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IT architecture flexibility and IT governance decentralisation as drivers of IT-enabled dynamic capabilities and competitive performance: The moderating effect of the external environment

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ABSTRACT

A question of central importance for researchers and practitioners is how information technology (IT) can help firms survive and thrive in turbulent and constantly changing business environments. To address this issue, this study develops the idea that IT architecture flexibility helps sustain competitive performance by driving the formation of IT-enabled dynamic capabilities, and that IT governance decentralisation strengthens this relationship. IT architecture flexibility and IT governance decentralisation, therefore, develop complementary effects. We argue that IT-enabled dynamic capabilities are a core antecedent for competitive performance gains, particularly under uncertain external environmental conditions. Tests of the proposed model using survey data from 322 international firms support these ideas. Our research also shows that, under conditions of high environmental heterogeneity, the value of IT architecture flexibility and IT governance decentralisation is increased, while the impact of IT-enabled dynamic capabilities on competitive performance is amplified.

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1. Introduction

In today's volatile and fast-moving competitive business environment, firms must be able to survive unprecedented threats, increase their market exposure and thrive on emerging opportunities. IT plays a critical role in the success of contemporary organisations, by impacting the means through which they create and capture value, and outperform competition (Chen et al., 2014; Lu & Ramamurthy, 2011). Prior studies suggest that IT-enabled dynamic capabilities can positively affect competitive performance by allowing the firm to sense and seize emerging opportunities to address rapidly changing external environments (Drnevich & Kriauciunas, 2011; Mikalef & Pateli, 2017). This requirement of developing IT-enabled dynamic capabilities is intensified when considering the dynamics of the external environment, which necessitates frequent and unforeseen changes in organisational operations and the digital infrastructures on which they are developed (El Sawy et al., 2010).

Modular designs and structures have been theoretically associated with the emergence of dynamic capabilities (Kay, 2010; Pil & Cohen, 2006; Sanchez & Mahoney, 2001; Teece, 2007, 2018). Unlike static conceptions of organisations, adaptive conceptions require that the architecture and organisation of firms adopts a design that enables adaptability and fluidity (Galunic & Eisenhardt, 2001; Rindova & Kotha, 2001). Modular systems theory suggests that increasing the modularity of any system allows for rapid changes in individual subsystems by reducing the need for coordinated changes in others (Schilling, 2000). Furthermore, modular designs can allow firms to identify emergent threats and opportunities faster, integrate external knowledge with greater speed, and enhance lateral coordination (De Waard et al., 2012). Hence, modular organising is what effectively drives the development of dynamic capabilities and facilitates the evolution and adaptiveness of the firm to external changes (Augier & Teece, 2006; Pil & Cohen, 2006). In effect, modular systems theory, with its biological orientation and emphasis on reactivity, is consistent with the evolutionary view of the firm, as argued by Teece (2018) in dynamic capabilities theory. This theoretical association is also particularly relevant in contemporary business environments, which are fast-paced, highly complex, and turbulent (Galunic & Eisenhardt, 2001), as it provides a link to the relationship between design (modular systems) and evolution (dynamic capabilities) (Teece, 2018).

In the literature, modularity has been described as both a technical and an organisational characteristic (Langlois, 2002). Correspondingly, modularity can characterise the technological architecture and organisational structure of the IT function through the notions of *IT architecture* and the *IT governance*, respectively (Tiwana & Konsynski, 2010). IT architecture refers to the arrangement through which various

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software applications and subsystems are interlinked (Kruchten et al., 2006). IT governance, on the other hand, is concerned with the appropriation of decision rights of the IT function (Weill & Ross, 2005). Specifically, the level to which an organisation has developed a flexible IT infrastructure, meaning that its portfolio is decomposed into independent subsystems, is suggested to positively contribute to market attunement and responsiveness (Byrd & Turner, 2001; Tafti et al., 2013; Tallon & Pinsonneault, 2011). In addition, modular arrangements of IT governance, in the form of decentralised decision-making structures, can foster faster receptivity of external stimuli and greater reactivity (Tiwana & Kim, 2015; Xue et al., 2011). Tiwana and Konsynski (2010) found that IT architecture modularity, coupled with IT governance decentralisation, can allow firms to be more agile in delivering IT applications for the line functions. Nevertheless, we still know very little about if modularity of the IT function impacts the underlying processes that facilitate firm evolution and competitive survival, especially in turbulent and fast-paced external environments. This is important to explore as the internal responding capability of firms by means of developing IT solutions is insufficient to sustain competitive performance without the ability to sense emerging opportunities and threats and seize them through coordinated actions (Overby et al., 2006).

The objective of this paper is, therefore, to explore how modularity of the IT architecture (measured in terms of IT architecture flexibility), complements with modularity in IT organisational design (measured in terms of IT governance decentralisation) to facilitate the emergence of IT-enabled dynamic capabilities, and subsequently impact firm competitive performance. In doing so, we also examine the role of the external environment in shaping these relationships. One of the main tenants of modular systems theory is that modularity in design facilitates adaptation and evolution (Schilling, 2000; Schreyögg & Sydow, 2010; De Waard et al., 2012). Therefore, under conditions that necessitate frequent and sudden change, such principles of modularity, and the emerging dynamic capabilities are argued to have amplified effects (Helfat et al., 2009; Schilling, 2000). In this study, we include a careful analysis of external environmental effects, differentiating between *dynamism, heterogeneity*, and *hostility*. We posit that under conditions of high dynamism, heterogeneity and hostility, IT architecture flexibility complemented with IT governance decentralisation will have enhanced effects on the emergence of IT-enabled dynamic capabilities. In turn, IT-enabled dynamic capabilities can produce greater competitive performance gains under such circumstances. Improving the theoretical clarity of the role of IT in business-level strategy and elucidating the causal associations through which value is derived, and the conditions under which these effects are amplified, contributes to the continued research on the IT-strategy relationship (Melville et al., 2004; Schryen, 2013). These gaps also have considerable practical significance since they reflect how managers implement technological and organisational aspects of the IT function in order to realise and sustain performance, particularly in turbulent and fast-paced business environments. Hence, the research questions that have motivated our study are:

RQ1. *How do IT architecture flexibility and IT governance decentralisation – independently and jointly – influence IT-enabled dynamic capabilities, and what is the effect of the latter on competitive performance?*

And,

RQ2. *Under what external environmental conditions are the effects of the previous relationships amplified?*

We build on modular systems theory and the dynamic capabilities view of the firm to develop our research model through which we investigate the above research questions. Empirical tests using primary data collected from 322 international firms support these arguments. The remainder of the paper proceeds as follows. The next section develops the theoretical basis of the paper, followed by the research model and the corresponding hypotheses. In section 4, the research methodology is outlined, followed by the results. Concluding, we discuss the contribution as well as the managerial implications of this research.

2. Theoretical background

2.1. Modular systems theory

Modularity is a general systems concept, describing the degree to which a system's components can be separated and recombined (Schilling, 2000). It refers both to the tightness of coupling between system components, as well as the degree to which it enables or prohibits the mixing and matching of components (Schilling, 2000). The concept of modularity is based on the premises of Simon (1991) which state that any system, whether an organisation or a product, is composed of some distinct, but interacting, subsystems that are to a certain degree autonomous and interdependent. Increased modularity facilitates flexibility in configuring systems (Xue et al., 2013). Decreasing interdependence between the components of a system provides greater autonomy in their evolution, without compromising the ability to operate jointly (Bush et al., 2010). In the context of IS studies, modularity can characterise the technological architecture and the organisational structure of the IT function (Tiwana & Konsynski, 2010).

An organisation's IT architecture refers to the arrangement through which various software applications and subsystems are interlinked (Kruchten et al., 2006). Abstracting the underlying premises of modular systems theory to the IS domain, IT architecture flexibility is broadly defined as the degree to which the focal firm's IT resources are sharable and reusable (Byrd & Turner, 2000). With IT systems increasingly being used as the key technological infrastructure to enable the coupling of business processes, IT architecture flexibility is regarded as a critical antecedent for a firms' competitive success (Xue et al., 2013). The overall strategic flexibility of firms is difficult to achieve when the underlying IT architecture is rigid and inflexible (Sambamurthy et al., 2003). Tightly integrated IT architectures do not only make it difficult for firms to change their internal IT-enabled processes, but also those that span beyond the focal firms' boundaries with suppliers and other business partners (Bush et al., 2010). Empirical studies have shown that flexible IT architectures lead to increased levels of strategic alignment under circumstances that require agile and swift responses (Tallon & Pinsonneault, 2011). Tiwana and Konsynski (2010) find that modularity of the IT architecture can enable IT agility, a key component of organisational adaptability. In this respect, a flexible IT architecture is critical in supporting continuous morphing in response to external conditions (Overby et al., 2006).

A modular organisation structure is one in which decision making is intentionally decentralised among departments (Karim, 2006). In the sphere of IT decision making, organisational modularity is presented as IT governance decentralisation, an aspect also noted in the conceptualisation of Byrd and Turner (2000) for IT flexibility. Centralisation and decentralisation correspond to two ends of a continuum since IT decision rights are most commonly shared between the corporate IT unit and the line functions units (Tiwana & Konsynski, 2010). A centralised IT governance, therefore, is present when design authority resides primarily with a central corporate IT unit, whereas a decentralised decision-making structure is present when decision authority resides primarily with business units (Boh & Yellin, 2006). The centralisation of IT governance facilitates greater efficiencies of economies of scale while decentralisation provides local control and ownership of resources as well as better responsiveness to business unit requirements (Boh & Yellin, 2006).

2.2. Dynamic capabilities

The Dynamic Capabilities View (DCV) has emerged as one of the most influential theoretical perspectives in strategic management over the past decade (Schilke, 2014). Originating from the Schumpeterian logic of creative destruction, dynamic capabilities enable firms to integrate, build, and reconfigure their resources and competencies in the face of changing business environments (Teece et al., 1997). Dynamic capabilities help sustain evolutionary fitness and allow firms to overcome organisational rigidities and inertia (Protogerou et al., 2011; Rowe et al., 2017; Schreyögg & Kliesch-Eberl, 2007; Vergne & Durand, 2011), sense and seize emerging business opportunities (Augier & Teece, 2009; Mikalef & Pateli, 2017), as well as to innovate and adapt to changing market conditions (Dixon et al., 2014). In essence, dynamic capabilities are conceptualised as strategic options that allow firms to renew their existing mode of operation when the opportunity or need arises (P. Pavlou & El Sawy, 2006).

One of the main tenants of the dynamic capabilities view is that they are purposefully developed and comprise of a set of identifiable and specific routines (Teece, 2007). If a firm lacks dynamic capabilities, it has a chance to make a competitive return for a short period, but it cannot sustain supra-competitive returns for the long-term due to continuous external changes (Teece, 2007). Past studies have relied on the definitions of Teece et al. (1997), and Teece (2007) to isolate the main dimensions of dynamic capabilities and empirically measure them. Following the approach described above, the existing literature suggests that dynamic capabilities comprise of the following dimensions: (i) sensing, (ii) coordinating, (iii) learning, (iv) integrating, and (v) reconfiguring capabilities (Mikalef & Pateli, 2017; Pavlou & El Sawy, 2011; Protogerou et al., 2011; Wilden et al., 2013).

In the IS domain, the principal concept used to express a firms' capacity to leverage its IT investments towards performance gains has been the notion of IT capability (Bharadwaj, 2000). However, it is becoming increasingly more evident in IS literature that instead of developing rare and non-substitutable IT resources, embedding IT in organisational capabilities is the source of significant and sustained competitive returns (Kohli & Grover, 2008; Rai et al., 2006). This transition dictates that IT capabilities should be measured and examined in terms of the organisational processes they enable or help strengthen (A. Bharadwaj et al., 2013; Kohli & Grover, 2008). In this respect, IT serves as the means through which new organisational capabilities can be created or existing ones can be improved (Mikalef et al., 2020). Firms may possess good organisational capabilities, but to make a meaningful difference in operational excellence and competitive response, these capabilities should be enhanced by IT (Rai et al., 2006; El Sawy et al., 2010).

