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The Effects of Enterprise Systems on the Absorptive Capacity of Greek Firms

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THE EFFECTS OF ENTERPRISE SYSTEMS
ON THE ABSORPTIVE CAPACITY OF GREEK FIRMS

Completed Research

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Abstract

In the highly dynamic, competitive, complex and 'knowledge intensive' modern economy the exploitation and management of external knowledge has become of critical importance for the success of firms, and this has led to increasing interest of both researchers and practitioners in the concept of firm's absorptive capacity (ACAP). It has been recognized that information and communication technologies (ICT) can be quite useful for the improvement of firms' ACAP. Some empirical research has been conducted in this direction, which however has not examined the role from this perspective of the most important ICT investments of firms: the different types of enterprise systems (ES) implemented by firms increasingly, which become critical infrastructures of their operation. This paper contributes to filling this research gap, by presenting an empirical investigation of the effects of the five most important and widely used types of enterprise systems (ERP, CRM, SCM, business intelligence/business analytics and collaboration support systems) on the ACAP of Greek firms. It is based on data collected through a survey from 122 Greek firms from both manufacturing and services sectors, which are used for the estimation of regression models of firm's ACAP. It has been concluded that the use of three of the above types of ES, the ERP, the CRM and the business intelligence/business analytics ones, have positive effects on firm's ACAP, which concern mainly two of its dimensions: the internal diffusion and analysis of external knowledge, and also the assimilation/integration in the knowledge base of the firm.

Keywords: enterprise systems, absorptive capacity, ERP, CRM, SCM, business intelligence, business analytics, collaboration support systems.

1   Introduction

As the modern economy has become much more dynamic (with frequent and fast changes in most industries, continuous emergence of new technologies and materials, changes in customers' needs and preferences, new products, services and processes, new competitors, etc.), complex and 'knowledge intensive' than in the past, the exploitation and management of external knowledge has become critical for the success of firms; this has led to increasing interest of both researchers and practitioners in firm's 'absorptive capacity' (ACAP) (Cohen and Levinthal, 1989 and 1990; Zahra and George, 2002; Lane et al., 2006; Camison and Fores, 2010). Cohen and Levinthal (1990) define ACAP as the ability to recognize the value of new external information, to assimilate it, and apply it to commercial ends. Subsequently, Zahra and George (2002) proposed a new conceptualization of the ACAP as a dynamic capability with two main aspects: potential absorptive capacity, which refers to firm's ability to acquire and then assimilate external knowledge, and realised absorptive capacity, which refers to firm's ability to transform the assimilated knowledge and then exploit it for the development of innovations in its processes, products and services, and in general for achieving firm's objectives.

It has been recognized that information and communication technologies (ICT) can be quite useful for the improvement of firms' ACAP (Malhotra et al., 2005; Roberts et al., 2012; Roberts, 2015). There has been some empirical research in this direction concerning the effects of ICT on ACAP (reviewed in section 2), which however has not examined the role from this perspective of the most important ICT investments of firms: the different types of enterprise systems (ES) that firms increasingly implement. Firms spend large amounts of money in order to develop various types of ES, which become critical infrastructures of their operation, such as enterprise resource planning (ERP), customer relationship management (CRM), supply chain management (SCM), business intelligence/business analytics (BI/BA) and collaboration (CS) support systems (Laudon and Laudon, 2014; Rainer et al., 2015). It is therefore important to investigate the impact that these multiple types of ES have beyond efficiency, on critical knowledge management processes of the firm, such as the ones concerning the management of external knowledge, which determine firm's ACAP. The findings of such research can be quite useful for firms users (or potential users) of ES, in order to make a better exploitation of their ES, not only towards increasing efficiency, but also towards supporting knowledge management processes; furthermore they can be quite useful for ES vendor firms, providing them guidance for improving their products and services, towards strengthening and enriching their features that enable firms to improving their ACAP.

