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Essays on information technology and operational capabilities

Ph.D. dissertation

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Abstract

Information technology (IT) plays a significant role in firm's involving in the worldwide competition that requires the firm to carefully invest in IT infrastructure capabilities to become more competitive and take a part in the race of global unlimited competitiveness. This doctoral dissertation examines the role of IT on two operational capabilities; a portfolio of operational competence (gross margin, employee productivity, operational talent management, and operational excellence) and green supply chain management. The dissertation consisting of tow studies; the first study examines the impact of e-business technology (as one example of IT infrastructure investment) on operational competence and profitability using a panel dataset of 154 large firms in Spain, and the second study examines in incorporating environmental sustainability practices across the internal and external supply chain based on green supply chain management as an important mediator of the IT infrastructure and competitive aggressiveness and their relationship with firm performance using a set of primary and secondary data on 203 firms in Spain. Findings argue that: (1) the timing of IT investments positively affect the operational competence and profitability over time through initial investment in IT capabilities, (2) green supply chain management fully mediates the relationships between IT infrastructure capability and competitive aggressiveness, and firm performance. The dissertation also provides an illustration methodology of how to perform a partial least squares (PLS) estimation using panel data.

Keywords: IT infrastructure, e-business technology, green supply chain management competitive aggressiveness, firm performance.

Resumen

La tecnología de la información (TI) juega un papel importante en la competitividad de la empresa a nivel mundial, lo que requiere que la empresa invierta cuidadosamente en sus capacidades de infraestructura de TI. Esta Tesis Doctoral examina el rol de la TI sobre el desarrollo de dos capacidades operativas: La competencia operativa (un portfolio con las siguientes capacidades operativas: La estimación de márgenes, la productividad del empleado, la dirección del talento operativo y la excelencia operativa), y la dirección medioambiental de la cadena de suministro. La Tesis se compone de dos estudios. En el primero, examinamos el impacto de la tecnología de Internet (como un ejemplo de inversión en infraestructura de TI) en la competencia operativa y la rentabilidad utilizando un conjunto de datos de panel de 154 grandes empresas en España. En el segundo, examinamos la incorporación de las prácticas de sostenibilidad medioambiental en la cadena de suministro interna y externa como una variable intermedia importante en las relaciones entre la infraestructura de TI y la agresividad competitiva, y el desempeño organizativo utilizando un conjunto de datos primarios y secundarios extraídos de 203 empresas en España. El análisis empírico indica que: (1) El momento de la inversión en TI afecta a la competencia operativa y a la rentabilidad empresarial por el mayor tiempo que las empresas tienen para desarrollar su competencia operativa; (2) la dirección medioambiental de la cadena de suministro media totalmente las relaciones entre la capacidad de la infraestructura de TI, la agresividad competitiva y el desempeño organizativo. El primer estudio también explica e ilustra cómo realizar una estimación con partial least squares (PLS) utilizando datos de panel.

Palabras claves: Infraestructura de TI, tecnología de Internet, competencia operativa, dirección medioambiental de la cadena de suministro, agresividad competitiva, desempeño organizativo.

Chapter one
(Introduction)

1. Introduction

1.1. Motivation

The role of information technology (IT) has become critical in the last years, firms invest millions of euros in IT to build process capabilities and increase their competitiveness and performance (Fosso et al. 2009, Chen et al. 2015, Wang et al. 2015). The investment in IT infrastructure capabilities has been raised in both operational and supply chain level, moreover, and because the increasing demand for more sustainable solutions among the stakeholders (e.g., Benitez and Walczuch, 2012) firms exceed the investment in IT capabilities to include activities related with all environmental management activities to reduce the impact on the natural environment, therefore saving cost and increasing revenues (Benitez et al 2015; Saeidi et al 2015). Although IT infrastructure capabilities have widely spread, little is known about how IT infrastructure can increase the firm's performance, in addition, not all IT investments generated the expected results (Carr, 2003) that require managers to carefully reassess their investments.

Regarding to internal firms operations, the majority of prior research focused on the impact of IT on manufacturing activities through cross sectional design (Rai et al. 2006, Devaraj et al. 2007, Sanders, 2007, Heim and Peng 2010, Ayabakan et al. 2012, Setia and Patel 2013, Huo et al. 2015) what remains unclear is the impact of IT investment on a set of operational competence, that demands researchers to deeply examine how IT can impact a set of operational capabilities and performance specially over the time, since the relation between IT investments and performance can be described as dynamic relationship (e.g., working in downwards periods) (Shao and Lin 2002, Mithas et al.2012).

The increasing demand for more sustainable solutions motivates firms to exploit various environmental management opportunities that reduce their activities' impact on the natural environment (Benitez et al., 2015; Saeidi et al., 2015), whereas sustainability related-activities typically refer to firm logistics, waste management, and purchasing activities (e.g., Green et al. 2012; Zhu and Sarkis, 2004), the importance of IT-related activities in contributing to a more sustainable future through enhancing environmental management activities has also been examined in recent research (Benitez and Walczuch, 2011; Dao et al. 2011).

Since IT represents a potential source of environmental contamination during the production process, usage and disposal, advanced IT capabilities can also have potential opportunities to improve resources efficiency in both firms and supply chain level (Elliot, 2011; Wang et al. 2015). Prior research focused on how IT enables firm's supply chain management capabilities to improve performance (Devaraj et al. 2007, Setia and Patel 2013), more research is needed to examine how IT can enables the green supply chain management capabilities to improve performance specially firms that operating in high degree of competitive aggressiveness, since the overall competitive aggressiveness that a firm faces in a specific industry consider an external factor drivers green supply chain management (Hofer et al. 2012) and this may affect the extent to which firms take advantage of benefits by executing environmental management (Bose and Pal, 2012). Thus, the core idea of the dissertation is to shorten the gap between IT implications and firm performance through firm's operational capabilities.

1.2. Objectives

The dissertation focuses on tow aspects: first, examining the e-business technology -as one type of IT capability investment- how and under what conditions this capability can create/add value to firm's performance over time. E-business technology can improve firm operations management system by enabling information interchange across its internal/external boundaries, (Devaraj et al 2007, Setia and Patel 2013) but e-business technology can be also easily commoditized and affordable for most firms which can reduce its effective role to create/add value over time (Carr 2003) this puts a question mark about how does e-business technology investment can affect firm operations management over time?

Operational competence for a firm refers to the firm's proficiency in exploiting its portfolio of operational capabilities that are the firm's proficiency in using a collection of interrelated operational activities to implement operations strategy, (Peng rt al. 2008, Wu et al. 2010, Setia and Patel 2013). Operational capabilities can be refined through time and experience, this means early developer of operational capabilities through early investment in e-business technology can achieve greater competitiveness based on longer duration and experience to develop their operational capabilities, this puts another question mark if the initial and sub-sequent e-business technology investments create a differences in the operations management over time?

In this sense, the conceptual theory suggests that- for a firm- early investing in e-business technology can positively affect its operational competence which can positively impact the final performance, moreover, the relation between e-business technology and operational competence may decrees over the time while the relation between operational competence and firm performance can be increasing through time.

Second, examining the role of IT infrastructure in enabling green supply chain and firm performance. Enabling IT capabilities in firm's internal operations activities may improve the firm's coordination with supply chain to achieve environmental management goals, whereas all environmental management activities monitored within the supply chain to improve the environmental performance refers to green supply chain management (Dao et al., 2011). Firms which operate in an industry with high level of competitive aggressiveness may search to exploit new opportunities to save cost and increase revenue (Bose and Pal 2012). Competitive aggressiveness indicates the level to which firms benefit from competitive attacks with high volume, duration, complexity, and unpredictability from industry key competitors (Chen et al., 2015; Ferrier, 2001).

Implementing environmental management activities in the supply chain provides a way for firms to differentiate themselves from their competitors to benefit from superior firm performance (Benitez et al., 2015; Chen et al. 2015; Ferrier, 2001), For example, firms operating in an industry with a high degree of competitive aggressiveness, experience greater need to adapt their course of action by searching and exploiting new business opportunities. The central point is to examine if internal IT capabilities and external competitive aggressiveness can impact firm performance through green supply chain management. Based on the above discussion, the conceptual model suggests that IT infrastructure capability and competitive aggressiveness can positively impact green supply chain, which positively can relates to firm performance.

Thus, we address the goals of this dissertation as follows: 1. Examining the evolution of the impact of e-business technology on operational competence and firm profitability over time, 2. Examining the relationship between IT infrastructure capability, competitive aggressiveness, and green supply chain management and firm performance. The dissertation tries to answer the following questions: 1) How does e-business technology can affect firm's operations management over time, and How does the operational competence affect firm performance over time? 2) How IT capabilities can enable green supply chain management to add value to firm's performance?

1.3. Studies' organization

In order to achieve our goals, this dissertation presented in tow studies: first study, examines the e-business technology and its effect on a set of firm's operational competence (gross margin, employee productivity, operational talent management, and operational excellence) and firm performance. The proposed model is tested based on an innovative secondary dataset collected from a sample of 154 large manufacturing and services firms in Spain for a panel data of three years period (2008-2010), samples obtained from four main database; the Monitor Empresarial de Reputacion Corporativa (MERCO) (http://www.merco.info/es/), Sistema de Analisis de Balances Ibericos (SABI), https://sabi.bvdinfo.com/ Actualidad Economica (http://www.actualidadeconomica.com/), and COMPUSTAT databases. The empirical analysis through using structural equation modeling (SEM) and partial least squares (PLS) techniques suggests a positive impact of e-business technology on operational competence decreases over time, while the positive impact of operational competence on firm profitability can increases over time. The findings provide some insights on how the initial and subsequent IT investments affect operational competence and firm profitability over time. Early development of IT-enabled operational capabilities maximizes firm profitability based on the greater time and experience the firm has to develop its operational capabilities. This study also illustrates methodologically how to perform a PLS estimation using panel data.

Second study, examining IT infrastructure and competitive aggressiveness impact on firm performance through green supply chain management. Using primary and secondary data on 203 large firms in Spain with a collected data through a survey and from the Actualidad Economica database. Empirical analysis for the conceptual model using PLS estimation method suggests that both IT infrastructure capability and competitive aggressiveness can impact firm performance through green supply chain management by means of a full mediation effect, the effect of an industry's competitive aggressiveness on development of green supply chain management capability can exceeds the effect of IT infrastructure capability on green supply chain management, this study contributes to the Information System (IS) and Operations Management literature in three ways. First, it opens the black box between IT infrastructure, competitive aggressiveness, and firm performance. Second, it shifts the focus from a general perspective on supply chain management activities to a more contemporary view of supply chain management that incorporates a sustainability focus. Finally, it discloses both internal (i.e. IT infrastructure capability) and external (i.e. competitive aggressiveness) drivers of green supply chain management and, by this means, provide important guidance for managerial practice.

1.4. Dissertation structure

The following chapter of the dissertation – methodology and results- consists of the tow studies: first study, the evolution of the impact of e-business technology on operational competence and firm profitability: A panel data investigation. This research is in preparation for being resubmitted to Information and Management journal (second round of review). The research is joint with Jose Benitez Ph.D., University of Granada, Spain; Yang Chen, Ph.D.

Southwestern University of Finance and Economics, China; Thompson Teo, Ph.D. National University of Singapore, Singapore.

Second study: IT infrastructure and competitive aggressiveness in explaining and predicting performance, the study has been published in the journal of Business Research, it is a joint research with Jose Benitez, Ph.D., Jessica Braojos, M.S. University of Granada, Spain, and Carsten Gelhard, University of Twente, Netherland. In last chapter for the dissertation a deep discussion will be illustrated, and overall conclusions with implications, limitations, and suggestion for future research.

Chapter two

(Methodology and results)

2. Methodology and results

2.1 First study: The evolution of the impact of e-business technology on operational competence and firm profitability: A panel data investigation

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Abstract

This study examines the evolution of the impact of e-business technology on operational competence and profitability using a panel dataset of 154 Spanish firms. We find that: (1) E-business technology has a positive effect on operational competence that decreases over time, and (2) the firm's proficiency in exploiting a portfolio of operational capabilities has a positive impact on profitability that becomes more significant over time. The findings provide some insights on how the initial and subsequent IT investments affect operational competence and profitability over time. This study illustrates methodologically how to perform a partial least squares estimation using panel data.

Keywords: E-business technology capability, operational capabilities, firm profitability, business value of IT, variance-based structural equation modeling, panel data.

