Enterprise Systems, ICT Capabilities and Business Analytics Adoption – An Empirical Investigation

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Abstract. Business Analytics (BA) has attracted great interest among firms of most sectors worldwide, as it enables a more advanced and valuable exploitation of firms' data assets, beyond operations, for the supporting of decision-making. However, though numerous firms take some first steps in this area, most of them make limited use of BA in some of their activities, and cannot advance to a more extensive adoption of BA throughout their activities, so they do not exploit the full potential of it. For this reason, some first research has been conducted on BA adoption and factors affecting it, however more research is required on this topic. Our study makes a contribution to this research stream, by investigating empirically the effect of the extent of enterprise systems (such as ERP, CRM and SCM ones) adoption, as well as the degree of development of firm's ICT capabilities, distinguishing between technological and management ones, on the extent of BA adoption. It has been based on the Technology, Organization and Environment (TOE) framework. We have used data collected from 363 Greek firms from both manufacturing and services sectors through a questionnaire, from which ordinal regression models are estimated. It has been concluded that both the adoption of enterprise systems, as well as the development of firm's ICT capabilities, and especially the ICT management capabilities, affect positively the extent of BA adoption.

Keywords: Business analytics · ICT adoption · Enterprise systems · ICT capabilities

1 Introduction

Firms, all over the world, are called upon to cope with a highly complex, globally competitive and dynamic business environment, and in order to address the multiple challenges it poses they are increasingly adopting and using various digital technologies to increase their efficiency and effectiveness (Aydiner et al. 2019). Among these technologies are definitely the enterprise systems (ES), defined as large and complex software packages that provide comprehensive support and integration of various business functions (Rainer et al. 2016; Laudon and Laudon 2019; Roztocki et al. 2020); the most important kinds of ES are the Enterprise Resource Planning (ERP), the

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Customer Relationship Management (CRM) and the Supply Chain Management (SCM) ones. These ES systems aim mainly to support firms' daily operations, however they offer only some limited decision support capabilities. This gave rise to the development of a 'second generation' of business information systems, oriented mainly towards decision support, which aim to support and enhance firms' decision making, through various kinds of sophisticated analysis of operational data, referred to as 'Business Analytics' (BA) systems. BA can be defined as "techniques, technologies, systems, practices, methodologies, and applications that analyze critical business data to help an enterprise better understand its business and market and make timely business decisions" (Nam et al. 2019).

BA has attracted great interest among firms of most sectors, as it enables a more advanced and valuable exploitation of firms' data assets, beyond operations, for the support of decision-making, by providing a better description and understanding of firm's previous activities and operations (descriptive analytics), as well as predictions of future evolutions and behaviors (predictive analytics), and also recommendations for future actions (usually recommending optimal selections among existing alternatives) (prescriptive analytics) (Aydiner et al. 2019). However, though numerous firms take some first steps in this area, most of them cannot progress further, so they make limited use of BA in some of their activities, but cannot advance to a more extensive adoption of BA throughout their activities, and therefore do not exploit the full potential of it (Ransbotham et al. 2016; Nam et al. 2019). For this reason, some first research has been conducted on BA adoption and factors affecting it, which investigates the effects of some firm's internal and external factors on BA adoption (a review of it is provided in Sect. 2). However, much more research is required in order to obtain a better understanding of the drivers and the barriers to the adoption of BA by firms (Nam et al. 2019), by investigating the effects of a wider range of firm's internal and external factors on BA adoption.

Our study makes a contribution in this direction, by investigating empirically the effects of two technological factors that have not been examined before on the extent of BA adoption by firms:

- the extent of enterprise systems (such as ERP, CRM and SCM ones) adoption,
- and also the degree of development of firm's ICT capabilities (Ravichandran and Lertwongsatien 2005; Gu and Jung 2013; Garrison et al. 2015), distinguishing between technological and management ones.

It has been based on the well-established and widely used Technology, Organization and Environment (TOE) framework of technological innovation adoption (Tornatzky and Fleischer 1990; Baker 2011). We use data collected from 363 Greek firms from both manufacturing and services sectors through a questionnaire, from which ordinal regression models are estimated. These models have as dependent variable the extent of BA adoption, and as independent variables: the extent of enterprise systems adoption (technological factor), the degree of development of firm's ICT capabilities (technological and management ones); and also firm's general and ICT-related human capital, innovativeness, size and sector (organizational factors), and finally the price and non-price competition (environmental factors).

