Efficiency and Innovation Oriented Business Value of Enterprise Systems Interoperability - An Empirical Investigation

Loukis Euripidis
University of Aegean
eloukis@aegean.gr

Charalabidis Yannis
University of Aegean
yannisx@aegean.gr

Abstract

The establishment of interoperability of enterprise IS with the ones of trading partners (e.g. customers, suppliers, business allies) is regarded, based on a variety of theoretical arguments, as an important source of business value associated with efficiency gains and innovation. However, there is a lack of empirical investigation of this business value. This paper presents an empirical study of the effect of adopting two types of IS interoperability standards for exchanging electronic data with trading partners, the industry-specific and the proprietary ones, on the benefits firms obtain from their ICT infrastructures, and finally on their business performance. Furthermore, it examines what part of these effects is through increasing effectiveness of existing business process for producing existing products and services, and what part of them is through driving innovation. It is concluded that the adoption of both these types of IS interoperability standards for exchanging electronic data with trading partners has positive effect on the benefits gained from ICT infrastructures, with the effect of the industry-specific standards being much higher than the effect of the proprietary ones. Also, it has been found that a large part of these effects (46% for the industry-specific standards and 62% for the proprietary ones) is through driving innovation.

Keywords: *interoperability, enterprise information systems, business value, efficiency, innovation.*

1. Introduction

The establishment of interoperability of enterprise information systems (IS) with the ones of current or potential trading partners (e.g. customers, suppliers, business allies) is regarded, based on a variety of theoretical arguments, as an important source of business value. IS interoperability is regarded in the 'Digital Agenda for Europe' [15] of the European Commission as a fundamental pre-condition for the development of an advanced digital economy and society in the European Union. The final report of a high level Informal Study Group launched by the European Commission (EC) to investigate the value proposition of enterprise IS interoperability [27] concludes that it has a great potential to increase the performance of business processes, to support deeper cooperation with other firms and to stimulate new value creation through innovation.

However, the business value and benefits of IS interoperability with trading partners have been empirically investigated only to a very limited extent, as explained in more detail in the following section. This research gap is strongly emphasized in the abovementioned EC report on the value proposition of enterprise IS interoperability [27], and also in the 'Enterprise Interoperability Research Roadmap' [28] developed under the auspices of the EC, together with its negative consequences on the adoption of IS interoperability standards by firms. Therefore more empirical research is required for assessing and understanding the different types of business value that this 'outward looking' enterprise IS interoperability with trading partners generates.

In this direction this paper makes the following contributions:

(a) It empirically investigates the effect of adopting interoperability standards in enterprise IS for exchanging data with trading partners on the benefits firms obtain from their information and communication technologies (ICT) infrastructures, and finally on their business performance, based on a large dataset collected from 13,231 European firms (from 25 countries and 9 sectors) through the e-Business Watch Survey of the European Commission.

(b) It examines and compares the abovementioned effects of adopting two different types of IS interoperability standards, the industry-specific and the proprietary ones, on the benefits firms obtain from their ICT infrastructures, and finally on their business performance. These two types of IS interoperability

standards differ significantly in the level of depth and detail and also in the extent of applicability. In particular, the industry-specific standards are characterized by lower depth and detail (since they are developed through a consensus seeking process among numerous firms belonging to an industry, their customers and their suppliers, so they usually constitute a minimum 'least common denominator' which is acceptable by all) than the proprietary standards (each of them is usually developed by a large powerful firm, which then forces its numerous smaller suppliers and subcontractors to adopt it, so they cover the whole set of requirements defined by the above powerful firm, covering all required documents and elements). On the contrary, the industry-specific standards are characterized by higher extent of applicability than the proprietary ones (since the former can be used for the electronic exchange of data and documents with most of the firms belonging to a particular industry, their customers and their suppliers, while the latter can be used for the electronic exchange of data and documents with a much smaller number of firms adopting the particular proprietary standard).

(c) It also examines what part of these effects is through increasing efficiency of existing business process for producing existing products and services, and what part is through driving innovation.