2.1.1. Introduction

Firms invest millions of Euros in IT to build process capabilities and increase their competitiveness (Fosso Wamba and Chatfield 2009, Chen et al. 2015, Wang et al. 2015). However, not all IT investments generate the expected results (Carr 2003). As the current economy worldwide turns downward, this situation demands managers to carefully (re) assess all their IT investments (Shao and Lin 2002, Mithas et al. 2012).

The majority of past research focused on IT impact on the supply chain and manufacturing activities through a cross-sectional design (Rai et al. 2006, Devaraj et al. 2007, Sanders 2007, Heim and Peng 2010, Ayabakan et al. 2012, Setia and Patel 2013, Huo et al. 2015). What remains unclear is whether and how IT investments impact on a broader set of operational capabilities and performance over time. Considering that IT and operational capabilities, their relationship and effect on firm performance can be dynamic, this seems to be a significant gap that needs to be filled in our field.

This research focuses on e-business technology (one type of IT capability investment/resource allocation) and on whether, how and under what conditions this capability creates business value. E-business technology can improve the firm's operations management system by enabling the real-time interchange of information across the supply chain (Devaraj et al. 2007, Setia and Patel 2013). However, e-business technology has become commoditized and can be affordable for most large firms, which can reduce its potential to create operational advantages over time (Carr 2003). This leads to our first research question: How does the time of investment in e-business technology affect the firm's operations management system (specifically, operational competence comprising a portfolio of capabilities) over time? We believe our field needs to provide an answer to this critical research question. This is what we try in this research.

The operational capabilities of the firm can be refined through time and experience. In this sense, early developers of operational capabilities through early investment in e-business technology can achieve greater competitiveness based on longer duration and experience to develop their operational capabilities. This leads to our second research question: Do initial and subsequent e-business technology investments result in differences in the operations management impact on the firm's competitiveness over time? We address the above two questions in this study. Specifically, by drawing on the IT-enabled organizational capabilities perspective (Benitez and Walczuch 2012, Braojos et al. 2015a, Chen et al. 2015, Dong and Yang 2015) and the operational capabilities-based theory (Peng et al. 2008, Benitez et al. 2015), the main goal of this study is to examine the evolution of the impact of e-business technology on operational competence and firm profitability over time. To achieve this goal we use the SEM technique with an innovative panel dataset for the period 2008-2010 on a sample of 154 large firms in Spain. The empirical analysis suggests that the e-business technology positive effect on operational competence decreases over time, while the positive impact of operational competence on firm profitability increases over time. The findings provide some insights on how the initial and subsequent IT investments affect operational competence and firm profitability over time. Early development of IT-enabled operational capabilities maximizes firm profitability based on the greater time and experience the firm has to develop its operational capabilities. This study also illustrates methodologically how to perform a partial least squares estimation (PLS) using panel data.

2.1.2. Theory and hypotheses

2.1.2.1 IT-enabled organizational capabilities perspective, and the operational capabilities-based theory

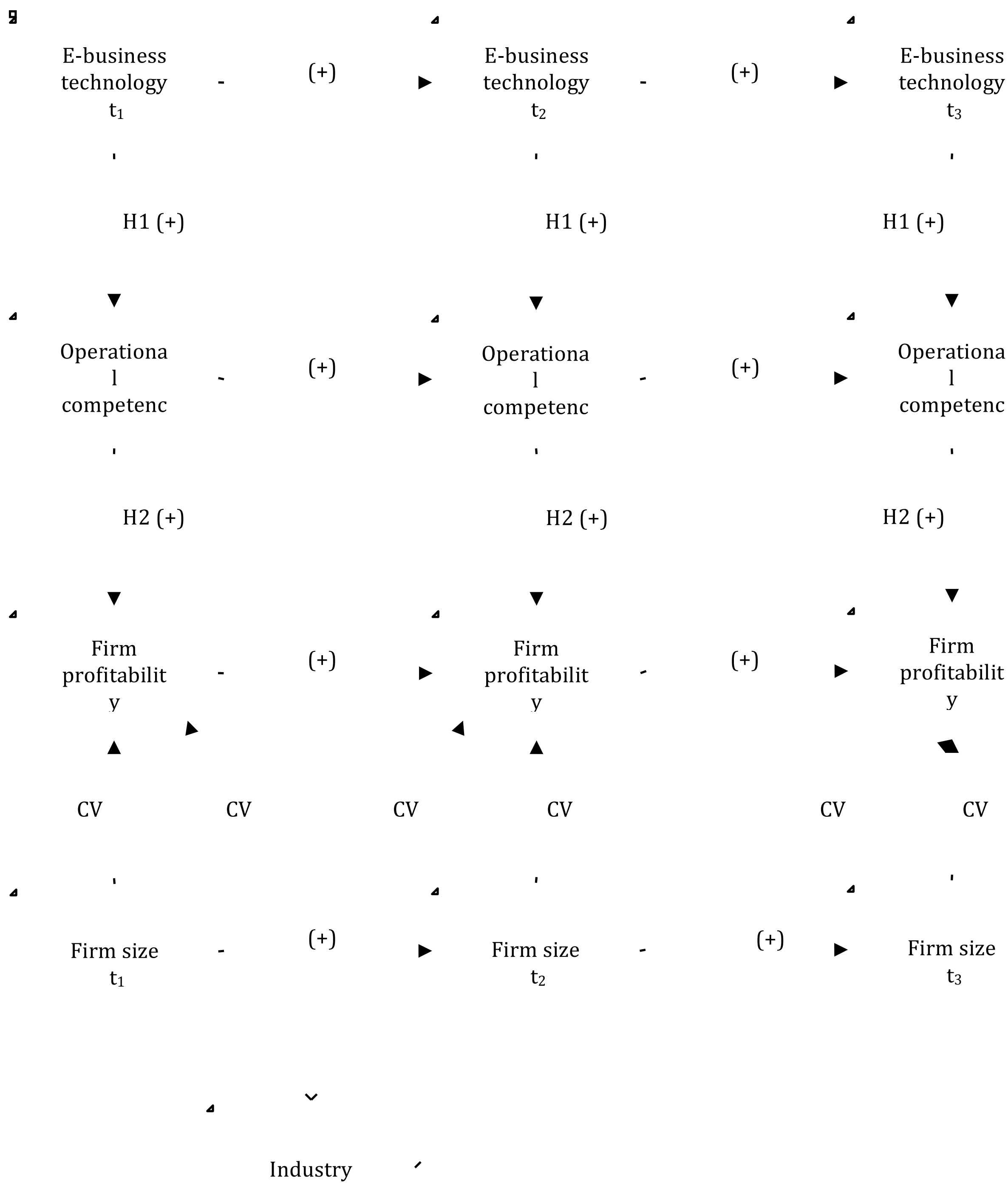
The IT enabled-organizational capabilities perspective has argued that one of the key mechanisms through which IT capability influences firm performance is by developing organizational/process capabilities, such as business flexibility, talent management, new product development or absorptive capability (Pavlou and El Sawy 2006, Benitez and Ray 2012, Benitez et al. 2015, Chen et al. forthcoming, Dong and Yang 2015). This study builds on the IT-enabled organizational capabilities to conceptualize e-business technology and to link theoretically e-business technology to operational competence and firm profitability over time. One of our differential effects is our focus on a three-year panel data.

Operational routines are patterns of activities/processes that a firm performs at the operations level, which can lead to superior firm performance. Operational capabilities are the firm's proficiency in using a collection of interrelated operational routines to solve operational problems and implement the operations strategy (Peng et al. 2008, Huang et al. 2014, Benitez et al. 2015). The theory of operational capabilities provides a strong theoretical framework to conceptualize e-business technology and operational competence, and to link these constructs both among themselves and to firm profitability.

2.1.2.2. Conceptualization of e-business technology, operational competence, and firm profitability

E-business technology capability is the firm's proficiency in leveraging its web-based technologies to interchange within and outside the firm for buying and selling activities with suppliers and customers (Teo and Choo 2001, Teo and Ranganathan 2004, Devaraj et al. 2007, Sanders 2007, Soto and Merono 2008, Xin et al. 2014, Braojos et al. 2015a, Liu et al. 2015). Operational competence refers to the firm's proficiency in exploiting its portfolio of operational capabilities (Wu et al. 2010, Setia and Patel 2013). Based on the work of Tatikonda et al. (2013) we focus on a portfolio of operational capabilities that determines operational competence: Gross margin, employee productivity, operational talent management and operational excellence. Gross margin is the firm's proficiency in managing/estimating proper product margins. Employee productivity refers to the firm's proficiency in stimulating the personnel to achieve a higher individual performance (Pan et al. 2015). Operational talent management is the firm's proficiency in recruiting (sourcing, attracting, selecting), getting on board, developing and retaining operational talent (Benitez et al. 2013, 2015). Operational excellence refers to the firm's proficiency in developing and executing operational routines to manufacture/supply products agilely (in an excellent way) to the market (Huang et al. 2014, Chen et al. forthcoming). This study focuses on firm profitability to assess the firm's business benefits. Figure 1 presents the conceptual model showing the interrelationships among e-business technology, operational competence and firm profitability over time.

Figure 2.1: Conceptual model (CV = Control variable)



2.1.2.3. E-business technology and operational competence

E-business technology can enable the development of operational competence by facilitating the improvement of gross margin, employee productivity, operational talent management and operational excellence. E-business technology can enable the firm's proficiency in managing successful product margins. Web-based technology enables the firm to have real-time interchange of accurate and timely information on product cost and demand with upstream suppliers and downstream customers, thereby enabling the firm to better manage its product margins (Devaraj et al. 2007, Sanders 2007, Benitez and Ray 2012, Jamali et al. 2015). Similarly, e-business technology can also be leveraged to increase employee productivity (Banker et al. 2006). The firm's web-based communication networks (e.g., email, Intranet) enable the employees to access and share more heterogeneous/diverse knowledge (e.g., information about the manufacturing process/other employees) and learn to perform multiple tasks, which increase the employee productivity (Bock et al. 2005, Aral et al. 2012).

E-business technology can also improve the management of operational talent. Through e-business technology, the firm acquires/provides accurate and timely information from/to the market to recruit and get on board outstanding operational talent to design and integrate its talent base. For example, Cortefiel (an apparel manufacturer in Spain) uses web-based social media tools such as LinkedIn, Facebook and Twitter to recruit operational managerial talent that fits the profile needed in designing its talent base (Benitez et al. 2013). Web-based technology enables the firm to implement scheduling and workplace flexibility activities to retain operational talent, and to provide reliable information on goals completion, performance appraisal and career planning to develop and retain operational talent (Benitez et al. 2015). Finally, leveraging web-based business applications (e.g., operational module of an enterprise resource planning) enables better execution of operational routines and agility in manufacturing/supplying products to the markets to pursue operational excellence (Law and Ngai 2007, Chen et al. forthcoming).

Firms may not need to invest in IT all years/periods. For example, Air Canada (the largest airline firm in Canada) invested in 2007 in its web-based technology to be the first airline in offering customer the online boarding pass and self-service IT applications in 2007 to save costs (increase gross margin) and improve operational excellence. After its initial investments in e-business technology, Air Canada did not need additional investments in e-business technology to keep its operational development in subsequent periods (Karimi and Rivard 2014).

We also predict that the positive effect of e-business technology on operational competence can decrease over time for two reasons. First, additional investments in e-business technologies (after investments in prior periods) can diminish the operational marginal returns (Aral et al. 2012). Second, e-business technology has been commoditized and can be affordable for most firms. Consequently, follower firms can learn to invest in e-business technology and develop e-business technology capability, which can convert e-business technology into a non-unique/imitable capability and its effect on operational competence can decrease over time (Carr 2003, Dutta et al. 2014). We therefore hypothesize that:

Hypothesis1 (H1): E-business technology has a positive effect on operational competence that decreases over time.

2.1.2.4. Operational competence and firm profitability

We also argue that operational competence has a positive impact on firm profitability. Since firms can develop different proficiencies in managing/estimating product margins, this operational capability can generate differences in firm's benefits and profitability (Tatikonda et al. 2013), thus indicating that it is rational to expect a positive impact of gross margin capability on firm profitability. Higher employee productivity and better firm's proficiency in recruiting, getting on board, developing and retaining operational talent reduce costs and increase revenues, which in turn increase business benefits and profitability (Ahmad and Schroeder 2003, Stahl et al. 2012). Mercadona (a leading retailer) is a top employer firm in Spain that offers excellent working conditions and an attractive career plan to develop and retain shop talent, which has enabled Mercadona to be the most profitable retailer of Spain (Ton and Harrow 2010, Benitez et al. 2015). Finally, by developing operational routines to achieve operational agility, operational excellence can increase profitability (Beach et al. 2000, Benitez and Ray 2012, Malhotra and Mackelprang 2012, Chen et al. 2014, Chen et al. forthcoming).