This paper consists of five sections. The following Sect. 2 reviews previous relevant literature, and then Sect. 3 formulates the research hypotheses. In Sect. 4 our method and data are described, and then in Sect. 4 our results are presented and discussed. The final Sect. 5 summarizes conclusions and proposes future research directions.

2 Literature Review

For the reasons mentioned in the Introduction some first research has been conducted concerning the factors that affect the adoption of BA. Most of these studies have been based on the Technology, Organization and Environment (TOE) framework, and investigate the effects of some firms' technological, organizational and environmental characteristics on the adoption of BA by them.

Malladi (2013) estimates a model of factors affecting the extent of organizational adoption of Business Intelligence and Analytics (BIA) technologies, concluding that perceived benefits from these technologies, technology sophistication in terms of data infrastructure, sectoral knowledge intensity and size affect positively the extent of BIA adoption, while the lack of relevant industry standards hinders its adoption. A similar study is presented by Malladi and Krishnan (2013), concluding that high level of data infrastructure sophistication has a positive impact on the use of BIA systems, while data management challenges as well as challenges concerning data integration and attraction/management of talented human resources prevent their use; also large organizations are more inclined to use BIA. With respect to the external environment, competitive intensity impacts positively the extent of BIA adoption, but environmental dynamism has no effect on it.

Boonsiritomachai et al. (2016) found that factors affecting the level of BI adoption by SMEs include the Relative Advantage it provides, its perceived complexity, the availability of organizational resources, the innovativeness of the owners and managers, as well as the competitive pressure, and vendor selection; on the contrary, it was found that the compatibility of BI with firm's needs and culture, the absorptive capacity of the firm and the ICT knowledge of the owners and managers do not affect the level of BI adoption. Puklavec et al. (2017) also focus on SMEs, and consider the adoption of BI systems as a process consisting of three stages, evaluation, adoption and use, investigating the factors affecting each of them. They find the perceived cost effectiveness of BI has a negative impact in the BIS adoption and use stage; also, if BI is part of ERP systems this has a positive impact in all three stages of BI adoption. At the organizational level, it follows that management support has a significant positive impact in the BI evaluation and use stages, and rational decision-making culture has a significant and negative impact only for the evaluation stage. Moreover, the existence of a project champion has a positive effect in all three stages of BI adoption. High-Quality Organizational Data is another positively important factor for the use stage, while organizational readiness has a positive impact in the evaluation and adoption stages. Finally, it is worth noting that the external support has been found to be not important.

Recently Nam et al. (2019) investigate factors affecting BA initiation, adoption and assimilation stages. They found that firm's data infrastructure affects all these stages, while data quality management affect the adoption and assimilation stages. The existence of management-related obstacles (concerning big changes and extensive training required, as well as difficulties in integrating BA into firm's processes and decision-making) prevent adoption and assimilation, while the organizational centralization of BA exploitation has negative impact in the assimilation stage. Finally, the competitive pressure faced by the firm affects positively the BA initiation stage, but none of the other stages, while government support affects none of these stages.

Summarizing, some studies have been conducted concerning the factors that affect BA adoption, which investigate the effects of some internal and external factors; however, further research is required in order to obtain a better understanding of BA adoption, its drivers as well as barriers, investigating of wider range of internal factors (firm's characteristics) and also external factors (characteristics of firm's external environment) on the extent of BA adoption. Our study makes a contribution in this direction, by investigating two widely debated in IS research factors, ES adoption and ICT capabilities, with respect to their impact on BA adoption.

3 Research Hypotheses

Our study, as mentioned in the Introduction, has as theoretical foundation the TOE framework: we have developed research hypotheses about the effects of one technological factor (extent of ES adoption), five organizational factors (ICT capabilities, general human capital, ICT-related human capital, innovativeness and size), and two environmental factors (price and non-price competition), on the extent of BA adoption.