Our paper consists of six sections. In section 2 relevant theoretical and empirical literature is reviewed. Then in section 3 the research model and hypotheses are described, while in section 4 are described the data and method of our study. The results are presented and discussed in section 5, while the final section 6 summarizes the conclusions and proposes future research directions.

2. Literature Review

2.1. Theoretical Literature

Previous literature has analyzed the business value generated by IS interoperability with trading partners, based on a variety of theoretical arguments, and identified several benefits it can offer. These benefits can be grouped into two main classes associated with efficiency gains and innovation respectively. Initially, the main focus of this 'outward looking' IS interoperability with trading partners was on the achievement of efficiency-oriented benefits, however recently the focus shifts towards the achievement of innovation-oriented benefits as well; this is similar with what has happened in the past with nearly all new ICT, which were initially viewed as efficiency increasing tools, but gradually it was realized that they

had a potential to drive and facilitate significant innovations in processes, products and services.

It is worth reviewing in more detail some representative theoretical literature on the benefits and business value generated by IS interoperability with trading partners. [12] argues that IS interoperability can improve significantly efficiencies in managing transactions with numerous participants dispersed geographically. At the same time it is a key enabler of innovative and highly beneficial business practices, such as supply chain management, logistics management and knowledge management, as it can make them easier to implement and reduce their costs. Similarly, it is an enabler of innovations associated with personalization of offerings and with composition of new complex products and services by combining and bundling complementary products and services from many different suppliers. [17] states that firms today increasingly tend to be active in several countries and cooperate with more and geographically dispersed suppliers and customers; also, they have to change the way they innovate and produce, and to exploit better the rich information flows in their supplier and distribution chains. It is argued that the interoperability of enterprise IS with the ones of trading partners is of vital importance for coping with these challenges. The same paper identifies three main 'functions' of IS interoperability which generate significant business benefits: informational function (exchange of information), transactional function (electronic execution of the whole life-cycle of various types of transactions) and collaboration function (collaborative products and services design).

The abovementioned report on the value proposition of enterprise IS interoperability [27] concludes that it has a strong potential to improve efficiency dramatically, which has been the main focus in the past, but additionally can also drive the collaborative development of significant value innovation by 'value networks', defined as 'webs of relationships that generate tangible and intangible value through complex dynamic exchanges between two or more individuals, groups, or organizations' [3]. The same report proposes an 'Enterprise Interoperability Value Framework', which identifies five types of interactions among firms that can be supported by IS interoperability: communication, coordination, cooperation, collaboration and creation of new sales channels. The first of these interaction types support and facilitate mainly 'red ocean strategies' (in which firms compete through lower prices or marginal innovations), while the last ones support and facilitate 'blue ocean strategies' (in which firms aim to create new market spaces, or "blue oceans", by introducing radical innovations in

products, services and processes), using the terminology proposed by [23]. The above framework has already been used for analyzing IS interoperability in the Architecture, Engineering and Construction (AEC) sectors [18-19].

Similarly, the 'Enterprise Interoperability Research Roadmap' [28] sheds light on the significance of IS interoperability not only for operations' efficiency, but also for the formation and operation of 'virtual organizations', defined as 'groupings of legally distinct or related enterprises coming together to exploit a particular product or service opportunity, collaborating closely whilst still remaining independent and potentially competing in other markets or even other products/services in the same market'. It also argues that in modern economy the competitiveness of a firm is to a large extent determined by its ability to seamlessly interoperate with other firms, so the capability for ICT-enabled collaboration becomes a decisive tool in the struggle for competitive advantage, and interoperability becomes a strategic necessity in all industries

Enterprise IS interoperability can facilitate and support many innovative highly beneficial business practices, making them easier and less costly, such as: electronic data interchange [22], [33], collaborative planning, forecasting and replenishment [2], [14], [34], vendor-managed inventory [1], [26], [31], open innovation [9], [10], [21], participation in value networks and digital business ecosystems [4], [7], [32] and development of new business models [36-38].