Because the firm's proficiency in exploiting its portfolio of operational capabilities is the core of the firm's business model (Peng et al. 2008, Wu et al. 2010) and this proficiency can be refined through time and experience (Benitez and Ray 2012), we expect that positive impact of operational competence on firm profitability to increase over time.

Hypothesis 2 (H2): Operational competence has a positive impact on firm profitability that increases over time.

Although not stated as formal hypotheses, we expect that e-business technology; operational competence, firm profitability and firm size (control variable) in one period should affect the same construct in the subsequent period (Johnson et al. 2006). For example, since current business benefits are influenced by prior business benefits (i.e., the so-called 'halo effect'), we can also expect that firm profitability obtained in the prior period affect the firm profitability in the subsequent period (Bharadwaj 2000, Santhanam and Hartono 2003, Benitez and Ray 2012).

Firm profitability can be affected by the type of industry, specifically in an economic downturn period (2008-2010, as in our study). We thus control for industry effect on firm profitability (Teo and Bhattacherjee 2014, Braojos et al. 2015a, 2015b).

2.1.3. Research methodology

2.1.3.1. Sample and data

The proposed model is tested with an innovative secondary dataset collected from a sample of 154 large manufacturing and service firms in Spain for the period 2008-2010. A panel of three repeated years is sufficient to investigate the evolution effects that we pursue in this research (Serva et al. 2011). Our sample is obtained from the Monitor Empresarial de Reputacion Corporativa (MERCO) database (http://www.merco.info/es/), which includes ranking and evaluation of corporate reputation and employer brand of firms in Spain and Latin America. Our sample is representative of the large manufacturing and service firms located in Spain because large firms in Spain participate in the annual MERCO evaluation and are included in the MERCO database.

We used the name of firms selected from the MERCO database to collect additional information from the firm's websites, Sistema de Analisis de Balances Ibericos (SABI), Actualidad Economica and COMPUSTAT databases. SABI is a database produced by

Bureau van Dijk that contains abundant financial information on firms in Spain and Portugal (https://sabi.bvdinfo.com/) (Benitez and Ray 2012). Actualidad Economica is a premier Spanish business magazine that develops annual rankings based on sales and innovation to compose a database with rich information on the most admired firms in Spain (http://www.actualidadeconomica.com/) (Benitez et al. 2015).

2.1.3.2. Measures

We measure all our constructs with secondary panel data for the period 2008-2010 that comes from five different sources. Table 1 provides the name, measure definitions and data sources for all the constructs. Consistent with prior IS research (e.g., Zhu and Kraemer 2002, Merono and Soto 2007, Braojos et al. 2015a), we measure e-business technology through the accumulated number of e-business technology services that each firm possesses to interact with its suppliers and customers with information collected from the firm's website.

Measurement models can be specified as factor or composite models (Rigdon 2012, Henseler et al. 2014). Factor models use reflective constructs and assume that the variance of a set of indicators can be perfectly explained by the existence of one unobserved variable and individual random error. It is the standard model of behavioral research (Henseler et al. 2014, Dijkstra and Henseler 2015). In contrast, composite models/constructs are formed as linear combinations of their respective indicators. A composite construct serves as proxy for the concept under investigation (i.e., the recipe) that is composed of a mix of indicators (i.e., the ingredients) (Henseler 2015). The composite model does not impose any restrictions on the co-variances among indicators of the same construct, thereby relaxing the assumption that all the co-variation among a block of indicators is explained by a common factor. Emergent and strong concepts should be modeled as composite constructs (Henseler et al. 2016). Composite models are likely to become the standard models of present and future IS research because of the nature of concepts in this field. Consequently, the model of this study is composite.

Operational competence is a composite first-order construct composed of gross margin, employee productivity, operational talent management and operational excellence (Henseler 2015, Henseler et al. 2016). Gross margin and employee productivity are measured through gross margin and operating revenues per employee with information collected from SABI database (Tatikonda et al. 2013). They are also the measures used by business executives to evaluate gross margin and employee productivity in the real world (Ton and Harrow 2010). Drawn from the Benitez's et al. (2015) measure scheme, we measure operational talent management through the score (from 0 to 10000) achieved by each firm in employer brand/reputation with information collected from MERCO database. Employer brand/reputation is a good proxy for operational talent management because top employers are also leading firms in recruiting, getting on board, developing and retaining talent (Stahl et al. 2012, Benitez et al. 2013).

Operational excellence is measured through the rate of sectoral excellence (RSE) in sales with information collected from Actualidad Economica database (Benitez and Walczuch 2012). We assume that excellent firms in operations are also leader firms in sales (Benitez and Walczuch 2011). RSE in sales has a value between 0 and a value very close to 1 (termed the industry's maximum value). The closer the RSE is to the maximum value for the industry, the better the operational excellence of the firm (Benitez and Ray 2012). Firm profitability is measured through the return on assets (ROA) with information from SABI database. We control for firm size and industry. We measure firm size through the natural logarithm of number of employees (Zhu and Sarkis 2004) using information collected from SABI and Actualidad Economica databases. We classified firms in manufacturing (0) or services (1) to control for industry (Braojos et al. 2015a). All variables are measured for the years 2008 (t_1), 2009 (t_2) and 2010 (t_3).

Prior to data collection, we arranged two informal meetings with four executives (two came from IT and two from business) and asked for their opinion about the congruence between the measures and constructs employed in the study (Benitez et al. 2015, Braojos et al. 2015b). They indicated that there was very good conceptual proximity between the measures and constructs. Overall, this shows satisfactory content validity for our constructs.

2.1.4. Empirical analysis

We use the variance-based SEM technique and the PLS method of estimation to test the hypotheses and examine the indirect effects involved in the proposed model. We use the statistical software package Advanced Analysis for Composites (ADANCO) 1.1.1 (http://www.composite-modeling.com/) (Henseler and Dijkstra 2015). ADANCO 1.1.1 is a modern statistical software package that enables the execution of a modern approach for variance-based SEM technique, including the method of estimation of PLS. ADANCO is particularly useful to estimate models that contain composite constructs, as in our study (Henseler et al. 2016).

Table 1: Construct name, measure definition and data sources

Construct name	Measure definition	Source
E-business technology	Accumulated number of e-business technology services that each firm possesses on the following list of 26 e-business technology services: Website, online catalogue, online ordering, banner, online order tracker, site map, search engine, bulletin subscription, email, discussion forum, online calendar/agenda, repository of documents, tools to provide recommendations to customers, invoice system, customer service management solution, shopping cart solution, payment system, website advertising, Intranet for employees, supplier management solution, shareholder solution, social media usage, frequently asked questions, online visitor counter and customer loyalty solution. This measure ranges from 0 to 26	Proprietary content analysis of the firm's website
Profit margin	Profit margin (%) = (Earnings before taxes / Operating incomes) * 100	SABI
Employee productivity	Operating revenues per employee (in thousands of Euro) = Operating incomes / Number of employees	SABI
Operational talent management	Score from 0 to 10000 given by MERCO to the firm in employer brand/reputation	MERCO
Operational excellence	RSE in sales = 1 - (Ranking position of firm in sales / Total number of firms in the industry). RSE ranges from to 0 to 1	Actualidad Economica
Firm profitability	Return on assets (%) = (Earnings before taxes / Total assets) * 100	SABI
Firm size	Natural logarithm of the number of employees	SABI and Actualidad Economica
Industry	Dummy variable (0 = Manufacturing, 1 = Service firm)	SABI, Actualidad Economica and COMPUSTAT
Advertising spending	Advertising expenditure per employee (in thousands of Euro) = Advertising expenditure / Number of employees	SABI and COMPUSTAT (only for 2009 and 2010, see the subsection 4.3)

It is appropriate to use PLS in this study as the method of estimation for the following reasons. First, PLS is a variance-based SEM technique that has been used in prior IS research (Rai et al. 2006, Benitez and Walczuch 2012, Benitez et al. 2015, Chou et al. 2015). Second, PLS is a full-fledged SEM method of estimation that can conduct exact test of model fit (Henseler et al. 2016). Third, the construct operational competence is identified as composite, and PLS is a suitable method for estimating models with this type of constructs (Rigdon 2012, Henseler et al. 2014). Fourth, the use of PLS and SEM is advisable to estimate models that employ secondary data like our model (Gefen et al. 2011, Benitez and Walczuch 2012). Finally, prior research in the marketing domain has proven that PLS estimation is useful for testing models that use panel data (e.g., Johnson et al. 2006). To estimate the level of significance of weights, loadings and path coefficients, we run the bootstrapping algorithm with 5000 subsamples (Barroso et al. 2010, Petter et al. 2007).

Prior to data collection, we performed a statistical power analysis. Assuming a medium effect size, the proposed model required a minimum sample size of 84 to achieve a power of 0.8 and an alpha level of 0.05 (Cohen 1988, Wang et al. 2015) while our sample size was 154, which suggested that 154 was a good sample size to estimate the proposed model.

2.1.4.1. Model fit evaluation

We evaluate the goodness of model fit for both the measurement and structural models by examining the standardized root mean squared residual (SRMR), unweighted least squares (ULS) discrepancy (d_{ULS}) and geodesic discrepancy (d_G) (Henseler et al. 2014). All these goodness of fit measures evaluate the discrepancy between the empirical correlation matrix and the model-implied correlation matrix (Henseler 2015). The lower the SRMR, d_{ULS} and d_G

the better the fit of the theoretical model (Henseler and Dijkstra 2015). For both the measurement and structural models, all discrepancies are below the 95%-quantile of the bootstrap discrepancies (see Table 2), which means that the measurement and structural models should not be rejected based on an alpha level of 0.05. Thus, this implies that our model has good measurement properties and that we can proceed with hypotheses testing (Henseler et al. 2016).

Table 2: Model fit evaluation

Discrepancy	Measurement model				Structural model			
	Value	HI_{95}	HI_{99}	Conclusion	Value	HI_{95}	HI_{99}	Conclusion
SRMR	0.164	0.427	0.427	Supported	0.153	0.29	0.296	Supported
d_{ULS}	6.52	44.085	44.085	Supported	5.666	20.327	21.161	Supported
d_G	2.943	75.355	75.355	Supported	2.718	49.373	53.595	Supported

2.1.4.2. Hypotheses testing

We test the proposed model by performing a PLS estimation and analyzing the evolution of the effect size (f^2) for the hypothesized relationships. f^2 values of 0.02, 0.15 and 0.35 indicate a weak, medium or large effect size of adding a link between an exogenous and endogenous variable (Henseler and Fassott 2010). Thus, we examine the evolution of beta coefficients, level of significance and f^2 values to test the hypotheses. Figure 2 presents the results of the PLS estimation. Table 3 provides the analysis of the effect size for every relationship included in the proposed model. The empirical analysis gives good support to H1 and H2. E-business technology has a positive effect on operational competence that decreases over time even becoming non-significant. The portfolio of operational capabilities has a positive impact on firm profitability that becomes more critical over time. The firm size effect on firm profitability is only significant in t_1. The effect of industry on firm profitability is significant at 0.05 level in t_1 and t_3. All constructs are affected by the same construct in the prior period (significant at 0.05 level).

The values of the beta coefficients, their level of significance, the f^2 values and the R^2 values are individual measures of the explanatory power of the model. Beta coefficients around 0.2 are considered economically significant, and R^2 values higher than 0.2 indicate good explanatory power of the endogenous variables of the model (Chin 2010, Benitez and Ray 2012).The beta coefficients of the hypothesized relationships in our model range from 0.199^{*} to 0.481^{**}. The f^2 values for the six endogenous variables involved in the hypothesized relationships range from 0.069 to 0.35. The R^2 values for these relationships range from 0.09 to 0.725. Overall, this analysis suggests a good explanatory power for the proposed model.