This paper contributes to filling the above research gap, by presenting an empirical investigation of the effects of the five most important and widely used types of ES, the ERP, CRM, SCM, business intelligence/business analytics and collaboration support systems, on the absorptive capacity of Greek firms. It examines to what extent Greek firms are exploiting the above main types of ES not only as efficiency improvement tools, but also for enhancing these important external knowledge management capabilities of them. Our study is based on data collected recently through a survey of 122 Greek firms from both manufacturing and services sectors, which are used for the estimation of regression models of firm's ACAP. Our study is conducted in a very interesting national context, which is characterised by:

i) A culture of lower propensity for innovation according to the European Innovation Scorecard (EIS, 2015); so it is interesting to examine to what extent in this 'innovation averse' national context the above important types of ES are used for enhancing this critical for innovation ACAP.

ii) A long economic crisis (from 2009 until today), which has resulted in huge losses of country's GDP, employment and consumption (Papadimitriou et al., 2013; Papageorgiou, 2015); it is interesting to examine whether Greek firms, facing big changes in their external environment due to this econom-

ic crisis, and continuously decreasing demand for their products and services, are exploiting their ES in order to support and improve these important innovation related activities.

Our paper consists of five sections. This introductory section is followed by section 2 briefly reviewing relevant previous literature. Then in section 3 the research hypotheses are formulated, while in section 4 the data and method are described. In section 5 the results are presented, and finally section 6 summarizes the conclusions.

2   Literature Review

According to the original publications on ACAP by Cohen and Levinthal (1989 and 1990), the ACAP of a firm has three components/dimensions, which concern its ability to: i) recognize, acquire and understand potentially valuable new knowledge from outside the firm through exploratory learning; ii) assimilate this valuable new knowledge through transformative learning; and iii) use the assimilated knowledge in order to create new knowledge and commercial outputs through exploitative learning. A re-conceptualization of ACAP by Zahra and George (2002) mentioned in the Introduction proposes a more detailed set of the following four components/dimensions of ACAP: a) acquisition capacity: it is a firm's ability to locate, identify, value and acquire external knowledge that is critical to its operations or/and products and services; b) assimilation capacity: it is firm's ability to absorb external knowledge; it can also be defined as the processes and routines that allow the new information or knowledge acquired to be analysed, processed, interpreted, understood, internalized and classified; c) transformation capacity: it is firm's ability to develop and refine the internal routines that facilitate the combination of previous knowledge base of the firm with the newly acquired knowledge, and the discovery of novel associations between elements of the continuously enriched firm's knowledge base, and in general new insights; d) application or exploitation capacity: it is the firm's ability to incorporate acquired, assimilated and transformed knowledge into its operations, not only in order to refine, perfect, expand and leverage existing routines, processes, competences and knowledge, but also to create new operations, competences, routines, and also new products and services. There has been considerable both theoretical and empirical literature arguing that ACAP is one of the main determinants of firm's innovation performance (Cohen and Levinthal, 1990; Zahra and George, 2002; Lane et al., 2006; Kostopoulos et al., 2011; Leal-Rodríguez et al., 2014).

This has motivated some empirical research concerning the organizational and ICT related determinants of ACAP. With respect to the former, the original publication on ACAP by Cohen and Levinthal (1990) identifies some organizational determinants of ACAP, which are associated with the internal communication structure; the most important of them are the existence of 'gate-keepers/boundary-spanners' (who monitor the external environment, identify knowledge useful for the firms and 'translate' it into a form understandable by firm's employees), a shared – language among firm's employees and cross-functional interface and communication. In Cohen and Levinthal (1989) is developed a theoretical model on the double role of R&D activities, first, as a process that generates new knowledge and, second, as the process that enables firms to monitor the environment for the identification and absorption of external knowledge than can be combined with internal knowledge generated by the firms themselves. This R&D-"double-role" hypothesis is confirmed by the econometric analysis in the empirical part of the study. Hence, the existence of R&D activities is identified as an important requisite for a high knowledge absorptive capacity. As complementary determinant of absorptive capacity besides R&D is often used in empirical literature the intensity of a firm's human capital (see, e.g., Vinding 2006).

Van den Bosch et al. (1999) and Jansen et al. (2005) identified that two types of organizational mechanisms that increase ACAP: the first of them is associated with coordination (cross-functional interfaces, participation in decision making, and job rotation); the second one is associated with socializa-

tion (connectedness and socialization). Recently, De Araújo Burcharth et al. (2015) identified a set of organizational characteristics that prevent inertia and increase ACAP: slack resources, tolerance for failure, willingness to cannibalize and external openness.