3.1 Technological Factors

As mentioned in the Introduction, firms are increasingly adopting various kinds of ES (Rainer et al. 2016; Laudon and Laudon 2019; Roztocki et al. 2020), such as ERP, CRM and SCM systems, which support their main activities and functions, and enable collecting extensive data about them. These data constitute the main 'raw material' for applying the techniques of BA (such as reporting, dashboards, data-warehousing, prediction models, etc.), which aim to convert these data into meaningful information that can be useful for decision making. In particular, the development and use of the above main kinds of ES by firms involves the collection of a large volume of data derived from all the in-house and inter-company functions they automate, coordinate and manage. In particular, ERP systems, which support all operations and business interfaces, are a source of data concerning sales, supplies, production, financial management, human resources management, etc. CRM systems offer more specialized data about existing and potential customers' needs and preferences, as they provide support capabilities for pre-sale, post-sale, and customer service operations in general. SCM systems allow the collection of a large volume of specialized external data about the firm's supply chain activities, concerning not only relevant internal activities, but also suppliers', affiliates' and customers' ones. Therefore, we expect that larger extent of ES

adoption will result in availability of higher volumes of data concerning firm's activities and functions, and therefore in more capabilities and opportunities for making highly beneficial use of BA techniques across more firm's activities and functions, which will lead to larger extent of BA adoption. So, our first research hypothesis is:

Hypothesis 1: *The extent of enterprise systems (ES) adoption has a positive effect on the extent of BA adoption.*

3.2 Organizational Factors

IS research has revealed that for the efficient and effective adoption of digital technologies by firms and the generation of business value from them quite important is the development of ICT-related capabilities (Ravichandran and Lertwongsatien 2005; Gu and Jung 2013; Garrison et al. 2015); the relevant literature distinguishes two kinds of such capabilities: technological ones, concerning mainly the development, modification and integration of applications, and managerial ones, concerning strategic planning of the use of these technologies closely associated with firm's overall strategic planning, co-operation between firm's ICT units and personnel with the business ones, as well as co-operation with firm's ICT vendors. With respect to ICT technological capabilities, the adoption of BA often requires combining/integrating data from several different applications, and also developing new decision-support applications using these data, or modifying existing applications in order to exploit these data for providing new decision support functionalities. The development or customization of BA solutions is a unique case for every firm, or even for every different need of the same firm, that requires special treatment, which might make it quite expensive and difficult, if the firm relies exclusively on outsourcing; so if the firm has relevant internal capabilities, this can lead to better and less costly BA solutions. Therefore, we expect that higher degree of such ICT technological capabilities will reduce the cost of BA development, and at the same time improve its quality, so will finally increase the extent of BA adoption. Thus, our second research hypothesis is:

Hypothesis 2: *The degree of development of firm's ICT-related technological capabilities has a positive effect on the extent of BA adoption.*

Furthermore, highly important is the identification of opportunities for highly beneficial BA use that addresses the particular problems, challenges and needs of each specific firm (which might be quite different from the ones of other firms); this necessitates close cooperation between on one hand firm's ICT units and personnel (who have knowledge about the existing BA technologies, systems and practices and on the other hand the business ones (who have knowledge about firm's activities, functions, as well as their problems, challenges and needs, and will finally use BA). The existence of good internal relations between the staff of firm's ICT and the staff of its business units that use ICT for supporting their tasks creates a high level of mutual understanding, trust, interdependence and finally co-operation. This can be the best source of ideas for identifying valuable, rare and difficult to imitate by other firms combinations of data from different sources, as well as decision-support functionalities based on them (e.g. highly valuable reports, dashboards, key performance indicators,

predictions, optimizations, etc.); furthermore, this is going also to be very important for the implementation of the above ideas, and the production of highly beneficial BA solutions that meet business users' needs, and are user friendly. Also, this might necessitate highly sophisticated exploitation of existing ICT infrastructure, and especially applications, and use of advanced features of them that had never been used before. Developing a good and deep relationship with ICT suppliers of hardware, software and networks, characterized by extensive exchange of information and knowledge, mutual understanding, trust and a positive attitude, will enable us to acquire from them the required knowledge about the above advanced features, resulting finally in higher levels of efficiency with respect to BA systems development.

Furthermore, IS research has extensively emphasized the importance and impact of adopting a strategic approach to ICT and connecting it with overall strategy, and revealed the high usefulness of ICT strategic planning and alignment between the ICT unit of the firm and its business units (Chan and Reich 2007; Leidner et al. 2011; Wu et al. 2015). So, if a firm has a good ICT strategic planning and alignment capability it can identify valuable strategic opportunities for BA use, which can support or even enhance its strategy, and provide strong support from higher hierarchical levels of the firm for their implementation, leading finally to larger extent of BA adoption. Summarizing, we can expect that higher degree of these ICT management capabilities will enable the identification of more valuable opportunities of BA use, as well as their efficient and effective implementation, so it will finally increase the extent of BA adoption. Thus, our third research hypothesis is:

Hypothesis 3: *The degree of development of firm's ICT-related management capabilities has a positive effect on the extent of BA adoption.*

Furthermore, in order to formulate a more complete BA adoption model, we have developed some more research hypotheses, concerning the effects on BA adoption of some factors that have been found in previous innovation research to affect positively the adoption of technological innovation: human capital (distinguishing between general and ICT-related human capital), innovativeness, size and competition (distinguishing between price and non-price competition).