Figure 2.2: PLS estimation of the proposed model ($^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$, one-tailed test)

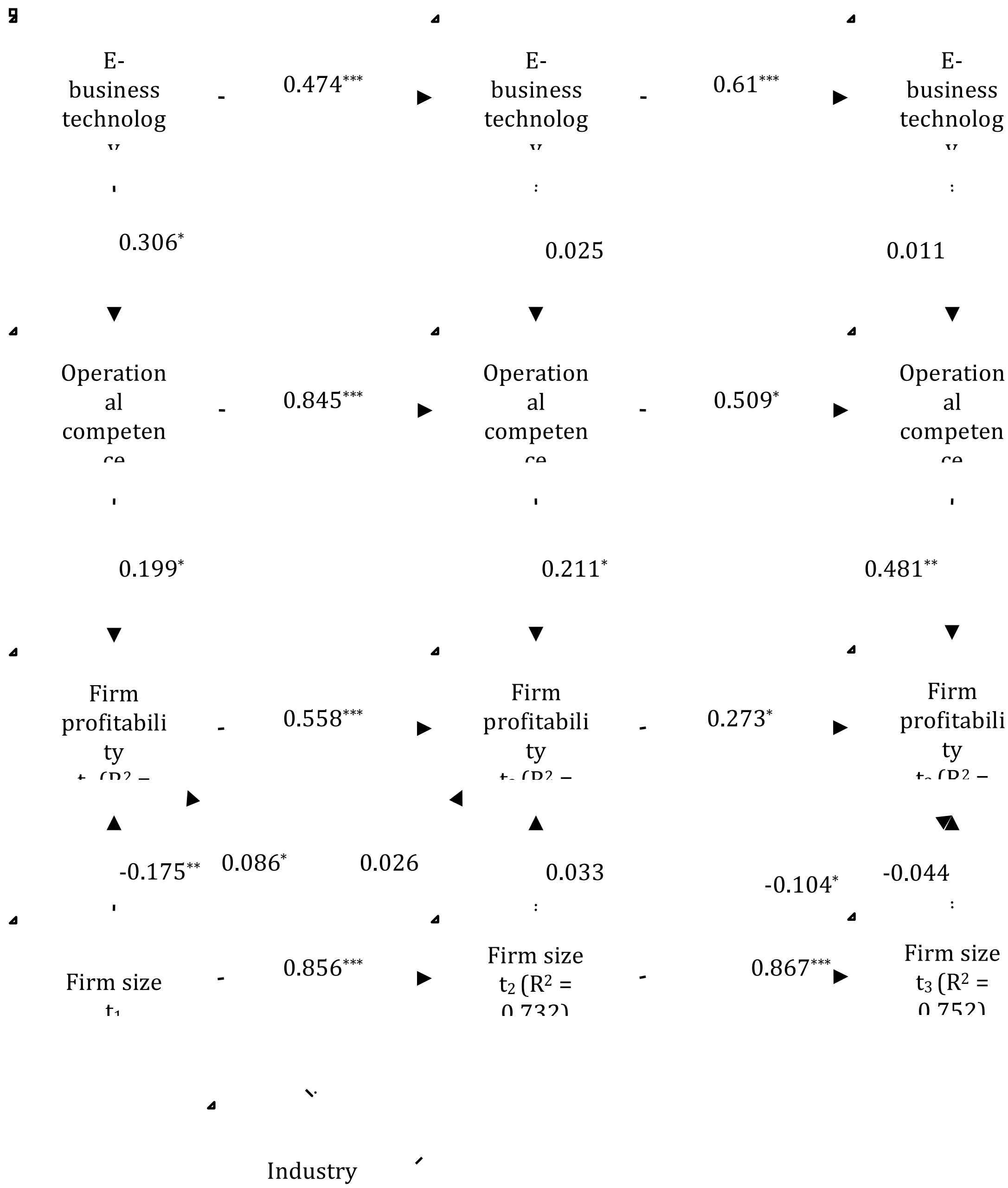


Table 3: Effect size analysis

Relationship	f^2 value	Effect size
Hypothesized relationship	**f^2 value**	**Effect size**
E-business technology$_{t1}$ → Operational competence$_{t1}$ (H1)	0.104	Medium
E-business technology$_{t2}$ → Operational competence$_{t2}$ (H1)	0.002	Very weak
E-business technology$_{t3}$ → Operational competence$_{t3}$ (H1)	0	Zero
Operational competence$_{t1}$ → Firm profitability$_{t1}$ (H2)	0.043	Weak
Operational competence$_{t2}$ → Firm profitability$_{t2}$ (H2)	0.069	Weak-medium
Operational competence$_{t3}$ → Firm profitability$_{t3}$ (H2)	0.35	Large
Control variables	**f^2 value**	**Effect size**
Firm size$_{t1}$ → Firm profitability$_{t1}$	0.032	Weak
Firm size$_{t2}$ → Firm profitability$_{t2}$	0.002	Very weak
Firm size$_{t3}$ → Firm profitability$_{t3}$	0.003	Very weak
Industry → Firm profitability$_{t1}$	0.008	Very weak

Industry → Firm profitability$_{t2}$	0.001	Very weak
Industry → Firm profitability$_{t3}$	0.017	Weak
Non-hypothesized relationships (between time periods)	**f^2 value**	**Effect size**
E-business technology$_{t1}$ → E-business technology$_{t2}$	0.289	Large
E-business technology$_{t2}$ → E-business technology$_{t3}$	0.594	Large
Operational competence$_{t1}$ → Operational competence$_{t2}$	2.444	Very large
Operational competence$_{t2}$ → Operational competence$_{t3}$	0.35	Large
Firm profitability$_{t1}$ → Firm profitability$_{t2}$	0.475	Large
Firm profitability$_{t2}$ → Firm profitability$_{t3}$	0.112	Medium
Firm size$_{t1}$ → Firm size$_{t2}$	2.734	Very large
Firm size$_{t2}$ → Firm size$_{t3}$	3.025	Very large

2.1.4.3. Effect of advertising spending on the proposed model

The firm's advertising spending can increase firm profitability and can affect the impact of operational competence on firm profitability (Mithas et al. 2012). These effects may happen also over time. Because of missing data for a significant number of firms of the sample for t_1 in the SABI and COMPUSTAT databases, we do not control for advertising spending on firm profitability in the proposed model. As a robustness check/test, we estimate an alternative model in which we control for advertising spending on firm profitability in t_2 and t_3 for which we have available data. The beta coefficients of these two effects are not significant (-0.082 and 0.002) while all the other results are identical.

2.1.4.4. Mediation analysis

We perform a mediation analysis to examine the more critical mediation effects involved in the proposed model. Specifically, we add to the proposed model a link between: (1) E-business technology$_{t1}$ and firm profitability$_{t1}$, (2) E-business technology$_{t1}$ and operational competence$_{t2}$, and (3) E-business technology$_{t1}$ and operational competence$_{t3}$. Because the proposed model has many potential indirect effects involved in the analysis, we select the more critical mediation effects for parsimony and to provide a simpler explanation (Henseler 2015). The direct effects of these three links are not significant, the indirect effects are significant (0.05 level), while the results of the hypothesized relationships remain consistent, which reinforces the results obtained in the test of hypotheses and suggests that the impact of early investments in e-business technology on the development of operational capabilities over time is significant (Zhao et al. 2010). Table 3 provides the details of this mediation analysis.

Table 4: Mediation analysis

Relationship	Direct effect	Indirect effect
E-business technology$_{t1}$ → Firm profitability$_{t1}$	0.109	0.046*
E-business technology$_{t1}$ → Operational competence$_{t2}$	0.043	0.284**
E-business technology$_{t1}$ → Operational competence$_{t3}$	0.01	0.199*

2.1.5. Discussion

2.1.5.1. Main findings

Although IT capability investments can develop and improve the firm's process capabilities and competitiveness (Benitez and Walczuch 2011, Chen et al. forthcoming), not all IT capability investments generate the expected results. This study focuses on e-business technology and examines the evolution of the impact of e-business technology on operational competence and firm profitability by performing a panel data investigation on a sample of 154 large firms in Spain. We uncover that: (1) E-business technology has a positive effect on operational competence that decreases over time even becoming non-significant, and (2) the firm's proficiency in exploiting a portfolio of operational capabilities has a positive impact on profitability that becomes more significant over time.

2.1.5.2. Research implications

This study has several research implications. First, the findings provide some insights on how the initial and subsequent IT investment affects operational competence and firm profitability over time. This study differentiates from past studies (e.g., Banker et al. 2006, Sanders 2007, Setia and Patel 2013) by performing a panel data investigation on the impact of e-business technology on operational competence and firm profitability. Our results suggest that early developers of operational capabilities through early investments in e-business technology maximize profitability based on a higher time and experience to develop their operational capabilities.

We find that the firm's proficiency in leveraging its web-based technologies has a positive effect on the firm's proficiency in exploiting a portfolio of operational capabilities (i.e., gross margin, employee productivity, operational talent management and operational excellence). Web-based technology enables the firm to perform real-time interchange of accurate and timely information on product cost and demand with upstream suppliers and downstream customers to improve gross margin management. E-business technology also enables the firm to: (1) Acquire/provide information from/to the market to recruit and get on board outstanding operational talent, (2) implement scheduling and workplace flexibility activities to retain operational talent, and (3) provide reliable information on goals completion, performance appraisal and career planning to develop and retain operational talent. Finally, e-business technology also facilitates better execution of operational routines and greater agility in manufacturing/supplying products to the markets. However, the positive effect of e-business technology on operational competence decreases over time even becoming non-significant. This result seems to suggest that firms can imitate IT investments from its competitors and learn to develop an e-business technology capability over time, which may convert e-business technology into a non-unique capability to enable operational competence. This implies that early investors/developers of e-business technology are the firms that mainly achieve e-business technology-based operational development.

We find that operational competence has positive impact on profitability that becomes more significant over time. Through a better management/estimation of product margins, greater employee productivity, an appropriate recruitment, the development and retention of operational talent, and higher product manufacturing/supply chain agility, the firm can increase its profitability. Since the firm's operational competence is the core of the business model and can be refined through time and experience, the operational competence impact on firm profitability increases over time. This result suggests that the timing of e-business technology investment for the operational development is critical to maximize firm profitability over time.

Prior IS research (Aral et al. 2006) has proposed the virtuous cycle argument to explain the firm IT investments over time. This argument suggests that firms that invest in IT in t_1 reap benefits and then invest more in IT in subsequent periods. Over time, these effects become magnified, leading some firms to continue investing more in IT compared with their historical investment and that of their competitors (Mithas et al. 2012). Is this IT behavior economically rational? Our results are consistent with the virtuous cycle argument [beta (e-business tecnology$_{t1}$ $\rightarrow$ E-business technology$_{t2}$) = 0.474^{***}] but also suggests two new interesting insights that extend the virtuous cycle argument: (1) Firms continue investing in IT in subsequent periods although they do not see immediate benefits [beta (e-business technology$_{t2}$ $\rightarrow$ Operational compertence$_{t2}$) = 0.025], and (2) firms may be investing in IT in subsequent periods although they do not really need it, which is not economically rational. This trend may also be due to capturing “low hanging fruits” (i.e., easy benefits compared to cost) through initial IT investment, with subsequent IT investment being more difficult to have similar impact.

Second, the findings also provide theoretical implications on the impact of IT on the development of operational capabilities. Past research has explored the effects of IT on the following manufacturing capabilities: Just-in time manufacturing, and supplier and customer participation program (Banker et al. 2006), supply chain information integration (Devaraj et al. 2007), organizational collaboration (Sanders 2007) and operational absorptive capability (Setia and Patel 2013). In a different way, we focus on the impact of e-business technology on a different set of operational capabilities: Gross margin, employee productivity, operational talent management and operational excellence. The results suggest that e-business technology has a positive effect on the development of operational capabilities, which is consistent with past studies (e.g., Banker et al. 2006, Setia and Patel 2013). However, a key insight from our results is that the effect of e-business technology on operational development decreases over time at least in subsequent periods.

Third, this study has also methodological implications because illustrates how to perform a panel data investigation focusing on the evolution effects by using SEM and the PLS method of estimation. Few studies have performed this type of analysis. In this sense, we develop and extend the Johnson et al.’s (2006) study (in the marketing domain) that uses the method of estimation of PLS to examine the evolution of loyalty intentions. While Johnson et al. use three-year survey dataset; we use a three-year secondary dataset. We also show that this method can be applied to IS research examining the evolutionary impact of e-business technology on operational competence and firm profitability. In addition, we show that the analysis of effect size is a useful tool to examine the evolution effects on this type of dynamic models.

2.1.5.3. Limitations and future research opportunities

This research has one key limitation. The results of this study may be only generalized to large firms in Spain. Future research can explore whether these results remain under other environmental conditions, in other countries and/or specific industries. Moreover, to the extent the effect of e-business technology on operational competence decreases over a three-year panel data even becoming non-significant, future research can explore whether this result remains valid over a longer panel data (e.g., 10 years) period.

2.1.5.4. Implications for practice

Our findings also provide important managerial implications. First, this study shows how managers can develop e-business technology and operational competence to maximize firm profitability. Second, our findings suggest to IT managers to control IT investments over time. Early e-business technology investments provide more time and experience to refine the firm's portfolio of operational capabilities, thus improving the operations management system and increasing their firm profitability in the long run. In other words, early investment in IT can enhance operational competence and result in an increase in profitability over time. Thus, deciding well when the firm should allocate IT resources is critical for operational development and maximizing firm profitability.