The strategic IS agenda calls for a reframing of the dominant research discourse on IT-business value, primarily due to the constantly changing and uncertain competitive landscape (Drnevich & Croson, 2013; Merali et al., 2012). Building on this reasoning, we define IT-enabled dynamic capabilities as *a firm's ability to leverage its IT resources and IT competencies, in combination with other organisational resources and capabilities, in order to address rapidly changing business environments* (Mikalef & Pateli, 2017). According to the IT-enabled capabilities perspective, by digitising organisational capabilities using IT investments firms are able to further generate business value (Benitez et al., 2018). Following the IT-enabled capabilities perspective, Chen et al. (2017) find that IT support for core capabilities has a positive impact on a firms' strategic flexibility, which ultimately results in performance gains. Limaj et al. (2016) empirically demonstrate that social information systems help develop IT-based absorptive capacity, which subsequently leads to enhanced levels of innovation. Yet, despite numerous studies drawing on the emerging IT-enabled capabilities perspective (Rai & Tang, 2010; Saraf et al., 2007; Setia & Patel, 2013), there is still scarce empirical work on the enabling effect of IT on dynamic capabilities and the overall impact on competitive performance particularly under different forms of external conditions (Drnevich & Kriauciunas, 2011).

2.3. Modular design as an enabler of dynamic capabilities

While modular principles in the design of organisational systems have long been recognised as important enablers of dynamic capabilities (Sanchez & Mahoney, 2001), there is little empirical research – particularly in the IT domain – to explore if, and under what conditions, such principles contribute to the enhancement of IT-enabled dynamic capabilities. In his recent work, Teece (2018) introduces a framework of dynamic capabilities as a workable systems theory. Teece (2018) argues that modular systems theory, with its biological orientation and emphasis on reactivity, is consistent with the evolutionary view advocated in the dynamic capabilities' perspective, as the design principles followed, influence the evolution and competitive survival of firms. Modularity as a design principle, has been suggested to impact the underlying processes that comprise a firms dynamic capabilities (Ravishankar & Pan, 2013). Specifically, modularity can enable the creation of new systems of configurations by recombing new or existing independent components (Karim, 2006). In addition, modularity stimulates the reallocation of functional and processional expertise into changeable temporary organisational structures, which in turn facilitates the acquisition, transformation, and exploitation of internal and external knowledge (De Waard et al., 2012).

Modularity can also accelerate the process of organisational learning by enabling localised adaptations as well as the integration of knowledge and other key resources (Garud & Kumaraswamy, 1995). Modular designs have been also associated with the emergence of strong sensing capabilities (De Waard et al., 2012). Organisational sensing includes both the ability to pick up signals from the environment, as well as the capacity to give meaning to the often equivocal environmental signals that are being picked up (De Waard et al., 2012). Identification and absorption of such external signals appear to benefit from such modular design principles since it enables organisations to boost diversifications of signals and processing of them through specialised, modular units (Sanchez & Mahoney, 2001). In addition, Hansen (1999) argues that loosely coupled systems that exchange codified and independent knowledge have major search benefits and few transfer problems, thus, facilitating flexibility in how organisations absorb knowledge. Pil and Cohen (2006) suggest that the autonomous character of modular designs facilitates the acquisition and exploitation of dedicated expertise, thus, enhancing the speed of problem-solving.

Modular design principles have also been argued to be particularly relevant towards the emergence of dynamic capabilities under conditions of high uncertainty and frequent change (Volberda, 1996). Modularity can allow organisations to better adapt to shifting market opportunities through *patching*, a strategic process by which firms routinely re-adjust their business offerings as market opportunities evolve, by adding, splitting, transferring, exiting, or re-combining business components (Eisenhardt & Brown, 1999). Thus, under conditions of frequent change and high complexity, modular designs have enhanced relevance in both, the emergence and value of dynamic capabilities by enabling firms to reposition themselves with speed and through focused actions (Pil & Cohen, 2006). Firms that operate in turbulent and uncertain environments, must adopt organisational designs that can identify and make sense of external conditions, and through loosely-coupled interfaces have the ability to transform accordingly (Teece, 2018). Thus, the need of continuous sensing and evolution of firms dictates a congruous relationship with the organisational design principles to facilitate such adaptations (Worren et al., 2002).

3. Research model and hypotheses

In this study, we propose that the technical and organisational facets of a firm's IT function modularity, reflected in its flexible IT architecture and decentralised IT governance scheme, develop complementarities that positively influence the formation of IT-enabled dynamic capabilities. Furthermore, we suggest that the development of IT-enabled dynamic capabilities can be the source of competitive performance gains. We incorporate in our model the following environmental factors: dynamism, heterogeneity, and hostility. The constructs and the corresponding definitions are presented in Table 1.

Table 1. Constructs and definitions.

Construct	Definition	Dimensions	Source(s)
IT Flexibility	IT flexibility is defined as the degree of decomposition of an organisation's IT portfolio into loosely coupled subsystems that communicate through standardised interfaces	• Loose coupling • Standardisation • Digital reach • Scalability	Adapted from Bhatt et al. (2010), Byrd and Turner (2000), Chanopas et al. (2006), Tiwana and Konsynski (2010)
IT Governance Decentralisation	IT governance decentralisation is defined as the distribution of IT decision-making rights and responsibilities amongst enterprise stakeholders, and the procedures and mechanisms for making and monitoring strategic decisions regarding IT		Adopted from Boh and Yellin (2006)
IT-Enabled Dynamic Capabilities	IT-enabled dynamic capabilities are defined as a firm's abilities to leverage its IT resources and IT competencies, in combination with other organisational resources and capabilities, to address rapidly changing business environments	• Sensing • Coordinating • Learning • Integrating • Reconfiguring	Adapted from Teece (2007), Pavlou and El Sawy (2011), Rai and Tang (2010), Liu et al. (2013), Saraf et al. (2007), Rajaguru and Matanda (2013)
Competitive Performance	Competitive performance is defined as the degree to which a firm performs better than its key competitor		Adapted from Rai and Tang (2010), Spanos and Lioukas (2001), J. J. Li and Zhou (2010)
Dynamism	Dynamism is defined as the rate and unpredictability of environmental change.		Adopted from Newkirk and Lederer (2006)
Heterogeneity	Heterogeneity reflects the complexity and diversity of external factors, such as the variety of customer buying habits and the nature of competition.		Adopted from Newkirk and Lederer (2006)
Hostility	Hostility is defined as the availability of key resources and the level of competition in the external environment.		Adopted from Newkirk and Lederer (2006)

The theoretical claims upon which we ground our corresponding hypotheses suggest that under conditions of high environmental uncertainty, the impact of modular design principles, and the value of the corresponding dynamic capabilities they enable will be amplified. Therefore, we hypothesise that the dynamism, heterogeneity and hostility of the environment will moderate the previously mentioned relationships. Figure 1 illustrates our research model.

3.1. The impact of IT architecture flexibility on IT-enabled dynamic capabilities

Developing a flexible IT architecture is long regarded as an important IT strategic goal (Kumar, 2004). Past studies have defined and subsequently refined the notion of IT architecture flexibility as a multi-dimensional notion. In this study we adopt the dimensions used by Bhatt et al. (2010), which define IT architecture flexibility through the dimensions of loose coupling (Byrd & Turner, 2000; Tiwana & Konsynski, 2010), standardisation (Gosain et al., 2004; Tafti et al., 2013), digital reach (Byrd & Turner, 2001; Tafti et al., 2013) and scalability (Bhatt et al., 2010; Chanopas et al., 2006). Each dimension represents a unique set of characteristics that is critical for firms to realise performance gains in competitive and constantly evolving landscapes. These four dimensions represent key aspects that enable firms to adopt, implement, and upgrade new systems in response to evolving business needs (Bhatt et al., 2010).

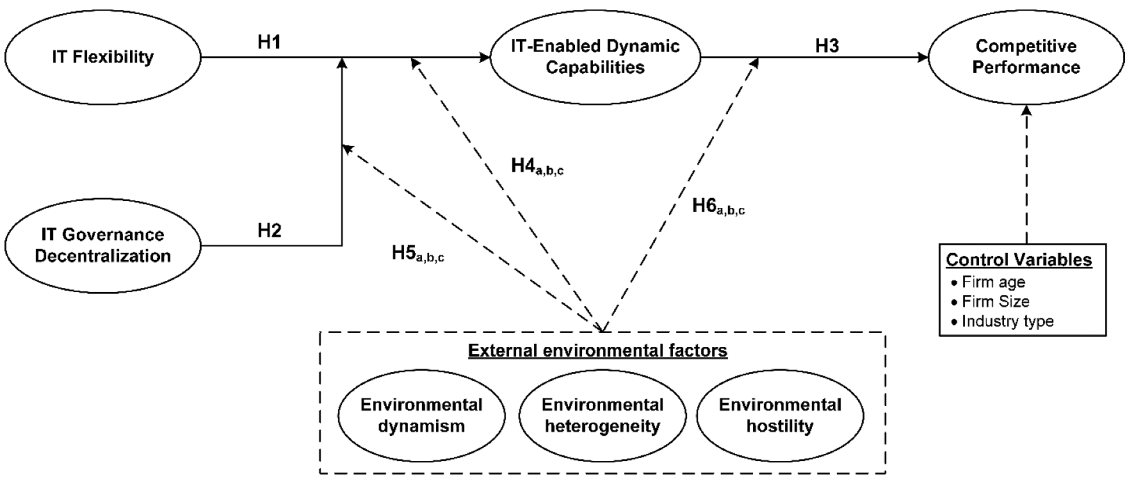

Figure 1. Research model.

IT architecture flexibility has been commonly associated with the strategic agility to respond to opportunities in the environment by enabling the firm to realign its strategy in response to new opportunities (Drnevich & Croson, 2013). As such, coevolution, the main tenant of IT-enabled dynamic capabilities implies flexibility in the line-up of IT resources (Sambamurthy et al., 2003). On transitioning from resource acquisition to capability development, it has been suggested that resource attributes, such as IT architecture flexibility, have an impact on the capabilities that use the resources (Fink & Neumann, 2009). Melville et al. (2007) argue that particularly in highly competitive industries, IT architecture flexibility is what facilitates rapid change in response to shifts in the competitive environment. A flexible IT architecture improves the ability of organisations to detect, process, and communicate information on emerging markets, thereby enabling sensing and responding capabilities (Chakravarty et al., 2013; Conboy et al., 2020; Lu & Ramamurthy, 2011). Furthermore, flexible IT architectures enable the IT function to develop solutions for the business line function in a more agile manner, thus facilitating alignment (Tiwana & Konsynski, 2010). Although each dimension of IT flexibility may to some extent strengthen a firm's armoury of digital options, it is the combined effect of the underlying dimensions of IT flexibility that allows a firm to develop the IT-enabled dynamic capabilities that are necessary to cope with changing conditions and mitigate bottlenecks and inertia issues (Besson & Rowe, 2012).

Loose coupling refers to the extent to which it is possible to add, modify, and remove any software, hardware, or data components of the architecture with ease and with no major overall effect (Tiwana & Konsynski, 2010). As such, the notion of loose coupling follows the design principles of modularity (Wagner et al., 2014). It allows the firm to decompose the IT architecture into atomic, fine-grained units of functionality, referred to as software components, modules, objects, or services. In turn, these atomic functionalities can be easily recombined and restructured to quickly construct new solutions (Tafti et al., 2013). Through modularisation, integration, and coordination of organisational as well as inter-organisational processes and applications, the combinations of a firm's digital offerings can be increased (Battleson et al., 2016). In addition, loose coupling lowers the cost and time required to form new partnerships since applications are less constrained by dependencies with others (Tafti et al., 2013).

Standardisation refers to the establishment of syntax, semantics, and policies on how applications connect and interoperate with each other (Weill & Ross, 2005). An important development in terms of standardising IT architecture is the adoption of open standards instead of proprietary or bilaterally established standards. Proprietary standards can lead to inflexibility in connecting of switching to new partners, whereas open standards facilitate greater flexibility in forming automated communication between firms (Zhu et al., 2006). Open standards for information systems, as well as for data formats, can help structure the information exchanged and enhance the flow of communication among various applications (Zhao & Xia, 2014). Moreover, open standards allow organisations to collect, analyse, and generate ideas and recommendations from a variety of data sources, such as data repositories and business networks (Karimi & Walter, 2015; Tafti et al., 2013).

Digital reach is defined as the degree to which data and system interfaces are visible, accessible, and deployable across different functions within the firm and outside its boundaries (Tafti et al., 2013). Digital reach builds on prior related work of information systems (Sambamurthy et al., 2003), such as that of data (Byrd & Turner, 2000) and service transparency (Erl, 2008), and accessibility over the Web (Moitra & Ganesh, 2005). This characteristic allows the service customer to invoke a service regardless of its actual location in the network (Pautasso et al., 2008). Digital reach promotes the processes necessary for alliance formation, since it exposes the mutual capabilities amongst partners creating opportunities for joint development (Malhotra et al., 2005). It also allows the discovery and use of services provided by different departments within organisational boundaries, thus facilitating data and knowledge flows (Erl, 2008).

