GmbH" to the European Commission, Enterprise and Industry Directorate General, in co-operation with renowned international partners (European Commission and the Sectoral e-Business Watch, 2007) while it was presented as a Confidentialized Unit Record File. The key objective of the SeBW is to gather information about the usage of ICT and their application to the electronic business in companies, in order to derive indicators on industrial sector level. The fieldwork was carried out from August 13 to October 08, 2007 and had a scope of 2.121 telephone interviews with decision-makers from three industry sectors (chemical, steel and furniture) in seven EU countries (UK, France, Germany, Sweden, Spain, Italy and Poland). The target respondent within the company was a person responsible for or taking part in decisions concerning the use of information and communication technologies and of e-business. This person could have been in different positions, depending on the size and kind of company or organisation – usually the IT manager or a senior professional in the IT department. Particularly in the case of larger companies, there are dedicated positions for e-business management while in micro and small enterprises, the respondent rather is someone at the level of managing director or owner. The questionnaire collected information on the background information of the firms, ICT-related characteristics (such as infrastructure, software systems, skills requirements, costs, impacts, drivers and inhibitors) and innovation activity (if any) of the firm during the past 12 months.

Sample and Data Collection: The sample drawn (for each sector) was a random sample of companies, stratified by sector and, where possible, size (number of employees in the company), was selected per country. The quality of the survey frame was of very high importance. In order to ensure the best possible quality of results in terms of raising the survey data, SeBW explicitly instructed the institutes that the sampling/ address purchase and the universe figures (sample frame) should be based to the largest possible extent on "official" business registers and company statistics, which are usually run by the National Statistical Office in the country. Wherever possible for the drawing of the sample the same source was chosen as for building-up the universe. However, in some countries the statistical offices that were used for the universe figures were not able (resp. were not allowed) to provide the institutes with full and up-to-date addresses or telephone numbers of companies at all. In case where the sampling/ address purchasing could not be obtained directly from the respective national statistical offices, the countries used renowned address supplier of the highest possible quality in terms of coverage and up-to-dateness. This is common practise in business-to-business surveys. Furthermore, the usage of computer/PC (including desktop computers and notebooks) within the company was required in order to qualify for an interview.

The final allocation of our sample (n=914) according to industry sector and company size as well as the sample sources were used, is illustrated in Table 1. In this survey, a cut-off was introduced with regard to company size: only companies with at least 10 employees were interviewed. The highest level of the population (at least 10 employees) was the set of all computer-using enterprises which were active within the national territory of one of the seven countries covered, and which had their primary business activity in one of the three industry sectors specified on the basis of NACE Rev. 1.1.

Table 1: Industry and Country Distribution of the Sample and Sampling Sources

			Countries							
			Germany	**Spain**	**France**	**Italy**	**Sweden**	**UK**	**Poland**	**Total**
Industry Sectors	Chemical, rubber & plastics	Count	129	26	88	43	6	74	30	**396**
		% within Industry Sector	32.6%	6.6%	22.2%	10.9%	1.5%	18.7%	7.6%	100.0%
	Steel	Count	36	11	28	21	8	16	13	**133**
		% within Industry Sector	27.1%	8.3%	21.1%	15.8%	6.0%	12.0%	9.8%	100.0%
	Furniture	Count	75	36	31	72	11	61	99	**385**
		% within Industry Sector	19.5%	9.4%	8.1%	18.7%	2.9%	15.8%	25.7%	100.0%
Total		Count	240	73	147	136	25	151	142	***914***
		% within Industry Sector	26.3%	8.0%	16.1%	14.9%	2.7%	16.5%	15.5%	100.0%
Sampling Sources			Heins and Partner Business Pool	Dun & Bradstreet	WEGENER DM. previously IDATA	Dun & Bradstreet	Statistics Sweden's Business Register	Dun & Bradstreet	Hoppenstedt Bonnier Information Poland (HBI)	

This table shows the allocation of sample and sampling sources by country and industry sector.