Financial analysts should pay attention to the firm's IT allocation decisions over time because these decisions can provide early signals about subsequent operational development and firm profitability over time (Mithas et al. 2012). Finally, our results also provide some empirical evidence to managers that investment in e-business technology do enhance operational competence and firm profitability. Such evidence can help managers to better justify investments in e-business technology.

2.1.6. Concluding remarks

This study examines the evolution of the impact of e-business technology on operational competence and firm profitability by performing a panel data investigation on a sample of 154 large firms in Spain. We find that e-business technology has a positive effect on operational competence that decreases over time even becoming non-significant, and that the firm's proficiency in exploiting a portfolio of operational capabilities has a positive impact on profitability that becomes more significant over time. One key implication of the findings is that early IT investment is critical for the operational development and effect on firm profitability over time. Early development of IT-enabled operational capabilities maximizes firm profitability based on a greater time and experience to develop their operational capabilities.

2.1.7. References

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2.1.8. Appendix

Construct	1	2	3	4	5	6	7	8	9	10	11	12	13
1. E-business technology$_{t1}$	1												
2. E-business technology$_{t2}$	0.474	1											
3. E-business technology$_{t3}$	0.376	0.61	1										
4. Operational competence$_{t1}$	0.306	0.242	0.136	1									
5. Operational competence$_{t2}$	0.3	0.23	0.115	0.851	1								
6. Operational competence$_{t3}$	0.132	0.09	0.07	0.35	0.51	1							
7. Firm profitability$_{t1}$	0.135	0.156	0.103	0.218	0.307	0.205	1						
8. Firm profitability$_{t2}$	0.028	0.11	0.047	0.173	0.38	0.21	0.619	1					
9. Firm profitability$_{t3}$	-0.14	0.025	0.061	0.06	0.128	0.543	0.359	0.366	1				
10. Firm size$_{t1}$	0.114	0.092	0.14	-0.106	-0.18	-0.108	-0.21	-0.128	-0.069	1			
11. Firm size$_{t2}$	0.143	0.121	0.176	-0.122	-0.157	-0.134	-0.206	-0.121	-0.084	0.856	1		
12. Firm size$_{t3}$	0.207	0.167	0.244	-0.061	-0.103	-0.107	-0.136	-0.113	-0.107	0.812	0.867	1	
13. Industry	0.038	-0.164	-0.172	0.005	0.096	-0.008	0.115	0.104	-0.071	-0.165	-0.207	-0.184	1

2.2. Second study: IT infrastructure and competitive aggressiveness in explaining and predicting performance

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Abstract

While prior Information Systems and Operations Management literature emphasizes the role of both the firm's IT infrastructure and the general degree of competition as antecedents of firm performance, the organizational capabilities that mediate these important relationships remain undetermined. Responding to the increasing importance of incorporating environmental sustainability practices across the internal and external supply chain, this study proposes green supply chain management as an important mediator of the IT infrastructure/competitive aggressiveness-firm performance relationship. Enabled by internal IT capabilities and external competitive pressure, green supply chain management capabilities support firms in achieving operational excellence, thereby contributing to the firm's overall performance. Using primary and secondary data on 203 large firms in Spain, this study applies the partial least squares approach to structural equation modeling. Its empirical analysis reveals that green supply chain management fully mediates the relationships between IT infrastructure capability and firm performance, and competitive aggressiveness and firm performance, respectively.

Keywords: IT infrastructure capability, competitive aggressiveness, green supply chain management, environmental sustainability, firm performance, partial least squares.

2.2.1. Introduction

Challenged by increasing demand for more sustainable solutions among stakeholders (e.g., Benitez & Walczuch, 2012), firms seek to exploit various environmental management opportunities that reduce their activities' impact on the natural environment, simultaneously saving costs and increasing revenues (Benitez et al. 2015; Saeidi et al. 2015). Whereas sustainability-related activities typically refer to firm logistics, waste management, and purchasing activities (e.g., Green et al. 2012; Zhu & Sarkis, 2004), recent research emphasizes the importance of IT-related activities in contributing to a more sustainable future (Benitez & Walczuch, 2011; Dao et al. 2011). Although IT represents a potential source of environmental contamination during the processes of product manufacturing, usage, and disposal, advanced IT capabilities have the potential to improve resource efficiency at both firm and supply chain level (Elliot, 2011; Wang et al. 2015).

Much prior IS and Operations Management literature aims to understand how IT triggers the firm's supply chain management capabilities (e.g., Devaraj et al. 2007; Setia & Patel, 2013), but research on the role of IT in enabling green supply chain management is very limited. To close this research gap, this study examines the extent to which internal IT capabilities strengthen pursuit of environmental management activities across the internal and external supply chain, which, in turn, might represent an important precursor of superior firm performance (Benitez et al. 2013; Wang et al., 2015).

Like the firm's internal IT capabilities, external factors may affect the extent to which firms exploit new opportunities to save costs and increase revenues by executing environmental management activities (Bose & Pal, 2012). One external driver of green supply chain management refers to the overall degree of competitive aggressiveness that a firm faces in a specific industry (Hofer et al. 2012). Firms operating in an industry with a high degree of competitive aggressiveness, for example, experience greater need to adapt their course of action by searching and exploiting new business opportunities. Implementing environmental management activities in the supply chain provides a way for firms to differentiate themselves from their competitors to benefit from superior firm performance (Benitez et al., 2015; Chen et al. 2015; Ferrier, 2001).

Using primary and secondary data on 203 large firms in Spain, SEM with PLS shows that both IT infrastructure capability and competitive aggressiveness impact firm performance through green supply chain management by means of a full mediation effect. The effect of an industry's competitive aggressiveness on development of green supply chain management capability exceeds the effect of IT infrastructure capability on green supply chain management. Based on these insights, this study contributes to the IS and Operations Management literature in at least three ways. First, it opens the black box between IT infrastructure, competitive aggressiveness, and firm performance. Second, it shifts the focus from a general perspective on supply chain management activities to a more contemporary view of supply chain management that incorporates a sustainability focus. Finally, this paper discloses both internal (i.e., IT infrastructure capability) and external (i.e., competitive aggressiveness) drivers of green supply chain management and, by this means, provide important guidance for managerial practice.

2.2.2. Hypotheses and proposed research model

2.2.2.1. IT infrastructure capability and green supply chain management

IT infrastructure capability is the firm's ability to leverage its technological, managerial, and technical IT resources effectively to perform business activities (Benitez & Walczuch, 2012; Chen et al. 2014). Whereas technological IT resources include servers, computers, laptops, operating systems, software, electronic communication networks (email, Intranet, wireless devices), and shared customer databases, managerial IT resources refer to IT managers' business and technical skills (Benitez & Ray, 2012). Technical IT resources, in contrast, comprise IT employees' business and technical skills (Chen et al., 2015; Wang et al., 2015). Firms that can leverage their IT resources effectively are in a better position to execute and coordinate various operational activities across their internal and external supply chain (Devaraj et al., 2007; Setia & Patel, 2013). These operational activities target the firm's processes of sourcing, developing, manufacturing, selling, and distributing products and services, the core processes of the firm's supply chain (Sousa et al. 2015). While addressing the firm's information and material flow in general, these activities leverage its IT resources, contributing to pursuit of various environmental management activities (Bose & Pal, 2012). Exploitation of advanced technological IT resources, for instance, not only supports firms in effective communication and coordination with suppliers and customers to execute environmental management activities jointly (e.g., green purchasing practices, or reverse logistics), but also supports internal execution of environmental management practices in manufacturing and logistics operations (e.g., eco-design, green manufacturing practices, and investment recovery) (Benitez et al., 2013; Benitez & Walczuch, 2012; Green et al., 2012; Zhu & Sarkis, 2004). Similarly, leveraging IT managers' business and technical IT skills fosters good IT decisions (e.g., acquiring the appropriate enterprise resource planning solution), affecting execution of environmentally beneficial activities in the supply chain. IT employees' business and technical skills may support the supply chain to solve IT (e.g., data incompatibility) and business problems (e.g., supplier's environmental resistance) in implementing environmental management activities.

Based on this discussion, this study proposes IT infrastructure capability as an important driver of green supply chain management—the firm's ability to pursue managerial practices that adopt and integrate environmentally friendly activities into the supply chain (Green et al., 2012; Zhu & Sarkis, 2004). The study thus hypothesizes that:

Hypothesis 1 (H1): IT infrastructure capability positively relates to green supply chain management.

2.2.2.2. Competitive aggressiveness and green supply chain management

This study further examines the role of competitive aggressiveness in developing and implementing environmental management activities throughout the supply chain. Competitive aggressiveness indicates the extent to which firms experience competitive attacks with high volume, duration, complexity, and unpredictability from industry key competitors (Chen et al., 2015; Ferrier, 2001). Firms operating in a highly competitive industry face continual and more serious pressure to adapt their course of action by exploiting new business opportunities than do firms that experience low competitive aggressiveness. Good responses to increasing competitive aggressiveness include not only cutting costs, expanding to markets abroad, or upgrading existing products with new functions or additional services, but also establishing product or process solutions that address ecological constraints (Bose & Pal, 2012; Zhu & Sarkis, 2004). Prior literature (Benitez et al., 2015; Green et al., 2012) suggests that differentiation based on contribution to a sustainable environment is increasingly important as a source of competitive advantage. To exploit this resource and respond adequately to high levels of competitive aggressiveness, firms must adapt their supply chain practices and ensure adoption and integration of environmental-friendly activities into their internal and external supply chain (Mignerat & Rivard, 2009; Zhu & Sarkis, 2004). Green supply chain management, for instance, supports firms in communicating and coordinating requests and requirements for more sustainable solutions (e.g., reduction of emissions and waste, improved material efficiency), from downstream to upstream supply chain partners. As these managerial practices enable firms to respond more holistically to customers' needs or to address new customers, they support firms in keeping and extending their customer base. Exploitation of sustainability-related business opportunities in the supply chain can constitute a good response to high levels of competitive pressure (Hofer et al., 2012). Based on this discussion, this study proposes competitive aggressiveness as an external driver of green supply chain management.

Hypothesis 2 (H2): Competitive aggressiveness positively relates to green supply chain management.

2.2.2.3. Green supply chain management and firm performance

While execution of green supply chain management practices may increase costs (e.g., changing supplier contracts, adapting manufacturing processes, implementing new incentive policies), such practices have the potential to reduce operational costs significantly and to increase the firm's revenue streams. For example, cross-functional cooperation for environmental improvements reduces consumption of raw materials to save costs (Benitez & Walczuch, 2011, 2012). Similarly, collaborative activities with suppliers (e.g., green purchasing) and customers (e.g., reverse logistics) improve customer satisfaction as well as firm reputation and brand value. Such measures grant firms increased revenues, resulting in higher firm performance. Apart from prior literature that similarly provides support for a positive relationship between green supply chain management and firm market performance (e.g., Bose & Pal, 2012; Green et al., 2012; Mitra & Datta, 2014), managerial practice suggests a positive relationship between green supply chain management and firm performance. For example, Mercadona (a leading Spanish retailer) works very closely with suppliers on a long-term basis, cooperating with its strategic suppliers to reduce packaging size of its home brand products (developed by a strategic supplier) to cut costs and increase firm performance, as well as to reduce the supply chain's impact on the natural environment (Benitez et al., 2015; Ton & Harrow, 2010). Similarly, Xerox Corporation and Siemens gain business benefits from take-back programs by refurbishing and remanufacturing pre-owned equipment (Xerox saves 200 million U.S. dollars annually by remanufacturing products). Based on this discussion, this study hypothesizes that:

Hypothesis 3 (H3): Green supply chain management positively relates to firm performance.

2.2.3. Research methodology

2.2.3.1. Data and sample

This study uses a combination of survey and secondary data on 203 large firms in Spain. The measures of IT infrastructure capability, competitive aggressiveness, green supply chain management, strategic flexibility (control variable), and quality management (control variable) make use of survey data. Firm performance and firm size (control variable) use information collected from the *Actualidad Economica* database (http://www.actualidadeconomica.com/) (Benitez & Ray, 2012; Benitez et al., 2015). Wherever possible, the final questionnaire adapts measurement items from existing scales. The authors use mail and email invitations to motivate senior IT and business executives of 1046 large firms (see 2007 edition of *Actualidad Economica*) to participate in the online survey. Data collection from December 2007 to April 2008 yields a total of 203 valid questionnaires, giving an effective response rate of 20.24%.