Scalability refers to the degree to which hardware/software can be scaled and upgraded to handle larger volumes of users, workload, or transaction volume (Chanopas et al., 2006; Kumar, 2004). Architectures that support scalability also handle the problem of rapidly increasing complexity, when a rising number of systems need to be integrated (Papazoglou & Van Den Heuvel, 2007). A scalable IT architecture allows for easier storage and analysis of bulk data. Scalable IT architectures provide the ability to scale resources up and down, reduce costs, react quickly, and provide services to customers and business partners (Battleson et al., 2016; Narasimhan & Nichols, 2011). In addition, scalable infrastructures also provide organisations with the necessary fluidity to cope with peaks due to changing business conditions.

In terms of strengthening a firms' IT-enabled sensing capability, Demirkan and Delen (2013) exemplify how the adoption of service-oriented cloud-based decision support systems enables the development of standardised interfaces with other systems, thus, increasing the amount of information received by sources internally and externally of the firm. A cloud-based infrastructure facilitates scalability in terms of data storage, as well as processing power required to analyse data and provide timely business intelligence (e.g., data mining, text mining, and simulation). Technologies such as SOA facilitate transparency of digitised services, and the use of open standards enable seamless coordination of activities (Joachim et al., 2013). Flexible IT architectures also enhanced IT-enabled learning. For instance, the use of open standards promotes easy coupling and decoupling with business partners, rendering the development of knowledge flows between firms easier to accomplish (Sambamurthy et al., 2003). In addition, cloud-based knowledge repositories and collaborative platforms provide the necessary scalability to accommodate large amounts of information when necessary and enable multiple users to work simultaneously on the development of new knowledge or products/services (Kim & Lee, 2006), and even crowdsourcing initiatives and on-demand workforce (Kaganer et al., 2013). A firm's IT-enabled integration capability is also greatly enhanced by flexible IT architectures (Bidan et al., 2012). Open standards regarding system interoperability and data formats, combined with modular and transparent digital processes, allow firms to broaden their scope of business partners and seamlessly integrate systems (Rai et al., 2006). Finally, regarding IT-enabled reconfiguration capability, numerous studies have argued that digitised granular business process can be reused or locally extended if business needs change or new needs arise (Yoon & Carter, 2007). As such, the loose coupling facilitated through modular IT architectures allows greater adaptability and reconfiguration of organisational processes (Rai & Tang, 2010). Based on the foregoing discussion, we expect that greater IT flexibility will positively impact the formation of IT-enabled dynamic capabilities.

H1: IT flexibility has a positive impact on IT-enabled dynamic capabilities

3.2. The moderating role of IT governance

Although IT architecture flexibility is suggested to enhance the formation of IT-enabled dynamic capabilities, we argue that the value-adding properties are amplified when it is complemented with IT governance decentralisation. By decentralising the IT governance, business units are empowered to initiate changes that support existing applications or deploy new ones to address emerging opportunities. In addition, the different business units are better attuned to their own operational requirements, and thus are more able to identify emerging trends, opportunities, and situations where IT can be leveraged (Sambamurthy & Zmud, 2000). For instance, a firm may need to incorporate new suppliers to introduce a new product to the market. Such an action would require that efficient coordination mechanisms are established, IT applications that support collaborative work are deployed, and repositories and structures for storing and disseminating newly acquired or co-developed knowledge are assimilated. A decentralised IT governance unshackles local business units to initiate changes in existing IT applications or to rapidly deploy new ones to deal with emerging opportunities and threats (Tiwana & Kim, 2015).

A flexible IT architecture complemented by decentralised IT governance allows individual line functions to deploy IT applications without being constrained by an extensive need for coordination with other line functions. Decentralising IT governance raises organisational alertness to new opportunities at the line function level, while the concurrent presence of IT architecture flexibility lowers the need for interdepartmental coordination in initiating changes in response to such opportunities (Tiwana & Konsynski, 2010). Individual business units are unlikely to have a comprehensive view of the complete organisational IT portfolio, and therefore will be less able to identify cross-application interdependencies and to integrate or add new IT applications to existing ones (Boh & Yellin, 2006). As such, the gains of increased readiness achieved by means of decentralising IT governance can be diminished by the requirement of elaborate intra- and inter-organisational coordination, if there is an absence of a flexible IT architecture (Choi et al., 2010).

When IT architectures follow the principles of flexibility, changes in one application will not incur adverse impacts on other applications or their interoperability (Voss & Hsuan, 2009). Flexible IT architectures also help streamline integration of other systems, since open standards dictate how the different components connect, interact, and interoperate (Wei & Blake, 2010). It is, therefore, through effects of adaptability facilitated by IT architecture flexibility and the complementary effect of alertness through IT governance decentralisation, which promotes the formation of IT-enabled dynamic capabilities. Thus, IT governance decentralisation is argued to exert a positive moderating impact on the relationship between IT flexibility and IT-enabled dynamic capabilities (Carte & Russell, 2003).

H2: IT governance decentralisation positively moderates the effect of IT flexibility on IT-enabled dynamic capabilities

3.3. The impact of IT-enabled dynamic capabilities on competitive performance

The dimensions that comprise IT-enabled dynamic capabilities are complementary in nature and empower synergies that serve in adapting the way the firm operates and competes, which is argued to ultimately result in competitive performance gains. An IT-enabled sensing capability helps ensure that customers and competitors are closely monitored so that sufficient feedback is received and analysed to inform strategic decisions (Roberts & Grover, 2012). Additionally, IT-enabled sensing can help firms detect functional areas, supply chain activities, or business processes that create bottlenecks and take corrective actions to increase efficiency (Estampe et al., 2013). IT-enabled capabilities of coordination and learning, increase the efficiency of generating, disseminating, and responding to market intelligence, allowing a firm to introduce products that better correspond to changing customer demands while simultaneously reducing reaction time (Sher & Lee, 2004; Swafford et al., 2008). Nevertheless, entering new markets or modifying an existing product often requires opting for a different set of partners and collaborators (Daugherty et al., 2006). An IT-enabled integration capability forms the basis for acquiring, transforming, mixing, and matching objects across firms and business partners (Saraf et al., 2007). In addition, IT-enabled integration and reconfiguration capabilities allow firms to closely collaborate with business partners, while at the same time been able to rapidly adapt inter-organisational relationships when the need arises (Gosain et al., 2004). When firms operate in uncertain environments, they need to be able to engage and disengage in partnerships while at the same time maintain a tightly coupled exchange of information with counterparts (Rai & Tang, 2010).

Apart from adapting to changing external conditions, IT-enabled dynamic capabilities can also yield competitive performance gains by enhancing a firm's ability to innovate. Firms that invest in strengthening their IT-enabled sensing capabilities are able to identify emerging technological opportunities and assess how they might be leveraged for the productions of new products and services before competitors (Teece, 2007). As a result, firms can redirect their partnerships and establish joint ventures or strategic alliances with entities that have the required complementary resources and knowledge to target them (Tafti et al., 2013). Also, by leveraging IT for integrating inter-organisational process, firms are in place to process information obtained from supply chain partners and reduce information asymmetries (Saraf et al., 2007). An IT-enabled integration capability can also help dissolve intra-organisational boundaries, providing coherent access to data across geographically dispersed or "siloed" organisational units (S. Bharadwaj et al., 2007). Such knowledge flows are a fundamental component for the emergence of innovation capacities (Subramaniam & Youndt, 2005). Furthermore, IT-enabled coordination can extend information sharing, and promote collaboration and bisociation by integrating and mapping disparate knowledge sets to uncover new knowledge (Joshi et al., 2010). The increased knowledge reach and richness, as well as the capacity to disseminate information, serves as a mechanism of enhancing a firm's innovation proclivity and subsequently its competitive performance (Malhotra et al., 2005; Mikalef et al., 2019; Roberts et al., 2012). The synergies developed by IT-enabled integration and coordination capabilities provide the necessary foundation for communication and cooperation of cohesive units (Enkel & Heil, 2014), which in turn enhances the firm's ability to transform and exploit new knowledge into new products, services, and processes (Setia & Patel, 2013). Finally, the capacity to reconfigure IT-based processes to accommodate new business partners and collaborators has been documented as a driver of innovation gains (Hanseth & Lyytinen, 2010). From the foregoing discussion, we expect that IT-enabled dynamic capabilities allow firms to achieve competitive performance gains.

H3: IT-enabled dynamic capabilities positively impact competitive performance

3.4. The moderating effects of environmental factors

The conditions under which dynamic capabilities add value have been a subject of much debate and have been argued to be heavily contingent on aspects of the external business environment (Drnevich & Kriauciunas, 2011). In stable environments, where externals changes are infrequent and tend to be predictable and incremental, dynamic capabilities play a minor role. Contrarily, in fast-paced, unpredictable, and volatile environments, existing modes of operating quickly erode, so dynamic capabilities are necessary to maintain competitiveness (Wilden & Gudergan, 2015). Similarly, the IT architecture that underlies IT-enabled dynamic capabilities is argued to demand increased flexibility in conditions of constant and unpredictable change (Tiwana & Konsynski, 2010). Along with more flexible IT architectures, competitive pressures stemming from the external environment have been shown to favour IT governance schemes that are decentralised (Y. Xue et al., 2008). An appropriate match between internal mechanisms and the external environment can help firms achieve competitive performance (Sirmon et al., 2007). The degree of such a match can moderate the value of internal resources, and their leveragability in response to external pressures. Prior research suggests that factors of the external environment are important exogenous variables, both at the internal – firm – level and also in realising competitive performance gains

(Schryen, 2013). In contrast with previous studies that have discussed the moderating effects of the environment using aggregate measures (Drnevich & Kriauciunas, 2011), we have deconstructed the impact of environmental uncertainty in terms of three distinct factors: dynamism, heterogeneity, and hostility (Mikalef & Krogstie, 2020; Newkirk & Lederer, 2006).

Firms that operate in dynamic environments are likely to require frequent adjustments to their marketing approach in order to satisfy the constantly changing customer needs (D.-Y. Li & Liu, 2014). Heterogeneous business environments put pressure on the firm to deal with varied external partners, complex and disparate business activities, and competitors from different domains. With increased heterogeneity comes the requirement of managing multiple business objectives, a large number of stakeholders and related information, and a broad range of IT-based applications (Dutot et al., 2014). A hostile business environment can occur from radical industry changes, intense regulatory burdens, and intense rivalry among competitors. Dynamism can be regarded as the unpredictability on the demand side, heterogeneity as the uncertainty on the supply side, and hostility as the variability regarding longer-term trends in the industry (Xue et al., 2011). While these external environmental conditions differ significantly, they are suggested to be significant influencers of a firm's internal structuring in relation to its IT investments and the derived business value. As such, we examine the moderating effect that each separate dimension has on the previously stated hypotheses.

In dynamic environments, it may be challenging to develop IT-enabled capabilities since the speed of change can render any IT investments obsolete. In such volatile conditions, to be able to operate efficiently and effectively, firms need to continuously reconfigure their IT resources, store and process fluctuating amounts of data for the generation of insight, and swiftly redirect their IT-based capabilities (Chen et al., 2014). A flexible IT architecture can help mitigate bottlenecks in utilising IT towards the formation of IT-enabled dynamic capabilities (Bhatt et al., 2010). In conditions of environmental heterogeneity, a flexible IT architecture can provide seamless and consistent access to relevant customer, production, market, and operation-related data (S. Bharadwaj et al., 2007). Also, in hostile environments characterised by conditions of scarce information, suppliers, and basic resources, a flexible IT architecture facilitates rapid knowledge sharing, flexible processes and relational coupling with business partners (Han et al., 2017). We, therefore, expect that under conditions of high environmental uncertainty the impact of IT architecture flexibility on IT-enabled dynamic capabilities will be stronger.

H4: Greater levels of environmental a) dynamism, b) heterogeneity, and c) hostility will amplify the positive relationship of IT architecture flexibility on IT-enabled dynamic capabilities

A decentralised IT governance scheme is particularly important under conditions of high dynamism since competitive pressures require organisations to make rapid decisions regarding the allocation of their IT resources to business areas where intense competition arises (Y. Xue et al., 2008). While decentralised IT governance schemes have the downside of limited economies of scale, they permit line function units to utilise flexible IT architectures more promptly towards their goals (Xue et al., 2011). As such, under conditions of high dynamism, the value of decentralising IT governance in order to develop IT-enabled dynamic capabilities will be greater than in conditions of low dynamism where responsiveness is not fundamental. Likewise, when firms operate in environments characterised by high levels of heterogeneity, there will be greater diversity in the objectives that IT-based capabilities should deliver. Therefore, IT governance decentralisation, coupled with a flexible IT architecture is more likely to enhance the development of IT-enabled dynamic capabilities compared to conditions of low heterogeneity (Tiwana & Kim, 2015). Finally, when business opportunities are scarce and fleeting, firms that opt for decentralising their IT governance will have line functions that are better attuned to their own business goals and are better positioned in identifying opportunities that IT-based capabilities can help them address (Sambamurthy et al., 2003). As such it is expected that the complementarities between IT governance decentralisation and IT flexibility will be higher under conditions of high environmental uncertainty.