Weighting Schemes: Due to stratified sampling, the sample size in each size-band is not proportional to the population numbers. If proportional allocation had been used, the sample sizes in the 250+ size-band would have been extremely small, preventing any reasonable presentation of results. Thus, weighting is required so that results reflect the structure and distribution of enterprises in the population of the respective sector or geographic area. The SeBW applies two different weighting schemes: by employment, and by the number of enterprises

*Measure Development and Statistical Method***:** In order to test the above seven hypotheses and determine the likelihood of conducting internal process innovations, a binary logistic regression analysis was applied. Table 2 details the research variables used to this study including concept, operational measure and sampling source. The raw data were coded and analyzed using the PASW Statistics 18.

Table 2: Description of Variables

Concept ***Dependent variable***	**Description – Operational Measure**	**Source**
Internal Process Innovation (IPI) Activity	A 0/1 dummy taking value 1 if firm had introduced any new or significantly improved their internal processes, during the past 12 months.	European Commission 'Sectoral e-Business Survey 2007'
Independent variable		
Adoption of ERP (ERP)	A 0/1 dummy taking value 1 if firm had implemented ERP system.	European Commission 'Sectoral e-Business Survey 2007'
Adoption of CRM (CRM)	A 0/1 dummy taking value 1 if firm had implemented CRM system.	European Commission 'Sectoral e-Business Survey 2007'
ICT Practitioners (ICTP)	A 0/1 dummy taking value 1 if firm had employed ICT practitioners (persons who were hired primarily to take care of the company's ICT infrastructure).	European Commission 'Sectoral e-Business Survey 2007'
ICT Investments (ICTI)	A 0/1 dummy taking value 1 if firm had made investments in ICT during the past 12 months, for example for new hardware, software or networks.	European Commission 'Sectoral e-Business Survey 2007'
ICT Applications for Information Exchange (ICTIE)	A 0/1 dummy taking value 1 if firm had implemented ICT applications to exchange information on their inventory levels or production plans with their business partners, during the past 12 months.	European Commission 'Sectoral e-Business Survey 2007'
Long-Term Relationships with Suppliers (LTRS)	A 0/1 dummy taking value 1 if firm was maintaining long-term relationships with its suppliers	European Commission 'Sectoral e-Business Survey 2007'
Firm Size (FS)	Companies were categorized according to number of their employees into 1 = small (10-49), 2 = medium (50-249) and 3 = large (250+).	European Commission 'Sectoral e-Business Survey 2007'

This table describes the measurement and sampling source of dependent and independent variables

RESULTS

Demographic Characteristics: As seen in Table 3, almost half of the responding firms (49.4 percent) in the sectors surveyed had implemented innovative activities during the previous year, whereas Germany, Poland and Spain shows the highest rates of 66.1%, 59.7% and 56.4% respectively. More than half (52 percent) of the responding firms have deployed an ERP system, and 47.8 percent had not. According the European e-Business Report 2008, the deployment of ERP systems has almost doubled among small enterprises from 2003 to 2007 and increased by about 20 percentage points in medium-sized and large firms (European Communities, 2008). On the other hand, only thirty percent of the responding firms reported having a CRM system. The current adoption rates (ERP, CRM) lead us to conclude that both enterprise systems are not widely used and, of course, there is still room for improvement. Moreover, about 42 percent of the firms interviewed employ ICT specialists with Spain and France showing the lowest percentages. At this point, we have to say that there is, however, a general concern, especially among larger companies, that e-business does have a significant impact on skills requirements (European Communities, 2008). Anyway, some countries seem more aware of the value of employees with ICT qualifications. Conversely, almost 80% of the responding firms had made investments in ICTs during the past 12 months, providing strong evidence that the EU manufacturing companies are interested in full potential of ICT usage. However, according OECD (2003) investments in ICT is no panacea. Firms may well overinvest in ICT, either in an effort to compensate for lack of skills or competitive pressure, or because they lack a clear market strategy. Firms that achieve the highest returns from ICT are often those that were already performing well or had successfully innovated in the past. The electronic exchange of information between business partners is found to be of different importance for the seven countries, with Poland, Germany and Sweden to present the highest percentages. Finally, the European manufacturing firms prefer to trade mostly with long-term business partners rather than having a changing supplier base.