To rule out the possibility that non-response bias might threaten research quality, this study assesses non-response bias by verifying that the responses of early and late respondents do not differ. All possible t-test comparisons between means of the two groups of respondents show non-significant differences. The sample firms operate in 25 different industries: wholesale (39 firms, 19.21%), real estate and/or construction (35 firms, 17.24%), chemical (15 firms, 7.39%), communications and graphic design (15 firms, 7.39%), retail (12 firms, 5.91%), non-metal mining (10 firms, 4.93%), consulting

(9 firms, 4.43%), food and beverage (8 firms, 3.94%), and other industries (60 firms, 29.56%).

2.2.3.2. Measures

This study measures IT infrastructure capability as a composite second-order construct composed of the following dimensions: technological IT infrastructure, managerial IT infrastructure, and technical IT infrastructure capabilities. The authors measure technological IT infrastructure capability by means of annual IT investment in technological IT infrastructure per employee (Ray et al. 2005). The constructs managerial and technical IT infrastructure capabilities have four indicators each, adapted from Byrd and Davidson (2003) and Ray et al. (2005), respectively.

Competitive aggressiveness consists of four new indicators based on the conceptual underpinnings of Ferrier (2001) and focuses on the volume, duration, complexity, and unpredictability of competitive attacks from each of the firm's key competitors. Green supply chain management consists of seven indicators adapted from Zhu and Sarkis (2004). Firm performance refers to rate of sectoral excellence (RSE) for the years 2007-2011. The corresponding information derives from the *Actualidad Economica* database for the years 2007-2011. RSE is an objective measure of the firms' sectoral positioning (Benitez & Ray, 2012; Benitez & Walczuch, 2012). Its estimation derives from the firm's ranking position as follows: RSE = 1 - (Ranking position of firm / Total number of firms in the industry). The present study calculates the RSE based on the firm's sales ranking in its industry, and values range from 0 to 1. The closer the RSE is to the maximum value of 1 for the industry, the better the firm's performance (e.g., Benitez et al., 2015).

This study controls for firm size, strategic flexibility, and quality management in firm performance. Firm size is the natural logarithm of number of employees (Benitez & Ray, 2012). Strategic flexibility includes four indicators created from Volberda (1996). Quality management consists of two indicators adapted from Zhu and Sarkis (2004). All constructs are composites at both first- and second-order levels (Henseler, 2015).

2.2.4. Empirical analysis

The study employs the variance-based SEM technique and the PLS method of estimation to test the proposed research model, using the statistical software package Advanced Analysis for Composites (ADANCO) 1.1.1 Professional (http://www.composite-modeling.com/) (Henseler & Dijkstra, 2015). The PLS approach to SEM is preferable to the alternative covariance-based SEM for the following reasons. First, PLS is a full-fledged SEM approach that can test for exact model fit and works very well in explanatory and predictive research (Chin, 2010; Hair et al., 2012; Henseler et al., 2016; Sarstedt et al., 2014; Shmueli & Koppius, 2011). Second, since all constructs specify as composites, PLS represents a suitable method that produces consistent estimations (Gefen et al., 2011; Hair et al., 2012; Henseler, et al., 2014; Rigdon et al., 2014). Third, using PLS-SEM is advisable when the underlying data refer to secondary data (Benitez & Walczuch, 2012; Gefen et al., 2011; Ringle et al., 2012). Fourth, compared with alternative covariance-based SEM techniques, PLS SEM achieves better results when estimating complex models (i.e., those with a large number of indicators or multidimensional constructs) (Hair et al., 2012; Roldan & Sanchez, 2012). Finally, PLS is a well-established variance-based SEM technique in the IS and Operations Management literature (Benitez et al., 2015; Braojos et al., 2015a, 2015b; Chen et al., forthcoming; Chou et al., 2015; Roldan & Sanchez, 2012). To estimate the significance levels of weights and path coefficients, this research runs the bootstrapping algorithm with 5000 resamples (Petter et al., 2007; Barroso et al., 2010; Hair et al., 2011).

2.2.4.1. Measurement model evaluation

To evaluate the measurement model, this research analyzes the content validity, multicollinearity, and weights of all composite constructs (Cenfetelli & Bassellier, 2009). First, the study assesses whether the indicators of all first-order constructs and the dimensions of second-order constructs capture the constructs' full domain. The study ensures that indicators and dimensions have content validity by using validated scales and pre-testing the questionnaire with 15 faculty members and eight IT/business executives.

After data collection, the authors examine multicollinearity by calculating variance inflation factors (VIFs) at first- and second-order level. All VIF values are below 3.3 and thus do not indicate serious multicollinearity problems (Petter et al., 2007; Roberts & Thatcher, 2009; Roldan & Sanchez, 2012).

This study also examines whether the weights of indicators and second-order dimensions are substantial and significant (Benitez & Ray, 2012). As shown in Table A1 (Appendix), all weights are substantial and significant at the 0.001 levels. The authors apply the two-step approach to calculate the second-order constructs (Chin, 2010). Table A1 (Appendix) provides detailed information on the VIF values and weights of the indicators and dimensions. Table A2 presents the correlation matrix.

2.2.4.2. Test of hypotheses

This study examines the beta coefficients, significance level, R^2, and f^2 values of the proposed research model. Figure 1 presents the results of the PLS estimation. Table 1 provides the analysis of the effect size for every relationship in the proposed model. f^2 values of 0.02, 0.15, and 0.35 indicate a weak, medium, or large effect size between an exogenous and endogenous variable (Henseler & Fassott, 2010). The empirical analysis generally supports H1, H2, and H3, as findings show that both IT infrastructure capability ($\beta = 0.26^{***}$) and competitive aggressiveness ($\beta = 0.40^{***}$) positively affect green supply chain management. Further, the study supports the positive relationship between green supply chain management and firm performance ($\beta = 0.21^{**}$).

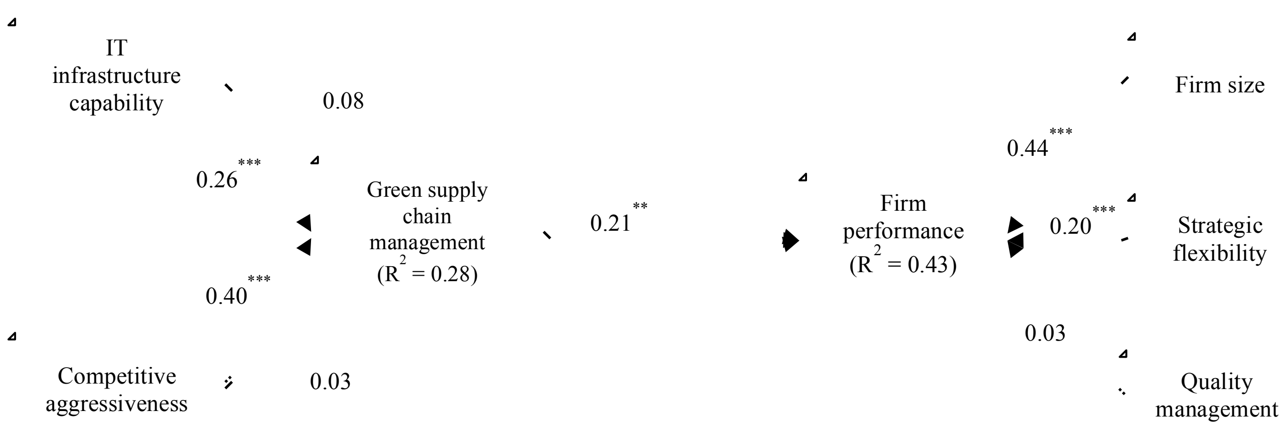

Figure 2.3: Results of the PLS estimation ($^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$, one-tailed test

Table 1: Effect size analysis

Relationship	f^2 value	Effect size
Hypothesized relationship	**f^2 value**	**Effect size**
IT infrastructure capability → Green supply chain management (H1)	0.08	Weak-medium
Competitive aggressiveness → Green supply chain management (H2)	0.20	Medium-large
Green supply chain management → Firm performance (H3)	0.05	Weak-medium
Control variables	**f^2 value**	**Effect size**
Firm size → Firm performance	0.30	Large
Strategic flexibility → Firm performance	0.06	Weak-medium
Quality management → Firm performance	0.01	Very weak

The beta coefficients, their significance level, the f^2 values, and the R^2 values are individual measures of the explanatory power of the model (Shmueli & Koppius, 2011). Beta coefficients around 0.20 are economically significant, while R^2 values higher than 0.20 indicate good explanatory power of the endogenous variables (Benitez & Ray, 2012; Chin, 2010). The beta coefficients of the hypothesized relationships in the proposed research model range from 0.21^{**} to 0.40^{***}. The effect size analysis suggests that industry competitive aggressiveness (f^2 = 0.20) has a greater influence than IT infrastructure capability (f^2 = 0.08) in explaining the development of green supply chain management. The R^2 values range from 0.28 to 0.43 and suggest good explanatory power for the proposed research model.

Finally, this study also evaluates goodness of model fit for the research model at first- and second-order levels by examining the SRMR, d_{ULS}, and d_G values (Henseler et al., 2014). These values evaluate the discrepancy between the empirical correlation matrix and the model-implied correlation matrix (Henseler, 2015). The lower the SRMR, d_{ULS}, and d_G, the better the research model fit (Henseler & Dijkstra, 2015). Since the SRMR values of the first and second step are below the recommended threshold of 0.08, the proposed research model shows adequate overall model fit (Hu & Bentler, 1998). Further, all discrepancies are below the 95%-quantile of the bootstrap discrepancies (see Table 2), suggesting a good model fit for the proposed research model.

Table 2: Overall model fit evaluation

Discrepancy	**First step**			**Second step**		
	Value	HI_{95}	Conclusion	Value	HI_{95}	Conclusion
SRMR	0.05	0.10	Supported	0.07	0.11	Supported
d_{ULS}	0.87	2.91	Supported	1.83	3.84	Supported
d_G	0.45	1.40	Supported	0.51	1.16	Supported

2.2.4.3. Mediation analysis

This study performs mediation analysis to examine the mediation effects of the proposed research model. To this end, the research models include links between: (1) IT infrastructure capability and firm performance, and (2) competitive aggressiveness and firm performance. Since direct effects of these two links are not significant (0.08 and 0.03) although their indirect effects are (0.05^{*} and 0.08^{**}), green supply chain management fully mediates the relationships between: (1) IT infrastructure capability and firm performance, and (2) competitive aggressiveness and firm performance, respectively (Zhao et al., 2010).

2.2.4.4. Qualitative comparative analysis for the second-order construct

The construct IT infrastructure capability refers to a composite second-order construct composed of the following three dimensions: technological, managerial, and technical IT infrastructure capabilities. While the PLS estimation considers the net effect of the second-order construct on the endogenous variable, this study additionally examines whether different configurations of the first-order dimensions of IT infrastructure capability cause high levels of green supply chain management. To this end, the study applies configurational approach fuzzy set qualitative comparative analysis (fsQCA) to control for equifinality (Fiss, 2011; Woodside, 2013). Equifinality implies that several causal paths may exist per outcome (Fiss, 2011). fsQCA follows three steps: (1) transform measures into fuzzy set membership scores, (2) construct and refine the truth table, and (3) analyze sufficient conditions for the outcome of interest (Fiss, 2011). When transforming the measures into fuzzy set membership scores, this study uses the unstandardized latent variables scores for the multiple-item measurement constructs. The constructs managerial IT infrastructure, technical IT infrastructure, and green supply chain management use the anchor point 6 for full membership, 2 for full non-membership, and 4 for the crossover point (Ordanini et al., 2014). The single-item construct technological IT infrastructure uses 21% as anchor point for full membership, 1% for full non-membership, and 11% as the crossover point. When redefining the truth table, this study sets 2 as cut-off value for the minimum number of cases per solution and 0.90 as cut-off value for the minimum consistency level of a solution. Analysis of the complex, parsimonious, and standard solution term produces the same configurations.

Overall solution coverage is 0.43, and overall solution consistency 0.87. The fsQCA eventually reveals two distinct configurations that cause a high level of green supply chain management. These configurations are: (1) presence of technological and managerial IT infrastructure, and (2) presence of technological and technical IT infrastructure. The presence of technological IT infrastructure in both solutions indicates its prominent role as a critical dimension for evaluating and measuring IT infrastructure capability, a finding consistent with prior IS research (e.g., Melville Kraemer, & Gurbaxani, 2004).