H5: Greater levels of environmental a) dynamism, b) heterogeneity, and c) hostility will amplify the positive moderating impact of IT governance decentralisation on the effect of IT flexibility on IT-enabled dynamic capabilities

There is a growing consensus in the literature that environmental uncertainty factors moderate the relationship between dynamic capabilities and performance (Wilden et al., 2013). The accepted view suggests that dynamic capabilities are more important in uncertain environments than in stable ones since they contribute towards change in the firm (Helfat & Peteraf, 2009). In uncertain environments, the value of existing firm competencies can quickly erode, therefore building up new functional competencies is a prerequisite in order to remain on the edge of technological and market developments (Protogerou et al., 2011). High levels of dynamism prompt firms to learn about changes through gathering, analysing, and making sense of a large amount of data, and responding by repositioning their offerings through internal adjustment of operations and by forming new partnerships (Prieto & Easterby-Smith, 2006). IT has the potential to add value under conditions of high dynamism, by enabling more swift responses in sensing changes, integrating core resources, and reconfiguring existing means of operation (Lu & Ramamurthy, 2011; Tallon, 2008). These capacities are also particularly critical for firms in driving their ability to innovate under conditions of high dynamism.

Highly heterogeneous and hostile environments place the firm at risk of losing its resource advantage, losing customers and diminishing their competitive edge (Sirmon et al., 2010). Due to the large amount of information that needs to be processed in such contexts, and the increased levels of task uncertainty, IT-enabled dynamic capabilities can help managers gather diverse information and gain insight for business planning (Chen et al., 2014). Furthermore, IT-enabled dynamic capabilities can be of increased relevance in such contexts since they facilitate the rapid identification of emerging opportunities through open innovation platforms and enable co-creation with existing and potential customers (Ashurst et al., 2012; Grover & Kohli, 2012). Consequently, the value of IT-enabled dynamic capabilities towards realising competitive performance gains in heterogeneous environments may be augmented, since they can help firms coordinate complex operations and innovate more effectively (Stoel & Muhanna, 2009).

Under conditions of hostility, where resources are scarce and business partners limited, IT-enabled dynamic capabilities can be particularly important since they can help alleviate geographic boundaries and provide a greater set of options to the focal firm. In the absence of other valuable resources and time where customer loyalty is no longer guaranteed, IT-enabled dynamic capabilities can be harnessed to expand the reach and locus of control for focal firms (Setia & Patel, 2013). In such turbulent environments, developing and maintaining an adaptive and innovative capacity is more of a necessity due to higher degrees of market uncertainty compared to stable settings (Sambamurthy et al., 2003). Our rationale suggests that IT-enabled dynamic capabilities contribute more to competitive performance gains in highly uncertain environments in comparison to more stable ones.

H6: Greater levels of environmental a) dynamism, b) heterogeneity, and c) hostility will amplify the positive effect of IT-enabled dynamic capabilities on competitive performance

4. Research methodology

4.1. Sample and procedure

To investigate our research hypotheses, we developed and administered a survey instrument. Target respondents included high-level executives (e.g., chief information officer, chief technology officer, or chief operations officer). Survey constructs were operationalised using seven-point Likert scales, a well-accepted practice in large-scale empirical studies since no archival data exist for quantifying resources and capabilities (Kumar et al., 1993). Before sending out the survey, we pretested the instruments intensively by conducting personal interviews and q-sort and hit-ratio tests from a pool of five academics and four senior managers who offered comments on how to improve the content, clarity, and wording of the measurement items (DeVellis, 2016). These tests were done on the constructed we either adapted or developed in this study. The survey instrument was then tested in a small-cycle study with executives of 17 firms to examine the statistical properties of the measures.

For the main study, a population of 1500 firms was randomly selected from the ICAP 2015 business directory. Contact details for respondents in each firm were obtained from various sources, such as mailing lists, professional directories and associations, and personal contacts. The firms varied in size, industry, and country, ensuring as such sufficient variation in environments and capabilities. The instructions asked respondents to consult other members of their firm if they were not highly knowledgeable about specific information. This guaranteed a collective response. The duration of the data gathering process was approximately nine months (December 2014 – September 2015). In total, 345 firms accepted to participate in the study providing 322 usable questionnaires, for a response rate of 21.4%, which is consistent with comparable studies using key informant methodology (Capron & Mitchell, 2009)

The vast majority of responses (89.2%) came from senior managers, such as chief information officers (CIOs), chief executive officers (CEOs) and IT managers, 6.4% had a commercial function (e.g., project manager, business analyst, vice-president of operations), and 4.4% performed technical functions (e.g., technology strategy consultant, enterprise architect, technical director). Most responses were from firms operating in Europe (48%), followed by America (33%), Asia (16%), and Australia & New Zealand (3%). To verify the appropriateness of the respondents, we asked them to indicate how long they had been working in the industry and the focal firm. On average, they had work experience exceeding 12 years, 3–5 of which were spent in the firm they were currently working for. Following the EU commission size-class recommendation (2003/361/EC), firms were grouped into large (38%), medium (20%), small (26%), and micro (16%), while industries represented in our sample are presented in Table 2.

To minimise informant bias, early and late responses were compared to confirm that respondents did not differ significantly in their answers. Two groups of responses were selected, those that replied within the first one month, and those that answered within the final month. For each item used in the study and for the constructs they formed, Mann-Whitney U-tests were run. Only 1 of the 70 items while none of the 16 first-order constructs indicated a significant difference, so non-response bias is not a concern. In addition, no significant differences were identified between responding and non-responding firms regarding their age, size, and ownership type (private or public). Given that all data were perceptual and collected from a single source at one point in time, we controlled for common method bias in accordance with suggestions of Chang et al. (2010). Ex-ante, respondents were assured that the data collected would remain anonymous and would be analysed for research purposes solely at an aggregate level. Also, we guaranteed complete confidentiality and reduced item ambiguity through the pre-test and pilot-test (Podsakoff et al., 2003). Ex-post, Harman's one-factor test was used, entering the study variables into a principal component factor analysis. The results indicated that one construct did not account for the majority of variance (Fuller et al., 2016). Next, we used a common method variable approach to examine this possibility further (Podsakoff et al., 2003). Following the guidelines of Sattler et al. (2010), we used a latent common method factor to estimate the loadings on every item in the PLS path model, in addition to each item loading on its theoretical construct. By comparing the estimated path model relationships with and without each additional marker variable, no significant differences were observed. Moreover, the presence of common method variance was unlikely in our study design, since we examined a moderating effect, so respondents could not manipulate their responses in relation to interaction effects (Dayan & Di Benedetto, 2010).

Table 2. Industry distribution of the sample.

Industry	N
Consulting services	77
High-tech	77
Financials	45
Consumer goods	33
Telecommunications	19
Industrials	19
Consumer services	16
Basic materials	9
Healthcare	8
Utilities	5
Oil & gas	5
Transportation	5
Education	4
Total	322

4.2. Variable definition and measurement

To operationalise the notions used in this study we followed the guidelines of Jarvis et al. (2003), and also relied on past empirical literature and pre-tests with academics and industry professionals for newly developed scales. For each construct, we asked respondents to assess the degree to which they agree/disagree with the underlying dimensions of each first-order construct (see Appendix A).

IT Flexibility. We define IT flexibility as the degree of decomposition of an organisation's IT portfolio into loosely coupled subsystems that communicate through standardised interfaces. It is developed as a type II second-order construct (first-order reflective and second-order formative), with first-order dimensions being, *loose coupling, standardisation, digital reach*, and *scalability* (Bhatt et al., 2010). Each dimension that comprises IT flexibility is adopted from past empirical work (Byrd & Turner, 2000; Chanopas et al., 2006; Tafti et al., 2013; Tiwana & Konsynski, 2010). We built on the dimensions proposed by Bhatt et al. (2010) and developed combined measures for them based on prior research. The choice of doing so was to provide more richness to concepts that are central in IT infrastructure flexibility for contemporary organisations. Nevertheless, the measurements items to capture these dimensions were not exhaustive.

IT Governance Decentralisation. We define IT governance as the distribution of IT decision-making rights and responsibilities amongst enterprise stakeholders, and the procedures and mechanisms for making and monitoring strategic decisions regarding IT (Boh & Yellin, 2006). IT governance is measured on the continuum of centralisation- decentralisation, as a first-order reflective latent construct comprising of 3 items, and adopted from the study of Boh and Yellin (2006).

IT-Enabled Dynamic Capabilities. We define IT-enabled dynamic capabilities as a firm's abilities to leverage its IT resources and IT competencies, in combination with other organisational resources and capabilities, to address rapidly changing business environments. We operationalise the notion as a type II second-order construct, consisting of five first-order constructs. The dimensions that comprise IT-enabled dynamic capabilities include *sensing, coordinating, learning, integrating*, and *reconfiguring* routines (Pavlou & El Sawy, 2011). Since IT-enabled dynamic capabilities is a newly developed construct, we referenced past empirical literature from the areas of strategic management, information systems, and organisational science to formulate adapted items and create new ones from conceptual definitions (Liu et al., 2013; Pavlou & El Sawy, 2010; Rai & Tang, 2010; Rajaguru & Matanda, 2013; Sambamurthy et al., 2003; Saraf et al., 2007; Teece, 2007; Teece et al., 1997). The construct and the underlying dimensions were then validated through several expert group tests, as well as through a small population study in accordance with the guidelines of MacKenzie et al. (2011) and DeVellis (2016).

Competitive Performance. We define competitive performance as the degree to which a firm performs better than its key competitors (Rai & Tang, 2010). To operationalise the notion, respondents were asked to evaluate on a 7-point Likert scale (1 – much weaker than competition, 7 – much stronger than competition) the relative performance of their firm in a number of key performance indicators (J. J. Li & Zhou, 2010; Liu et al., 2013; Rai & Tang, 2010). Following the argument that subjective data can measure competitive advantage, this study operationalised the construct as a formative latent variable comprising of 10 indicators as illustrated in Appendix A (Spanos & Lioukas, 2001).

Environmental Uncertainty. The degree of environmental uncertainty was assessed through three constructs; *dynamism, heterogeneity*, and *hostility* (Newkirk & Lederer, 2006). Dynamism is defined as the rate and unpredictability of environmental change. Heterogeneity reflects the complexity and diversity of external factors, such as the variety of customer buying habits and the nature of competition. Hostility is defined as the availability of key resources and the level of competition in the external environment. All items were adopted from the study of Newkirk and Lederer (2006).

Control Variables. We also included three control variables: firm size, firm age, and industry. Firm size was measured as an ordinal variable in accordance with recommendations of the European Commission (2003/361/EC) into micro (0–9 employees), small (10–49 employees), medium (50–249 employees), and large (more than 250 employees). A firm's age was measured in years since the beginning of operations. We included industry as a control variable, and created two effect-coded variables, representing service-only and manufacturing-only firms, using mixed firms as a reference category.

4.3. Statistical techniques

We analysed the data using partial least squares structural equation modelling (PLS-SEM), and specifically the SmartPLS software package (Ringle et al., 2015). PLS-SEM is a soft modelling technique and is variance-based, with the advantage for allowing (i) flexibility with respect to the assumptions on multivariate normality, (ii) usage of both reflective and formative constructs, (iii) the ability to analyse complex models using smaller samples, (iv) the capacity to examine chain of effects, and (v) the potential use as a predictive tool for theory building (Nair et al., 2018). PLS-SEM is widely used in analysing data for the estimation of complex relationships between constructs in many subject areas including in management information systems and business research (Ahammad et al., 2017; West et al., 2016). In addition, PLS-SEM enables the analysis of indirect and total effects, making it possible to not only simultaneously assess the relationships between multi-item constructs, but also to reduce the overall error associated with the model (Astrachan et al., 2014). PLS-SEM exhibits higher statistical power than covariance-based SEM for multiple causal relationships between one or more independent variables and one or more dependent variables, which is relevant for this study due to its small subgroup sizes (Hair & Hult, 2016). Finally, one of the advantages of PLS-SEM is that it is best suited in scenarios of exploratory theoretical development, and particularly in cases sensitive to moderator effects, such as the one of the present research (Lowry & Gaskin, 2014). The 322 responses received exceeds both the requirements of (1) ten times the largest number of formative indicators used to measure one construct and (2) ten times the largest number of structural paths directed at a particular latent construct in the structural model (Hair & Hult, 2016). Finally, PLS-SEM can include both reflective and formative measurement modes, which enabled us to test the higher-order type II constructs used in this research (Becker et al., 2012). In our empirical model variables are modelled as both formative (higher-order) and reflective, which minimises problems of interpretational confounding (Hsu et al., 2017).