The relationship between human capital and innovation has been traditionally investigated and discussed extensively in many previous studies (Aghion and Howitt 1998; Barro 1999; Arvanitis et al. 2013). Business human resources are the driving force of all kinds of innovation, as it is a key factor for acquiring business skills to identify new needs and requirements as well as external knowledge absorption skills, which enables firms to create new knowledge and apply it for making valuable innovations (Vandenbussche et al. 2006; Vinding 2006; Lopez-Garcia and Montero 2012). Thus, taking into account the requirements of BA technologies for business personnel who have: i) a good knowledge and understanding firm's activities and processes, as well as their problems, challenges and needs, ii) ability to 'associate' them with the results and outputs that the existing BA techniques can provide, and therefore identify opportunities, and identify opportunities of using these techniques for addressing the above problems, challenges and needs, iii) and high level of abilities to use BA results for making decisions, we can expect that higher levels of 'general'

human capital (e.g. higher share of employees having higher education) will result in larger extent of BA use. Thus, our fourth research hypothesis is:

Hypothesis 4: *Firm's human capital has a positive effect on the extent of BA adoption.*

The complexity of processes of modern firms requires ICT personnel to have advanced ICT skills, as well as business understanding of firm's activities and processes, in order to make innovative use of ICT in the different business areas of the firm (Arvanitis et al. 2013). The advantage provided by competent ICT personnel is therefore vital for the effective adoption of new innovative ICT, so they constitute firm's ICT-related human capital critical for technological innovations. With respect to BA firm's ICT personnel is highly important for monitoring evolutions in BA technologies, identifying the ones that might be useful for the firm, disseminating them to business personnel, and collaborating with them in order to identify valuable BA use opportunities, as well as for implementing them efficiently and effectively. However, ICT personnel have multiple duties related to the operation, management and support of the users of existing applications and systems, the development of new ones, and the management of several ICT projects in progress, usually in collaboration with external partners and consultants (Shih et al. 2011). Therefore, it is necessary to have a sufficient number of ICT personnel, so that these the above necessary and urgent ICT tasks can be completed, and at the same time there is some time left for creative thinking concerning the introduction of new innovative technologies, including BA. Innovation research has traditionally emphasized the importance of 'slack resources' for innovation (Nohria and Gulati 1996). So, our fifth research hypothesis is:

Hypothesis 5: *Firm's ICT-related human capital has a positive effect on the extent of BA adoption.*

The innovativeness of top management and their support has been identified as an important factor for the adoption of many technological innovations (e.g. see Low and Chen (2011) for cloud computing adoption), including BA (Boonsiritomachai et al. 2016; Puklavec et al. 2017). In this study we investigate the wider concept of innovativeness at the level of the whole firm, manifested through the frequent introduction of new products and services. If a firm is innovative it has a culture of and familiarity with searching for, learning and experimenting with new ideas and technologies, managing their inherent problems and risks, and finding solutions for overcoming them; furthermore, their personnel exhibits low level of 'resistance to change'. We expect that these will facilitate and assist the adoption of BA as well, so our sixth research hypothesis is:

Hypothesis 6: *Firm's innovativeness has a positive effect on the extent of BA adoption.*

The size of organizations has been systematically associated positively with business innovation, with larger organizations appearing to be more innovative than smaller ones, as they have more financial and human resources for this (Malladi and Krishnan 2013; Rogers 2003; Mytinge 1968; Mahler and Rogers 1999). Previous studies traditionally show that the level of complexity that firms have to cope with in order to

achieve their smooth and efficient operation is proportional to their size; however, proportional to their size are also their organizational resources, and especially their economic resources, that can be made available for the introduction of innovative technological infrastructures (Geroski 2000; Rogers 2003). Large firms, due to economies of scale are able to adopt technologies with the lowest increase of costs per unit compared to small and medium-sized firms. Also, due to the great complexity large-scale firms face at all levels of their operations, they are necessarily turning to integrating innovations to cope with these challenges, and BA can be quite useful for this. Furthermore, large firms have more extensive and complex activities and processes, and also larger volumes of data, so they have stronger motivation to use the latter for gaining a better insight into the former, which can be useful for improving and optimizing them. Furthermore, previous studies have found that the degree of availability of organizational resources, and relevant organizational readiness, has a positive impact on the adoption of BA technologies (Puklavec et al. 2017; Boonsiritomachai et al. 2016). Hence, the firm's size is expected to have a positive effect on the extent of adoption of BA, so our next research hypothesis is:

Hypothesis 7: *Firm's size has a positive effect on the extent of BA adoption.*

3.3 Environmental Factors

Previous innovation research has traditionally dealt with the impact of competition on firms' innovation activities, concluding that intense competition between firms leads to an increase in the adoption of innovations (e.g. Mansfield 1968; Mansfield et al. 1977; Arvanitis et al. 2013). In this study we distinguish between two dimensions of competition. The first one relates to the competition that the firms face with respect to the prices of products and services (price competition), while the second one relates to all other axes of competition, beyond price, such the quality of products and services, the ability to customize them to special needs of customers, the introduction of new products and services, the provision of support services, etc. (non-price competition). Competition intensity has been found in previous studies to promote BA adoption (Malladi and Krishnan 2013; Boonsiritomachai et al. 2016, Nam et al. 2019). Higher competition, both price and non-price one, put pressure on firms to increase their efficiency, as well as to improve the quality of their products and services, and meet to the highest possible extent the needs of their customers; these increase firms' propensity to exploit better their data assets, through advanced processing of them using BA techniques, for the above purposes. Thus, our final research hypotheses are:

Hypothesis 8: *The intensity of price competition has a positive effect on the extent of BA adoption.*

Hypothesis 9: *The intensity of non-price competition has a positive effect on the extent of BA adoption.*

Our research model is shown in Fig. 1.

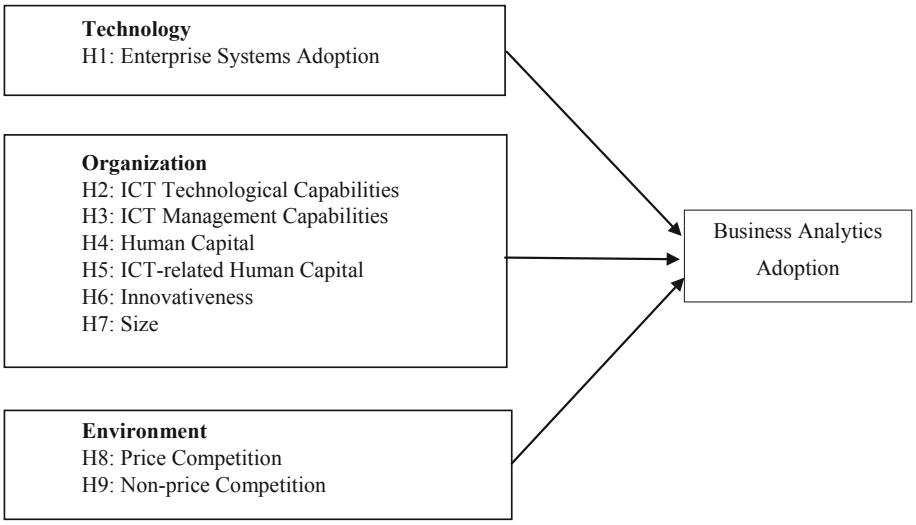

Fig. 1. Research model

4 Data and Method

This study was based on data collected from 363 Greek firms, through a survey, conducted in cooperation with ETH Zurich and ICAP SA, a leading Greek business information and consulting firm, titled "Innovation - Use of Information Technology and Cloud - Effects of the Economic Crisis on Greek Enterprises". We received from ICAP SA a random sample of Greek firms of all sizes from the most advanced sectors of the Greek economy (food and beverages, footwear, papermaking, ICT production, electronics, shipbuilding and repairs, construction, tourism, telecommunications and hospital services). The research team developed the questionnaire and sent it via e-mail to the CEOs of these firms, asking them to return it completed via the electronic form, fax or email within one month. From the respondent firms 52.9% are small businesses (1–49 employees), 36% are medium-sized ones (with 50–249 employees) and the remaining 11.2% are large enterprises (with more by 250 employees).

In order to test the research hypotheses formulated in the previous section we used data concerning a subset of the questions of the above questionnaire, which are shown in the Appendix.

Our dependent variable is the extent of BA adoption (BA_AD), which is measured in a 5-points Lickert scale (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).