2.2. Empirical Literature

However, the degree of realization of the above expectations of this theoretical literature has been to a very limited extent investigated empirically. Only a very small number of empirical studies have been conducted on the business value of IS interoperability with trading partners. [5] investigates empirically the effect of the extent of deployment and integration in business processes of a single industry-specific standard (the RosettaNet) on the operational and strategic benefits generated for the adopting firms; it is based on a small dataset collected from 62 firms from China, Japan, Malaysia, Singapore and Taiwan. It concludes that the extent of integration and deployment of this standard have both positive effects of similar magnitude on the strategic benefits, while only the former is the main determinant of the operational benefits. [30] investigates empirically the effect of five layers of interoperability (network, data, application, process and business) on the required B2B integration effort; it is based on a dataset collected from 239 Greek firms which had successfully completed at least one

B2B integration project. It concludes that interoperability at the data, process and business layers have a negative impact on integration effort.

We remark that the above two empirical studies on the business value generated by IS interoperability with trading partners are based on small datasets, do not examine its effect on firm's innovation activity, and also do not distinguish between different types of IS interoperability standards. The present study contributes to filling these research gaps.

3. Research Model and Hypotheses

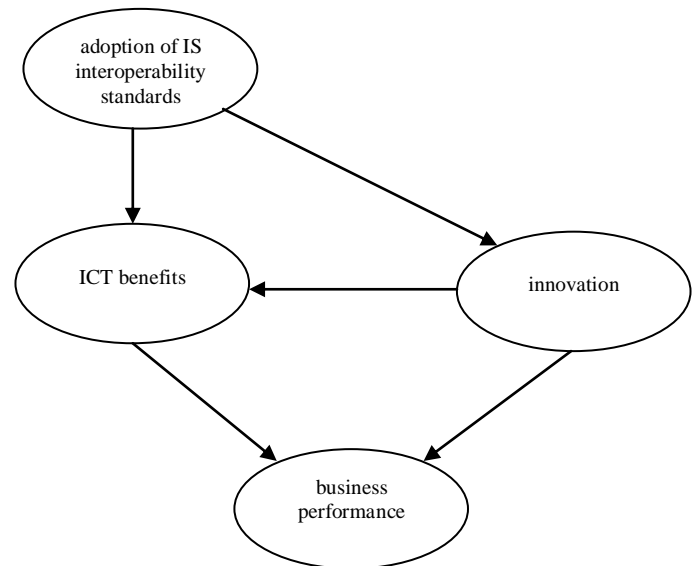The research model of this study is shown in Fig 1.

Figure 1. The research model of the study

Our first research hypothesis concerns the effect of adopting IS interoperability standards for exchanging data with trading partners on the benefits that the firm obtains from its ICT infrastructure. As mentioned in 2.1 the adoption of such standards allows easy and low cost exchange of various types of electronic documents between the firm and its customers, suppliers and business allies (e.g. products descriptions, quotations, orders, shipments, receipts, invoices, payments and returns) [8], [22]. This electronic data interchange generates significant operational efficiency oriented benefits, such as reduction of paperwork, required personnel time and costs, less errors, faster payments, improved cash-flow, avoidance of production stoppages due to lack of raw material and reduction of stock levels. These are expected to increase the benefits generated by firm's ICT infrastructure.

Furthermore, as mentioned in 2.1 the adoption of IS interoperability standards for exchanging data with trading partners also facilitates and drives various types

of innovations in processes, products and processes. It allows easier and lower cost personalization of products and services offered to customers, so that they serve better their specialized needs and tastes, and also composition of complex products and services by bundling complementary ones from many different suppliers [12]. Furthermore, it can support and facilitate the collaborative design and implementation of innovations, promoting 'open' innovation practices involving firm's customers, suppliers and business allies [10], [21]. The adoption of IS interoperability standards is also critical for the effective and efficient participation in inter-organizational networks [4] and digital business ecosystems [32], which have become of critical importance for innovation development and diffusion. Additionally, it can facilitate various innovative highly beneficial business practices, such as collaborative planning, forecasting and replenishment, vendor-managed inventory, value co-creation in cooperation with customers, and also enable new business models. Previous theoretical and empirical literature has shown that innovation leads to a better exploitation of firm's ICT infrastructures and increases the benefits and value obtained from it [20], [29].