2.2.4.5. Prediction analysis

While affirming that green supply chain management mediates the relationships between IT infrastructure and firm performance, and competitive aggressiveness and firm performance, this study also explores whether the proposed research model performs well with regard to prediction. Since a model with good overall fit and explanatory power (both evident from the previous sections) does not automatically produce good predictions, this study also assesses the proposed model's predictive ability by performing: (1) blindfolded cross-validation analysis, and (2) k-fold cross-validation analysis (Gigerenzer & Brighton, 2009; Shmueli & Koppius, 2011; Shmueli et al., 2016; Woodside, 2013). The blindfolded cross-validation analysis uses SmartPLS 2.0.M3 (Ringle et al., 2005). This study indicates 5 as omission distance and uses the cross-validated redundancy approach in SmartPLS (Hair et al., 2011). Table 3 presents the resulting Stone-Geisser Q^2 values for each endogenous variable as well as the relative prediction relevance (q^2) of each exogenous variable (Hair et al., 2012).

Table 3: Blindfolding analysis

	Green supply chain management (Q^2 = 0.17)	**Firm performance** (Q^2 = 0.23)
	q^2	
IT infrastructure capability	0.04	0.00
Competitive aggressiveness	0.11	0.00
Green supply chain management		0.03

While the blindfolded cross-validation analysis indicates adequate predictive ability (all Stone-Geisser Q^2 values are greater than zero), this study also uses k-fold cross-validation analysis to describe predictive ability in greater detail. In contrast to the blindfolded cross-validation procedure, which represents an in-sample prediction method, the performed k-fold cross-validation analysis refers to an out-of-sample prediction evaluation method (Shmueli et al., 2016). To this end, this study randomly splits the original dataset into k equally sized subsamples (k = 10) (Hastie et al., 2009). While the training sample consists of k – 1 subsamples, the remaining single subsample constitutes the validation (holdout) sample. The parameter estimates that emerge from the training sample build the basis for predicting the values of the validation (holdout) sample. Prediction analysis generally occurs at construct and item level, providing various types of prediction (Shmueli et al., 2016). The present study performs and reports the results of the following prediction procedures: latent and operative prediction (Shmueli et al., 2016). While the latent prediction analysis generates predictions of endogenous construct scores (Y_i) based on the manifest items of the exogenous constructs (x_{ij}), the operative prediction analysis generates predictions of the manifest items of the endogenous construct (y_{ij}) based on the manifest items of the exogenous constructs (x_{ij}) (Shmueli et al., 2016). Operative prediction analysis thus considers the full information in the proposed research model (i.e., estimations of both measurement and structural models). Following the procedure shown in Table A3 (Appendix), this study calculates the resulting correlations and prediction errors manually. The study calculations use unstandardized data and apply the redundancy-based prediction approach, predicting the endogenous construct scores (Y_i) from the exogenous constructs (X_i) using the path coefficients (β_i), and then predicting the measurement items of the exogenous constructs (y_{ij}) from the exogenous construct (Y_i) via the loadings (λ_{ij}). To estimate the exogenous constructs (X_i), the calculation uses the manifest items of the exogenous constructs (x_{ij}), and their corresponding measurement weights (w_{ij}). To predict the construct firm performance, this study uses the predicted values of the construct green supply chain management that emerge from a prediction using the construct scores of both exogenous constructs (i.e., IT infrastructure capability and competitive aggressiveness) and their corresponding path coefficients, instead of predicting the construct scores of green supply chain management using its manifest items and the corresponding weights.

The resulting correlations (r) and prediction errors (residual = Actual value - Predicted value) form the basis for evaluating the overall prediction ability of the proposed research model. Table 4 presents the squared correlations (r^2) and root mean squared error (RMSE) values for each of the 10 folds as well as the corresponding averaged values for both prediction procedures (latent and operative prediction).

Table 4: k-fold cross-validation analysis

r^2	Latent		Operative				
k-fold	**GSCM**	**RSE**	**RSE 2007**	**RSE 2008**	**RSE 2009**	**RSE 2010**	**RSE 2011**
1	0.45	0.19	0.22	0.04	0.18	0.20	0.04
2	0.25	0.36	0.69	0.33	0.12	0.08	0.00
3	0.30	0.44	0.45	0.34	0.17	0.27	0.16
4	0.17	0.48	0.67	0.22	0.16	0.10	0.17
5	0.21	0.30	0.29	0.10	0.19	0.25	0.22
6	0.24	0.27	0.43	0.03	0.02	0.09	0.08
7	0.41	0.57	0.65	0.43	0.24	0.10	0.31
8	0.15	0.33	0.40	0.18	0.02	0.16	0.17
9	0.00	0.55	0.52	0.29	0.50	0.50	0.17
10	0.28	0.17	0.22	0.15	0.08	0.03	0.03
Mean	**0.25**	**0.37**	**0.45**	**0.21**	**0.17**	**0.18**	**0.14**
SD	**0.13**	**0.14**	**0.18**	**0.13**	**0.14**	**0.14**	**0.10**
RMSE	**Latent**		**Operative**				
k-fold	**GSCM**	**RSE**	**RSE 2007**	**RSE 2008**	**RSE 2009**	**RSE 2010**	**RSE 2011**
1	1.15	0.27	0.37	0.22	0.23	0.25	0.26
2	1.46	0.20	0.29	0.23	0.30	0.24	0.25
3	1.50	0.22	0.30	0.20	0.24	0.22	0.21
4	1.48	0.21	0.36	0.21	0.20	0.17	0.20
5	1.55	0.27	0.43	0.23	0.22	0.22	0.23
6	1.39	0.19	0.37	0.21	0.21	0.16	0.19
7	1.60	0.17	0.65	0.43	0.24	0.10	0.31
8	1.55	0.20	0.34	0.16	0.19	0.19	0.22
9	1.43	0.21	0.34	0.19	0.22	0.16	0.31
10	1.34	0.24	0.40	0.23	0.22	0.26	0.21
Mean	**1.45**	**0.22**	**0.39**	**0.23**	**0.23**	**0.20**	**0.24**
SD	**0.13**	**0.03**	**0.10**	**0.07**	**0.03**	**0.05**	**0.04**

GSCM = Green supply chain management
SD = Standard deviation, RMSE = Root mean squared error

2.2.5. Discussion and conclusions

By testing the proposed research model through PLS estimation, this research finds that IT infrastructure capability and competitive aggressiveness impact firm performance through green supply chain management. In so doing, this research adds the following contributions to the fields of IS and Operations Management. First, the findings open the black box between IT infrastructure, competitive aggressiveness, and firm performance, and reveals green supply chain management as an important mediator. Second, while prior research primarily explores potential antecedents and the impact of a firm's supply chain management capabilities in general, this research shifts focus to a more contemporary view of supply chain management that incorporates a sustainability focus and enriches the literature on green supply chain management (e.g., Bose & Pal, 2012; Hofer et al., 2012; Zhu & Sarkis, 2004). In addition to affirming the positive impact of green supply chain management on firm performance, this study shows that the drivers promoting the firm's ability to pursue environmental management practices throughout the internal and external supply chain correspond to both a resource-based and a market-based view on capability formation. On the one hand, green supply chain management derives from leveraging the firm's internal resource base. Leveraging their technological, managerial, and technical IT base, firms run cutting-edge business applications to coordinate with suppliers and customers in executing environmental management activities. Green supply chain management derives, however, from external market conditions (here in terms of degree of competitive aggressiveness) that force the firm to exploit new opportunities to save costs and increase revenues by executing environmental management activities. Firms that operate in an industry with a high degree of competitive aggressiveness may experience a greater trigger to integrate environmental management activities into their supply chain as a possible solution for long-term survival.

While generating these important theoretical contributions, the research also has practical relevance. Firstly, firms' investments in IT infrastructure provide the required IT platforms and IT knowledge to coordinate better with suppliers and customers in executing environmental management activities. Firms that pursue greener supply chain management should invest more in IT infrastructure and leverage their IT knowledge. Secondly, managing the supply chain in a more environmentally sustainable way enables firms to achieve superior performance. Practices such as recycling, remanufacturing, and energy efficiency enable cost saving. Further, collaborative green activities with customers (e.g., reverse logistics) improve customer satisfaction, firm reputation, and brand value, and may lead to increased sales and revenues. The case of PerkinElmer exemplifies the lesson learned in this study. PerkinElmer (a global technology firm that develops advanced precision instruments for health and environmental sciences) implements end-of-life management practices (i.e., reuse, remanufacturing, recycling, or disposal) to contribute to sustainable development along the supply chain. The firm motivates customers to return their equipment to the firm and receive a 10% discount on the next purchase. PerkinElmer in return helps to reduce the environmental impact of products and improves customer relations, inhibits competitors from refurbishing and reselling their equipment, and reduces processing costs (remanufacturing costs are lower than manufacturing new equipment) (Veleva et al., 2013).

This research has some limitations. First, the study findings generalize only to large firms in Spain. Future research might explore whether this study's theory and prediction are valid in small and medium-sized firms from other national entrepreneurial contexts. Second, although this study measures firm performance with five-year panel data, the measures of IT infrastructure capability, competitive aggressiveness, and green supply chain management are cross-sectional. Future research might revisit the explanatory and predictive power of the proposed model by using panel data for all model variables.

2.2.6. References

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2.2.7. Appendix

Table A1: Measurement model evaluation at first- and second-order level

Construct/indicator	VIF	Weight
Technological IT infrastructure	1.44	0.31^{***}
Annual investment in technological IT infrastructure per employee	1.00	1.00
Managerial IT infrastructure: 1: Strongly disagree, 7: Strongly agree	1.93	0.53^{***}
IT managers identify and support IT-enabled business activities	1.88	0.28^{***}
IT managers provide adequate funding to execute IT innovation projects	1.88	0.27^{***}
IT managers redesign IT processes to sense and respond to business opportunities	1.61	0.37^{***}
IT managers work closely with business managers to execute the firm's business strategies	1.94	0.31^{***}
Technical IT infrastructure: 1: Strongly disagree, 7: Strongly agree	1.43	0.40^{***}
Skills of our IT personnel in designing databases are excellent	2.05	0.31^{***}
Skills of our IT personnel in developing new IT applications are excellent	2.46	0.28^{***}
Skills of our IT personnel in improving the efficiency of the IT services are excellent	1.79	0.33^{***}
IT personnel know different programming languages	1.54	0.31^{***}
Competitive aggressiveness: Please indicate, on a scale of 1 to 7, the degree to which you agree or disagree with the following statements as they apply to your industry in the last 5 years: 1: Strongly disagree, 7: Strongly agree		
Key competitors typically carried out competitive attacks with a high number of competitive action events (e.g., pricing, new product development, capacity, or service actions)	2.45	0.30^{***}
Key competitors typically carried out competitive attacks of long duration	2.03	0.30^{***}
Key competitors typically carried out competitive attacks with a broad range of types of competitive actions (complex repertoire of competitive actions)	2.66	0.28^{***}
Key competitors typically carried out unpredictable sequences of competitive moves	2.61	0.28^{***}
Green supply chain management: How would you evaluate your firm's ability to implement the following green supply chain management practices when they are perceived to be useful to create business and/or environmental value? 1: Poor, 4: Good, 7: Excellent		
Commitment and support for green supply chain management from managers	2.50	0.19^{***}
Cross-functional cooperation for environmental improvements	2.57	0.18^{***}
Design of products (or services) for reduced consumption of material/energy	2.11	0.17^{***}
Environmental management system exists	2.50	0.19^{***}
Collaboration with suppliers on environmental issues	2.33	0.21^{***}
Cooperation with customers on environmental issues	2.02	0.14^{***}
Making decisions about ways to reduce overall environmental impact of our products	2.06	0.15^{***}
Firm performance		
RSE 2007	1.88	0.36^{***}
RSE 2008	2.01	0.23^{***}
RSE 2009	2.18	0.23^{***}

RSE 2010	2.13	0.23***
RSE 2011	1.89	0.17***
Strategic flexibility		
Our firm changes current strategies quickly with low costs	2.82	0.30***
Our firm can easily increase the variety of products for delivery	2.29	0.28***
Our firm can enter in new markets for delivery	1.62	0.31***
Our firm periodically adopts new technologies	2.86	0.29***
Quality management: How would you evaluate your firm's (degree of) implementation of the following quality management practices? 1: Not considering it, 2: Planning to consider it, 3: Currently considering it, 4: Implementation will begin in the short term, 5: Currently initiating implementation, 6. Intermediate implementation phase, 7: Implementing successfully		
ISO 9000 serial certification	1.19	0.57***
Total Quality Management type programs	1.19	0.62***