With respect to ICT related determinants of ACAP, as mentioned in the Introduction there has been some empirical research concerning the effects of some ICT variables on ACAP. One of the main functions of modern ICT is the ability to process and handle large amounts of information; thus, it is an interesting research question to investigate the contribution of ICT, particularly of broadly used business application of it, to knowledge absorptive capacity. In this direction Liu et al. (2013), based on data collected through a survey from 286 Chinese firms, found that ICT infrastructure flexibility (i.e. high levels of connectivity between its components, compatibility/data sharing ability among them and modularity) and ICT assimilation (i.e. high level of using ICT applications in firm's business processes, functional areas and management) affect positively firm's ACAP, as well as its supply chain agility, and through them firm's performance. Setia and Patel (2013), using a dataset collected from 153 USA manufacturing firms, conclude that integrated IS capability, defined as the "ability to provide integrated and consistent access to relevant information and to connect seamlessly with the organization's customers and supply chain partners", enhances the ACAP of the operations management department; furthermore, this effect is moderated positively by the business – IT alignment (i.e. it is stronger in firms with higher level of business-IT alignment in comparison with organizations with lower levels of business-IT alignment). Jimenez-Castillo and Sanchez-Perez (2013), using data from 211 Spanish industrial firms, found that the use of integrated ICT for the provision of market related information to employees increase their relevant ACAP. Bolívar-Ramos et al. (2013), using data from a sample of 160 European high technology firms, conclude that the mastery of technical ICT skills and the use of ICT in interdependent tasks positively affect ACAP, which in turn enhances firm's performance. Recently, Iyengar et al. (2015), examine the use of ICT as a learning mechanism, through its effects on the knowledge transfer and ACAP; using data collected from a sample of 783 independently owned real estate franchisees, they have reached the conclusion that franchisee use of ICT provided by the franchisor impacts positively the effectiveness of knowledge transfer from the latter to the former, and through it the former, and finally their financial performance. Also, Roberts (2015), using a dataset collected from 178 high tech USA firms, examines the effects of an ICT related variable, the data integration (defined as the provision to firm's employees of the capability of integrated access to customers, partners, industry and market data), and an organizational variable, the connectedness (defined as culture of communication and exchange of knowledge among employees across functional units and hierarchical levels), on ACAP; he concludes that both these variables affect positively the ACAP.

So, the abovementioned previous research has examined the effects of some characteristics of firm's ICT infrastructures on their ACAP; however, it has not examined from this perspective the major ICT investments of firms: the different types of ES that firms increasingly implement, which tend to become critical infrastructures of their operation. There is a lack of empirical research on the impact of the use of the main types of ES on firm's ACAP. Filling this gap is an important issue, particularly in view of the big investments made by firms for the implementation of various types of ES, which increasingly become critical infrastructures for firms' operation. Our study contributes to filling this research gap, by investigating the effect of the use of the five most important and widely used types of ES (ERP, CRM, SCM, business intelligence/business analytics and collaboration support systems) on firm's ACAP. The corresponding research hypotheses are formulated in the following section.

3 Research Hypotheses

The most important type of ES is definitely the ERP systems, which are defined as integrated software packages, consisting of modules that support and link various functions of a firm, such as sales, procurement, accounting, manufacturing and human resources management modules, and are integrated by having a common shared database (Bradford, 2010; Madapusi and D' Souza, 2012; Laudon and Laudon, 2014). They increasingly become the backbone of the ICT infrastructure of numerous firms of all sectors and sizes. So our first research hypothesis concerns the effect of the use of ERP systems on firm's ACAP. The ERP systems through their sales and procurement modules allow the collection and integration of large quantities of data about customers (quotations proposed to customers or potential customers, orders received from them, shipments, receivable invoices, payments from them, returns from them, etc.) and suppliers (quotations received from them, concerning specific products and services, their characteristics, quality levels and prices, orders submitted to suppliers, receipts from them, payable invoices, payments to them, returns to them, etc.). Also, ERP systems provide some basic data analysis and reporting capabilities (e.g. calculation of total sales by region, product/service, customers' group, month, etc.), which allow the extraction of useful knowledge from the above data concerning important aspects of firm's external environment, such as customers, needs and preferences of them, market demand for firm's products/services, suppliers, procurement terms and conditions, and also time-wise fluctuations of them, or differences across geographic regions. These data and knowledge are easily accessible to different functional units and hierarchical levels, which enables a wide dissemination of them. Therefore ERP systems enable the acquisition of the abovementioned market demand and supply related external knowledge, and also its wide dissemination throughout the firm, which supports its assimilation, integration in the existing knowledge base of the firm, and possibly its transformation (as it is viewed through the different perspectives and knowledge structures of different firm's functions) and exploitation for innovations in firm's processes, products and services. The ERP systems provide capabilities that according to previous literature (reviewed in section 2) affect positively firm's ACAP: data integration and connectedness (Roberts, 2015) and cross-functional interface (Van den Bosch et al., 1999; Jansen et al., 2005). For all the above reasons our first research hypothesis is:

H1: The use of ERP systems has a positive effect on firm's ACAP.