5. Results

5.1. Measurement model

First-order reflective latent variables were assessed in terms of reliability, convergent validity, and discriminant validity. We examined reliability at both construct and item level. At construct level, composite reliability (CR) and Cronbach's alpha (α) indicators were assessed, with all values being above the threshold of 0.70, suggesting acceptable construct reliability (Fornell & Larcker, 1981). Indicator reliability was assessed through construct-to-item loadings, with those below the threshold of 0.70 being omitted. All remaining items had loadings above 0.74 (Appendix B). Convergent validity was assessed by examining if the average variance extracted (AVE) for each construct was above the threshold value of 0.50. The lowest AVE was 0.65, which greatly exceeds the lower limit. We established discriminant validity through three ways. First, we examined whether each constructs AVE square root was greater than its higher correlation with any other construct (Fornell-Larcker criterion) Second, we checked if each indicator's outer loadings on its assigned construct was greater than its cross-loadings with other constructs (Farrell, 2010). Third, we examined the heterotrait-monotrait ratio (HTMT) of the correlations. HTMT is a more reliable approach that measures what the true correlation between constructs would be if they were perfectly measured (Hair & Hult, 2016). The outcomes of these tests suggest that first-order reflective measures are reliable and valid to further analyse and support the suitability of items as appropriate indicators for the respective latent variables (Table 3, Appendix B and Appendix C).

Two type II higher-order constructs are formed from the underlying first-order latent variables (Jarvis et al., 2003). To operationalise them, we used a mixture of the repeated indicator approach and latent variables scores in a two-stage approach, in line with the guidelines of Ringle et al. (2012). In the first stage, the repeated indicator approach was used to obtain latent variable scores for the first-order constructs, which in the second stage served as manifest variables in the measurement model of the higher-order construct. Path weights were estimated through the path weighting scheme of SmartPLS. The path weights of first-order constructs suggested that each dimension was an important determinant of their respective higher-order construct. Additionally, variance inflation factors (VIF) were all below the threshold of 3.3, indicating low multicollinearity (Petter et al., 2007) (Table 4).

5.2. Structural model assessment

The structural model from the PLS analysis is summarised in Figure 2, in which the explained variance of endogenous variables (R^2) and the standardised path coefficients (β) are presented. The significance of estimates (t-statistics) were obtained by performing a bootstrap analysis with 5000 resamples. As illustrated in Figure 2, all six direct hypotheses were confirmed. In support of H1, we found a positive relationship between a firms' level of IT flexibility and its IT-enabled dynamic capabilities (H1, β = 0.650, t = 17.958, p < 0.001). To examine if IT governance decentralisation has a moderating effect on the relationship between IT flexibility and IT-enabled dynamic capabilities, we built on the guidelines of Carte and Russell (2003). Based on their suggested approach, we first added the direct effect of IT governance decentralisation to IT-enabled dynamic capabilities. The main effect was significant and positive (β = 0.167, t = 2.255, p < 0.05). We then added an interaction term between IT flexibility and IT governance decentralisation, which was created using the standardised product-indicators approach (Chin et al., 2003). The interaction term had a positive and significant relationship with IT-enabled dynamic capabilities (H2, β = 0.083, t = 2.352, p < 0.05). Adding the interaction term also resulted in a decrease in the magnitude of the main effect of the moderator of the variable (β = 0.71, t = 1.921, p > 0.05). With the addition of the moderator, the R^2 for IT-enabled dynamic capabilities increased from 43.2% to 56.9% (F-change 11.78; p < 0.001), suggesting that it contributes additional explanatory power to the models. Thus, we can conclude that IT governance decentralisation positively and significantly moderates the relationship between IT flexibility and IT-enabled dynamic capabilities, with the moderator effect size being 13.7%, thus supporting H2. Finally, results indicated that IT-enabled dynamic capabilities exert a positive and significant effect on competitive

Table 3. Assessment of reliability, convergent and discriminant validity of reflective constructs.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. LC	**0.82**													
2. STND	0.46	**0.80**												
3. DR	0.67	0.53	**0.81**											
4. SCAL	0.65	0.60	0.65	**0.90**										
5. GOV	0.31	0.41	0.35	0.38	**0.89**									
6. SNS	0.64	0.56	0.45	0.51	0.38	**0.84**								
7. CRD	0.62	0.56	0.48	0.62	0.38	0.69	**0.83**							
8. LRN	0.58	0.51	0.45	0.56	0.41	0.68	0.69	**0.91**						
9. INT	0.52	0.53	0.42	0.50	0.39	0.70	0.69	0.65	**0.87**					
10. REC	0.58	0.45	0.47	0.53	0.40	0.71	0.68	0.70	0.69	**0.87**				
11. DYN	0.24	0.39	0.25	0.33	0.26	0.26	0.34	0.36	0.30	0.26	**0.86**			
12. HET	0.22	0.07	0.20	0.10	0.05	0.28	0.16	0.31	0.20	0.35	0.11	**0.85**		
13. HOST	0.09	0.13	0.07	0.06	0.11	0.20	0.11	0.14	0.12	0.18	0.22	0.46	**0.81**	
14. CP	0.47	0.38	0.39	0.28	0.29	0.49	0.45	0.37	0.36	0.49	0.22	0.24	0.26	**0.80**
Mean	4.80	5.01	5.12	5.43	4.10	5.01	5.07	5.08	4.86	4.85	4.38	4.57	3.98	4.77
Standard deviation	1.45	1.53	1.54	1.37	1.06	1.37	1.33	1.36	1.42	1.38	1.44	1.65	1.66	1.54
Composite reliability	0.92	0.90	0.90	0.94	0.92	0.91	0.90	0.95	0.92	0.93	0.85	0.90	0.85	0.94
Cronbach's alpha	0.90	0.87	0.87	0.92	0.87	0.86	0.85	0.93	0.89	0.90	0.72	0.82	0.74	0.93
AVE	0.67	0.65	0.66	0.80	0.80	0.71	0.69	0.82	0.75	0.76	0.74	0.73	0.66	0.64

Note: LC – Loose Coupling; STND – Standardisation; DR – Digital Reach; SCAL – Scalability; GOV – IT Governance Decentralisation; SNS – Sensing; CRD – Coordinating; LRN – Learning; INT – Integrating; REC – Reconfiguring; DYN – Dynamism; HET – Heterogeneity; HOST – Hostility; CP – Competitive Performance

Table 4. Multicollinearity diagnostics and path weights of formative second-order measurements.

Construct	Dimension	Weight	VIF
IT Flexibility			
	Loose Coupling (LC)	0.368***	2.137
	Standardisation (STND)	0.256***	1.686
	Digital Reach (DR)	0.271***	2.393
	Scalability (SCAL)	0.291***	2.628
IT-Enabled Dynamic Capabilities			
	Sensing (SNS)	0.226***	2.938
	Coordinating (CRD)	0.209***	3.075
	Learning (LRN)	0.243***	2.885
	Integrating (INT)	0.218***	2.644
	Reconfiguring (REC)	0.244***	3.086

*** Significant at 0.001 (two-tailed), ** Significant at 0.01 (two-tailed), * Significant at 0.05 (two-tailed)

performance (H3, β = 0.514, t = 12.316, p < 0.001). The structural model explains 56.9% of variance for IT-enabled dynamic capabilities (R^2 = 0.569) and 29.7% for competitive performance (R^2 = 0.297). These coefficients of determination represent moderate to substantial predictive power (Jr, J. F. Hair et al., 2016). In addition to examining the R^2, the model is evaluated by looking at the effect size f^2. The effect size f^2 allows us to assess an exogenous constructs contribution to an endogenous latent variables R^2. The effect size (f^2) of the relationship between IT architecture flexibility and IT-enabled dynamic capabilities had a value of *0.393*, the moderating effect of IT governance decentralisation *0.165*, and the effect of IT-enabled dynamic capabilities on competitive performance *0.213*. Since all direct values are either above the thresholds of 0.15 and 0.35, we can conclude that they have moderate to high effect sizes. The summarized results of the hypotheses are presented in Table 5.

5.3. Prediction analysis

In addition to examining the R^2 and f^2 respectively, the model was assessed by examining the the Q^2 predictive relevance of exogenous and the effect size q^2 (Woodside, 2013). This indicator measures how well observed values are reproduced by the model and its parameter estimates, verifying as such the model`s predictive validity through sample re-use (Chin, 1998). The technique is a synthesis of cross-validation and function fitting and examines each construct's predictive relevance by omitting selected inner model relationships and computing changes in the criterion estimates (q^2) (J. F. Hair et al., 2012). Values of the Q^2 predictive relevance that are greater than 0 imply that the structural model has predictive relevance, whereas values below 0 are an indication of insufficient predictive relevance (Jr, J. F. Hair et al., 2016). We find that IT-enabled dynamic capabilities (Q^2 = 0.289), and competitive performance (Q^2 = 0.221) have satisfactory predictive relevance (Jr, J. F. Hair et al., 2016). In addition, q^2 value range from moderate to high revealing (above 0.15 and 0.35 respectively) adequate effect size of predictive relevance.

A test of composite-based Standardised Root Mean Square Residual (SRMR) was performed to examine model fit. The SRMR value is obtained through the difference between the observed correlation, and the

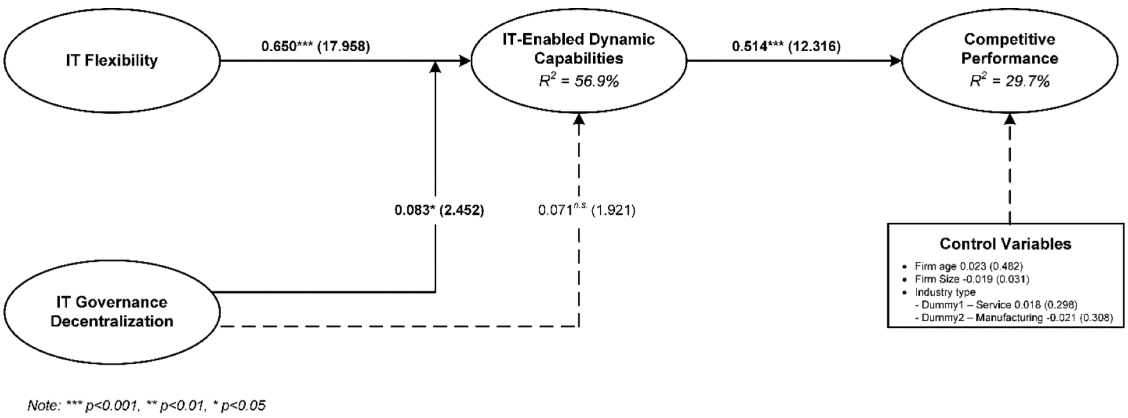

Figure 2. Estimated relationships of structural model.

Table 5. Summary of hypotheses and results.

Structural path	Effect	t-value [a]	Bias corrected 95% confidence interval	Conclusion
FLX → ITDC	0.650	17.958***	[0.574–0.713]	H1 Supported
GOV x FLX → ITDC	0.081	2.293*	[0.057–0.098]	H2 Supported (Moderation)
GOV → ITDC	0.071	1.921	[0.045–0.085]	
ITDC → CP	0.066	1.391	[−0.052–0.148]	H3 Supported

[a]* significant at p < 0.05; ** significant at p < 0.01; *** significant at p < 0.001 (two-tailed test)

model implied correlation matrix. The current SRMR yields a value of 0.062, which is below the threshold of 0.08 thus confirming the overall fit of the PLS path model (Henseler et al., 2016). To further establish the predictive validity of the model, this study employs cross-validation with holdout samples (J. F. Hair et al., 2012; Woodside, 2016). Following the guidelines of Carrión et al. (2016), the sample is randomly divided into a training sample (n = 212) and a holdout sample (n = 110). The training sample is initially used to calculate the path weights and coefficients. Then, the holdout sample observations are normalised, and construct scores are created using the training sample estimations. The next step was to normalise the construct scores of the holdout sample and then use them to create prediction scores. The results confirm the predictive validity of the model since the R^2 for the holdout sample (R^2 = 0.284) is close to that of the training sample (R^2 = 0.299) for the dependent variable competitive performance. Even though model fit assessment criteria are not a prerequisite, researchers have called for the development of evaluation criteria that can better support the prediction-oriented nature of PLS-SEM (Sarstedt et al., 2014).