Table A2: Correlation matrix

Construct	1	1.1	1.2	1.3	2	3	4	5	6	7
1. IT infrastructure capability	1.00									
1.1. Technological IT infrastructure	0.69***	1.00								
1.2. Managerial IT infrastructure	0.91***	0.55***	1.00							
1.3. Technical IT infrastructure	0.76***	0.23***	0.54***	1.00						
2. Competitive aggressiveness	0.27***	0.21***	0.16**	0.26***	1.00					
3. Green supply chain management	0.36***	0.27***	0.24***	0.35***	0.47***	1.00				
4. Firm performance	0.24***	0.05	0.24***	0.25***	0.22***	0.41***	1.00			
5. Firm size	-0.02	-0.25***	0.15*	-0.01	0.07	0.19**	0.53***	1.00		
6. Strategic flexibility	0.39***	0.27***	0.23***	0.40***	0.13*	0.30***	0.40***	0.22***	1.00	
7. Quality management	0.11	0.11	0.06	0.11	0.27***	0.36***	0.27***	0.25***	0.18**	1.00

Table A3: Procedures for latent and operative prediction analysis

Latent prediction analysis
1. Estimation of proposed research model parameters with training data (loadings λ_{ij}, weights w_{ij}, path coefficients β_{i_STD}, unstandardized construct scores X_i and Y_i). 2. Calculation of measurement intercept (b_i) of construct scores (X_i and Y_i) using multiple regression analysis with manifest items (x_{ij} and y_{ij}) and construct scores (X_i and Y_i) from training sample (step 1). 3. Calculation of construct scores (X_i and Y_i) using manifest items (x_{ij} and y_{ij}) from validation sample and corresponding weights from training sample (w_{ij}) (step 1), as well as measurement intercept (b_i) (step 2). 4. Calculation of unstandardized path coefficients (β_i) using standardized path coefficients (β_{i_STD}) (step 1) and standard deviation ($SD_{x/y}$) of construct scores (X_i and Y_i) from training sample (step 1): $\beta_i = \beta_{i\_STD} * SD_y/SD_x$ x = Exogenous variable, y = Endogenous variable 5. Calculation of structural intercept (b_i) of construct score of endogenous variable (Y_i) (step 1) using multiple regression analysis with construct scores (X_i and Y_i) of training sample (step 1). 6. Prediction of construct score of endogenous variable (Y_i) using construct scores of exogenous variables (X_i) (step 3), corresponding unstandardized path coefficients (β_i) (step 4), and structural intercept (b_i) (step 5). 7. Calculation of correlation (r) and squared correlation (r^2) between predicted construct score of endogenous variable (Y_i) (step 6) and construct score of endogenous variable (Y_i) (step 3). 8. Calculation of RMSE based on squared residual of construct score of endogenous variable (Y_i) (step 3) and predicted construct score of endogenous variable (Y_i) (step 6).
Operative prediction analysis
Steps 1-6: see latent prediction analysis 7. Calculation of intercept (b_i) of each item (y_{ij}) of endogenous construct using simple regression analysis with manifest item score (y_{ij}) and unstandardized construct scores (Y_i) of training sample (step 1). 8. Prediction of each item score (y_{ij}) for endogenous construct using predicted construct score of endogenous variable (Y_i) (step 6), corresponding loading (λ_{ij}) (step 1), and intercept (b_i) (step 7). 9. Calculation of correlation (r) and squared correlation (r^2) between predicted item score of endogenous variable (y_{ij}) (step 8) and manifest item of endogenous variable from validation sample. 10. Calculation of RMSE based on squared residual of manifest item of endogenous variable from validation sample and predicted item score of endogenous variable (y_{ij}) (step 8).

Chapter three

(Discussion and conclusions)

3. Discussion and conclusions

3.1. Implications

The dissertation examines the impact of IT on firm's operational capabilities and performance. On the one hand, since IT capabilities investments increase, the demand for more investigations on how effective these investments should impact performance over time increases, on the other hand, the increasing demand for more sustainable future motivates firms to exploit environmental management to reduce the impact of their activities on the natural environment through implementing IT capabilities. The dissertation built on the basis of achieving tow main goals; examine the impact of IT on operational competence and firm performance over time, and examine the relationship between IT infrastructure capability, competitive aggressiveness, green supply chain management and firm performance.

Related to the first study, the evaluation of e-business technology -as one example of IT capabilities- on a set of operational competence (gross margin, employees productivity, operational talent management, operational excellence, and firm profitability) by analyzing a set of panel data on a sample of 154 large firms in Spain, results indicate a positive effect of e-business technology on operational competence that decreases over time even becoming non significant, and firm's proficiency in exploiting a portfolio of operational capabilities has a positive impact on profitability becomes more significant over time, the result provides some insights on how the initial and subsequent IT investment affects operational competence and firm profitability over time.

Early developers of operational capabilities through early investments in e-business technology maximize profitability based on a higher time and experience to develop their operational capabilities, firm's proficiency in leveraging its web-based technologies has a positive effect on the firm's proficiency in exploiting a portfolio of operational capabilities (i.e., gross margin, employee productivity, operational talent management, and operational excellence). Web-based technology enables the firm to perform real-time interchange of accurate and timely information on product cost and demand with upstream suppliers and downstream customers to improve gross margin management. E-business technology also enables the firm to: (1) acquire/provide information from/to the market to recruit and get on board outstanding operational talent, (2) implement scheduling and workplace flexibility activities to retain operational talent, and (3) provide reliable information on goals completion, performance appraisal and career planning to develop and retain operational talent, e-business technology also facilitates better execution of operational routines and greater agility in manufacturing/supplying products to the markets. However, the positive effect of e-business technology on operational competence decreases over time even becoming non-significant, the result suggests that firms can imitate IT investments from its competitors and learn to develop an e-business technology capability over time, which may convert e-business technology into a non-unique capability to enable operational competence. This has answered the question of how does e-business technology investment can affect firm operations management over time.

Finding also addresses that operational competence has positive impact on profitability which becomes more significant over time, through a better management/estimation of product margins, greater employee productivity, an appropriate recruitment, the development and retention of operational talent, and higher product manufacturing/supply chain agility, the firm can increase its profitability, since the firm's operational competence is the core of the business model and can be refined through time and experience, the operational competence impact on firm profitability increases over time , this suggests that the timing of e-business technology investment for the operational development is critical to maximize firm profitability over time which answers the question addressed about how does the operational competence impact firm profitability over time.

Theoretically, this work provides implications on the impact of IT on the development of operational capabilities. First, prior research has explored the effects of IT on the following manufacturing capabilities: just-in time manufacturing, and supplier and customer participation program (Banker et al. 2006), supply chain information integration (Devaraj et al.2007), organizational collaboration (Sanders 2007) and operational absorptive capability (Setia and Patel 2013), this work becomes in a different way focusing on the impact of e-business technology on a different set of operational capabilities: gross margin, employees productivity, operational talent management, and operational excellence. The results suggest that e-business technology has a positive effect on the development of operational capabilities, which is consistent with past studies (e.g., Banker et al. 2006, Setia and Patel 2013) but a key insight from the results is that the effect of e-business technology on operational development decreases over time at least in subsequent periods.

Second, prior IS research (Aral et al. 2006) has proposed the virtuous cycle argument to explain the firm IT investments over time. This argument suggests firms that invest in IT in t1 (period 1) reap benefits and then invest more in IT in subsequent periods. Over time, these effects become magnified, leading some firms to continue investing more in IT compared with their historical investment and that of their competitors (Mithas et al. 2012). Is this IT behavior economically rational? Results are consistent with the virtuous cycle argument but also suggest two new interesting insights that extend the virtuous cycle argument: (1) firms continue investing in IT in subsequent periods although they do not see immediate benefits [beta (e-business technologyt2 → Operational compertencet2) = 0.025], and (2) firms may be investing in IT in subsequent periods although they do not really need it, which is not economically rational. This trend may also be due to capturing "low hanging fruits" (i.e., easy benefits compared to cost) through initial IT investment, with subsequent IT investment being more difficult to have similar impact.

Methodologically, this study illustrates how to perform a panel data investigation focusing on the evolution effects by using SEM and the PLS method of estimation; the methodology used in the study becomes to develop and extend the Johnson et al.'s (2006) study (in the Marketing domain) that uses the method of estimation of PLS to examine the evolution of loyalty intentions analyzing three years survey dataset, while this study uses a three-year secondary dataset, and also it shows that this method can be applied to IS research examining the evolutionary impact of e-business technology on operational competence and firm profitability. In addition, the method shows that the analysis of effect size is a useful tool to examine the evolution effects on this type of dynamic models.

Related to the second study, the impact of IT infrastructure capability and competitive aggressiveness on firm performance; testing the proposed model through PLS method estimation on a survey and secondary data set for 203 large firms in Spain, result indicates that IT infrastructure capability and competitive aggressiveness impact firm performance through green supply chain management. This finding adds some contributions to the fields of IS and Operations Management. The findings open the black box between IT infrastructure, competitive aggressiveness, and firm performance, and reveals green supply chain management as an important mediator. Moreover, while prior research primarily explores potential antecedents and the impact of a firm's supply chain management capabilities in general, this study shifts focus to a more contemporary view of supply chain management that incorporates a sustainability focus and enriches the literature on green supply chain management (e.g., Bose & Pal, 2012; Hofer et al., 2012; Zhu & Sarkis, 2004).

In addition to affirming the positive impact of green supply chain management on firm performance, this study shows that the drivers promoting the firm's ability to pursue environmental management practices throughout the internal and external supply chain correspond to both a resource-based and a market-based view on capability formation. Green supply chain management derives from leveraging the firm's internal resource base. Leveraging their technological, managerial, and technical IT base, firms run cutting-edge business applications to coordinate with suppliers and customers in executing environmental management activities. Green supply chain management derives, however, from external market conditions (here in terms of degree of competitive aggressiveness) that force the firm to exploit new opportunities to save costs and increase revenues by executing environmental management activities. Firms that operate in an industry with a high degree of competitive aggressiveness may experience a greater trigger to integrate environmental management activities into their supply chain as a possible solution for long-term survival. In this sense, the third question of the dissertation has been answered.

3.2. Managerial implications

Findings provide important managerial implications. For the first study, result shows how managers can develop e-business technology and operational competence to maximize firm profitability, it helps IT managers to control IT investments over time. Early e-business technology investments provide more time and experience to refine the firm's portfolio of operational capabilities, thus improving the operations management system and increasing their firm profitability in the long run. In other words, early investment in IT can enhance operational competence and result in an increase in profitability over time. Thus, deciding well when the firm should allocate IT resources is critical for operational development and maximizing firm profitability.

Financial analysts also should pay attention to the firm's IT allocation decisions over time because these decisions can provide early signals about subsequent operational development and firm profitability over time (Mithas et al. 2012). Results also provide some empirical evidence to managers that investment in e-business technology do enhance operational competence and firm profitability. Such evidence can help managers to better justify investments in e-business technology.

The second study also has practical contributions, firms' investments in IT infrastructure provide the required IT platforms and IT knowledge to coordinate better with suppliers and customers in executing environmental management activities. Firms that pursue greener supply chain management should invest more in IT infrastructure and leverage their IT knowledge. Managing the supply chain in a more environmentally sustainable way enables firms to achieve superior performance, practices such as recycling, remanufacturing, and energy efficiency enable cost saving. Further, collaborative green activities with customers (e.g., reverse logistics) improve customer satisfaction, firm reputation, and brand value, and may lead to increased sales and revenues.

The case of PerkinElmer exemplifies the lesson learned in this study. PerkinElmer (a global technology firm that develops advanced precision instruments for health and environmental sciences) implements end-of-life management practices (i.e., reuse, remanufacturing, recycling, or disposal) to contribute to sustainable development along the supply chain. The firm motivates customers to return their equipment to the firm and receive a 10% discount on the next purchase. PerkinElmer in return helps to reduce the environmental impact of products and improves customer relations, inhibits competitors from refurbishing and reselling their equipment, and reduces processing costs (remanufacturing costs are lower than manufacturing new equipment) (Veleva, Montanari, Clabby, & Lese, 2013).

3.3. Limitations and future research

This dissertation has some limitations. First and for the first research Results of this study only generalized to large firms in Spain. Future research can explore whether these results remain under other environmental conditions, in other countries and/or specific industries. Moreover, to the extent the effect of e-business technology on operational competence decreases over a three-year panel data even becoming non-significant, future research can explore whether this result remains valid over a longer panel data (e.g., 10 years) period.

The second study findings also generalize only to large firms in Spain. Future research might explore whether this study's theory and prediction are valid in small and medium-sized firms from other national entrepreneurial contexts. Although this study measures firm performance with five-year panel data, the measures of IT infrastructure capability, competitive aggressiveness, and green supply chain management are cross-sectional. Future research might revisit the explanatory and predictive power of the proposed model by using panel data for all model variables.

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