

**Enabling Innovation in the Face of Uncertainty through IT
Ambidexterity: A fuzzy set Qualitative Comparative Analysis
of Industrial Service SMEs**

Ana Ortiz de Guinea

&

Louis Raymond

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Enabling Innovation in the Face of Uncertainty through IT Ambidexterity: A fuzzy set Qualitative Comparative Analysis of Industrial Service SMEs

Abstract

Taking a configurational approach, this paper investigates the causal configurations of IT ambidexterity (i.e., IT capabilities for exploitation and exploration), dynamic capabilities (i.e., innovation and networking capabilities) and environmental uncertainty that are associated to service innovation performance in small and medium-sized enterprises (SMEs). Results from a fuzzy set qualitative comparative analysis (fsQCA) of 63 industrial service SMEs show that these firms attain high service innovation performance with three different configurations under conditions of high uncertainty. Two configurations highlight the importance of IT exploration capabilities (combined with the absence of innovation and networking capabilities in one configuration and with the absence of networking capabilities and IT capabilities for exploitation in another), whereas another configuration accentuates the importance of IT exploitation capabilities (combined with the presence of innovation and networking capabilities). Our study contributes to the literature in multiple ways. For instance, due to the equifinal properties of the configurational approach, our results suggest that SMEs can attain high innovation performance through both sequential and simultaneous IT ambidexterity, thus providing a starting point for reconciling competing views of IT ambidexterity. Other contributions to theory and practice and avenues for future research are also discussed.

Keywords: IT ambidexterity; exploration; exploitation; dynamic capabilities; environmental uncertainty; service innovation; performance; IT capabilities; SME; configuration; equifinality.

1. Introduction

Investments in information technology (IT) capabilities have long been assumed to be essential to the survival and competitive performance of businesses (Ravinchandran & Lertwongsatein, 2005). In fact, more than 80% of business leaders believe IT capabilities to be fundamental to their business model (ComputerScienceSociety, 2012). For example, Canada's private sector invests an average of \$40.6 billion per year in information and communications technology (ICT) (Dhubat, 2015), with the ICT sector accounting for 11.5% of all real gross domestic product (GPD) growth since 2002 (StatisticsCanada). Those numbers make sense when a majority of chief information officers (CIOs) assert that IT capabilities play a key role in enabling change and growth in their businesses (ComputerScienceSociety, 2014-2015).

Reflecting the situation described above, the business value of the firm's IT capabilities has been one of the defining cores of the information systems (IS) discipline in the last 25 years. The 'IT-business value' literature thus focuses on IT capabilities as key enablers of firm performance (A. S. Bharadwaj, 2000; Chae, Koh, & Prybutok, 2014; Chen, Wang, Nevo, Benitez-Amado, & Kou, 2015; Liu, Ke, Wei, & Hua, 2013). Given the fact that firms operate in environments where they often face conflicting demands (i.e., the need for exploitation vs. the need for exploration) (Levinthal & March, 1993), recent IS studies have focused in particular on the concept of IT ambidexterity and its effect on performance-related outcomes (Lee, Sambamurthy, Lim, & Wei, 2015; Mithas & Rust, 2016). IT ambidexterity is defined as the firm's ability to both exploit and explore with IT capabilities (Lee et al., 2015). While exploitation deals with the efficient leverage of existing resources and processes, exploration's objective is to experiment in novel ways so as to discover new business opportunities (March, 1991). Although certain IS researchers have provided evidence for a relation between IT ambidexterity and performance related outcomes (Lee et al., 2015), three main gaps remain in the literature.

First, IT ambidexterity has been conceptualized exclusively as a combined capability (i.e., operationalized using item-level interaction terms of its two dimensions: IT for exploitation and IT for exploration) (e.g., Chi, Zhao, George, Li, & Zhai, 2017; Lee et al., 2015). Likewise, IS studies focusing on other ambidexterity-related concepts (e.g., contextual ambidexterity) have, for the most part, been also operationalized as a combined capability (e.g., Im & Rai, 2008, 2014; Tiwana, 2010) or as a second order construct (with exploitation and exploration as the two sub-dimensions) (e.g., Soto-Acosta, Popa, & Martinez-Conesa, 2018). As a result, calls have been made to further study IT capabilities for exploitation and exploration in terms of their different combinations, their different effect on performance-related outcomes (Lee et al., 2015) as well as the required trade-off between both types of IT capabilities in order to enhance the firm's competitive performance (Pavlou & El Sawy, 2011).

Second, all studies focusing on the concept of IT ambidexterity have been conducted in large enterprises (e.g., Chi et al., 2017; Lee et al., 2015). Likewise, IS studies focusing on other ambidexterity-related constructs have overwhelmingly sampled large firms (e.g., Cao, Mohan, Ramesh, & Sarkar, 2013; Im & Rai, 2008, 2014; Mithas & Rust, 2016) or do not provide information about the size of the sampled firms (e.g., Subramani, 2004). This is worrisome for two reasons. Firstly, conclusions drawn from large enterprises might not be generalizable to small and medium-sized enterprises (SMEs), as prior management studies have demonstrated that differences in organizational size influence performance outcomes (Benito-Osorio, Colino, Guerras-Martín, & Zúñiga-Vicente, 2016; Hong & Oxley, 2016; Hwang, Hwang, & Dong, 2015). Secondly, SMEs are paramount for the economy. In Canada, the context of this study, SMEs encompass 99.7% of all enterprises and employ 90.3 percent of the private sector workforce¹ (Innovation, Science, and Economic Development Canada, 2016). As a result, there

¹ As of December 2015.

have been calls for research both on the strategic management of IT (Street, Gallupe, & Baker, 2017) and on ambidexterity in the specific context of SMEs (Senaratne & Wang, 2018).

Third, research on IT ambidexterity (and other ambidexterity-related constructs) has overlooked the two competing views found in the strategic management literature, that is, ‘simultaneous’ vs. ‘sequential’ ambidexterity. On the one hand, some argue that to achieve performance, firms need to pursue simultaneous ambidexterity, that is, they must pursue both exploitation and exploration concurrently (e.g., Tan & Liu, 2014; Tushman & O’Reilly, 1996). On the other hand, others argue that firms attain performance through sequential ambidexterity, that is, by focusing on either exploitation or exploration at a time (e.g., Duncan, 1976; Mudambi & Swift, 2014). Consequently, these competing views regarding ambidexterity have led to calls for researchers to take a configurational approach that could resolve conflicting results in this regard, as this approach allows for ‘equifinality’ (Fiss, 2011).

To address these three gaps in the IS literature, we study the two dimensions of IT ambidexterity (i.e., IT capabilities for exploitation and IT capabilities for exploration) – along with other strategic constructs – in the specific context of industrial service SMEs, and from a configurational approach. In this context, the firm’s competitiveness in a global economy that has become knowledge-based (instead of product-based) is mostly determined by its innovation performance (Aragón-Sánchez & Sánchez-Marín, 2005), and by its service innovation performance in particular (Barrett, Davidson, Prabhu, & Vargo, 2015). Thus, we focus on service innovation performance as the performance outcome of interest in this study. It is important to note, however, that IT ambidexterity’s enablement of service innovation performance is deemed to be contingent upon the co-existence of certain dynamic capabilities (DCs) and environmental conditions (Lee et al., 2015). Here, two such DCs are deemed to be especially relevant to the service innovation performance of SMEs, namely their innovation capability and their networking capability (Mitrega, Forkmann, Zaefarian, & Henneberg, 2017;

Mu, 2013; Prajogo & Ahmed, 2006), along with their environmental uncertainty (Prajogo & McDermott, 2014). We refer to the interplay of IT ambidexterity (i.e., IT capabilities for exploration and exploitation), DCs (i.e., innovation and networking capabilities), and environmental uncertainty, as the ‘digital ecodynamics’ of industrial service SMEs, following El Sawy et al. (2010). As a result, we look at the different configurations of digital ecodynamics as they affect the service innovation performance of these firms, and we do so from a configurational approach.

As it pertains to our study, the configurational approach differs greatly from the traditional universalistic approach. Whereas the latter aims to establish bivariate relations between each of the digital ecodynamic elements and the performance outcome, the configurational approach involves a systems perspective in which the three elements are viewed in holistic fashion. More precisely, IT ambidexterity, DCs and environmental uncertainty are viewed as the constitutive elements of the different ‘configurations’ that account for the nonlinear complex interplay between these elements as they affect service innovation performance. Furthermore, a configurational approach, as it will be explained later, allows for equifinality, or the possibility that the same outcome could be reached through different paths and from diverse starting positions (Gresov & Dazin, 1997; Meyer, Tsui, & Hinings, 1993). Thus, different configurations of digital ecodynamics could attain the same level of service innovation performance. In addition, another critical characteristic of the configurational approach that differs from the universalistic approach is the notion of causal asymmetry. Causal asymmetry refers to the possibility that the configurations that lead to the presence of service innovation performance might be different from the configurations that lead to the absence of this outcome (Fiss, 2011). Consequently, the two exploratory research questions addressed by this study are as follows:

1. What are the different configurations of digital ecodynamics that equally lead to high service innovation performance in industrial service SMEs?
2. What are the different configurations of digital ecodynamics that equally lead to the absence of high service innovation performance in industrial service SMEs?

Thus, our research objective is to determine the different digital ecodynamic configurations that enable and do not enable industrial service SMEs to attain high service innovation performance from a configurational approach. That is, we seek to uncover the different configurations of IT ambidexterity (i.e., IT capabilities for exploitation and exploration), DCs (i.e., innovative and networking capabilities), and environment uncertainty that equally result in the presence of high service innovation performance, as well as those configurations that equally result in the absence of the same outcome.

The rest of the paper is organized as follows. We first provide the theoretical background of the article where we explain configurational theory, provide definitions for all the constructs included in the study, present the conceptual model, and develop propositions on both types of ambidexterity (i.e., simultaneous and sequential) and on the way in which the three digital ecodynamic elements interrelate in producing service innovation performance. We then describe the survey method employed as well as the measures utilized to capture the different research constructs. We further provide the results of a fuzzy set qualitative comparative analysis (fsQCA) of the survey data and test the developed propositions. Finally, we end the article with a discussion of this study's contributions to research and practice, as well as future opportunities for research.