For the above reasons we expect the adoption of IS interoperability standards for exchanging data with trading partners will increase the benefits generated by firm's ICT infrastructure through i) increasing efficiency of existing business process for producing existing products/services (this being the 'traditional' direct path), and also ii) facilitating and driving processes, products and services innovations (this being a mediator). So our first research hypothesis is:

Hypothesis 1: *The adoption of IS interoperability standards for exchanging data with trading partners has a positive effect on the benefits the firm obtains from its ICT infrastructure, which is partially mediated by innovation,*

which can be analyzed into the following three hypotheses 1.1 – 1.3:

Hypothesis 1.1: *The adoption of IS interoperability standards for exchanging data with trading partners has a positive effect on innovation.*

Hypothesis 1.2: *Innovation has a positive effect on the benefits the firm obtains from its ICT infrastructure.*

Hypothesis 1.3: *The adoption of IS interoperability standards for exchanging data with trading partners has also a direct positive effect on the benefits the firm obtains from its ICT infrastructure.*

We expect that these higher business benefits from ICT infrastructure will finally result in higher business performance. Furthermore, we expect that the above higher innovation activity will also result in higher business performance, both directly and indirectly through the increase of ICT benefits it will drive as

mentioned above. In particular the development of innovative products and services by a firm results in additional sales in new markets which are developed, where the firm has a monopolistic position for some time, so it can enjoy high levels of profitability. Also, process innovations improve efficiency and reduce costs. For the above reasons innovation in processes, products and services will result in higher business performance. Previous empirical research on this has found that innovation has a positive impact on business performance [13], [25]. Therefore our second and third research hypotheses are:

Hypothesis 2: *ICT benefits have a positive effect on business performance.*

Hypothesis 3: *Innovation has a positive effect on business performance, both directly and indirectly through the increase of ICT benefits it causes.*

4. Data and Method

For this empirical study we used data from 13,231 European firms from 29 countries (European Union (EU) member states, acceding and candidate countries and also countries of the European Economic Area (EEA)) and 9 highly important economy sectors (Food and Beverages, Footwear, Pulp and Paper, ICT Manufacturing, Consumer Electronics, Shipbuilding and Repair, Construction, Tourism and Tele-communication Services). They were collected in the 'e-Business Survey' conducted by the European e-Business Market W@tch (www.ebusiness-watch.org) through telephone interviews with firms' decision-makers. The target population of this survey included all firms of the above countries which are active in one of these sectors. A stratified sample by firm size and sector was randomly selected from this population, including a 10% share of large firms (with 250+ employees), a 30% share of medium sized firms (with 50-249 employees), a 25% share of small firms (with 10-49 employees), while the remaining 35% were micro firms (with less than 10 employees).

The adoption of IS interoperability standards for exchanging data with trading partners has been measured through a binary (Yes/No) variable (variable INDU_ST for industry-specific IS interoperability standards, and variable PROP_ST for proprietary ones). The other three basic variables of this study (innovation, ICT benefits, business performance – see Figure 1), since they were more abstract and multidimensional concepts, have been measured as reflective constructs using several items. In particular:

- innovation has been measured through four items (INV1-INV4): two of them measure whether the firm during the past 12 months has launched any new or

substantially improved products or services (product/service innovations), or has introduced any new or significantly improved internal processes (process innovations); the other two items measure whether any of these product/service innovations, or any of the process innovations, has been directly related to or enabled by ICT,

- in order to measure firm's benefits from ICT we used six items (ICTB1-ICTB6), which measure whether ICT has had positive influence, no influence at all or negative influence on revenue growth, efficiency of business processes, internal work organization, quality of products and services, quality of customer service and firm productivity,

- and finally business performance was measured through three items (BP1-BP3), which measure whether the turnover, the market share and the productivity of the firm has increased, stayed roughly the same or decreased over the past 12 months.

Using these data the research model shown in Fig. 1 was estimated through covariance-based structural equation modeling (SEM) using the AMOS 6 software [24], [6]. Both maximum likelihood and Bayesian estimation (more suitable when items are discrete valued) were performed; the differences in the results were very small, and this indicates strong robustness.