Another highly important type of ES are the customer relationship management (CRM) systems (Khachaturyan, 2012; Khodakarami and Chan, 2014). The growing competition in many sectors has increased the importance of firms' relationships with their customers, and this has led to increasing adoption of CRM systems. According to Khodakarami and Chan (2014) they provide three main kinds of capabilities: operational (concerning the automation and increase of efficiency of CRM processes), analytical (concerning the analysis of customer data) and collaborative (concerning the management and integration of communication channels and customer interaction touch points). They provide extensive functionality for supporting the pre-sales, post-sales and customer service processes, and allow the collection of a wider range of customer data than a typical sales module of an ERP system (e.g. data about all the pre-sales communications with customers and potential customers, marketing actions taken for each of them, particular needs, preferences, etc., and also data about all post-sales communications and services provided to customers). These richer customer data usually originate from multiple sales, marketing and communication channels, but are integrated, and become accessible to many interested persons within the firm, in different functional units and hierarchical levels. The above data, in combination with the analysis and reporting capabilities provide by CRM systems, allow the acquisition of wide and deep knowledge about this critical aspect of firm's external environment: its customers (and potential customers), its sales, marketing and communication channels, and

in general the markets the firm competes in. They also enable the wide dissemination and assimilation of this extensive, wide and deep customer and market related external knowledge, its integration in the existing knowledge base of the firm, and possibly its transformation (as it is viewed through the different perspectives and knowledge structures of different firm's functions) and exploitation for innovations in firm's processes, products and services. In general, CRM systems provide important capabilities that affect positively firm's ACAP: a common language concerning firm's activities for attracting and retaining customers (Cohen and Levinthal, 1990), data integration and connectedness (Roberts, 2015) and cross-functional interface (Van den Bosch et al., 1999; Jansen et al., 2005). For all the above reasons our second research hypothesis is:

H2: The use of CRM systems has a positive effect on firm's ACAP.

Another important trend of the modern economy is firms' concentration on their core competences, and at the same time reliance on other firms for their non-core activities, which supply a wide variety of goods and services; however, this necessitates high levels of co-ordination with these multiple suppliers, and with customers as well, and in general effective management of the whole supply chain (SC) (Rainer et al., 2015; Chopra and Meindl, 2016). The complexity of this task leads many firms to use supply chain management (SCM) systems, which support the planning and monitoring of the whole SC, and the required electronic exchange of information with the most important customers, suppliers and business partners, concerning inventory levels, orders, production plans, shipment plans, invoices, etc. So our third research hypothesis concerns the effect of the use of SCM systems on firm's ACAP. SCM systems enable the collection of large quantities of data concerning firm's 'immediate external environment', which includes its most important suppliers, business partners and customers; these data are characterised by more breadth and depth than the external data collected through the ERP and the CRM systems, as they concern internal operations and plans of the above firms. Also SCM systems provide basic data analysis and reporting capabilities, which allow the acquisition of useful knowledge from the above data. So SCM systems can be used on one hand for achieving operational efficiency, and on the other hand for acquiring knowledge about the markets, the existing and emerging needs of customers, as well as the capabilities, processes and in general the behaviour of suppliers. Furthermore, the SCM systems make the above data and knowledge accessible within the firm across functional areas and hierarchical levels. According to Malhotra et al. (2005) this valuable external knowledge can be exploited for the development of 'new products and services (products and services are embodiments of knowledge), new categories of products and services (which come from understanding the competition and market needs), new ways to make, assemble, or deliver products and services (process innovation), new ways to organize to make, assemble, or deliver products (architectural or organizational innovation), and, in extreme cases, creation of new industries—category killers, again a function of market understanding'. Therefore SCM systems provide capabilities that according to previous literature affect positively firm's ACAP: data integration and connectedness (Roberts, 2015), and cross-functional interface (Van den Bosch et al., 1999; Jansen et al., 2005). Summarizing, the SCM systems can significantly support the acquisition, dissemination, analysis, assimilation and exploitation of valuable external knowledge concerning firm's 'immediate environment', so we expect them to affect positively firm's ACAP. Thus our third research hypothesis is:

H3: The use of SCM systems has a positive effect on firm's ACAP.