2. Theoretical Background

2.1. Configurational Theory

Strategic IS studies, like those in the broader strategic management literature, aim to offer an understanding of the reasons why certain firms succeed while others fail (Wilden, Devinney, &

Dowling, 2016). From our research perspective, one seeks to understand the complex ways in which dynamic capabilities, IT ambidexterity, and environmental uncertainty interact and combine in order to influence a given outcome, in our case, service innovation performance. The configurational approach to organizational analysis, proposed herein, stems from ‘open systems’ theory, which puts the emphasis on the complex interactions between the elements of a system in producing an outcome (Meyer et al., 1993).

Despite the complexity inherent to explaining organizational performance outcomes, variance-based approaches (and associated data analysis techniques such as regression and structural equation modeling) remain dominant in strategic management and IS research. While variance approaches are well-suited to investigate changes in outcomes based on predictor variables (Ortiz de Guinea & Webster, 2017), they cannot explain the changes in the system’s elements and the interplay of these elements that lead to a given outcome (Wilden et al., 2016). Furthermore, variance approaches have two main characteristics that prevent them from capturing the inherent complexity associated with explaining organizational performance outcomes. First, variance studies are based on unifinality, that is, on the assumption that a factor or several specific factors lead to a given outcome. In other words, such studies are based on the traditional universalistic or ‘best practices’ approach that assumes that there is only one way (i.e., through the one or multiple factors or determinants identified) to achieve high performance (Delery & Doty, 1996). Second, variance studies employ correlational-based techniques that assume causal symmetry because “correlations are by their very nature symmetric” (Fiss, 2011, p. 394). In our case, if one modeled the inverse of high service innovation performance, the results of a correlational-based analysis would be unchanged except for the sign of the correlation coefficients. The result, as Pappas (2018, p. 1681) puts it, is that “to capture, understand and explain complex phenomena, current approaches of variance-based techniques are not enough”. In fact, the relation between capabilities and performance is viewed as being

“complex” and thus unexplainable by the simple direct effects afforded by the variance approach (Wang & Ahmed, 2007, p. 42; Wilden et al., 2016). In a similar vein, some researchers argue that an organizational outcome of interest rarely results from single causal factors (Woodside, 2013) and thus call for research on organizational capabilities to take a configurational approach (El Sawy et al., 2010; Wilden et al., 2016).

Now, a configuration is a specific combination or bundle of elements (also called conditions) – in our case, IT ambidexterity, DCs, and environmental uncertainty – that together generate an outcome of interest – again in our case, service innovation performance (Rihoux & Ragin, 2009). Thus, configurational theory identifies causal ‘recipes’ that specify the relevant elements that, in combination, produce a particular outcome (El Sawy et al., 2010). Furthermore, the configurational approach, in contrast to the variance approach, allows for equifinality and causal asymmetry.

In terms of equifinality, the configurational approach argues that system elements (in our case, the elements of the firm’s digital ecodynamics) may be combined in multiple and complex ways to produce the chosen performance outcome (Meyer et al., 1993); that is, equifinality, unlike unifinality, allows for different ways of reaching the same outcome. Here, this means that service innovation performance can be equally achieved through different configurations of the firm’s digital ecodynamics (Ragin, 2000). The idea, then, is that from a configurational view, the relationships of individual causal elements with service innovation performance are not seen in terms of correlations but in terms of equally effective patterns or configurations of the elements that form the digital ecodynamics of SMEs (Doty, Glick, & Huber, 1993; Van de Ven & Drazin, 1985). Now, if different configurations of digital ecodynamics are equifinal in leading to high service innovation performance, this also means that a particular element in one configuration must be present for high performance to occur, while in another configuration this same element must instead be absent. That is, the same

element of the SME's digital ecodynamics could enable or inhibit its attainment of high service innovation performance, depending on how it is configured with other elements that form effective configurations.

Causal asymmetry is the possibility that the causes leading to the existence of the outcome of interest will be different than those leading to its absence (Fiss, 2011; Ragin, 2008a). Causal asymmetry is thought to be more aligned with the complex reality of contemporary organizations: "reality usually indicates that any insightful combination of conditions has an asymmetrical relationship with an outcome not a symmetrical" one (Woodside, 2013, p. 2). The notion of causal asymmetry thus allows us to go beyond the traditional linear or interaction theories most often used in strategic IS studies, by shifting the focus towards nonlinear relations among the configurational elements (Doty et al., 1993; Meyer et al., 1993). Thus, the concept of causal asymmetry allows for equifinal configurations to vary depending on performance levels (Fiss, 2011). That is, a specific set of configurations may be associated with average performance, while a different set may lead to high performance, and yet another set of equally configurations may be associated to low performance or to the absence of performance (Fiss, 2011).

2.2. Definition of constructs

We now turn to explaining the research constructs mobilized in this study. We first explain the outcome variable, service innovation performance. We then explain the variables composing the concept of digital ecodynamics: DCs (innovation and networking capabilities), IT ambidexterity (IT for exploitation and IT for exploration), and environmental uncertainty.

2.2.1. Service innovation performance

According to Toivonen and Tuominen (2009, p. 893), and building upon Schumpeterian economics, service innovation can be defined as "a new service or such a renewal of an existing service which is put into practice and which provides benefit to the organization that has

developed it; the benefit usually derives from added value that the renewal provides the customers”. That is, service innovation is seen as a new or modified service that is different from previous offerings (Witell, Snyder, Gustafsson, Fombelle, & Kristensson, 2016). From this definition, one can think of service innovation performance as the realization of economic value derived from service innovation (i.e., either from new services or from the renewal of existing ones).

Service innovation is thus, conceptualized as encompassing both incremental improvements of current offerings (i.e., modified services) and radical innovations (i.e., totally new services) (Andriopoulos & Lewis, 2009; Brem, Maier, & Wimschneider, 2016). This definition therefore covers the two dimensions of innovation usually associated with ambidexterity, that is, incremental and radical innovation. Incremental innovation is related to exploitation activities and takes the form of improvements to current services, whereas radical innovation is related to exploration activities and takes the form of new services creation (Benner & Tushman, 2003; Brem et al., 2016; Cembrero & Sáenz, 2018; Popadiuk, 2012). Incremental innovations are usually realized in a timely manner, are low-risk, help the firm remain competitive in the short term, and deal with modifications or newer versions of established services (Brem et al., 2016). Radical innovations usually take longer to realize, are high-risk, have the potential for high growth, and deal with the development of new services not offered before (Brem et al., 2016).

2.2.2. Dynamic capabilities: innovation capability and networking capability

Dynamic capabilities are the ability of a firm to reconfigure its resources and competences in order to respond to changing environmental conditions (Teece, Peteraf, & Leih, 2016). Two dynamic capabilities, namely innovation capability and networking capability, have been identified in the literature as being paramount for the competitive performance of SMEs in a globalized economy (Marques & Ferreira, 2009; Saunila, 2014; Spriggs, Yu, Deeds, &

Sorenson, 2013) and for their innovation performance in particular (Gronum, Verreyne, & Kastelle, 2012; Prajogo & Ahmed, 2006; Zeng, Xie, & Tam, 2010).

Innovation capability is a dynamic capability (Un, 2002) that refers to the potential to produce innovations (Laforet, 2011; Lawson & Samson, 2001; Neely, Filippini, Forza, Vinelli, & Hii, 2001) in order to add value to a firm (Hogan, Soutar, McColl-Kennedy, & Sweeney, 2011; Szeto, 2000). When a firm develops a strong capacity to innovate, it is able to develop new ideas and eventually transform these into new products, services and processes (Akman & Yilmaz, 2008). More specifically, the innovation capability is composed of reinforcing practices that act as key mechanisms for stimulating innovation (Lawson & Samson, 2001). Such practices can encompass idea generation and management activities (Janssen, Castaldi, & Alexiev, 2016; Lawson & Samson, 2001; Smith, Busi, Ball, & Van der Meer, 2008), learning about the external environment in general (Neely et al., 2001), and learning about customers and competitors in particular (Janssen, Castaldi, & Alexiev, 2016; Lawson & Samson, 2001). As a result, we define the innovation capability of a SME as the extent to which it conducts certain practices, such as idea generation, prefeasibility analysis of ideas, analysis of customers' suggestions and complaints, and analysis of competitors' offerings and economic trends. It is important to note that such definition focuses on the activities that have the potential to generate new knowledge and innovation (Un, 2002) and thus, could eventually be translated into the design and offering of new services or the renewal of existing ones. This makes the innovation capability construct (i.e., activities that have the potential to produce innovations) different from the outcome of interest (i.e., innovation performance as the realization of economic value derived from new or modified services) and thus, avoids a potential 'tautological trap'. As a result, it is possible that firms may have a strong innovation capability (e.g., they may often conduct practices such as idea generation, analysis of economic trends, analysis of customers' suggestions and complaints, etc.) but fail to effectively transform the output of such activities

into new or modified services that provide economic value (Neely et al., 2001). In general, however, research has shown that developing an innovation capability enables SMEs to improve their competitive performance (Keskin, 2006; Marques & Ferreira, 2009; Saunila, 2014; Spriggs et al., 2013), and to attain a higher level of innovation performance in particular (Prajogo & Ahmed, 2006; Verhees & Meulenbergh, 2004).