5. Results and Discussion

Initially the measurement parts of the two estimated models were examined. As a first step we assessed for each model the convergent validity of the three reflective constructs (innovation, ICT benefits, business performance) by examining for each construct the loadings of its items [16], [35], which are shown in the third and fourth column of Table 1 of the Appendix. We can see that in both models all of them are statistically significant, and most of them exceed the cut-off level of 0.6 suggested by [11]; only a few items have loadings slightly lower than 0.6, which were however regarded as marginally acceptable, so they were retained. Therefore we can conclude that our constructs have convergent validity. As a second step for each model we assessed the discriminant validity of the constructs. For this purpose the factor structure behind the 14 items was examined by performing Principal Components Analysis (PCA) with Varimax rotation (using the SPSS 15.0 software). The results indicated that for each model four factors were formed (having eigenvalues exceeding 1.0), and each of them is characterized by high loadings of all the items corresponding to one of the constructs and much lower loadings of all the other items. Therefore we can conclude that the constructs have discriminant validity.

As a third and final step we assessed the reliability of each construct by calculating its Cronbach Alpha using the SPSS 15.0 software, and the results are shown in the fifth column of Table 1 of the Appendix. All constructs have values exceeding the cut-off level of 0.7 recommended by the relevant literature [16-35], so we can conclude that they are characterized by reliability as well.

Then we assessed the goodness of fit of the two models by examining the values of their basic fit indices, which are shown in Table 2 of the Appendix. We can see that for both models we have acceptable values, in accordance with the recommendations of the relevant literature [16], [35], for both the incremental fit indexes NFI, RFI, IFI, TLI and CFI (> 0.9) and for the RMSEA (<0.05); so we can conclude that the two estimated models have acceptable fit to the data.

Finally we examined the structural parts of the two estimated models, shown in Figures 2 and 3 (for all statistically significant paths standardized coefficients are shown), which allow hypotheses testing.
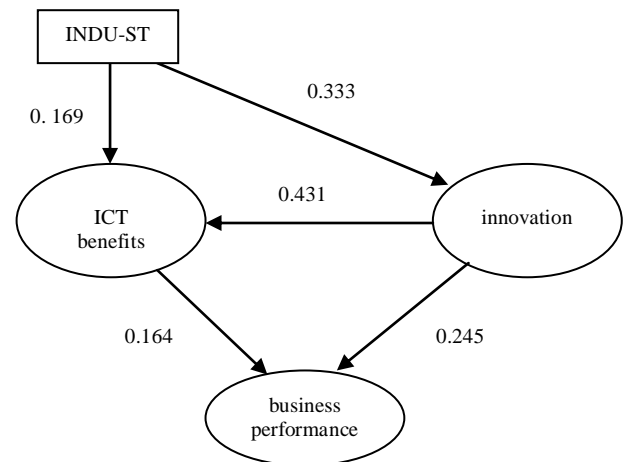

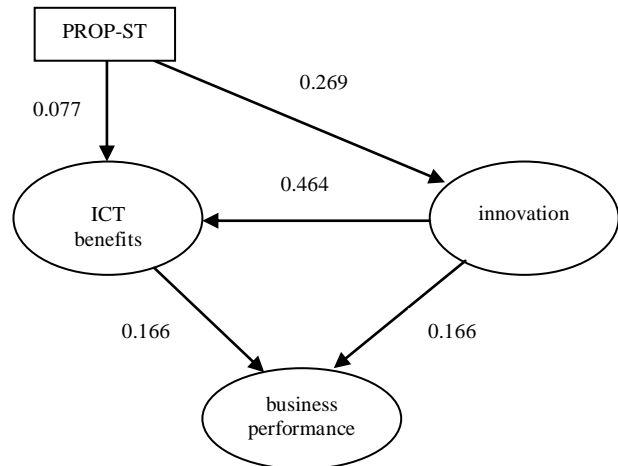**Figure 2. The structural part of the INDU-ST model**

Figure 3. The structural part of the PROP-ST model

We remark that in both models the adoption of interoperability standards in enterprise IS for exchanging data with trading partners has a statistically significant positive medium size effect (according to the classification of effects proposed by [24]) on innovation; so hypothesis 1.1 is supported. These results confirm the expectations of the relevant theoretical literature outlined in 2.1 on the innovation potential of this 'outward looking' IS interoperability, and indicate that it is a considerable driver and facilitator of innovations in firms' processes, products and services.