Though the three abovementioned three important types of ES (ERP, CRM and SCM) provide some basic data analysis and reporting capabilities, and enable some extent of knowledge generation from their data, it is widely recognized that much more knowledge can be generated from them by using

more advanced processing techniques, and this has given rise to the development and increasing adoption by firms of the business intelligence/business analytics (BI/BA) systems for this purpose (Davenport, 2006; Davenport and Harris, 2006; Davenport, 2013). According to Davenport and Harris (2006) 'by analytics we mean the extensive use of data, statistical and quantitative analysis, explanatory and predictive models, and fact-based management to drive decisions and actions'. BI/BA systems support advanced forms of processing business data (which may originate from various other systems, such as ERP, CRM, SCM, etc., or even from external sources), which lead to the creation of useful highly customized and insightful reports, as well as various types of predictive and prescriptive models (e.g. decision trees, regression models, etc.). They support the integration (both at the technical and the semantic level) of data from various both internal and external sources, make them accessible throughout the firm, across functional units and hierarchical levels, and enable each of them to make their own advanced processing of these data, based on their own perspectives and knowledge structures, and extract from them different types of deeper knowledge. Therefore BI/BA systems promote the acquisition of wider and deeper knowledge from external environment related data, as well as its assimilation and transformation, and finally exploitation. They provide capabilities that according to previous literature affect positively firm's ACAP: data integration and connectedness (Roberts, 2015), cross-functional interface (Van den Bosch et al., 1999; Jansen et al., 2005), and a common language concerning many different aspects of firm's activities (as they integrate technically and semantically data from many different internal and external sources) (Cohen and Levinthal, 1990). Summarizing, the BI/BA systems can support the acquisition, dissemination, analysis, assimilation and exploitation of valuable external knowledge, so we expect them to affect positively firm's ACAP. Thus our fourth research hypothesis is:

H4: *The use of BI/BA systems has a positive effect on firm's ACAP*

Finally, another type of ES increasingly used by firms are the collaboration support (CS) systems (Bafoutsou and Mentzas, 2002; Laudon and Laudon, 2014; Rainer et al., 2015), which are defined as software packages that support the internal collaboration between employees of the firm, as well as the external collaboration with customers, suppliers and business partners, by offering capabilities of sharing various forms of content (e.g. text files, images), instant messaging (and other forms of communication), discussion forum, project management, etc. The CS systems enable, on one hand through the easy and low cost external electronic collaboration they support, the identification and acquisition of useful external knowledge from customers, suppliers and business partners; on the other hand they enable through the easy and low cost internal collaboration they support, the internal dissemination of this knowledge in different functional units and hierarchical levels, as well as its assimilation and integration into firm's knowledge base. Furthermore, CS systems support the exploitation of this knowledge for the collaborative design and implementation of innovations in firm's products and services, through co-operation and contribution of several different functional units (Troy et al., 2008; Ernst et al., 2010). CS provide a strong electronic cross-functional interface, which according to previous literature can affect positively firm's ACAP (Van den Bosch et al., 1999; Jansen et al., 2005). For all the above reasons we expect that CS will affect positively ACAP, so our fifth research hypothesis is:

H5: *The use of CS systems has a positive effect on firm's ACAP*

4   Data and Method

This study has been based on data collected from 122 Greek firms through a survey concerning 'Innovation – Use of ICT and Cloud – Impact of the Economic Crisis on Greek Enterprises' between September 2015 and May 2016. An initial sample of 500 Greek firms from the most important sectors of the Greek economy was taken from ICAP, a leading Greek business information and consulting firm. The questionnaire of this survey was sent by e-mail to the CEOs of these firms, asking them to fill and return it (by fax or by e-mail) within a month; reminder e-mails were sent, and telephone calls were made to the firms that did not return filled questionnaire in time. With respect to firm size, 40.3% of the respondents were small firms (with 5-49 employees), 41.2% were medium (with 50-249 employees) and the remaining 18.5% were large firms (with more than 250 employees); 42.3% of them were from manufacturing sectors, 41.5% from services and 16.3% from construction.