The firm's networking capability, which is related to its innovation capability (Romijn & Albaladejo, 2002), is defined as its ability to establish and manage collaborations with other firms (Mu, Thomas, Peng, & Di Benedetto, 2017). The organizational innovation literature emphasizes that many innovation activities are realized by firms of all sizes through the use of external networks (Hagedoorn, 2002). In fact, some see innovation as a process resulting from the interactions of different institutions and organizations (Doloreux, 2004). Since SMEs generally face a lack of resources, networks represent key enablers of innovation among such firms (Chesbrough, 2006; Diez, 2002). Prior empirical research has supported such claims by showing that a lack of partnerships with other organizations has a negative impact on the innovation performance of SMEs (Hewitt-Dundas, 2006). Conversely, participating in networks can increase the rate of innovation (Fukugawa, 2006) and has a positive impact on the degree of innovation novelty (Nieto & Santamaría, 2007). More specifically, the networking capability has been found to positively influence the innovation performance of organizations in general (Mitrega et al., 2017), and that of SMEs in particular (Gronum et al., 2012; Mu, 2013; Zeng et al., 2010).

2.2.3. IT ambidexterity: IT capabilities for exploitation and exploration

To conceptualize the notion of IT ambidexterity, one must start by describing its components, that is, IT capabilities for exploitation and IT capabilities for exploration. First-off, the firm's IT capabilities and IT assets are considered to be a sub-category of its IT resources (Piccoli & Ives, 2005; Wade & Hulland, 2004). That is, IT resources can be broadly defined as the

collection of IT-related assets and capabilities with which a firm endows itself (Piccoli & Ives, 2005; Wade & Hulland, 2004). While IT-related assets typically refer to the specific information and communication technologies available within a firm, IT capabilities refer to the competences and practices that are enabled by the use of IT (Aral & Weil, 2007). In this study, we examine IT-related assets in the form of IT infrastructure capabilities as well as a specific form of IT capabilities, namely, e-business capabilities (Uwizeyemungu, Raymond, Poba-Nzaou, & St-Pierre, 2018).

IT infrastructure capabilities encompass “the ability of the IT unit to provide extensive firm-wide IT infrastructure services that support the organization’s business processes” and it is “reflected in the range and number of IT infrastructure services” available (Neumann & Fink, 2007, pp. 441–442). Thus, IT infrastructure capabilities include the different technical platforms and software in use in a given organization (Ross, Beath, & Goodhue, 1998; Uwizeyemungu et al., 2018). E-business capabilities in contrast, can be defined as “the usage of the Internet and Web-related technologies for different business purposes” (Uwizeyemungu et al., 2018, p. 5). These capabilities include recruiting personnel online (i.e., e-HRM), conducting business activities with customers and suppliers (i.e., e-commerce) (Bi, Davison, & Smyrnios, 2017; Soto-Acosta & Meroño-Cerdan, 2008), collaborative capabilities (i.e., e-collaboration) (Chi, Wang, Lu, & George, 2018; Zhao, Huang, & Zhu, 2008), and e-business intelligence capabilities (Uwizeyemungu et al., 2018).

Now, in order to capture the firm’s strategic IT priorities, certain IT infrastructure and e-business capabilities may be categorized as being IT capabilities ‘for exploitation’, whereas others may be categorized as IT capabilities ‘for exploration’, following Levinthal and March’s (1993) conceptualization of how firms pursue either exploitation for efficiency and productivity purposes, or exploration for innovation and growth purposes, or both simultaneously. For example, certain transactional software applications (e.g., ERP) are associated with cost

reduction and are thus exploitation-oriented (Aral & Weil, 2007). Certain other applications or technologies (e.g., CAD/CAM and rapid prototyping) are focused on product or service innovation, thus prioritizing exploration goals. Likewise, certain e-business capabilities such as selling products and services online aim to reduce costs and increase productivity and are thus essentially exploitative in nature, whereas others such as e-business intelligence capabilities have a more explorative orientation.

As a result of the preceding considerations, we define IT capabilities for exploitation as those that aim to enhance the firm's efficiency and productivity, whereas IT capabilities for exploration aim to enhance its agility, innovativeness and growth. This conceptualization refers in particular to the notion of IT ambidexterity, i.e. to the firm's ability to use IT capabilities both for exploitation and exploration in the pursuit of performance (Lee et al., 2015). It is important to note that, from a technological innovation perspective, exploitation usually deals with incremental innovation or improvements (e.g., the modification of existing services to meet existing customers' or markets' needs) whereas exploration is concerned with radical innovation (e.g., new services to meet emergent customers' or markets' needs) (Benner & Tushman, 2003; Cembrero & Sáenz, 2018; Popadiuk, 2012). Although the empirical literature on IT ambidexterity is rather scarce and eclectic (e.g., Cao, Gedajlovic, & Zhang, 2009; Chi et al., 2017; Gregory, Keil, Muntermann, & Mähring, 2015; Kranz, Hanelt, & Kolbe, 2016; Napier, Mathiassen, & Robey, 2011), IT ambidexterity has been found to positively influence organizational agility (Lee et al., 2015) and performance outcomes (Mithas & Rust, 2016).

2.2.4. Environmental uncertainty

The final element of the SME's digital ecodynamics, its environmental uncertainty, is defined as the extent to which the business environment in which it operates is perceived to remain unchanged over time or to be in constant flux (Duncan, 1972). Environmental uncertainty has been identified as the fundamental problem with which managers must deal with (Kearns, &

Lederer, 2004); thus it must be taken into consideration when linking both dynamic capabilities and IT capabilities with performance outcomes (Pezeshkan, Fainshmidt, Nair, Frazier, & Markowski, 2016). In fact, environmental uncertainty is a key construct that has often been ignored when studying DC-performance and IT-performance relationships (e.g., Chae et al., 2014; Ray, Muhanna, & Barney, 2005; Wang, Liang, Zhong, Xue, & Xiao, 2012). Some authors have even characterized this lack of attention to the firm's environmental context as “surprising” (Pezeshkan et al., 2016, p. 2953). As a result, it was deemed necessary to include environmental uncertainty as an essential component of the SME's digital ecodynamics (El Sawy et al., 2010), and even more so, given that prior empirical research has found characteristics of the business environment (e.g., its dynamism) to significantly influence the firm's innovation performance (Cingöz & Akdoğan, 2013).

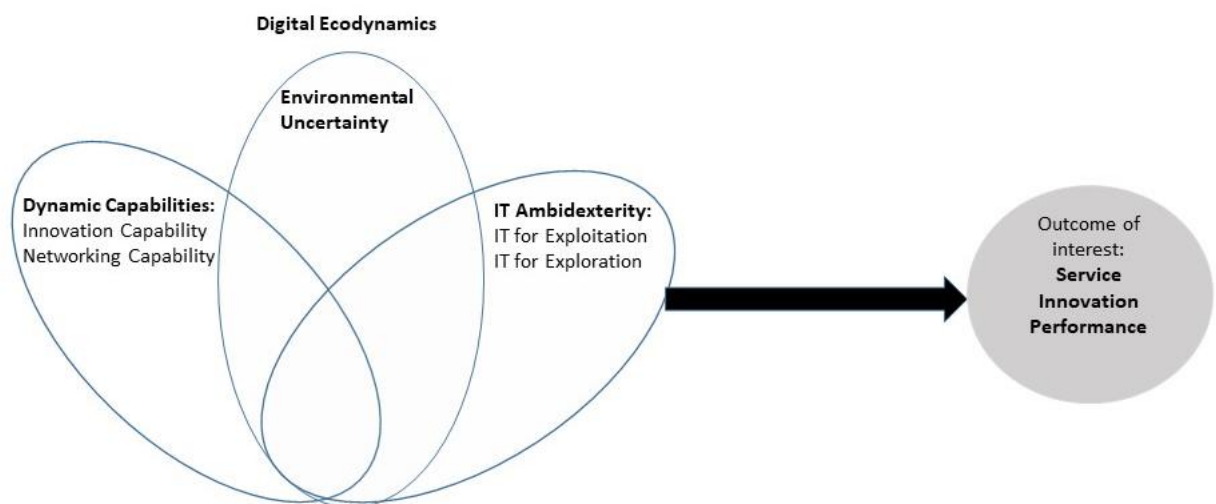
2.3. Conceptual model

By taking a configurational approach, we seek to uncover how IT ambidexterity (IT capabilities for exploitation and exploration), DCs (innovation and networking capabilities), and environmental uncertainty – the three elements composing the firm's digital ecodynamics – combine into specific configurations that produce high innovation performance. This reasoning leads us to develop a research model that is based on configurational theory, as presented in Figure 1.

Although difficult due to the lack of prior research that integrates all three elements composing the firm's digital ecodynamics, be it in the strategic IS or strategic management domain, we attempt to develop general and specific propositions regarding potentially ‘effective’ configurations, i.e. configurations associated to a high level of service innovation performance. Firstly, we review conflicting and competing views in the ambidexterity literature, posit that the configurational approach due to its equifinal properties may well provide a starting point from which to reconcile such conflicting results (Fiss, 2011), and

formulate general propositions that capture the two competing views of IT ambidexterity. Secondly, we theorize the potential complex interactions between the digital ecodynamic elements in producing service innovation performance and propose two specific configurations that should enable high service innovation performance. Note here that our theorizing and propositions, by identifying different roles played by the digital ecodynamic elements in producing service innovation performance, also point to the necessity of the configurational approach.

Figure 1: Configurational model of the digital ecodynamics of SMEs for service innovation performance



2.3.1. Conflicting results with regard to IT ambidexterity

The IS literature on ambidexterity is eclectic, often investigating different ambidexterity-related constructs without converging on a particular one. Prior studies have focused on supply chain management systems use for exploitation and for exploration (Subramani, M., 2004), on exploitive and explorative patch development activities (Temizkan & Kumar, 2015), on contextual ambidexterity defined as the simultaneous pursuit of alignment and adaptability (Cao et al., 2013; Im & Rai, 2008, 2014; Napier et al., 2011; Tiwana, 2010), on the general concept of ambidexterity as the pursuit of two opposing things at the same time (Gregory et al., 2015; Mithas & Rust, 2016), on the more specific concept of ambidexterity as the pursuit of

both exploitative and explorative ideas (Kranz et al., 2016; Soto-Acosta et al., 2018), and finally on IT ambidexterity, defined as the simultaneous pursuit of IT flexibility and IT standardization (Chi et al., 2017) or as the capability to both acquire/experiment with new technologies and practices and reutilize existing technologies and practices (Lee et al., 2015).