5.4. Unobserved heterogeneity and subgroup analysis

To test Hypotheses 4–6, we employ the finite mixture partial least squares (FIMIX-PLS) algorithm (Sarstedt & Ringle, 2010). The FIMIX-PLS algorithm can detect whether there are factors that are not included in our analysis which might explain differences across various groups of firms. An a priori subgroup analysis might not provide the most appropriate segmentation method due to heterogeneity being unobservable, making it difficult to separate observations into subpopulations (i.e., the process of creating subgroups by pre-specifying subgroup sizes might not distinguish suitably different levels of uncertainty within an environment). While observable characteristics are often inadequate in capturing heterogeneity in data, ignoring heterogeneity can lead to biased parameter estimates and potentially flawed conclusions (Wilden & Gudergan, 2015). Hence, we apply FIMIX-PLS, which can provide more fine-grained results, while accounting for unobserved heterogeneity. For segmentation tasks in the PLS context, FIMIX-PLS represents the primary choice, since as a response-based segmentation approach, it facilitates the effective identification of subgroups and can classify data of the inner path models estimates on the basis of heterogeneity (Sarstedt & Ringle, 2010). As such, FIMIX-PLS combines the advantages of PLS path modelling with the strengths of classifying groups by finite mixture models.

We follow the unobserved heterogeneity detection method to define segments as proposed by Becker et al. (2013). We start by applying the FIMIX-PLS algorithm to narrow the range of statistically well-fitting segments. The FIMIX-PLS algorithm was executed 10 times for g = 2–5 segments, using the Akaike Information Criterion (AIC), Modified AIC with Factor 3 (AIC3), Bayesian Information Criterion (BIC), Consistent AIC (CAIC), Hannan-Quinn Criterion (HQ), and the normed Entropy Statistic (EN) as indicators to identify the appropriate segmentation solution (Sharma & Kim, 2012; Sarstedt, Ringle, & Gudergan, 2016). According to Sarstedt et. al. (2016), the appropriate number of segments depends on a joint evaluation of the CAIC and AIC_3 indicators. These indicators, as presented in Table 6, indicate that the two-segment solution is the most appropriate. In addition, we did not consider solutions with more than the three segments, since segment sizes become increasingly fragmented (smallest subgroup size attains levels of less than 2%) which are likely to be irrelevant to theory and practice. These small subgroups are relatively less important for deriving managerial implications and are presumably caused by outliers. In the two-subgroup solution, each case exhibits a probability of membership in either subgroup, resulting in a larger group with $\pi_1 = 0.62$ and a smaller one with $\pi_2 = 0.38$.

Next, we assigned each case to either subgroup 1 or subgroup 2, according to its probability of group membership, and analysed both subgroups by applying the multi-group analysis partial least square (MGA-PLS) algorithm. We do so in order to identify if segments differentiate by assessing the measurement invariance/equivalence, and the significance of differences in path coefficients between segments. For both subgroups, measurement model criteria were established, as in the global model. The results of the multi-

Table 6. FIMIX-PLS evaluation criteria.

							Relative segment sizes Π_G				
S	AIC	AIC_3	BIC	CAIC	HQ	EN	$g = 1$	$g = 2$	$g = 3$	$g = 4$	$g = 5$
$s = 2$	2455.63	2437.63	2568.17	2566.17	2516.52	0.497	0.62	0.38			
$s = 3$	2632.57	2674.57	2796.19	2813.19	2688.54	0.562	0.54	0.31	0.15		
$s = 4$	2546.21	2588.21	2635.27	2768.27	2594.39	0.601	0.50	0.24	0.16	0.10	
$s = 5$	2496.38	2522.38	2689.79	2754.79	2591.42	0.783	0.57	0.20	0.11	0.11	0.02

AIC: Akaike Information Criterion; AIC_3: Modified AIC with Factor 3; BIC: Bayesian Information Criterion; CAIC: Consistent AIC; HQ: Hannan-Quinn Criterion; EN: Entropy Statistic.

group analysis and the significance of the differences between the two subgroups paths and coefficients of determination are reported in Table 7. IT flexibility exerted a stronger impact on IT-enabled dynamic capabilities in subgroup 1 (β = 0.777, t = 35.103, p < 0.001) than in subgroup 2 (β = 0.539, t = 9.511, p < 0.001). Significant differences also appeared in the moderating impact of IT governance decentralisation on the relationship between IT flexibility and IT-enabled dynamic capabilities. In subgroup 1 the positive influence of IT governance decentralisation was strengthened (β = 0.117, t = 2.934, p < 0.001) whereas in subgroup 2 it was rendered as non-significant (β = 0.041, t = 0.664, p > 0.05). Finally, concerning the effect of IT-enabled dynamic capabilities on competitive performance, we find that subgroup 1 demonstrated a greater (β = 0.514, t = 14.332, p < 0.001), and statistically significant difference, compared to subgroup 2 (β = 0.422, t = 10.617, p < 0.001).

The two sub-group solutions resulting from FIMIX-PLS provided a better fit than the global model, particularly for explaining a firm's IT-enabled dynamic capabilities and competitive performance. The final step of the unobserved heterogeneity detection method is to turn unobserved heterogeneity into observed heterogeneity by making segments accessible (Becker et al., 2013). We used multiple statistical techniques to assess the theoretical meaning of the segments in relation to environmental uncertainty variables. First, we tested a binary logistic regression model using the membership values (1 – subgroup1, 0 – subgroup2) as the dependent variable, and dynamism, heterogeneity, and hostility as the independent variables. The results demonstrate that the subgroups can be separated meaningfully on the basis of environmental heterogeneity (p < 0.001), since the other environmental factors are found to be non-significant, and the classification corresponded to 69.5% of the FIMIX-PLS segregation. The Hosmer and Lemeshow test further confirmed our model. Finally, the Wald criterion suggested that only environmental heterogeneity contributed significantly to accurate FIMIX-PLS segment allocations (p = 0.01) since dynamism and hostility were not significant predictors. To validate these results, we also performed a discriminant analysis in which both groups are found to have equal variance (Box's M = 13.307 p > 0.01), and environmental heterogeneity (p < 0.05) is noted as the only significant contributor to the FIMIX classification. Furthermore, standardised canonical discriminant functions coefficients and structure matrix indicate heterogeneity as the highest predictor of group membership.

6. Discussion

The aim of this study was to examine how modularity of the IT function, captured through the interplay of IT flexibility and IT governance decentralisation, positively influences the emergence of IT-enabled dynamic capabilities, and in turn leads to competitive performance gains. Our theoretical argumentation and corresponding hypotheses suggest that increasing modularity of the IT function, and the enhanced effect that this has on the emergence of IT-enabled capabilities, will be of increased value under uncertain external conditions. To gauge the influence that the environment may have on such choices, we distinguish between three types of external conditions: dynamism, heterogeneity, and hostility. Building on

Table 7. Global model and MGA-PLS results for two subgroups.

		FIMIX				
	Global	S_1 High environmental heterogeneity (n = 200)	S_2 Low environmental heterogeneity (n = 122)	Path Coefficients Diff. (S_1-S_2)	Welch-Satterthwait Test Diff.	Parametric Test Diff.
IT Flexibility → IT-Enabled Dynamic Capabilities	0.650***	0.777***	0.539***	0.238	Sig. ***	Sig. ***
IT Flexibility x IT Governance Decentralisation → IT-Enabled Dynamic Capabilities	0.083*	0.117**	0.041	0.076	Sig. **	Sig. **
IT Governance Decentralisation → IT-Enabled Dynamic Capabilities	0.071	0.079*	0.063	0.016	n. sig.	n. sig.
IT-Enabled Dynamic Capabilities → Competitive Performance	0.514***	0.597***	0.422***	0.175	Sig. ***	Sig. ***
Age → Competitive Performance	0.023	0.064	0.002	0.062	n. sig.	n. sig.
Size → Competitive Performance	−0.019	−0.034	−0.009	0.025	n. sig.	n. sig.
Industry_Service → Competitive Performance	0.018	0.032	−0.011	0.043	n. sig.	n. sig.
Industry_Manufacturing → Competitive Performance	−0.021	−0.045	0.012	−0.057	n. sig.	n. sig.
R^2 (IT-Enabled Dynamic Capabilities)	0.569	0.830	0.341	0.489	Sig. ***	Sig. ***
R^2 (Competitive Performance)	0.297	0.384	0.214	0.170	Sig. ***	Sig. ***

Diff. = Significance of the path difference for the multi-group analysis
*** p < 0.001, ** p < 0.01, * p < 0.05

a sample of 322 high -level executives and by employing PLS-SEM analyses on our sample, our results include the following findings.

First, we find empirical support for the claim that flexible IT infrastructures facilitate the emergence of IT-enabled dynamic capabilities, thus, confirming H1. This finding essentially means that departing from monolithic architectures and transitioning to IT infrastructures that follow the principles of loose coupling, standardisation, digital reach, and scalability, allows organisations to construct IT-based capabilities that are critical for competitive survival. This finding is important as more and more companies are using IT as a means of supporting some of their key activities. For instance, the rise of big data and business analytics means that sensing external signals of change, such as shifting customer preferences, detecting trends, or ascertaining opinions of individuals is becoming ever more dependent on IT solutions. Therefore, the IT architecture upon which these solutions are developed is important to be able to launch digital solutions to support key activities. The idea of IT as the platform upon which digital solutions are developed has been a recurrent theme in the literature (Sambamurthy et al., 2003). Our findings show that increasing flexibility of the IT infrastructure can facilitate the emergence of IT-enabled dynamic capabilities which, as we empirically demonstrate, are a prerequisite for competitive survival (Helfat et al., 2009).

Second, we find empirical support for the hypothesis that decentralising IT governance will amplify the positive relationship between IT flexibility and IT-enabled dynamic capabilities, confirming H2. This indicates that moving decision rights to line function units will enable them to generate more value out of the flexible IT architectures by facilitating the creation of strong IT-enabled dynamic capabilities. Decentralising the IT governance allows firms to be better positioned towards changes of the external environment by enhancing the ability to develop sensing, integrating, learning, coordinating and reconfiguring IT-enabled capabilities. Prior studies have shown that IT governance decentralisation allows for better responsiveness to internal demands when coupled with a flexible IT architecture (Tiwana & Konsynski, 2010). Nevertheless, to date little is known regarding the impact that opting for such governance modes has on repositioning the firm in the external environment. This is a particularly important issue as IT-based capabilities have become increasingly more central in core activities of organisations. Thus, a decentralised IT governance can allow firms to leverage their existing flexible IT infrastructures more efficiently and contribute to strategic objectives.

Third, our findings indicate that IT-enabled dynamic capabilities have a positive and significant effect on a firm's competitive performance, confirming H3. This outcome highlights the importance of digitally enabling the underlying processes that jointly comprise dynamic capabilities, and also show that the strategic use of IT can lead to significant performance gains. An important implication of this positive association is that IT can be embedded in the core capabilities that facilitate competitive survival in the market, and thus be the driver of change and evolution (A. Bharadwaj et al., 2013). While past empirical studies have shown that IT can be leveraged to reconfigure some of the core capabilities required to attain performance gains (Drnevich & Kriauciunas, 2011; Kim et al., 2011), they did not examine the effect of the ability to sense for emerging threats and opportunities and seize them by means of IT-based capabilities. An ability, for instance, to reconfigure value propositions through IT without the capacity to sense, can mean that the firm misses critical ques to adapt to changes in the external environment (Overby et al., 2006).

Fourth, we conducted a careful analysis of the potential effect of different environmental conditions on the previous hypotheses. Our results indicate that flexible IT architectures coupled with decentralised IT governance contribute more substantially to the emergence of IT-enabled dynamic capabilities under conditions of high complexity. In turn, IT-enabled dynamic capabilities have amplified effects on the attainment of competitive performance in such conditions. These results highlight the conditions under which modular designs of the IT functions, as well as the emergent IT-enabled dynamic capabilities can generate more value. Specifically, in conditions of increased heterogeneity, there is typically a higher information processing load, as firms must manage to identify, acquire, and respond to external signals of various sources, and reposition their offerings accordingly.

Our findings highlight that modular designs of the IT function can enable firms to develop such strategically important digitally based capabilities. While other studies have documented the positive effects of developing flexible IT architectures and IT governance decentralisation (Kim et al., 2011; Liu et al., 2013; Tiwana & Konsynski, 2010), our study is one of the first to show that these principles are particularly relevant in complex and heterogeneous environments. It also shows that under conditions where firms must pursue multiple goals and effectively manage a diverse market, IT governance decentralisation allows localised units to take ownership of their IT initiatives more effectively. This contrasts with the idea of having a centralised IT function that is responsible for delivering IT solutions, and highlights that in such circumstances, where quick and accurate positioning of IT solutions is key, a decentralised structure generates greater value.