Also, in both models innovation has a statistically significant strong effect on the benefits firms obtain from their ICT infrastructures; so hypothesis 1.2 is also supported. This is in agreement with the conclusions of previous theoretical and empirical literature [20], [29] that innovation leads to a better exploitation of firm's ICT infrastructure, and increases the benefits and value obtained from it.

At the same time we remark that in both models the adoption of interoperability standards in enterprise IS for exchanging data with trading partners has a statistically significant positive direct effect on the benefits firms obtain from their ICT infrastructures. This effect is through efficiency improvements of existing business process producing existing products and services. So hypothesis 1.3 is supported.

Therefore the whole hypothesis 1 is supported by both models. So our total conclusion is that he adoption of interoperability standards in enterprise IS for exchanging data with trading partners has a positive impact on the benefits firms obtain from their ICT infrastructures, which is partially through increasing efficiency of existing business process for producing existing products and services (efficiency-oriented business value), and partially through driving innovation (innovation-oriented business value).

We also remark that in both models the benefits from ICT infrastructure have a statistically significant positive effect on business performance, so hypothesis 2 is supported. Furthermore, in both models innovation has both a statistically significant positive direct effect on business performance, and also an indirect one through ICT benefits increase, so hypothesis 3 is supported as well. This is in agreement with previous theoretical and empirical literature on the impact of innovation on business performance [13], [25]. The above results provide a deeper insight of the whole mechanism (i.e. network of effects) of business value generation from the adoption of interoperability standards in enterprise IS for exchanging data with trading partners.

Using the two models of fig. 2 and 3 we can also make a comparison between the effects of the two examined types of standards, addressing the second research question b) of this study, as mentioned in the Introduction. We remark that the direct effect of adopting industry-specific standards on the benefits from the ICT infrastructure is much higher than the one of the proprietary standards (standardized coefficients 0.169 versus 0.077 respectively). This indicates that the adoption of industry-specific standards leads to much higher efficiency gains than the adoption of proprietary ones. Also, the effect of adopting industry-specific standards on innovation is higher than the one of the proprietary standards (standardized coefficient 0.333 versus 0.269). Therefore the adoption of industry-specific standards is a stronger driver of innovation than the adoption of proprietary ones. As a consequence of the above the total effect of adopting industry-specific standards on ICT benefits $(0.169+0.333*0.431 = 0.312)$ is higher than the one of the proprietary standards $(0.077 +0.269*0.464 = 0.202)$. This can be explained taking into account the particular characteristics of these two types of standards. The industry-specific standards are characterized by higher extent of applicability than the proprietary ones. The former can be used for the electronic exchange of data and documents with a bigger number of firms belonging to a particular industry, their customers and their suppliers and subcontractors; on the contrary the latter can be used for the electronic exchange of data and documents with a much smaller number of firms adopting the particular proprietary standard (usually a large firm and the network of its suppliers/subcontractors). For this reason the adoption of industry-specific IS interoperability standards for exchanging data with trading partners gives more opportunities for efficiency gains and innovation, and therefore leads to more efficiency-oriented and innovation-oriented business value, than the proprietary ones (despite the lower level of depth and detail of the former, which has a negative impact on the business value it generates).

Finally, the two models of fig. 2 and 3 can be used for examining what part of the business value generated by the adoption of the above two standards is through increasing efficiency of existing business process for producing existing products and services, and what part of it is through driving innovation. From the model of fig. 2 we can derive that $0.333*0.431/0.312=46\%$ of the total effect of the adoption of industry-specific standards on the benefits obtained from ICT infrastructure is through innovation. Similarly, the model of fig. 3 shows that an even larger $0.269*0.464/0.202=62\%$ of the total effect of the adoption of proprietary standards on the benefits obtained from ICT infrastructure is through innovation. The above results indicate that though as mentioned in

2.1 initially the focus of IS interoperability with trading partners was on efficiency gains, and only recently it shifts towards innovation, a large part of the increase of ICT benefits it generates is through driving innovation. This part is larger for the proprietary standards, in comparison to the industry-specific ones (62% versus 46%); this is mainly due to the much less efficiency gains, but a little less innovation (as the dominant large firm which has developed the proprietary standard can put pressure on the smaller supplier/subcontractor firms not only to adopt the standard and also to make some innovations in their processes, products and services), the former generate, as mentioned above.