Although this nascent literature is rich in terms of topics and concepts studied, it has been silent with respect to which type of ambidexterity (i.e., either simultaneous or sequential or both) improves performance. That is, given the conflicting demands for exploitation and exploration faced by firms (Levinthal & March, 1993), there are opposing views in the strategic management literature regarding which demands organizations need to focus on in order to increase their performance. Whereas one stream of the literature states that organizations, if ambidextrous, are capable of pursuing both demands simultaneously, namely simultaneous ambidexterity (e.g., Tan & Liu, 2014; Tushman & O'Reilly, 1996), another stream posits that organizations need to focus primarily on one demand at a time, namely sequential ambidexterity (e.g., Duncan, 1976; Mudambi & Swift, 2014). We may now turn to the management literature on ambidexterity to explore these two competing perspectives.

The main argument for the proponents of simultaneous ambidexterity is that pursuing only one activity (i.e., either exploitation or exploration) could have detrimental effects on performance because focusing only on exploitation will lead to obsolescence while focusing only on exploration will hamper a firm's ability to gain returns on its know-how (Levinthal & March, 1993). Tushman and O'Reilly (1996) further argued that in rapidly changing environments, pursuing one demand at a time would be ineffective, thus the need to focus simultaneously on exploitation and exploration goals. Organizations can attain simultaneous ambidexterity through structural separation. Such structural separation involves putting parallel and differentiated structures for exploitation and exploration activities (Birkinshaw, Zimmermann, & Raisch, 2016; Puranam, Singh, & Zolo, 2006). This structural separation

allows for exploitative units to ensure efficient operations while it enables explorative units to investigate new areas for expansion and growth (Benner & Tushman, 2003; O'Reilly 3rd & Tushman, 2004; Turner, Swart, & Maylor, 2013).

On the other hand, the proponents of sequential ambidexterity emphasize that firms can competently deal with only one functional demand at a time (either exploitation or exploration), and thus firms should pursue exploitive and explorative activities in sequence (as opposed to in parallel) (Winter & Szulanski, 2001) for three main reasons. First, the pursuit of exploitation and exploration simultaneously involves a competition for resources that leads to organizational tensions (March, 2006; March, 1991). Second, pursuing both goals in parallel requires different processes that are likely to be inconsistent (W. K. Smith & Tushman, 2005). Finally, simultaneous ambidexterity involves different learning models (Benner & Tushman, 2003; Eisenhardt & Martin, 2000). The result is that management efforts to attend to one goal may hamper or cancel out efforts to attend the other (Dougherty, 1996; James G. March, 2006; March, 1991). Thus, firms attain sequential ambidexterity by switching their structures and routines over time to focus on exploitative goals during certain periods of time and on explorative ones at other times (Duncan, 1976; Puranam et al., 2006; Raisch, Birkinshaw, Probst, & Tushman, 2009).

Empirical research into these competing views of ambidexterity has yielded inconsistent and conflicting results for the most part. In support of the simultaneous ambidexterity perspective, research has found that the interaction between exploitative and exploration activities has a positive effect on performance while the imbalance between these two strategies negatively influences growth (He & Wong, 2004). In the specific context of SMEs, simultaneous ambidexterity was found to have a more positive effect than either explorative and exploitative strategies on performance (Tan & Liu, 2014). Likewise, research conducted in industrial SMEs has shown that simultaneous ambidexterity enables improvements in

manufacturing performance (Tamayo-Torres, Roehrich, & Lewis, 2017). In contrast, empirical research also exists that supports the sequential ambidexterity perspective. For example, certain researchers have compared simultaneous ambidexterity with sequential ambidexterity, finding that the latter outperforms the former in the long run (Boumgarden, Nickerson, & Zenger, 2012). Likewise, while the simultaneous pursuit of exploitation and exploration is seen to worsen performance, focusing on either exploitation or exploration at a given time improves it (Kauppila, 2015). Furthermore, Payne (2006) demonstrated that strategies and structures that align with one functional demand, either exploitation or exploration, lead to better performance than those focusing on both demands simultaneously.

The preceding discussion on competing views and conflicting results regarding ambidexterity has led to calls for research that adopts a configurational approach in order to shed more light on this issue (Fiss, 2011). More specifically, a shift toward an equifinal and asymmetric understanding of how the different types of ambidexterity relate to performance outcomes could resolve prior conflicting results (Fiss, 2011). For example, given configurational theory's equifinal properties, it is possible that simultaneous ambidexterity and sequential ambidexterity could both lead to positive performance outcomes. Therefore, configurations showing either the presence of IT for exploitation or IT for exploration or the presence of both IT capabilities for exploitation and IT capabilities for exploration could be equally effective in achieving service innovation performance. As a result, we posit three general propositions:

General Proposition 1: Both IT capabilities for exploitation and IT capabilities for exploration must be present in at least one configuration of the SME's digital ecodynamics for it to achieve high service innovation performance.

General Proposition 2: IT capabilities for exploitation (or IT capabilities for exploration) must be present while IT capabilities for exploration (or IT capabilities for exploitation) must be absent in at least one configuration of the SME's digital ecodynamics for it to achieve high service innovation performance.

General Proposition 3: IT capabilities for exploitation (or IT capabilities for exploration) must be present while IT capabilities for exploration (or IT capabilities for exploitation) must be an immaterial condition² in at least one configuration of the SME’s digital ecodynamics for it to achieve high service innovation performance.

General Proposition 1 aligns with the simultaneous IT ambidexterity perspective, General Proposition 2 supports the sequential IT ambidexterity perspective, while General Proposition 3 encompasses possibilities for both sequential and simultaneous ambidexterity. These propositions are summarized in Table 1, along with the two specific propositions developed in the next section. Note here that black circles represent the presence of a condition and circles with a cross-out represent the absence of a condition, and blank spaces represent a ‘don’t care’ situation in which the condition is immaterial to the outcome, that is, it may be either present or absent (Ragin, 2008a). Interrogation marks represent configurational elements for which we could not theoretically specify a concrete value *a priori* and thus, can be present, absent or represent an immaterial condition.

Table 1: Research Propositions for the Attainment of High Service Innovation Performance

Configurational element	General Propositions			Specific Propositions	
	GP1	GP2	GP3	SP4	SP5
<i>Environmental Uncertainty</i>	?	?	?	●	●
<i>Innovation Capability</i>	?	?	?	●	⊗
<i>Networking Capability</i>	?	?	?	●	⊗
<i>IT Capabilities for Exploration</i>	⊗ / ●	●	blank / ●	⊗	●
<i>IT Capabilities for Exploitation</i>	● / ⊗	●	● / blank	●	?

Legend. ●: presence of a condition blank: ‘don’t care’
 ⊗: absence of a condition ? : presence, absence, or ‘don’t care’

² An immaterial condition represents a situation in which the element may be either present or absent without altering the causal relation between the configuration and the outcome (Ragin, 2008a).

2.3.2. Relationships between IT ambidexterity, DCs and environmental uncertainty with regard to service innovation performance

Uncertainty in their business environment generally creates incentives for firms to innovate through the introduction of new or modified products and services, with the goal of safeguarding and improving their market positions (Freel, 2005; Miller & Friesen, 1982). Now, one strength of the configurational approach is that it allows for the elements of the firm's digital ecodynamics to be strongly interdependent in leading to service innovation performance. Environmental uncertainty's relation with the other digital ecodynamic elements appears to be a complementary one, as the effect of the firm's DCs on its performance is greater when it operates in highly uncertain environments (Teece, 2007). For instance, the effect of its networking capability on the firm's innovation performance, has been found to increase as environmental uncertainty increases (Mu & Di Benedetto, 2012). The idea is that environmental uncertainty creates the context for the networking capability to become more critical for the firm as it seeks, establishes, manages and leverages inter-organizational ties in order to obtain fine-grained information, resources, and support to facilitate its engagement in the design of new services and the refinement of existing services (Capaldo, 2007; Lorenzoni & Lipparini, 1999). Likewise, prior research has found that environmental uncertainty positively influences the innovation capability of firms (Uzkurt, Kumar, Kimzan, & Sert, 2012). Thus, organizations further develop their innovation capability as a response to changing environments in order to remain competitive. With respect to ambidexterity, environmental uncertainty is not only seen to be an antecedent of ambidexterity (Jansen, Tempelaar, Van den Bosch, & Volberda, 2009), but researchers have also theorized and empirically shown that ambidexterity is typically more valuable under conditions of high environmental uncertainty (Simsek, 2009; Soto-Acosta et al., 2018). In particular, environmental uncertainty was found to positively moderate the relation between IT ambidexterity and organizational ambidexterity, which in turn influences

organizational agility (Lee et al., 2015). The idea is that firms' IT capabilities (either for exploitation or exploration) must respond to changing environmental demands by enabling productivity, through continuous improvement as well as by product, service and process innovation (Chakravarty, Grewal, & Sambamurthy, 2013; Chen et al., 2014). Furthermore, explorative and exploitative activities have been found to have greater effect on firms' performance under conditions of high uncertainty and high competitiveness respectively (Jansen, Van Den Bosch, & Volberda, 2006). As a result, it is likely that an increase in environmental dynamism strengthens the relationship between IT ambidexterity and service innovation performance.

With respect to the two dynamic capabilities studied here, the relation between innovation capability and networking capability appears to be mutually reinforcing. Network forms, types and relationships influence the innovative capability of a firm (Szeto, 2000) because networking provides input for developing technical or commercial resources with a more effective understanding of customer needs (Chen, Sun, Helms, & Jih, 2008; Corsaro, Ramos, Henneberg, & Naudé, 2012). In other words, the value of a firm's internal capabilities, such as its innovation capability, can be amplified through connections with external entities (Lavie, 2006). Wider and more heterogeneous networks provide information that is more diverse and more aligned with market and competitive shifts (Zheng, Liu, & George, 2010). In turn, the innovation capability of a firm is essential to its assimilation of valuable external information and knowledge, that is, to the development of its absorptive capacity (Cohen & Levinthal, 1990). Hence, the two DCs explored here appear to be strongly interrelated, and their aim is to enable SMEs to achieve a high level of innovation performance by sensing and seizing new opportunities that better match environmental demands (Teece, 2007; Winter, 2003).