Also, while there is a well-established link of dynamic capabilities with performance in dynamic environments (Fainshmidt et al., 2016), our findings show that IT-enabled dynamic capabilities are of heightened relevance in heterogeneous environments. This illustrates the strengths of IT-specific dynamic capabilities in contrast with other types, such as managerial dynamic capabilities, for instance. Therefore, the core strength of IT-enabled dynamic capabilities is in being able make sense out of large amounts of data, and suggesting, or even undertaking, specific courses of action. Furthermore, the ability to facilitate codification, exchange, and integration of knowledge of physically dispersed units in a flexible manner is one of the key strengths of IT-enabled dynamic capabilities, particularly in environments that are information-complex.

6.1. Research implications

In terms of theoretical contribution, this work is positioned at *Level 2: Modification*, of the taxonomy of theory borrowing in IS, as described in the work of Jiang et al. (2016). This is because it incrementally modifies constructs of the theory of dynamic capabilities applied in a specific context (IS) and incorporates multiple environmental factors as moderators. Specifically, in this study we showed that characteristics of a firm's IT architecture play an important role on how they are leveraged strategically. Effectively, the hypothesised association, which places IT flexibility as a facilitator of IT-enabled dynamic capabilities, builds on theoretical underpinnings presented in modular systems theory (Schilling, 2000), as well as on structural antecedents discussed in the dynamic capabilities view (Augier & Teece, 2006; Teece, 2007; De Waard et al., 2012). The main argument in these theories is that moving towards modular forms increases the possible combinations of outcomes, while simultaneously enhancing flexibility in adaptations. With regard to IT resources, our hypothesis suggests that flexible IT architectures provide the necessary platform on which digital options can be enacted (Sambamurthy et al., 2003; Tafti et al., 2013). Although IT architecture flexibility has been extensively researched in past studies (Kim et al., 2011), the mechanisms and capabilities through which its value is harnessed have remained underexplored. In this study, and through our hypothesising, we elucidate the value generating mechanisms through which flexible IT infrastructures can be leveraged.

Second, outcomes highlight the virtuous cycles of modularity that develop between IT architecture and IT governance structure, since a decentralised IT governance scheme is found to exert complementary effects on flexible IT architectures. This finding is also in accordance with the theoretical suggestion by Teece (2007), who argues that decentralising decision making and providing more local autonomy will allow firms to avoid being blindsided by market and technological developments. The sustainability of dynamic capabilities, according to the author Teece (2007), requires decentralisation, since it brings management closer to new technologies, the customer, and the market. Nevertheless, in the case of IT-based capabilities this can only be achieved with the concurrent existence of flexible IT infrastructures. The local autonomy and responsiveness that a decentralised decision-making structure offers can only be attained when there is no requirement for extensive coordination with other business units over IT applications. Thus, our analysis contributes towards a theoretical extension of the dynamic capabilities view, demonstrating how the principles of modular systems can serve as facilitators of dynamic capabilities.

Third, our study provides new evidence on the IT-enabled capabilities literature by capturing the mechanisms through which IT investments produce competitive performance gains (Kim et al., 2011). In line with the commentary by Kohli and Grover (2008), our findings reveal that IT may not necessarily be the direct antecedent of business value, but rather, dynamic organisational capabilities enabled by IT are more likely to be the primary driver of performance gains. This finding is line with the growing discussion around the importance of enhancing or enabling organisational capabilities by virtue of IT solutions (A. Bharadwaj et al., 2013). We demonstrate this by examining the extent to which firms embed their dynamic capabilities with IT and the effect that this has on producing improvements in organisational performance. Through the effects that are a product of IT-enabled dynamic capabilities, firms are suggested to be in a better position to maintain evolutionary fitness and competitive success.

Fourth, by differentiating between conditions of dynamism, heterogeneity, and hostility, we argue that the value of flexible IT architectures coupled with decentralised IT governance schemes, as well as the effect of IT-enabled dynamic capabilities on performance gains will be more apparent under situations of high environmental uncertainty. This outcome denotes that in complex environments that require processing a large amount of information and maintain better relationships with a broad set of stakeholders, developing strong IT-enabled dynamic capabilities can be seen as a prerequisite. Compared to previous research, our study raises the importance of other external environmental conditions, such as heterogeneity, as a condition under which dynamic capabilities, and specifically IT-enabled dynamic capabilities result in increased competitive performance.

6.2. Practical implications

The results of this study provide several implications for managers. First, our results indicate that IT architecture flexibility plays a fundamental – yet not directly associated with performance – role in realising competitive gains and generating economic payoffs. This underscores the importance of investing in flexible IT architecture and considering the diversity of characteristics that comprise them since they facilitate rapid repositioning of firms' when the need or opportunity arises. Nevertheless, the main premise of investing in flexible IT architectures is that they are used to digitise processes and are designed in modular form. Managers should see the use of information technology as a dynamic, ongoing process, in which flexibility is imperative. If the need for such frequent adaptations is low and the complexity of operations is minimal, such investments are less likely to contribute to business value.

Second, the decision to invest in flexible IT architectures and select decentralised IT governance schemes should be interdependent. The benefits of decentralised IT governance can only be realised when it is in alignment with the organisational IT architecture. Careful consideration of the external environment can ensure that there is a correspondence between IT architecture and IT governance design choices, resulting in alignment with business objectives. If local authority from decentralised business units cannot be exercised through new or adapted IT applications as the need or opportunity requires, then a decentralised IT governance may prove to be more of a hindrance than an enabler of business value.

Third, our findings demonstrate that in the case of high environmental heterogeneity, IT flexibility and IT governance decentralisation are of heightened importance. In such conditions, flexible IT architectures and decentralised IT governance can allow firms to be more responsive. Business units can work more independently and develop IT-based initiatives that better serve their functional needs. The value of resulting IT-enabled dynamic capabilities is also enhanced in such circumstances, as these conditions necessitate mean that they are more likely to be utilised. In conditions of low heterogeneity, on the other hand, the impact of IT-enabled dynamic capabilities is considerably lower. Therefore, managers should carefully assess the tradeoffs between the value of IT-enabled dynamic capabilities and the cost of developing them, depending on the complexity of the environment in which they operate.

6.3. Limitations and future research directions

Despite its contributions, the present study is constrained by a number of limitations that future research should seek to address. First, as noted already, self-reported data are used to test hypotheses and propositions. Although considerable efforts are undertaken to ensure data quality, the potential of biases cannot be excluded. The perceptual nature of the data, in combination with the use of a single key informant, could mean that there is bias, and that factual data do not coincide with respondents' perceptions. Although this study relies on top management respondents as key informants, sampling multiple respondents within a single firm would be useful to check for inter-rater validity and to improve internal validity.

Second, the conceptualisation and measurement of IT-enabled dynamic capabilities as a higher order construct comprising of five dimensions is derived by theoretical suggestions. Therefore, the underlying IT-based routines cannot be considered exhaustive, but merely representative core areas of focus. Future work can be directed towards novel areas of interest, such as that of IT-enabled information generating capabilities; meaning the opportunities facilitated by unstructured data processing, and the knowledge that can be extracted through the focused use of IT. A highly prominent area in this area is the domain of big data and business analytics. Our study considers the effect of IT-enabled dynamic capabilities at an aggregate level; that is, through a higher-order construct comprising of five underlying dimensions. By measuring IT-enabled dynamic capabilities in such a way, the interrelationships that govern the capabilities are hidden. In considering the cost incurred in developing each dimension of IT-enabled dynamic capabilities, future research could also investigate the balance between cost and effectiveness and prioritise their importance based on the internal and external business context.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix A. Survey Instrument.

	Mean	S.D.
IT Flexibility		
To what extent do you agree with the following statements? (1 – totally disagree 7 – totally agree)		
- Loose Coupling		
Our information systems are highly modular	5.11	1.34
The manner in which the components of our information systems are organised and integrated allows for rapid changes	4.80	1.39
Functionality can be quickly added to critical applications based on end-user requests	4.78	1.50
Exchanging or modifying single components does not affect our IT infrastructure	4.89	1.56
Organisational IT infrastructure and applications are developed on the basis of minimal unnecessary interdependencies	4.65	1.45
Organisational IT infrastructure and applications are loosely coupled	4.59	1.50
- Standardisation		
We have established corporate rules and standards for hardware and operating systems to ensure platform compatibility	5.27	1.51
We have identified and standardised data to be shared across systems and business units	5.09	1.45
Our systems are developed in order to incorporate electronic links to external parties	4.78	1.69
Organisational IT infrastructure and applications are highly interoperable	5.29	1.50
Organisational IT applications are developed based on compliance guidelines.	5.16	1.58
- Digital Reach		
Remote users can seamlessly access centralised data and processes	5.45	1.52
Our user interfaces provide transparent access to all platforms and applications	5.25	1.49
Software applications can be easily transported and used across multiple platforms	4.71	1.58
Data of one system can be easily used in other systems	4.77	1.56
Our firm offers multiple interfaces or entry points (e.g., web access) to external users.	4.89	1.49
- Scalability		
Our IT infrastructure easily compensates peaks in transaction volumes	5.31	1.40
Our information systems are scalable	5.57	1.31
Our IT infrastructure offers sufficient capacity in order to fulfill additional orders	5.59	1.31
The performance of our IT infrastructure completely fulfils our business needs regardless of usage magnitude	5.25	1.46
IT Governance Decentralisation		
Please assess the degree to which decision-making rights of the following IT-related services reside primarily in a centralised corporate IT group or are decentralised amongst lines of business (1 – Centralised in corporate IT group 5 – Decentralised in lines of business)		
Infrastructure planning and management	3.99	1.02
Application development, project prioritisation and approval	4.14	1.07
IT development and implementation	4.17	1.09
IT-Enabled Dynamic Capabilities		
Please indicate how effective your company is in using IT systems for the following purposes: (1-Not effective at all, 7-Highly effective)		
- Sensing		
Scanning the environment and identifying new business opportunities	4.88	1.51
Reviewing our product development efforts to ensure they are in line with what the customers want	5.06	1.36
Implementing ideas for new products and improving existing products or services	5.29	1.32
Anticipating discontinuities arising in our business domain by developing greater reactive and proactive strength	4.82	1.32
- Coordinating		
Providing more effective coordination among different functional activities	5.12	1.35
Providing more effective coordination with customers, business partners and distributors	5.24	1.20
Ensuring that the output of work is synchronised with the work of other functional units or business partners	5.03	1.30
Reducing redundant tasks, or overlapping activities performed by different operational units	4.90	1.48
- Learning		
Identify, evaluate, and import new information and knowledge	5.14	1.40
Transform existing information into new knowledge	5.01	1.34
Assimilate new information and knowledge	5.09	1.38
Use accumulated information and knowledge to assist decision making	5.08	1.35
- Integrating		
Easily accessing data and other valuable resources in real time from business partners	4.92	1.43
Aggregating relevant information from business partners, suppliers and customers. (e.g., operating information, business customer performance)	4.99	1.37
Collaborating in demand forecasting and planning between our firm and our business partners	4.68	1.49
Streamlining business processes with suppliers, distributors, and customers	4.87	1.40
- Reconfiguring		
Adjusting for and responding to unexpected changes easily	4.82	1.37
Easily adding an eligible new partner that you want to do business with, or removing ones which you have terminated your partnership	4.95	1.41
Adjusting our business processes in response to shifts in our business priorities	4.91	1.33
Reconfiguring our business processes in order to come up with new productive assets	4.74	1.40
Environmental Uncertainty		
- Dynamism		
With respect to the uncertainty of your environment, please indicate how much you agree or disagree with the following statements: (1 – totally disagree 7 – totally agree)		
Products and services in our industry become obsolete very quickly	4.51	1.73
The product/services technologies in our industry change very quickly	4.69	1.72
We can predict what our competitors are going to do next (Reverse coded)	4.33	1.22
We can predict when our products/services demand changes (Reverse coded)	4.02	1.11
- Heterogeneity		
With respect to the uncertainty of your environment, please indicate how much you agree or disagree with the following statements: (1 – totally disagree 7 – totally agree)		
In our industry, there is considerable diversity in:		
Customer buying habits	4.54	1.67
Nature of competition	4.62	1.64
Product lines	4.57	1.64
- Hostility		

(*Continued*)

Appendix A. (Continued).