Our technological independent variable is the extent of ES adoption (ES_AD), which is calculated as the average of three variables assessing the extent of adoption of an ERP, a CRM and a SCM system respectively (measured in the same 5-points Likert scale). The degree of development of firm's ICT technological capabilities (ICT_TC) is calculated as the average of three variables assessing the degree of having capability for: a) rapid internal implementation (by the ICT staff of the firm) of various changes in the

application software of its IS in order to meet new requirements; b) rapid internal development (by the ICT staff of the firm) of new software applications in order to meet new requirements; c) rapid internal implementation (by the ICT staff of the firm) of various interconnections/integrations of existing applications, so that there is interoperability of them (= one application can use data and functionality of other applications). All these variables are measured in a 5-points Lickert scale (where 5 = to a very high degree, 4 = to a high degree, 3 = to a moderate degree, 2 = to a low degree, 1 = not at all). The degree of development of firm's ICT management capabilities (ICT_MC) is calculated as the average of three variables assessing the degree of having capability for: i) good cooperation, mutual understanding and trust between the ICT staff of the firm and the staff of the other business units that use ICT; ii) good cooperation, trust and exchange of information with the ICT suppliers (of hardware/software/networks), as well as support from them for solving all relevant problems; iii) ICT strategies and plans which are connected with the overall strategies and plans of the firm (ICT business alignment).

The general human capital has been measured through the share of firm's personnel who are graduates of higher education (HC), while the ICT-related human capital has been measured by the number of firm's ICT personnel divided by total number of firm's personnel (ICT_HC). Firm's innovativeness has been measured through the extent of firm's strategy including the introduction of new products and services with significant innovations (INNOV), measured in the same 5-points Likert scale used for measuring the dependent variable BA_AD. The size of the firm is quantified through a dummy variable based on firm's number of employees in full-time equivalents, taking value 1 for small-sized firms with less than 50 employees, 2 for medium-sized firms with 50 to 249 employees and 3 for large-sized firms with 250 or more employees (D_SZ). Also, we used another sector dummy variable (D_SECT), taking value 0 for service sectors firms and 1 for manufacturing or construction sectors firms.

Finally, the two environmental independent variables, intensity of price and non-price competition, were measured both in 5-points Likert scales (where 5 = very strong, 4 = strong, 3 = moderate, 2 weak, 1 = very weak) (P_COMP and NP_COMP).

Based on the above data we estimated ordinal regression models having the following specification:

$$\begin{aligned} \text{BA\_AD} = {} & b_0 + b_1 * \text{ES\_AD} + b_2 * \text{ICT\_C} + b_3 * \text{HC} + b_4 * \text{ICT\_HC} + b_5 * \text{INNOV} \\ & + b_6 * \text{COMP} + b_7 * \text{D\_SZ} + b_8 * \text{D\_SECT} + e \end{aligned}$$

Since there was high level of correlation between the two competition independent variables P_COMP and NP_COMP it was not possible to include both of them in one regression model as independent variables, as this would lead to multi-collinearity problems (unreliable estimations of their corresponding bi coefficients) (Greene 2018), so we estimated one model with the former, and another model with the latter as independent variable. The same happens with the two ICT capabilities' independent variables ICT_TC and ICT_MC, so we estimated one model with the former, and another model with the latter as independent variable, and also an additional one with their average ICT_C as an overall measure of firm's ICT capabilities. So, we estimated $2 \times 3 = 6$ ordinal regression models in total.

5 Results - Discussion

The estimated ordinal regression models are shown in Table 1. The statistically significant bi at the 1%, 5% and 10% levels are denoted with asterisks (***, ** and * respectively).

Table 1. Results from the regression models.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
ES_Adoption	1,287*** (,120)	1,284*** (,120)	1,239*** (,122)	1,242*** (,122)	1,248*** (,121)	1,248*** (,121)
Size	,582*** (,173)	,552*** (,172)	,503*** (,177)	,481*** (,176)	,512*** (,177)	,488*** (,176)
Sector	−,318 (,223)	−,311 (,224)	−,299 (,224)	−,287 (,225)	−,312 (,224)	−,301 (,224)
Human Capital	,440 (,406)	,357 (,406)	,297 (,411)	,222 (,412)	,373 (,408)	,291 (,408)
ICT Human Capital	−,212 (,491)	−,227 (,492)	−,205 (,480)	−,200 (,481)	−,308 (,489)	-,309 (,491)
ICT Capabilities					,349*** (,124)	,346*** (,124)
ICT Technological Capabilities	,197** (,100)	,208** (,100)				
ICT Management Capabilities			,383*** (,125)	,361*** (,124)		
Innovativeness	,150 (,280)	,261 (,281)	,204 (,281)	,321 (,281)	,168 (,280)	,285 (,281)
Price Competition	,212* (,104)		,239* (,104)		,220* (,104)	
Non-Price Competition		−,106 (,096)		−,093 (,097)		−,099 (,096)