In similar fashion, one may theorize the relationship between dynamic capabilities and the two components of IT ambidexterity, IT capabilities for exploitation and exploration. The

two DCs included here in the digital ecodynamics of SMEs allow these firms to scan their business environment through information and knowledge exchanges with other organizations, institutions and individuals (networking capability), as well as to analyze customers' opinions and competitors' offering (innovation capability). Such capabilities also allow these firms to address newly sensed opportunities via, again, information and knowledge exchanges with others (networking capability), and via the prefeasibility analysis of ideas for new products or services (innovation capability). These dynamic capabilities would however require the firm to develop IT capabilities for exploitation in order to produce the new or modified products or services identified by the sensing and seizing processes. That is, in the case of industrial service SMEs, once novel ideas for services have been identified through their networking and innovation capabilities, a collection of routines enabled by their IT capabilities for exploitation would ensure the translation of such ideas into new service offerings. Moreover, IT capabilities for exploitation would enable new or modified service offerings through two components, namely the firm's IT infrastructure and e-business capabilities. Thus, it appears that for service innovation performance to be high, SMEs should have both strong networking and innovation capabilities as well as strong IT capabilities for exploitation, under conditions of high uncertainty.

The relationship between DCs and IT capabilities for exploration in the attainment of service innovation performance appears to be more complex, however. Such IT capabilities are essentially meant to support the business processes and activities that are enabled by the firm's networking and innovation capabilities. For instance, developing stronger IT infrastructure capabilities, such as CRM systems, and e-business capabilities, such as e-business intelligence, enable the firm to better sense the environment for new market opportunities. Furthermore, the feasibility of new market opportunities can be enabled by IT infrastructure capabilities for exploration such as modeling and simulation, computer-aided drafting, design and

manufacturing, and rapid prototyping. And e-business capabilities for exploration such as e-collaboration facilitate the SME's interaction with its business partners for the design of new or modified services. Thus, it appears that DCs and IT for exploration have a substitutive relation. This idea is not new; according to Pavlou and El Sawy (2011, p. 242), "dynamic capabilities would correspond to the exploration of new opportunities". As a result, IT capabilities for exploration and DCs appear to enable similar activities and processes involved in achieving service innovation performance, but through different means. In other words, if one set of capabilities is present (i.e., IT for exploration), the other (i.e., DCs) need not be, and vice-versa. In this case, however, the role played by the firm's IT capabilities for exploitation is not clear. Following the theoretical development made with regard to our three general research propositions, IT capabilities for exploitation could be present or absent (or be an immaterial condition) when combined with IT for exploration in the achievement of service innovation performance. As a result, we posit the following specific propositions:

Specific Proposition 1: Environmental uncertainty, innovation capability, networking capability, and IT capabilities for exploitation must be present, and IT capabilities for exploration must be absent in at least one configuration of the SME's digital ecodynamics for it to achieve high service innovation performance.

Specific Proposition 2: Environmental uncertainty and IT capabilities for exploration must be present, and innovation capability and networking capability must be absent in at least one configuration of the SME's digital ecodynamics for it to achieve high service innovation performance.

3. Methodology

3.1. Sample

Data on 63 SMEs located in the province of Quebec, Canada, and operating in the industrial services sector, were obtained from a database created by a university research center for benchmarking purposes. These firms offer to the manufacturing industry high-knowledge value-added services, high knowledge support services, and technical/functional services, usually equipment-based, in areas such as marketing, production, logistics, human resources,

information technologies and systems, finance, and accounting. To create the database, the SMEs' CEO and functional executives such as the marketing manager, accounting/finance manager and IT manager were asked fill-out a 20-page questionnaire to provide wide-ranging information on the competitive performance and business practices of their firm. Firms that participated in the benchmarking exercise, received in exchange for their participation, a full comparative diagnostic of their strategic positioning and competitive vulnerability. The number of employees of the sampled SMEs ranges from 2 to 101, with a median of 21, while their annual revenue ranges from 0.10 to 28.5 million Canadian dollars, with a median of 2.1 million. The age of these firms ranges from 6 to 79 years, with a median of 25. They operate in various high-knowledge and technical/functional support service sectors such as engineering, computing, printing and machinery/equipment supply services (see Table 2). Furthermore, nearly a quarter of the sampled SMEs (24%) export their services.

Table 2: Breakdown of the sampled SMEs by industrial service sector

Industrial service sector	no. of SMEs (N = 63)
Engineering services	15
Computer systems design and related services	9
Printing and related support activities	8
Machinery, equipment and supplies merchant wholesalers	7
Architectural services	4
Other professional, scientific and technical services	4
Data processing, hosting, and related services	3
Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance	3
Advertising, public relations, and related services	2
Telecommunications	2
Management consulting services	1
Scientific research and development	1
Commercial and industrial machinery and equipment rental and leasing	1
Electronic and precision equipment repair and maintenance	1
Educational services	1
Couriers and messengers	1

3.2. Measures

Environmental uncertainty was measured by a five-scale instrument initially validated by Miller and Dröge (1986). The SME's owner-manager is asked to evaluate on five-point Likert scales,

the degree of change and unpredictability in the firm's markets and technologies. Innovation capability was estimated from the frequency with which activities such as idea generation, prefeasibility analysis of ideas, and analysis of customer information (suggestions, complaints), competitors' offerings and economic trends are undertaken (Akman & Yilmaz, 2008; Hogan et al., 2011). Networking capability was measured by the number of business collaborations with various business partners established by the firm in matters of R&D and service development, operations and marketing (Raymond, & St-Pierre, 2013). IT ambidexterity was measured through the capture of IT infrastructure and e-business capabilities. The SME's IT infrastructure and e-business capabilities were assessed through two summative index variables obtained from the identification of the various IT-based systems implemented by the firm and the different activities carried out through the web or the Internet, following the approach taken by Tantopoulus et al. (2017). In the case of IT infrastructure capabilities, each identified system was classified as being either mainly for exploitation (e.g., ERP) or for exploration (e.g., computer-aided design). In the case of e-business capabilities, each identified activity carried out through the web or the Internet was classified as being either mainly for exploitation (e.g., e-commerce) or for exploration (e.g., e-business intelligence). Finally, since the benefit of innovations is traditionally measured in economic value (Witell et al., 2016), service innovation performance was measured by the average percentage of sales attributed to new or modified services, this measure being appropriate to the reality of SMEs (Mennens, Van Gils, Odekerken-Schröder, & Letterie, 2018) and thus commonly used in this context (Sachdeva & Agarwal, 2011). The questionnaire items used to measure the research variables are included in Appendix A.

One important aspect to note is that all the research variables, except for environmental uncertainty and innovation capability, are 'index' rather than 'scale' variables (Babbie, E., 2013), and are measured objectively rather than in a perceptual manner (cf. questionnaire items

in Appendix A). Furthermore, it is important to note that the questionnaire was answered by multiple respondents. To test for the presence of common method bias in the data, the ‘marker variable’ approach was used (Lindell & Whitney, 2001). This approach consists of including an additional variable that is not supposed to be linked theoretically to any of the research variables, and whose correlation with all of these variables should thus be near zero (Lindell & Whitney, 2001). Using the sampled SMEs’ productivity (gross profit per employee) as a marker, the average correlation of this variable with the research variables equaled 0.10 (with a maximum of 0.16), and thus did not indicate any presence of common method bias.

4. Results

We investigated our configuration framework using fuzzy set qualitative comparative analysis (fsQCA), a second generation configurational analysis technique (Ragin, 2000, 2008a). This analytical technique was originally developed in political science to deal with small sample sizes (Cooper & Glaesser, 2016; Ragin, 2000). However, it can also be to intermediate-sized samples (15 to 99 cases) and to large-sized samples (100 cases or more) (Ragin, 2008a). Thus, our intermediate-sized sample of 63 SMEs is appropriate for fsQCA. Consistent with configurational theory, fsQCA allows for equifinality and causal asymmetry (Fiss, 2011; Liu, Mezei, Kostakos, & Li, 2017). In a nutshell, fsQCA is an analytical technique that uses Boolean algebra for determining the different configurations of elements (variables) that generate the same outcome (Ragin, 2000, 2008a).

4.1. Calibration

In fsQCA, each variable is considered to be a fuzzy set, that is, is defined as having different degrees of membership (Ragin, 2000). Thus, the initial step before the fsQCA analysis take place is to convert each research variable into a fuzzy set, using a procedure called ‘calibration’ (Mendel & Korjani, 2013; Ragin, 2008a). Calibration relies on the researchers’ substantive knowledge (about the problem domain, the measurement model, and/or the cases) and can be

done in two ways: directly (by identifying three points of membership into a set: ‘fully in’, ‘crossover’ and ‘fully out’) or indirectly (by qualitatively assessing cases and rescaling the original measurements) (Liu et al., 2017; Ragin, 2008a). When Likert scales and indexes are used for quantitative data gathering (as opposed to qualitative ‘thick’ data), the recommendation is to use the direct calibration procedure by identifying the three points of membership based on the scales’ (or indexes’) values (Liu et al., 2017; Ragin, 2008a). Thus, given our measures, direct calibration was used here.