	Mean	S.D.
With respect to the uncertainty of your environment, please indicate how much you agree or disagree with the following statements: (1 – totally disagree 7 – totally agree)		
The survival of this organisation is currently threatened by:		
Scarce supply of labour	3.31	1.83
Scarce supply of materials	2.49	1.62
Tough price competition	4.71	1.72
Tough competition in product/service quality	4.67	1.55
Tough competition in product/service differentiation	4.72	1.61
Competitive Performance		
Compared with your key competitors, please indicate how much you agree or disagree with the following statements regarding the degree to which you perform better than them: (1 – totally disagree 7 – totally agree)		
Return on investment (ROI)	4.60	1.43
Profits as percentage of sales	4.57	1.40
Decreasing product or service delivery cycle time	4.57	1.51
Rapid response to market demand	4.77	1.65
Rapid confirmation of customer orders	4.87	1.58
Increasing customer satisfaction	5.07	1.58
In profit growth rates	4.54	1.48
In reducing operating costs	4.65	1.59
Providing better product and service quality	5.09	1.65
Increasing our market share	4.98	1.58

Appendix B. Measurement model statistics.

	LC	STND	DR	SCAL	GOV	SNS	CRD	LRN	INT	REC	DYN	HET	HOST	CP
LC_1	**0.86**	0.43	0.58	0.64	0.37	0.60	0.58	0.57	0.46	0.54	0.21	0.06	−0.01	0.38
LC_2	**0.85**	0.33	0.48	0.54	0.24	0.58	0.61	0.55	0.49	0.53	0.18	0.18	0.05	0.38
LC_3	**0.78**	0.32	0.50	0.54	0.23	0.54	0.53	0.52	0.44	0.48	0.24	0.29	0.10	0.36
LC_4	**0.83**	0.39	0.66	0.56	0.28	0.49	0.49	0.40	0.33	0.49	0.33	0.19	0.14	0.48
LC_5	**0.82**	0.44	0.56	0.52	0.24	0.53	0.48	0.47	0.43	0.50	0.23	0.21	0.13	0.47
LC_6	**0.77**	0.32	0.56	0.42	0.16	0.44	0.33	0.42	0.29	0.31	0.24	0.23	0.03	0.32
STND_1	0.39	**0.83**	0.44	0.60	0.41	0.46	0.49	0.43	0.41	0.40	0.21	−0.01	0.06	0.32
STND_2	0.45	**0.81**	0.42	0.53	0.30	0.48	0.46	0.50	0.44	0.39	0.29	0.16	0.04	0.33
STND_3	0.35	**0.75**	0.41	0.39	0.25	0.55	0.47	0.40	0.45	0.36	0.21	0.10	0.14	0.32
STND_4	0.30	**0.88**	0.40	0.48	0.35	0.31	0.37	0.32	0.38	0.27	0.28	−0.04	0.08	0.30
STND_5	0.35	**0.86**	0.45	0.51	0.32	0.35	0.42	0.35	0.45	0.34	0.23	−0.01	0.05	0.34
DR_1	0.53	0.39	**0.80**	0.55	0.38	0.29	0.31	0.34	0.20	0.33	0.24	0.05	−0.02	0.31
DR_2	0.56	0.46	**0.87**	0.66	0.35	0.35	0.43	0.40	0.35	0.37	0.25	0.10	0.03	0.27
DR_3	0.61	0.45	**0.84**	0.54	0.25	0.43	0.45	0.39	0.40	0.39	0.26	0.18	0.11	0.35
DR_4	0.60	0.37	**0.78**	0.58	0.20	0.42	0.38	0.38	0.34	0.40	0.23	0.28	0.01	0.23
DR_5	0.46	0.46	**0.76**	0.47	0.29	0.42	0.35	0.30	0.34	0.42	0.14	0.13	0.09	0.41
SCAL_1	0.52	0.54	0.60	**0.88**	0.35	0.49	0.52	0.49	0.46	0.48	0.21	0.10	0.04	0.28
SCAL_2	0.63	0.55	0.67	**0.93**	0.37	0.52	0.56	0.52	0.46	0.53	0.22	0.07	0.06	0.32
SCAL_3	0.55	0.55	0.62	**0.93**	0.38	0.43	0.56	0.53	0.40	0.44	0.28	0.08	0.04	0.24
SCAL_4	0.65	0.60	0.61	**0.84**	0.29	0.45	0.62	0.56	0.48	0.44	0.19	0.03	−0.01	0.28
GOV_1	0.26	0.38	0.33	0.39	**0.86**	0.29	0.35	0.36	0.31	0.32	0.23	−0.05	0.09	0.21
GOV_2	0.30	0.31	0.33	0.32	**0.92**	0.40	0.37	0.37	0.40	0.40	0.27	0.08	0.09	0.31
GOV_3	0.28	0.40	0.31	0.35	**0.90**	0.35	0.34	0.36	0.32	0.33	0.26	0.00	0.09	0.23
SNS_1	0.46	0.42	0.35	0.36	0.28	**0.83**	0.56	0.54	0.58	0.59	0.28	0.24	0.19	0.40
SNS_2	0.48	0.46	0.36	0.39	0.43	**0.84**	0.57	0.61	0.67	0.61	0.25	0.18	0.21	0.41
SNS_3	0.63	0.45	0.43	0.53	0.32	**0.84**	0.68	0.63	0.60	0.61	0.23	0.22	0.19	0.46
SNS_4	0.61	0.45	0.44	0.50	0.30	**0.86**	0.65	0.60	0.64	0.68	0.32	0.28	0.19	0.43
CRD_1	0.55	0.46	0.45	0.62	0.37	0.63	**0.88**	0.64	0.55	0.61	0.29	0.12	0.08	0.39
CRD_2	0.44	0.39	0.39	0.49	0.25	0.60	**0.82**	0.59	0.60	0.53	0.27	0.13	0.06	0.30
CRD_3	0.52	0.52	0.37	0.52	0.39	0.59	**0.83**	0.59	0.56	0.58	0.30	0.15	0.13	0.39
CRD_4	0.53	0.43	0.37	0.47	0.29	0.60	**0.79**	0.53	0.57	0.60	0.20	0.14	0.21	0.43
LRN_1	0.53	0.46	0.45	0.53	0.37	0.67	0.62	**0.90**	0.60	0.66	0.35	0.28	0.16	0.37
LRN_2	0.54	0.44	0.39	0.53	0.36	0.62	0.63	**0.93**	0.58	0.68	0.34	0.27	0.16	0.32
LRN_3	0.59	0.45	0.41	0.55	0.35	0.65	0.68	**0.93**	0.56	0.65	0.33	0.29	0.16	0.33
LRN_4	0.50	0.45	0.37	0.51	0.39	0.62	0.64	**0.86**	0.60	0.67	0.25	0.25	0.08	0.35
INT_1	0.53	0.42	0.47	0.51	0.39	0.67	0.63	0.59	**0.85**	0.63	0.33	0.12	0.11	0.35
INT_2	0.49	0.50	0.39	0.44	0.33	0.68	0.60	0.58	**0.90**	0.63	0.24	0.16	0.12	0.36
INT_3	0.34	0.46	0.24	0.37	0.32	0.62	0.54	0.52	**0.87**	0.59	0.38	0.25	0.18	0.26
INT_4	0.36	0.44	0.29	0.42	0.30	0.59	0.62	0.54	**0.85**	0.55	0.23	0.16	0.16	0.33
REC_1	0.56	0.35	0.41	0.52	0.35	0.58	0.62	0.60	0.58	**0.85**	0.32	0.30	0.18	0.41
REC_2	0.43	0.33	0.38	0.41	0.33	0.61	0.57	0.60	0.55	**0.84**	0.22	0.22	0.20	0.39
REC_3	0.46	0.37	0.35	0.40	0.30	0.64	0.62	0.65	0.64	**0.91**	0.28	0.33	0.14	0.46
REC_4	0.58	0.47	0.50	0.53	0.39	0.74	0.64	0.71	0.66	**0.91**	0.37	0.34	0.18	0.47
DYN_1	0.18	0.15	0.17	0.14	0.23	0.22	0.18	0.21	0.26	0.28	**0.84**	0.36	0.36	0.09
DYN_2	0.27	0.20	0.23	0.16	0.18	0.26	0.24	0.27	0.25	0.26	**0.89**	0.44	0.42	0.16
DYN_3	0.14	0.34	0.16	0.22	0.14	0.20	0.27	0.27	0.25	0.21	**0.71**	0.04	0.09	0.21
DYN_4	0.22	0.35	0.27	0.31	0.29	0.24	0.33	0.34	0.27	0.23	**0.73**	0.13	0.20	0.18
HET_1	0.12	0.01	0.13	0.04	0.04	0.23	0.14	0.29	0.19	0.31	0.35	**0.84**	0.42	0.17
HET_2	0.29	0.07	0.26	0.14	0.00	0.28	0.16	0.29	0.18	0.32	0.36	**0.86**	0.42	0.23
HET_3	0.18	0.05	0.07	0.02	0.00	0.20	0.12	0.19	0.14	0.24	0.35	**0.86**	0.46	0.12
HOST_1	−0.10	−0.15	−0.08	−0.11	−0.11	−0.02	0.02	−0.09	−0.01	0.00	0.10	0.18	0.43	0.08
HOST_2	0.15	0.02	0.05	0.07	0.10	0.25	0.23	0.23	0.25	0.23	0.11	0.30	0.49	0.19
HOST_3	0.00	0.11	0.07	0.03	0.16	0.14	0.04	0.13	0.05	0.08	0.29	0.33	**0.72**	0.12
HOST_4	0.09	0.11	0.04	0.05	0.05	0.19	0.11	0.11	0.14	0.16	0.48	0.39	**0.84**	0.24
HOST_5	0.10	0.09	0.06	0.04	0.09	0.17	0.10	0.11	0.10	0.18	0.31	0.43	**0.80**	0.24
CP_1	0.40	0.29	0.37	0.28	0.24	0.43	0.39	0.23	0.28	0.40	0.17	0.20	0.23	**0.76**
CP_2	0.37	0.31	0.35	0.27	0.25	0.44	0.38	0.30	0.36	0.38	0.14	0.16	0.27	**0.79**
CP_3	0.38	0.22	0.26	0.25	0.27	0.42	0.33	0.32	0.31	0.47	0.14	0.23	0.17	**0.76**
CP_4	0.44	0.33	0.29	0.28	0.26	0.46	0.42	0.36	0.36	0.51	0.15	0.13	0.18	**0.85**
CP_5	0.38	0.23	0.35	0.21	0.20	0.39	0.33	0.29	0.27	0.45	0.17	0.23	0.24	**0.81**
CP_6	0.36	0.36	0.26	0.22	0.20	0.34	0.35	0.31	0.22	0.33	0.17	0.09	0.16	**0.78**
CP_7	0.35	0.35	0.28	0.19	0.12	0.37	0.31	0.25	0.28	0.33	0.07	0.17	0.27	**0.83**
CP_8	0.40	0.37	0.33	0.36	0.19	0.41	0.35	0.35	0.41	0.37	0.07	0.06	0.12	**0.68**
CP_9	0.38	0.36	0.24	0.21	0.27	0.38	0.38	0.31	0.24	0.34	0.20	0.07	0.17	**0.82**
CP_10	0.39	0.30	0.31	0.21	0.26	0.32	0.35	0.30	0.24	0.30	0.24	0.21	0.27	**0.77**

Appendix C. Heterotrait-monotrait ratio (HTMT).

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. LC														
2. STND	0.512													
3. DR	0.713	0.609												
4. SCAL	0.712	0.689	0.776											
5. GOV	0.347	0.466	0.414	0.438										
6. SNS	0.729	0.617	0.542	0.590	0.448									
7. CRD	0.705	0.636	0.555	0.697	0.450	0.841								
8. LRN	0.652	0.555	0.498	0.644	0.452	0.790	0.799							
9. INT	0.550	0.589	0.455	0.553	0.431	0.839	0.792	0.709						
10. REC	0.642	0.490	0.533	0.586	0.441	0.833	0.792	0.801	0.774					
11. DYN	0.382	0.421	0.390	0.386	0.404	0.443	0.493	0.5011	0.483	0.460				
12. HET	0.276	0.133	0.233	0.125	0.073	0.316	0.196	0.344	0.234	0.394	0.477			
13. HOST	0.193	0.201	0.163	0.142	0.212	0.301	0.262	0.242	0.255	0.235	0.603	0.639		
14. CP	0.529	0.433	0.434	0.346	0.312	0.523	0.514	0.422	0.419	0.527	0.295	0.229	0.341	

Note: LC – Loose Coupling; STND – Standardisation; DR – Digital Reach; SCAL – Scalability; GOV – IT Governance Decentralisation; SNS – Sensing; CRD – Coordinating; LRN – Learning; INT – Integrating; REC – Reconfiguring; DYN – Dynamism; HET – Heterogeneity; HOST – Hostility; CP – Competitive Performance