In order to test the abovementioned research hypotheses H1 – H5, we estimated the following regression model:

$$ACAP = b0 + b1*ES + b2*HQUAL + b3*SIZE + b4*SECTOR + ei$$

The definitions of our variables (questions of the abovementioned survey used in this study) are shown in the Appendix. We investigated as dependent variable firm's overall absorptive capacity ACAP, measured by the mean of the scores of four items assessing dimensions of it (ACAP_IDE, ACAP_DIFAN, ACAP_ASSIM and ACAP_EXPL – see Appendix) (based on Ettlie and Pavlou 2006; Liu et al., 2013; Roberts, 2015); we also investigated as dependent variable separately each single dimension. The independent variables included, beside the measures of the extent of usage of five types of ES (ERP, CRM, SCM, BI_BA and CS), and the mean of the scores for these five measures (ES_AV as a general measure of the overall extent of use of these highly important types of ES), also a further important determinant of ACAP, namely the intensity of human capital as measured by the share of employees with tertiary-level education (HQUAL), and controls for firm size (SIZE, taking values 1, 2 and 3 for small, medium and large firms as defined above respectively) and sector affiliation (SECT, taking values 1, 2, 3 for construction, manufacturing and services firms respectively). We used OLS for the estimation of the overall ACAP model (as this variable is considered as a metric variable), and Ordered Probit regression for estimation of the single ACAP dimensions models (as these are measured as five-level ordinal variables). The estimations were done with the econometric software STATA.

5   Results

In Table 1 we can see the estimates for the model of the overall measure of ACAP. This variable correlates positively and statistically significantly with the variable ES_AV that measures the overall extent of use of the five types of ES taken into consideration in this paper (column 1). The results in column 2 and column 3 demonstrate that this overall effect can be primarily traced back to two types of ES, namely ERP and CRM. Estimations of model versions containing one of the other three ES types (SCM, business intelligence/business analytics systems and collaboration support systems) could not be effectively evaluated because the F-values of the respective models were statistically insignificant at the 10% test level (invalid models). The above results provide support for research hypotheses H1 and H2. They indicate the use of ERP and CRM systems have both positive effects on the ACAP of Greek firms. The large quantities of integrated data collected through the ERP systems about customers and suppliers, and in general about external supply and demand, the wide accessibility to these data across functional units and hierarchical levels, and also the data analysis and reporting capabilities provided by the ERP systems, seem to be leveraged by the Greek firms beyond efficiency improve-

ment, for the improvement of their ACAP with respect to the above important aspects of their external environment. Furthermore, the even wider range of customer data collected through the CRM systems (concerning both the pre-sales and the post-sales stages), usually originating from multiple sales, marketing and communication channels, which are integrated, and become accessible to many different functional units and hierarchical levels, in combination with the data analysis and reporting capabilities provided by the CRM systems, are also used by the Greek firms for the improvement of their customer related ACAP.

	(1)	(2)	(3)
HQUAL	0.283	0.449*	0.297
	(0.238)	(0.238)	(0.227)
ES_AV	0.198***		
	(0.074)		
ERP		0.121**	
		(0.051)	
CRM			0.156***
			(0.050)
SIZE	0.011	0.016	0.071
	(0.107)	(0.107)	(0.100)
SECT	0123	0.074	0.132
	(0.108)	(0.103)	(0.107)
N	116	116	116
F	2.6***	2.1*	3.2***
R^2	0.084	0.061	0.096
RMSE	0.799	0.809	0.794

Table 1.   *Overall Absorptive Capacity (ACAP) and ES types; OLS Estimates.*

Standard errors in brackets under the coefficients; *, **, and *** denote statistical significance at the 10%, 5% and 1% test level respectively; constants are left out; heteroskedasticity-robust standard errors.

Table 2 presents the estimates for the dimension of ACAP that refers to the firm's ability to analyse and disseminate external new knowledge within the firm (variable AC_DIFAN). This variable correlates positively and statistically significantly with the variable ES_AV (column 1). This overall ES effect can be traced back to three single types of ES, namely ERP, CRM and BI/BA), as the results shown in column 2, column 3 and column 4, respectively, show. For the other two technologies no statistically valid models could be estimated. Therefore Greek firms seem to use the data integration,

analysis and reporting capabilities of the ERP and the CRM systems, and also the even more extensive ones of the BI/BA systems, as well the wide data accessibility across functional boundaries enabled by these three types of ES, for external knowledge analysis and wide dissemination purposes.