Table 3: Respondent Characteristics per Country (n = 914)

Variables		EU Countries							MEAN	SD
		Germany %	Spain %	France %	Italy %	Sweden %	UK %	Poland %	%	%
Internal Process Innovations	*Yes*	66.1	56.4	41.8	40.7	43.7	37.2	59.7	***49.37***	***11.17***
	No	33.9	43.6	58.2	59.3	56.3	62.8	40.3	***50.63***	***11.17***
Adoption of ERP System	*Yes*	82.1	52.3	64.0	37.6	49.9	43.4	34.9	***52.03***	***16.47***
	No	17.9	47.7	36.0	62.4	50.1	56.6	65.1	***47.97***	***16.47***
Adoption of CRM System	*Yes*	38.7	38.4	23.3	16.7	26.6	38.3	33.6	***30.80***	***8.73***
	No	61.3	61.6	76.7	83.3	73.4	61.7	66.4	***69.20***	***8.73***
Employment of ICT-qualified	*Yes*	46.8	17.0	21.3	43.8	61.2	43.8	56.0	***41.41***	***16.56***
personnel	*No*	53.2	83.0	78.7	56.2	38.8	56.2	44.0	***58.59***	***16.56***
ICT Investments,	*Yes*	86.8	72.5	68.0	72.1	81.9	88.7	83.2	***79.03***	***8.08***
	No	13.2	27.5	32.0	27.9	18.1	11.3	16.8	***20.97***	***8.08***
Intra-Organizational	*Yes*	26.9	7.8	10.9	12.5	26.0	17.8	31.5	***19.06***	***9.15***
Information Exchange	*No*	73.1	92.2	89.1	87.5	74.0	82.2	68.5	***80.94***	***9.15***
Type of Relationships with	*Long-Term*	93.5	98.9	100.0	85.9	92.2	92.8	88.3	***93.09***	***5.12***
Suppliers	*Short-Term*	6.5	1.1	.0	14.1	7.8	7.2	11.7	***6.91***	***5.12***

This table shows respondent descriptive characteristics per variable and country.

A Prediction Model for the Factors Influencing the Development of Process Innovations The main goal of this study was to examine the factors affecting the development of process innovation. Since the research model uses a dichotomous dependent variable and categorical independent variables, the binary logistic regression analysis was used to validate the research model empirically. Thus, the final logit model is specified as follows:

$$\text{Ln}\left(\frac{Prob(IPI\ Activity=Yes)}{1-Prob(IPI\ Activity=Yes)}\right) = \beta_0 + \beta_1 * ERP_i + \beta_2 * CRM_i + \beta_3 * ICTP_i + \beta_4 * ICTI_i + \beta_5 * ICTIE_i + \beta_6 * LTRS_i + \beta_7 * FS_i + \varepsilon_i$$

Logit analysis is a preferred technique because it does not assume equal variance-covariance matrices across groups and multivariate normality of the variables (Hair et al., 1998). Moreover, the output from the analysis is very similar to regression and is therefore easier to draw inferences. Logit uses a binomial probability function for the dichotomous dependent variable and estimates whether it is one way or the other using an odds ratio. Unlike regression, where we try to minimize the squared deviations, in logit we maximize the likelihood of a firm adopting IS innovations (Premkumar, 2003).

As shown in Table 4, all dimensional hypotheses were supported. The likelihood-ratio test is used instead of Wald statistics (the square of the ratio of the parameter estimate to its standard error) because the Wald statistics has undesirable properties. For large coefficients, the standard error can be too large, resulting in too small Wald statistics. That is, we may fail to reject the null hypothesis when it is false (Norusis, 2008). For that cause, the likelihood-ratio test was chosen. The overall model's fit is significant ($p < 0.001$).

Table 4: Logistic Regression Results

Independent Variables	Hypothesis	Coef (β)	Likelihood Ratio Chi-Square	Sig.	Exp(β)
Constant		-2.892	0.110		
Adoption of ERP (ERP)	H1	0.445**	4.738	0.029	1.561
Adoption of CRM (CRM)	H2	0.862***	18.755	0.000	2.369
ICT Practitioners (ICTP)	H3	0.434**	5.276	0.022	1.543
ICT Investments (ICTI)	H4	1.189***	22.169	0.000	3.284
ICT Applications for Information Exchange (ICTIE)	H5	0.865***	14.298	0.000	2.375
Long-Term Relationships with Suppliers (LTRS)	H6	0.693**	4.147	0.042	2.001
Firm Size (FS)	H7	2.329***	18.918	0.000	10.266