We can see that the extent of ES adoption has a statistically significant positive effect on the extent of BA adoption, so research hypothesis 1 is supported. This indicates that the adoption of ES, such as ERP, CRM and SCM ones, generates large amounts of data concerning various different firm's activities and processes, which are of comprehensive, integrated and of high quality, so the basis and 'raw material' for building high value BA applications that summarize these data and extract useful knowledge from them, providing substantial support for making better and more evidence-based decisions. Comparing the correlations of the extent of BA adoption with the extent of adoption of ERP, CRM and SCM reveals that the CRM one has the highest value, followed by the SCM one, and finally the CRM one. Therefore, the extensive data about our interactions with existing as well as potential customers, and

their needs and preferences, generated by CRM systems are strong drivers for the development of BA applications that extract from them valuable knowledge (having the form of advanced reports, dashboards, customer clusters and segments, relevant predictions, etc.) concerning our markets, which can be very useful for increasing our sales. Also, the extensive data concerning our supply chain activities generated by SCM systems are strong divers for the development of BA applications enabling the identification of inefficiencies in these activities, which can be very useful for reducing our operating costs.

Also, we can see that the degree of development of ICT technological capabilities, ICT management capabilities, and also overall ICT capabilities, have a statistically significant positive effects on the extent of BA adoption, so research hypotheses 2 and 3 are supported. By comparing the corresponding bi, and also the correlations with the dependent variable, it can be concluded that the positive effect of firm's ICT management capabilities on the extent of BA adoption is higher than the one of ICT technological capabilities. This indicates that firms having good capabilities in managing ICT usage, initially by carefully planning their exploitation, by developing ICT strategic plans, which support and enhance firm's overall strategic plans (ICT strategic alignment) (Chan and Reich 2007; Leidner et al. 2011; Wu et al. 2015), and then by establishing an effective co-operation of the ICT unit with the business units (who use ICT for their work) as well as with ICT vendors, will be better positioned for identifying highly valuable opportunities of BA use and then implementing the corresponding BA applications. They will be able to identify strategic BA applications, and also to exploit and combine both the business-related knowledge of their business units and personnel, with the BA-related knowledge of their ICT units and personnel, in order to identify a variety of valuable opportunities of BA use for supporting and improving decision-making in a multitude of firm's activities and processes. Also, they will be able to acquire knowledge from their ICT vendors for exploiting efficiently and effectively their existing ICT infrastructure (e.g. existing hardware, software, data, networks, etc.) in order to build to realize these opportunities and build the corresponding BA applications at a low cost and with good quality. These are going to lead to a more extensive development and use of BA within the firm. Furthermore, firms having good ICT technological capabilities, concerning applications development, modification and integration/interconnection, will be able to integrate existing data and applications, which is of critical importance for the development of highly valuable BA applications, which combine data from different activities and functional areas, and provide holistic pictures, quite useful for evidence-based decision-making.

On the contrary, from Table 1 we can see both the general and the ICT-related human capital variables do not have statistically significant effects on the extent of BA adoption, so research hypotheses 4 and 5 are not supported. This is not in agreement with previous research finding that human capital, both generic and ICT-related, affect positively innovation (see research hypotheses 4 and 5 in Sect. 3); it possibly reflects lack of awareness and knowledge about BA of the highly educated personnel, as well as the ICT personnel, of the Greek firms, and also lack of direction and motivation of them by higher management towards BA exploitation. Similarly, firm's general innovativeness does not have statistically significant effect on the extent of BA adoption, so research hypothesis 6 is not supported. This probably indicates that the adoption of BA

required quite different skills, attitudes and mentalities from the ones required from the 'classical' products and services innovation activity of firms (e.g. the change of decision-making style from mainly intuitive towards a more evidence-based one). The size has a statistically significant effect on the extent of BA adoption, so research hypothesis 7 is supported; this in agreement with our expectations and the findings of relevant innovation literature (see arguments for research hypothesis 7 in Sect. 3).