	(1)	(2)	(3)	(4)
HQUAL	0.173	0.389	0.197	0.186
	(0.379)	(0.376)	(0.374)	(0.382)
ES_AV	0.240***			
	(0.092)			
ERP		0.170***		
		(0.066)		
CRM			0.177***	
			(0.067)	
BI_BA				0.130*
				(0.068)
SIZE	0.137	0.123	0.214	0.142
	(0.139)	(0.144)	(0.131)	(0.143)
SECT	0.072	0.014	0.080	0.032
	(0.161)	(0.151)	(0.157)	(0.158)
N	116	116	116	116
Wald chi^2	11.3**	10.8**	10.8**	7.7*
Pseudo R^2	0.030	0.027	0.030	0.021

Table 2.   Absorptive Capacity – Diffusion and Analysis Dimension (AC_DIFAN) and ES types; ordered Probit Estimates

Standard errors in brackets under the coefficients; *, **, and *** denote statistical significance at the 10%, 5% and 1% test level respectively; constants are left out; heteroskedasticity-robust standard errors.

Table 3 contains the estimates for the dimension of ACAP that refers to firm's ability to assimilate external knowledge and combine it with existing internal knowledge (variable AC_ASSIM). Also in this case we find a positive correlation with the overall ES use variable (column 1). This effect can be traced back to two types of ES, namely ERP and CRM (column 2 and column 3, respectively). We could not find valid models for the other three technologies. These results indicate that Greek firms make even more advanced exploitation of the abovementioned data integration, analysis, reporting and enterprise-wide accessibility capabilities of the ERP and the CRM systems for supporting highly so-

phisticated external knowledge management tasks, concerning assimilation of external knowledge and association and integration of it with the existing knowledge base of the firm.

	(1)	(2)	(3)
HQUAL	0.405	0.653*	0.427
	(0.379)	(0.349)	(0.338)
ES_AV	0.304***		
	(0.101)		
ERP		0.189***	
		(0.065)	
CRM			0.253***
			(0.074)
SIZE	-0.059	-0.054	0.030
	(0.145)	(0.139)	(0.142)
SECT	0.179	0.106	0.198
	(0.155)	(0.147)	(0.156)
N	116	116	116
Wald chi^2	10.8**	10.5**	13.8***
Pseudo R^2	0.038	0.028	0.047

Table 3.   Absorptive Capacity – Assimilation Dimension AC_ASSIM and ES types; Ordered Probit Estimates

For the other two dimensions of the ACAP (identification of relevant external knowledge (ACAP_IDE) and exploitation of external knowledge in combination with internally generated know-how ((ACAP_EXPL))) we could not estimate valid models, this meaning that these is not a significant relationship of these two dimensions of ACAP with the examined types of ES in the framework of the model used in this study.

6   Results

In many sectors of the economy are observed frequent and fast changes, continuous emergence of new technologies and materials, changes in customers' needs and preferences, new competitors, new products and services, strong demand for innovations in firms' products, services and processes, and at the

same time they become more complex and 'knowledge intensive' than in the past. These trends make the exploitation and management of external knowledge of critical importance for the success of firms. For this reason there is increasing interest of both researchers and practitioners on firms' ACAP, with main emphasis on gaining a better understanding on the factors that affect it positively or negatively. ICT has been recognized as having a good potential to assist firms in improving their ACAP. Some empirical research has been conducted concerning the effect of some characteristics of firm's ICT infrastructures on their ACAP, which however has not examined from this perspective the major ICT investments of firms: the different types of ES that firms increasingly implement, which tend to become critical infrastructures of their operation. This paper contributes to filling this research gap, by presenting an empirical investigation of the effects of the five most important and widely used types of ES (ERP, CRM, SCM, business intelligence/business analytics and collaboration support systems) on the ACAP of Greek firms. It is based on data collected through a survey from 122 Greek firms from both manufacturing and services sectors, which are used for the estimation of regression models of firm' ACAP.