6. Conclusions

There is a lack of empirical investigations of the business value of IS interoperability, so the present study aims to contribute to filling this research gap. It investigates empirically the efficiency-oriented and the innovation-oriented business value generated by establishing enterprise IS interoperability with trading partners, based on a large dataset collected from 13,231 European firms (from 25 countries and 9 sectors) through the e-Business Watch Survey of the European Commission.

It has been concluded that the adoption of interoperability standards in enterprise IS for exchanging data with trading partners has a positive impact on the benefits firms obtain from their ICT infrastructures; this is partially through increasing efficiency of existing business process for producing existing products and services (efficiency-oriented business value), and partially through driving innovation (innovation-oriented business value). This leads to a positive impact on business performance. The comparison between the above two types of IS interoperability standards revealed that the adoption of industry-specific IS interoperability standards for exchanging data with trading partners, due to their higher extent of applicability, gives more opportunities for efficiency gains and innovation, and therefore leads to more efficiency-oriented and innovation-oriented business value, than the proprietary ones. Also, it has been found that a large part of these effects (46% for the industry-specific standards and 62% for the proprietary ones) is through driving innovation.

The findings of our study have interesting implications for IS research and practice. It provides a framework for future empirical research on the business value of various IS interoperability approaches, standards and tools, and also on the mechanisms of its generation. The research approach of this study can be extended in order to incorporate various additional mediators (e.g. different types of innovative business practices enabled by IS interoperability with trading allies, such as the ones discussed in section 2). This framework allows also a comparison of the business value generated by various types of IS interoperability approaches, standards and tools, and also of the corresponding business value generation mechanisms. With respect to IS management practice, our conclusions indicate that it is necessary to put strong emphasis not only on developing the functionality and capabilities of enterprise IS, but also on establishing interoperability of them with the ones of trading partners, in order to maximize value generation. Also, in order to maximize the business value generated by IS interoperability, it is necessary to exploit it to the highest possible extent both for achieving efficiencies and for making innovations in processes, products and services. Since IS interoperability is an infrastructure, which facilitates and drives various innovative and highly beneficial business practices, the level of business value it generates depends on the extent of exploiting the above capabilities and introducing these practices.

Further empirical research is required on the business value that IS interoperability generates, examining various IS interoperability approaches, standards and tools. Also, it is necessary to understand better the mediators of the effects of the adoption of various IS interoperability approaches standards and tools and business performance. It would be interesting to assess and compare the effects of them on the degree of application of the abovementioned practices, and then the effect of the latter on various measures of business performance. This would enable a better understanding of 'how' IS interoperability business value is generated.

7. References

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Appendix

Table 1.   Constructs' items loadings and reliabilities.

Construct	Items	Loadings INDU-ST model	Loadings PROP-ST model	Reliability
Innovation	INV1	0,584	0,577	0,789
	INV2	0,633	0,631	
	INV3	0,643	0,647	
	INV4	0,699	0,704	
ICT Benefits	ICTB1	0,682	0,682	0,831
	ICTB2	0,716	0,716	
	ICTB3	0,637	0,637	
	ICTB4	0,596	0,596	
	ICTB5	0,644	0,644	
	ICTB6	0,742	0,742	
Business Performance	BP1	0,705	0,707	0,802
	BP2	0,840	0,835	
	BP3	0,736	0,736	

Table 2.   Model fit indices

Model	NFI	RFI	IFI	TLI	CFI	RMSEA
INDU-ST	0,992	0,988	0,993	0,990	0,993	0,024
PROP-ST	0,992	0,988	0,993	0,989	0,993	.024