In calibrating our research variables, we identified the three points of membership for each variable of interest, following the recommendations found in the fsQCA literature. For instance, for seven-point Likert scales, several studies have used the values of 6 for full membership, 4 for the cross-over point, and 2 for full non-membership into the set (Ordanini, Parasuraman, & Rubera, 2014; Pappas, Kourouthanassis, Giannakos, & Chrissikopoulos, 2016). Other studies calibrate the measures using percentiles (Pappas, Mikalef, Giannakos, & Pavlou, 2017; Plewa, Ho, Conduit, & Karpen, 2016). Here, the nature of some of the measures causes the distribution of the variables to be skewed, and thus, percentiles were used for data calibration (Dul, 2016) because calibrating based on survey scales or indexes is likely to produce only one solution with all the conditions identified as necessary, thus, offering less meaningful results (Plewa et al., 2016). This type of calibration, based on the distribution of the measures, has also been recommended elsewhere (Glaesser & Cooper, 2014). As shown in Table 3, for all the variables or elements forming the digital ecodynamic configurations, we used the top quartile value across cases as the threshold for full membership, the median as the cross-over point, and the bottom quartile value as the threshold for full non-membership.

Table 3: Calibrations and descriptive statistics of the research variables

Configurational element [range]	Fuzzy Set Calibrations ^a			mean	sd	max	min
	fully in	crossover	fully out				
Environmental Uncertainty [1 – 5]	2.9	2.5	1.9	2.4	0.7	4.2	1.0
Innovation Capability [1 – 5]	3.1	2.8	2.3	2.8	0.5	4.0	1.4
Networking Capability [0 – 36]	5.5	2.5	0.0	3.4	3.4	14	0
IT Capab. for Exploration [0 – 10]	5.5	4.5	2.5	4.1	2.0	9	0
IT Capab. for Exploitation [0 – 10]	3.5	3.0	2.5	3.1	1.5	7	0
Service Innovation Perform. ^{b, c} [0 – 1]	0.39	0.11	0.00	0.23	0.30	1.0	0.0
^a calibration thresholds: [fully in = top quartile crossover = median fully out = bottom quartile] ^b calibration for Very High Service Innovation Performance: [fully in = 0.75 (top decile)] ^c sales of new or modified services / total sales							

The same thresholds were utilized for the preferred outcome, ‘high’ service innovation performance. Once the three threshold values were identified for each variable, a nonlinear stepwise logistic function embedded in the fsQCA software was used to translate all cases of the variables of interest into a fuzzy set (Liu et al., 2017; Ragin, 2008a; Ragin, & Davey, 2014; Thiem, 2014). Given that a continuous fuzzy set allows cases to take values anywhere in from 0 to 1, it utilizes “the two qualitative states (fully out and fully in) and also uses the crossover point to distinguish cases that are more out from those that are more in” (Ragin, 2008a, p. 32).

The research variables’ reliability and intercorrelations are presented in Table 4. Note that IT capabilities for exploration and IT capabilities for exploitation, are intercorrelated ($r = 0.49$). Note also that these two capabilities and the networking capability are operationalized through ‘index’ rather than ‘scale’ measures (Babbie, E., 2013). An index variable tends to follow a Poisson-type rather than a normal distribution, that is, to be right-skewed if the mean is small. Moreover, an index regroups elements not expected to be highly intercorrelated, hence the inappropriateness of Cronbach’s α coefficient to test its reliability (Bollen, & Lennox, 1991).

Table 4: Reliability and intercorrelations of the research variables

Variable	reliability		intercorrelations					
	α^a	c.r. ^b	1.	2.	3.	4.	5.	6.
1. Environmental Uncertainty	.60	.76	-					
2. Innovation Capability	.74	.82	.04	-				
3. Networking Capability	-	-	.16	.22	-			
4. It Capability for Exploration	-	-	.27	.36	.34	-		
5. IT Capability for Exploitation	-	-	.14	.27	.01	.49	-	
6. Service Innovation Performance ^c	-	-	-.04	.21	.12	.36	.14	-

^a Cronbach's alpha reliability coefficient [inappropriate for index variables]
^b composite reliability coefficient [inappropriate for index variables]
^c sales of new or modified services / total sales

4.2. Necessity analysis

The study of necessary conditions (or configurational elements/variables) is usually the first step in fsQCA analysis (Ragin, 2000). A condition is necessary when its consistency score is above 0.9 (Schneider & Wagemann, 2012; Schneider, Schulze-Bentrop, & Paunescu, 2010). Consistency measures the extent to which cases that are members in a condition also show membership in the outcome (Ragin, 2006). That is, they represent the proportion of fuzzy set scores in a condition (across all cases) that are less than or equal to the corresponding scores in the outcome (Ragin, 2006). As shown in Table 5, the consistency scores indicate that no single element of the digital ecodynamics of the sampled SMEs is, alone, necessary to achieve a high level of service innovation performance.

Table 5: Analysis of necessary elements

Configurational element	High Service Innovation Performance	
	Consistency	Coverage
Environmental Uncertainty	.605	.594
Innovation Capability	.652	.613
Networking Capability	.634	.589
IT Capabilities for Exploration	.611	.631
IT Capabilities for Exploitation	.576	.593

4.3. Sufficiency analysis

Up to now, we have described fsQCA in terms of relationships between the case sets constructed for the individual elements (or causal conditions or variables) and for the preferred outcome. However, the major analytical contribution of fsQCA resides in its ability to evaluate relationships between configurations (that is, combinations of causal conditions) and the outcome (Ragin, 2000, 2008a). The solution or configuration sets are constructed by Boolean addition of individual conditions, such that fuzzy set scores reflect membership in each of the conditions making up the configuration.

The configurational analysis begins with the creation of a truth table of 2^k rows with a list of all possible configurations, with k representing the number of individual elements (Pappas, Giannakos, & Sampson, 2019; Pappas et al., 2016). The truth table is then sorted based on frequency and consistency (Pappas et al., 2017; Ragin, 2008a). While frequency represents the number of observations for each possible configuration (Pappas et al., 2019, 2017), consistency³ describes “the degree to which cases correspond to the set-theoretic relationships expressed in a solution” (Fiss, 2011, p. 402). For samples larger than 150 cases, the recommendation is to set the frequency threshold at 3, while for smaller samples the recommended threshold is 2 (Fiss, 2011; Ragin, 2006). As a result, the frequency threshold was set here at 2 and thus, all configurations with a smaller frequency were removed for further analysis. Furthermore, the recommended threshold of 0.75 for consistency (Liu et al., 2017; Pappas, 2018; Ragin, 2006, 2008a) was also used. For configurations above the consistency threshold, the outcome variable was set at 1 (because these configurations are the ones that fully explain the outcome) and for the rest was set at 0 (Pappas, 2018). The fsQCA software then computes three sets of solutions: complex, parsimonious, and intermediate (Pappas, 2018).

³ Consistency can be simply estimated “as the proportion of cases consistent with the outcome – that is, the number of cases that exhibit a given configuration of attributes as well as the outcome divided by the number of cases that exhibit the same configuration of attributes but do not exhibit the outcome” (Fiss, 2011, pp. 402–403).

While the complex solution represents all possible configurations of conditions when traditional logical operations are applied (Pappas et al., 2019), the interpretation of the resulting configurations is difficult and often impractical (Mendel & Korjani, 2012). The complex solution is thus further simplified into parsimonious and intermediate solutions. The parsimonious solution yields the most important conditions, called ‘core’ conditions or elements, which cannot be left out from any configuration (Fiss, 2011; Pappas et al., 2019). Core elements are those for which the evidence for a causal relationship with the outcome is strong (Fiss, 2011). The intermediate solution is obtained through the performance of counterfactual analysis⁴ on the complex and parsimonious solutions (Liu et al., 2017; Pappas et al., 2019; Ragin, 2008a). The intermediate solution includes the parsimonious solution and is part of the complex solution (Liu et al., 2017; Pappas et al., 2019; Ragin, 2008a). As a result, the conditions that are not part of the parsimonious solution but are part of the intermediate solution are called ‘peripheral’ conditions or elements (Fiss, 2011; Pappas et al., 2019). Peripheral elements are those for which the evidence indicates a weak causal relationship with the outcome (Fiss, 2011). The recommendation is to use a combination of the parsimonious and intermediate solutions for interpreting fsQCA results (Pappas et al., 2019). More specifically, the researcher should identify the conditions of the parsimonious solution in the intermediate solution so that a table can be created that includes both core and peripheral elements (Fiss, 2011; Pappas et al., 2016). This results in a combined solution that presents core and peripheral elements and helps in the interpretation of the resulting configurations.

4.3.1. Configurations for high service innovation performance

Table 6 shows the results of the fsQCA analysis with the configurations for the presence and absence (indicated by ‘~’) of high service innovation performance. The notation for solution

⁴ Please see Mendel and Korjani (2012) for a detailed description of the steps involved in counterfactual analysis.

tables introduced by Ragin (2008a) is used: black circles represent the presence of a condition, circles with a cross-out indicate the absence of the condition, large circles represent core conditions, small circles indicate peripheral ones, and blank spaces represent an immaterial condition, i.e. a ‘don’t care’ situation in which the condition may be either present or absent without altering the outcome.

Table 6: Causal configurations for the presence and absence (~) of high service innovation performance

Configurational element	High Service Innovation Performance			~High Service Innovation Performance	
	HP1	HP2	HP3	NHP1	NHP2
<i>Environmental Uncertainty</i>	●	●	●	⊗	●
<i>Innovation Capability</i>	⊗		●		⊗
<i>Networking Capability</i>	⊗	⊗	●	⊗	
<i>IT Capabilities for Exploration</i>	●	●		⊗	⊗
<i>IT Capabilities for Exploitation</i>		⊗	●	⊗	⊗
Conditions tested					
Consistency	.905	.920	.821	.817	.813
Raw coverage	.169	.172	.225	.151	.138
Unique coverage	.022	.028	.163	.116	.103
Overall solution consistency	.825			.808	
Overall solution coverage	.369			.358	

Legend. ●: presence of a core condition ●: presence of a peripheral condition
 ⊗: absence of a core condition ⊗: absence of a peripheral condition
 blank: ‘don’t care’

With respect to the presence of the outcome, the analysis yields three different configurations that are deemed to be ‘sufficient’ for achieving high service innovation performance. The raw coverage, or the proportion of cases (in terms of fuzzy membership value) that can be described by each configuration is between .169 and .225 (Ragin, 2000). The unique coverage, or the proportion of cases (in terms of fuzzy membership value) that can be described by a configuration appearing in a solution set but cannot be described by any other configuration

from the set is between .022 and .163 (Ragin, 2000). The consistency⁵ values, or the extent to which a given configuration is a sufficient condition for the outcome, are above .82 for all configurations (Ragin, 2008b). According to Ragin (2008a), a consistency score below .75 indicates substantial inconsistency, which is not the case here. Finally, the overall solution consistency is .825, and the overall solution coverage, or the proportion of cases (in terms of fuzzy membership value) that can be described by at least one configuration in a solution set, is .369 (Ragin, 2000).