In sum, the main hypothesis of this paper stating that ES contribute to a high ACAP is confirmed by our estimates. Our more detailed results for the single dimensions of ACAP and the single types of ES examined give additional insights of exploratory character with respect to (a) the high relative importance of particularly three types of ES (ERP, CRM and business intelligence/business analytics) for ACAP improvement, and (b) the dimensions of ACAP they mainly affect (the internal diffusion/analysis of external knowledge, and also its assimilation/integration in the knowledge base of the firm). Our results provide a first empirical evidence concerning the potential of these three types of ES to support the increase of a quite important external knowledge management capability of the firm, its ACAP. They indicate that in the crisis hit and 'innovation averse' national context of Greece, firms facing big changes in their external environment due to the crisis, and continuously decreasing demand for their products and services, move towards increasing the business value provided by some of their ES investments (concerning the implementation of ERP, CRM and business intelligence/business analytics), by exploiting them beyond the usual efficiency improvement, towards supporting important external knowledge management and innovation related activities. However, another interesting finding is that Greek firms do not exploit to a significant extent two types of ES that we would expect to have significant potential to contribute to ACAP improvement: the SCM systems (as they enable collecting a large amount of data from firm's 'immediate' external environment, from which useful external knowledge might be extracted) and the collaboration support systems (as they enable extensive interaction, both with firm's external environment, e.g. suppliers, customers, business partners, and also internally among firm's employees, which can enable external knowledge acquisition, internal diffusion, assimilation and exploitation).

The findings of our study have interesting implications for research and practice. With respect to research they open up new research directions concerning the effects of widely used types of ES beyond efficiency improvement, with respect to knowledge creation and management. As to practice our findings are useful for firms that are users (or potential users) of ES, in order to make a better exploitation of their ES and increase the business value generated by them, not only towards increasing efficiency, but also towards supporting critical knowledge creation and management processes. Furthermore our results are useful for ES vendor firms, providing them guidance for improving their products and services, by strengthening and enriching their features that enable improving user firms' knowledge creation and management processes. Further research is required in order to i) test our research hypotheses in other national contexts; ii) understand better (probably through qualitative in-depth interviews and focus-group discussions) on one hand how ERP, CRM and BI/BA systems are used for supporting and enhancing various dimensions of ACAP, and on the other hand why SCM and CS systems are not leveraged for the improvement of firm's ACAP; and iii) examine the impact of other 'soft' ICT variables (e.g. associated with firm's ICT human resources and processes) on firm's ACAP.

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Appendix: Questions used

To what extent does your firm have the following capabilities of acquisition/ management/exploitation of useful external knowledge (concerning the market, e.g. customers' requirements, products/services of competitors, etc., or new technologies and materials, legislation, opportunities, threats) (absorptive capacity) ?

Can you recognize/identify useful knowledge for your company from the external environment (e.g. suppliers, partners, research centers and universities, etc.) (ACAP_IDE)	1 2 3 4 5

It has internal practices and procedures for the internal dissemination and analysis of this external knowledge (ACAP_DIFAN)	1 2 3 4 5
It can absorb/assimilate this external knowledge and integrate it into the existing knowledge base of the company, so that it can be enriched and broadened (ACAP_ASSIM)	1 2 3 4 5
It can use/exploit this external knowledge, in combination with existing internal knowledge, for the improvement of the operation and competitiveness of the company, and the creation of innovative products/services – methods/procedures (ACAP_EXPL)	1 2 3 4 5

To what extent are the following categories/types of business software used in your company? Answer in a scale of 1 to 5, where: 5 = to a very large extent, 4 = to a large extent, 3 = to a moderate extent, 2 = to a small extent, 1 = not at all (i.e. you are not using the category/format of business software at all) – circle the appropriate number.

Enterprise Resource Planning (ERP) system	1 2 3 4 5
Customer Relationship Management (CRM) system	1 2 3 4 5
Supply Chain Management (SCM) system (= Software that supports the electronic exchange of information with customers, suppliers and business partners, such as inventory levels, orders, production, shipments, invoices, etc.)	1 2 3 4 5
Business Intelligence/Business Analytics (BI_BA) system (= Software that supports advanced forms of processing business data, which lead to the creation of useful reports, as well as various types of models that aim at the support of decision-making – this can be either a separate software, or a module of an ERP or CRM system)	1 2 3 4 5
Collaboration support (CS) system (= Software that supports the internal collaboration between employees of the company, and/or external collaboration with customers, suppliers and partners, offering capabilities of sharing various forms of content (e.g. text files, images), forum, instant messaging (and other forms of communication), project management, etc.)	1 2 3 4 5

Provide the percentages of the following main educational categories in the personnel of your company:

- Graduates of Universities/Technological Education Institutes (TEI) ___%
- Graduates of Professional Training Institutes (IEK), Technical Schools

  or Vocational High Schools ___ %
- Graduates of High School ___ %
- Graduates of Elementary School ___ %
  - **TOTAL** 100 %