This table shows the logistic regression coefficient, likelihood-ratio test, and odds ratio for each of the predictors Employing a 0.05 criterion of statistical significance, all variables had significant partial effects. The overall model's fit is significant ($p < 0.001$).
** The estimated regression coefficients are significant at the 0.1 level.** The estimated regression coefficients are significant at the 0.05 level.*
**** The estimated regression coefficients are significant at the 0.01 level.*

The repressors' are not directly of interest in statistics but the exponent of each term is the odds ratio and thus reveals the contribution of each term in the probability for an EU manufacturing firm to introduce an IPI. The term 0.445 when exponentiated gives exp(0.445)=1.56. This means that the odds of introducing an IPI, for a firm, which has implemented an ERP system, are 1.56 times the odds for a company that has not. Similarly, the odds of introducing an IPI, for a firm, which has implemented a CRM system, are 2.37 times the odds for a company that has not. Moreover, the odds attributes to ICTP, ICTI and ICTIE are equal to 1.54, 3.28 and 2.37 respectively. This gives a clear indication that the odds of introducing an IPI, for a firm, which has employed ICT practitioners, has made investments in ICTs and has deployed ICT applications for information exchange with the business partners, are correspondingly 1.54, 3.28 and 2.37 times the odds for a company that has not. Likewise, the manufacturing firms which maintain long-term relationships with suppliers are more likely (two times the odds) to conduct internal process innovations, compared with their peer-group. Finally, the odds of introducing an IPI are excessively rising (10.27 times the odds) according to the employment size of the firms.

DISCUSSION

The findings of this study extend the innovation literature and help build a foundation for further understanding the factors, which are found to be critical in IPI activity of manufacturing firms. From the results, we are able to make multiple observations. First, our findings provide strong support for H1 that manufacturing firms implementing an ERP system are more likely to introduce any new or significantly improve their internal processes *($p = 0.029$).* This is in line with previous studies (e.g. Papastathopoulos

and Beneki, 2010; Davenport et al., 2004; Davenport and Brooks, 2004), indicating that the deployment of an ERP system contributes to firm's internal process innovation activity. Second, the results reveal (H2) that firms implementing a CRM system have a greater propensity *($p < 0.0001$)*to introduce any new or significantly improve their internal process activities. This is consistent with prior studies (e.g. Ramani and Kumar, 2008; Papastathopoulou et al., 2007; Wang and Ang, 2004; McGee and Sawyerr, 2003). CRM is touted as an imperative strategy to improve a firm's innovation activity. Manufacturing firms must carefully align their CRM practices with the specific types of innovation capability they desire to possess (Ru-Jen Lin et al., 2010). Third, the regression results point to strong support for H3 that manufacturing firms characterized by a higher share of employees with ICT qualifications are more likely to realize an internal process improvement *($p = 0.022$)*. ICT- practitioners with very specific skills seem to be of crucial importance. This is consistent with the observation that the success of the ICT-driven innovation processes relies on the availability and quality of complementary assets such as labor (Brynjolfsson and Hitt, 2000). Logically, this suggests that firms have to employ ICT practitioners who are qualified to effectively incorporate ICTs into innovation activities. Apparently, firms that do not employ ICT professionals have fewer chances to be innovative. Fourth, the results (H4) with respect to investments in ICT have been found to be a significant factor influencing introduction of process innovations *($p < 0.0001$)*. This is consistent with results from previous research that have found ICT investment to be a significant effect on innovation activity of firms (Brynjolfsson and Hitt, 2000). Investments in ICT can enable process innovations if the implementation of new ICT succeeds, the routines are changed and the new system is actually utilized European Commission (2006). Empirical studies have stressed that ICT investments must be combined with complementary investments in work practices, human capital and firm restructuring to have an impact on performance (Brynjolfsson and Hitt, 2000; Greenwood and Jovanovic, 1998). These complementary investments that are usually not counted as ICT specific lead to comparatively high returns to ICT investment (Brynjolfsson and Hitt, 2003).