The first configuration of the SMEs' digital ecodynamics that is sufficient to achieve high-levels of service innovation performance, HP1, is characterized by firms facing a highly uncertain environments with strong IT capabilities for exploration, without strong innovation and networking capabilities (core conditions), and regardless of their IT capabilities for exploitation (immaterial condition). The second configuration, HP2, is similar to the first in that it is characterized by the presence of both a high level of environmental uncertainty and strong IT capabilities for exploration and by the absence of a strong networking capability (core conditions). Nevertheless, HP2 is dissimilar to HP1 in that there is also an absence of IT capabilities for exploitation (core condition), and regardless of innovation capability (immaterial condition). The third digital ecodynamic configuration, HP3, is characterized by a high level of environmental uncertainty, strong innovation and networking capabilities (core conditions), and strong IT capabilities for exploitation (peripheral condition), with or without strong IT capabilities for exploration (immaterial condition). Finally, it is important to note that, notwithstanding the prior analysis of necessary conditions, environmental uncertainty appears to be a necessary condition for high service innovation performance because it is present in all three sufficient configurations (Dul, 2016).⁶

⁵ It is important to note that consistency is distinct from coverage and the two might sometimes counter each other because high consistency may yield low coverage (Ragin, 2008a).

⁶ The necessity analysis performed with fsQCA and reported in Table 5, indicates the consistency of environmental uncertainty to be 0.605, below the recommended threshold of 0.90 for identifying necessary

With respect to the absence of high service innovation performance, the analysis yields two different configurations. The first configuration, NHP1, is characterized by the absence of high environmental uncertainty, of a strong networking capability and of strong IT capabilities for exploration and for exploitation (core conditions), and regardless of the firms' innovation capability (immaterial condition). The second configuration, NHP2, involves firms facing high environmental uncertainty without strong IT capabilities for exploration and for exploitation (core conditions), without a strong innovation capability (peripheral condition), and regardless of their networking capability (immaterial condition).

4.3.2. Configurations for very high service innovation performance

Table 7 shows results for the presence and absence ('~') of a different outcome, that is, 'very high' (instead of 'high') service innovation performance, obtained by recalibrating the performance data. The threshold for full membership for very high innovation performance was set as the top decile value across cases (instead of the top quartile value utilized for high service innovation performance) (cf. Table 3). This additional outcome was tested to provide further evidence with regard to causal asymmetry and further validation of the digital ecodynamic configurations initially found for the presence (and absence) of high service innovation performance (Fiss, 2011).

This additional analysis yields three configurations, each being sufficient for industrial service SMEs to attain very high levels of service innovation performance. Interestingly, the results are similar to those for the attainment of high service innovation. In fact, the first two configurations for very high service innovation performance, VHP1 and VHP2, are the same

conditions (Ragin, 2008a; Rihoux & Ragin, 2009; Schneider & Wagemann, 2012). However, with this recommended threshold of 0.90, it is likely that fsQCA fails to identify single necessary conditions and thus, a false negative or type II error may occur (Dul, 2016). Relaxing this threshold, however, can result in identifying conditions that may not be actually necessary, thus producing false positives or type I errors (Dul, 2016). As a result, a second approach that might produce fewer false negatives and positives is to identify single necessary conditions by selecting the conditions that are present in all configurations (Dul, 2016). Following this second approach, environmental uncertainty can be considered a necessary condition because it is present in all sufficient configurations for high service innovation performance.

as the first two for high service innovation performance, HP1 and HP2. The third configuration (VHP3) is similar to the third configuration of high service innovation performance (HP3) except for one causal condition, as strong IT capabilities for exploration are absent from the VHP3 configuration (core condition), while such capabilities represented a ‘don’t care’ situation in the HP3 configuration. Thus, the VHP3 configuration is a subset of the HP3 configuration (i.e., $HP3 \supset VHP3$). Finally, as before, environmental uncertainty appears to be a necessary condition for very high service innovation performance since it is present in all three sufficient configurations (Dul, 2016).⁷

With respect to the absence of very high innovation performance, the analysis yields three different configurations. The first configuration, NVHP1, is characterized by SMEs that operate in a business environment that is not highly uncertain and who are without strong IT capabilities for exploration (core conditions), with the rest of the configurational elements being immaterial. Interestingly, the NVHP1 configuration is a superset of the NHP1 configuration (i.e., $NVHP1 \supset NHP1$). The second configuration, NVHP2, is characterized by SMEs with a strong networking capability, without a strong innovation capability and without strong IT capabilities for exploration (core conditions), and regardless of their environmental uncertainty and IT capabilities for exploitation (immaterial conditions). The third configuration, NVHP3, is rather similar to NVHP2 in that strong innovation and networking capabilities are present (core conditions); in such cases however, the SMEs operate in highly uncertain environments, without strong IT capabilities for exploitation (peripheral conditions), and regardless of their IT capabilities for exploration.

⁷ cf. footnote 6

Table 7: Causal configurations for the presence and absence (~) of very high service innovation performance

Configurational element	Very High Service Innovation Performance			~ Very High Service Innovation Performance		
	VHP1	VHP2	VHP3	NVHP1	NVHP2	NVHP3
<i>Environmental Uncertainty</i>	●	●	●	⊗		●
<i>Innovation Capability</i>	⊗		●		⊗	⊗
<i>Networking Capability</i>	⊗	⊗	●		●	●
<i>IT Capability for Exploration</i>	●	●	⊗	⊗	⊗	
<i>IT Capability for Exploitation</i>		⊗	●			⊗
Conditions tested						
Consistency	.902	.906	.806	.779	.846	.855
Raw coverage	.188	.188	.138	.444	.259	.169
Unique coverage	.025	.032	.087	.274	.033	.044
Overall solution consistency	.819			.772		
Overall solution coverage	.312			.578		

Legend. ●: presence of a core condition ●: presence of a peripheral condition
 ⊗: absence of a core condition ⊗: absence of a peripheral condition
 blank: 'don't care'

4.3.3. Test of propositions

The propositions are tested by comparing the resulting configurations with the configuration associated to each proposition. More specifically, a research proposition is supported if any of the resulting configurations is equal to or represents a subset of the configuration specified in the proposition⁸, and rejected otherwise (see Table 8).

⁸ Although not formally presented as such, this is the logic underlying the test of propositions that may be found in various studies. For example, Pappas et al. (2019, p. 652) put forward the proposition that “configurations with the absence of at least one cognitive characteristics that lead to m-learning [mobile learning] adoption will also require the presence of at least affective characteristics or social factors”. This proposition was tested by observing in the resulting configurations that “when one cognitive characteristic is absent, at least an affective characteristic or social factor needs to be present to lead to high m-learning adoption” (p. 655). In this case, the resulting configurations represented subsets of the overall possible configurations specified in the proposition.

Table 8: Test of Propositions

Configurational element	Results				Propositions				
	Configurations for High (HP) and Very High (VHP) service innovation performance				General Propositions (GP)			Specific Propositions (SP)	
	HP1 = VHP1	HP2 = VHP2	HP3	VHP3 [HP3 \supset VHP3]	GP1	GP2	GP3	SP1	SP2
<i>Environmental Uncertainty</i>	●	●	●	●	?	?	?	●	●
<i>Innovation Capability</i>	⊗		●	●	?	?	?	●	⊗
<i>Networking Capability</i>	⊗	⊗	●	●	?	?	?	●	⊗
<i>IT Capabilities for Exploration</i>	●	●		⊗	⊗ / ●	●	blank / ●	⊗	●
<i>IT Capabilities for Exploitation</i>		⊗	●	●	● / ⊗	●	● / blank	●	?
Assessment of Propositions	Evaluation				GP1 \supset (HP2; VHP2; VHP3)		GP3 \supset (HP1; HP3; VHP1)	SP4 = VHP3	SP5 \supset (HP1; VHP1)
	Conclusion				✓	✗	✓	✓	✓

Legend. ●: presence of a core condition ●: presence of a peripheral condition
 ⊗: absence of a core condition ⊗: absence of a peripheral condition
 blank: 'don't care' ? : presence, absence, or 'don't care'
 \supset : indicates a subset

General Proposition 1, regarding sequential IT ambidexterity, is supported because configurations HP2, VHP2 and VHP3 are subsets of the configuration embedded in the proposition. General Proposition 2, regarding simultaneous IT ambidexterity, is not supported as there is no resulting configuration that is either equal to or a subset of the configurations implied by this proposition. General Proposition 3, which allows for both sequential and simultaneous IT ambidexterity, is supported because configurations HP1, HP3, and VHP1 represent subsets of the configuration specified in the proposition. Specific Proposition 1 is supported since its embedded configuration is equal to configuration VHP3. Finally, Specific Proposition 2 is supported because configurations HP1 and VHP1 represent a subset of the configuration implied by this proposition.

5. Discussion

The purpose of this exploratory research was to determine the digital ecodynamic configurations that enable (and do not enable) industrial service SMEs to attain high service innovation performance from a configurational approach and with special attention to IT ambidexterity. In doing so, this study's findings contribute to the ambidexterity, IT capabilities and strategic management research domains in several ways.