Finally, we can see that the intensity of price competition has a statistically significant positive effects on the extent of BA adoption, while the intensity of non-price competition does not have a statistically significant effect; so, research hypothesis 8 is supported, but research hypothesis 9 is not supported. This probably indicates that Greek firms perceive BA mainly as a means of identifying inefficiencies and reducing their operating costs, and much less as a means of improving the quality of their products and services, and customer service. This is in agreement to some extent with previous studies on the factors affecting BA adoption finding that competition intensity is a driver of BA adoption (Malladi and Krishnan 2013; Boonsiritomachai et al. 2016; Nam et al. 2019).

6 Conclusions

In the previous sections has been presented a study that contributes to the research on the factors that affect the extent of BA adoption, by investigating the effects of two factors that had not been examined before: the extent of ES adoption, and the degree of development of firm's ICT capabilities, distinguishing between technological and management ones. For this purpose, we have specified a BA adoption model, based on the TOE framework, which includes as independent variables the above two factors, and also (for the completeness of our model) some additional factors that have been found in previous innovation research to affect positively the adoption of technological innovation: human capital (distinguishing between general and ICT-related human capital), innovativeness, size and competition (distinguishing between price and non-price competition).

We have found that both the extent of ES adoption, and the degree of development of firm's ICT capabilities (and especially the ICT management ones) have a positive impact on BA adoption. Furthermore, we have found that the intensity of price competition, as well as size, impact positively the extent of BA adoption. On the contrary, firm's human capital, both the generic and the ICT-related ones, general innovativeness, and non-price competition, do not have any effect on the extent of BA adoption of the Greek firms.

Future research should look into the effects on more variables – firm's characteristics concerning the three dimensions of the TOE framework (technological, organizational and environmental). As far as the technological dimension is concerned, various other new digital technologies or other technologies (e.g. production ones) need to be studied. Regarding the organizational dimension, it is necessary to examine the relationship between the adoption and use of BA technologies with decision-making styles of the firm, the characteristics of its processes (e.g. their complexity), its structures (e.g. the degree of centralization of decision-making), its strategic choices and

business plans. With regard to the environmental dimension, it is necessary to examine the effects on BA adoption of other characteristics of firm's external environment, such as its dynamism, complexity, etc. These should be examined in different kinds of national contexts, characterized by different levels of economic and technological development, as well as culture.

Appendix

Variable	Question
BI_BA adoption	To what extent are Business Analytics systems used in your firm? (= software that supports advanced forms of processing business data, which lead to the creation of useful reports, as well as various types of models, aiming at the support of decision-making)
ERP adoption	To what extent are Enterprise Resource Planning (ERP) systems, used in your firm?
CRM adoption	To what extent are Customer Relationship Management (CRM) systems used in your firm?
SCM adoption	To what extent are Supply Chain Management (SCM) systems used in your firm? (=software that supports the electronic exchange of information with customers, suppliers and business partners, such as inventory levels, orders, production, shipments, invoices, etc.)
Size	Number of firm employees
General Human Capital	Percentage of the personnel of your firm who are Graduates of Higher Education
ICT Personnel	Number of qualified ICT specialists of your firm
ICT Technological Capabilities	To what degree does your firm have: a) Capability of rapid internal implementation (by the ICT staff of your firm) of various changes in the application software of your information systems in order to meet new requirements; b) Capability of rapid internal development (by the ICT staff of your firm) of new software applications in order to meet new requirements; c) Capability of rapid internal implementation (by the ICT staff of your firm) of various interconnections/integrations of existing applications, so that there is interoperability of them (=one application can use data and functionality of other applications)
ICT Management Capabilities	To what degree does your firm have: a) Good cooperation, mutual understanding and trust between the ICT staff of your firm and the staff of the other business units that use ICT, b) Good cooperation, trust and exchange of information with your ICT suppliers (of hardware/software/networks), as well as support from them for solving all relevant problems; c) ICT strategies and plans which are connected with the overall strategies and plans of the firm (ICT business alignment)

(*continued*)

(*continued*)

Variable	Question
Innovativeness	To what extent does your business strategy include introduction of new products/services with significant innovations
Price Competition	How intensive is the competition you face from other firms with respect to price (price competition)
Non-Price Competition	How intensive is the competition you face from other firms with respect to other competition dimensions beyond price, such as quality of products/services, adaptation to specific customer needs (customization), introduction of new products/services, provision of support services, etc. (non-price competition)

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