Clearly, this factor warrants more attention from future researchers working in this area. Fifth, the results (H5) indicate towards a close link between IPI activity and the extent to which firms exchange information electronically *($p < 0.0001$)*. Consistent with Carr and Pearson (1999), Lee (2000) and Ru-Jen Lin et al., (2010), intra-organizational information exchange is important for the creation and diffusion of innovations within complex multiunit organizations. Frequent and close interactions allow actors to know each other, share important information, and create common ideas (Ru-Jen Lin et al., 2010). Sixth, based on regression results (H6) we can confirm that long-term relationships with suppliers has been found to be a significant factor influencing firm's IPI activity *($p = 0.042$)*. Last but not least, the results show strong support for H7, indicating that firm size has been a fundamental variable, and larger firms have a greater propensity to conduct a process innovation *($p < 0.0001$)*. On the one hand, these findings corroborate the views put forth by Camison-Zornoza and Lapiedra-Alcami (2004), Sullivan and Kang (1999) and Damanpour (1992) that firm size associates with firm's innovation activities. On the other hand, our results contradict the findings of the study conducted by Wolff and Pett (2006).

Summarizing, the results suggest that the development of IPI activities could be further enhanced by the implementation of ICT-software systems (ERP and CRM), the employment of ICT-qualified personnel, the investments in advanced technologies, the efficient flow of information between business partners and the long-term relationships with the suppliers. Moreover, the study makes clear the need to blend the dictates of technology and innovation management techniques to make manufacturing firms more competitive. Based on the evidence presented in this cross-country empirical study, ICT remains an important variable both for strategic management and for policy aiming at improving business performance and economic progress. In many sectors and firms, the innovative potential of ICT has not yet been fully exploited. This implies that technologies can still be used to influence a firm's ability to gain a competitive advantage (e.g., Dibrell et al., 2008) through the linkage of ICTs with firm's strategy. As a conclusion to this discussion, the EU manufacturing industries have to intertwine closely their innovation strategies with those related to ICT in order to reap future tangible and sustainable benefits.

CONCLUSION, IMPLICATIONS AND FUTURE RESEARCH

This multi-country empirical research provides an understanding of the factors that influence the Internal Process Innovation (IPI) activity of the European manufacturing firms. Moreover, a predictive model was developed that can be used to predict which manufacturing firms are more likely to introduce any new or significantly improve their internal processes.

The major contribution of this study is statistically validating the factors influencing internal process innovation activity of EU manufacturing firms. Thus, it can be predicted that manufacturing firms with greater implementation of Enterprise Systems (ERP and CRM), greater share of employees with ICT qualifications, greater investments in ICTs, greater ICT applications to exchange information on their inventory levels or production plans with their business partners, greater long-term relationships with their suppliers and a larger size are more likely to introduce any new or significantly improve their internal processes.

This work is not free from limitations. Taken that the findings in this study are based on seven selected European countries, they cannot be generalized to other countries. The analytical investigation of hypothesized associate influences has been approached from a European point of view. Thus, the interpretation and utilization of the research findings should be thoroughly scrutinized. Additionally, this study focused on three industries only. It would be interesting to see whether firms in other industry sectors are influenced by the same factors.

The above results provide a starting point for future studies on this important topic for scholars and practitioners. Practitioners can use this model to increase the development of IPI among their firms, while researchers can replicate the same study in other aspects of innovation scope, such as product innovation, marketing innovation, service innovation, and administrative innovation. Future research may use other techniques such as structural equation modeling (e.g. Ramdani and Kawalek, 2009) to investigate the interaction among the variables.

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BIOGRAPHY

Dr. Avraam Papastathopoulos is an Adjunct Lecturer of Entrepreneurship at Technological Educational Institute of Ionian Islands. He can be contacted at: Department of Business Administration, Technological Institute of Ionian Islands, Stylianou Typaldou, 28200 Lixouri, Kefallinia, GREECE. E-mail: apapast@hotmail.com

Dr. Christina C. Beneki is an Assistant Professor of Mathematics-Statistics and Associate Head at Department of Business Administration, Technological Educational Institute of Ionian Islands. She can be contacted at: Department of Business Administration, Technological Institute of Ionian Islands, Stylianou Typaldou, 28200 Lixouri, Kefallinia, GREECE. E-mail: benekic@teiion.gr