First, we contribute to the organizational ambidexterity literature by answering calls for adopting a configurational approach to shed light on the conflicting results and competing views that emanate from prior ambidexterity studies (Fiss, 2011; Wilden et al., 2016). As explained before, two competing views exist when linking ambidexterity to performance outcomes: simultaneous ambidexterity versus sequential ambidexterity. Our results, afforded by the equifinal properties of fsQCA (and the configurational approach), suggest that both high and very high service innovation performance can be achieved by both IT sequential ambidexterity and IT simultaneous ambidexterity. In this regard, in the specific context of industrial service SMEs, the sequential ambidexterity view is supported by three different digital ecodynamic configurations (i.e., HP2, VHP2, VHP3). In contrast, there are three digital ecodynamic configurations (i.e., HP1, HP3, and VHP3) that support both, the sequential ambidexterity view and the simultaneous ambidexterity view. These configurations represent situations in which IT capabilities for exploration (or IT capabilities for exploitation) are present while IT capabilities for exploitation (or IT capabilities for exploration) are immaterial conditions, i.e. where such capabilities could be present or absent without altering the outcome, thus supporting both views. This contribution is further enriched with the results for not achieving high and very high service innovation performance. According to these results, there are two configurations (i.e., NHP1 and NHP2) that clearly show IT capabilities for exploitation and for exploration to be absent, pointing to the fact that a lack of simultaneous IT ambidexterity

prevents SMEs from achieving high service innovation performance. Furthermore, there are three configurations (i.e., NVHP1, NVHP2, and NVHP3) showing that in the absence of either sequential or simultaneous IT ambidexterity, industrial service SMEs cannot attain very high innovation performance. Thus, it appears that a minimum level of IT capabilities needs to be present, either IT capabilities for exploitation or IT capabilities for exploration or both, which points to the strategic criticality of IT capabilities for these firms to attain high and very high service innovation performance. As a result, and thanks to the equifinal properties of the configurational approach, our study suggests that, industrial service SMEs can achieve high or very high service innovation performance through both IT simultaneous and sequential ambidexterity. In doing so, we also answer calls for research on simultaneous and sequential ambidexterity in the specific context of SMEs (Senaratne & Wang, 2018).

As a second research contribution, our results demonstrating equifinal pathways to service innovation performance (and its absence) reconcile, to a certain point, conflicting findings linking IT capabilities with performance (e.g., positive effect: Bharadwaj, 2000; Santhanam & Hartono, 2003; statistically non significant effect: Chae et al., 2014). Thus, while variance or ‘universalistic’ approaches can well identify conflicting effects of IT capabilities on performance-related outcomes, a configurational approach can reconcile such results by allowing the same configurational element to either enable or inhibit service innovation performance depending on how it relates with other elements of the digital ecodynamics of SMEs. All in all, our results contribute by showing IT capabilities to be critical in achieving high service innovation performance (i.e., all high-performing configurations have at least one type of IT capabilities – either exploitation or exploration – present, while all non-high-performing configurations have at least one type of IT capabilities absent).

The way in which IT ambidexterity was conceptualized and operationalized in this study constitutes a third contribution to the literature. For instance, by conceptualizing and analyzing

IT ambidexterity with two distinct constructs, we contribute to the literature by answering researchers' calls for studying IT capabilities for exploitation and IT capabilities for exploration in terms of the distinct values they can take, their possible combinations, and their effect on performance-related outcomes (Lee et al., 2015). This need stems from the fact that IT ambidexterity has been so far studied as a combined capability (i.e., operationalized using item-level interaction terms of its two subdimensions, IT for exploitation and IT for exploration) (e.g., Chi et al., 2017; Lee et al., 2015). Our results thus address this need by looking into what the equilibrium between these two types of capabilities should be in order to enhance competitive performance (Lee et al., 2015; Pavlou & El Sawy, 2011). Finally, our operationalization of IT capabilities for exploitation and exploration to capture specific and concrete IT infrastructure and e-business capabilities constitutes both a departure from past research as well as a contribution. A departure because operationalizations of IT ambidexterity have utilized self-perceptual measures that capture, for example, the reutilization of legacy systems (i.e., exploitation) and the experimentation with new IT (i.e., exploration), without identifying specific technology or activities enabled by it (e.g., Lee et al., 2015). A contribution because by replacing abstract mental representations of technology with specific IT infrastructure and e-business capabilities we capture the ontological dimension of technology (Ortiz de Guinea & Webster, 2013). Doing so also provides managers with more concrete and actionable options with respect to specific IT and IT-enabled activities. Future research thus, could build upon this work and link specific IT infrastructure capabilities (e.g., CAD / CAM) and e-business capabilities (e.g., e-business intelligence) to the competitive performance of SMEs.

As a fourth theoretical contribution, our results highlight the criticality of environmental conditions for SMEs to achieve high service innovation performance. In fact, environmental uncertainty appears to be a necessary condition for the attainment of high service innovation

performance, which makes sense when situating these findings within the strategic management literature. Changing environmental conditions and high levels of uncertainty cause firms to pursue innovation (Eisenhardt & Schoonhoven, 1996; Ritter & Gemünden, 2004; Wu, 2007) because greater environmental uncertainty generates increased competitive opportunities and threats (Drechsler & Natter, 2012), and thus crucially impacts the firms' response in order to maintain its competitiveness (Uzkurt et al., 2012). Consequently, environmental uncertainty has been found to positively influence the innovation performance of SMEs (Mukherji & Mukherji, 2017; Uzkurt et al., 2012). Thus, uncertain environments lead to both incremental (i.e., modified services) and radical (i.e., new services) innovations (Çiğdem, Ataman, & Elbasi, 2018). These results represent a contribution since most empirical studies of the IT capabilities-performance and DCs-performance relationships have not included important environmental factors, such as environmental uncertainty, that are likely to play a role in shaping these relationships (e.g., Ray, Muhanna, & Barney, 2005; Wang, Liang, Zhong, Xue, & Xiao, 2012). As a result, our results answer calls for research into the role of environmental uncertainty when associating IT capabilities and DCs to performance outcomes (Pezeshkan et al., 2016).

As a fifth and final contribution, our results also shed light into the relationship between DCs and different types of IT capabilities in producing service innovation performance. From our results, it appears that there is a trade-off between the firm's IT capabilities for exploration and two of its dynamic capabilities, namely its innovation and networking capabilities: the former (in the absence of the latter) or the latter (in the absence of the former) appear to be sufficient for high service innovation performance. This makes sense when some have argued that there is a correspondence between IT capabilities for exploration and certain DCs (Pavlou & El Sawy, 2011). In contrast, these DCs appear to complement IT capabilities for exploitation in producing high service innovation performance. This also contributes to the literature since most strategic management studies have explored the dynamic capabilities-performance

relationship without including IT-related constructs, while the reverse is true for most IS studies with regard to the IT capabilities-performance relationship (Orlikowski, 2010; Zammuto, Griffith, Majchrzak, Dougherty, & Faraj, 2007). Thus, our results answer calls from leading authors to study the interplay between the firm's DCs and IT capabilities as they affect its agility, organizational performance and competitiveness (El Sawy et al., 2010; Nevo & Wade, 2010, 2011), and to do so from a configurational approach (El Sawy et al., 2010; Wilden et al., 2016).

Finally, it is important to note that this study falls within the paradigm shift in strategic IS research advocated by Merali, Papadopoulos and Nadkani (2012). Such a shift calls for viewing strategic IS as complex adaptive systems (CAS); that is, a view grounded in complexity theory in order to better apprehend the dynamism, uncertainty and unpredictability of the social and economic landscape (Merali et al., 2012; Tanriverdi, Rai, & Venkatraman, 2010). Complexity theory and its associated methods, such as fsQCA, have three overarching characteristics that are also present in this study: a) holistic interconnectedness and mutual causality among system elements, b) equifinality and multiple 'realities', and c) nonlinearities or causal asymmetry (van de Wetering, Mikalef, & Helms, 2017). Thus, our study complements recent studies that have adopted this paradigm shift and view system elements through a configurational lens that is more appropriate to study complex adaptive systems such as strategic IS. For instance, one of these studies has focused on big data analytics through the configurational exploration of data, technology, people, organization, process, and context as they affect performance (Mikalef, Boura, Lekakos, & Krogstie, 2019). In similar fashion, another study has focused on business intelligence systems through the configurational identification of IT, environmental velocity, organizational size, and top-management team energy as they influence the organization's sensing agility, decision-making agility, and action-taking agility (Park, El Sawy, & Fiss, 2017). All in all, our study fits well with recent arguments

for studying organizational innovation from a holistic perspective that is grounded in complexity and configurational theory, and for doing so by identifying the bundles of technological, organizational, and environmental factors that enable (and do not enable) firms to successfully innovate (van de Wetering et al., 2017).

5.1. Implications for Practice

Our exploratory study also has implications for practice. Our configurational approach provides a taxonomy (Bailey, 1994) of different digital ecodynamic configurations that are equifinal in leading to service innovation performance. Such a taxonomy provides managers of industrial service SMEs with equally effective digital ecodynamic configurations that they can emulate in order to achieve high levels of innovation performance, given the IT and non-IT resources and competences at their disposal and their firm's initial strategic posture. Specifically, under high environmental uncertainty, managers should invest in IT capabilities for exploration, or in IT capabilities for exploitation if the latter are accompanied by efforts to develop their firm's innovation and networking capabilities.

Furthermore, given causal asymmetry, managers may avoid the capability configurations that are associated to the absence of high service innovation performance. For instance, managers should avoid a lack of both strong IT capabilities for exploration and strong IT capabilities for exploitation, something that would prevent them from attaining high service innovation performance in both certain and uncertain environments. All in all, managers may examine the various components of their firm's digital ecodynamics in order to improve its service innovation performance, emulating the top-performing configurations that are coherent with their firm's strategic posture, and avoiding those configurations that prevent performance to occur. Consequently, from an IT 'strategy-as-practice' perspective (Whittington, 2014), our configurational approach appears to be more practical than a 'best practices' approach because it gives managers more strategic options in their pursuit of service innovation performance.

5.2. Limitations and Future Research

The present study has certain limitations that warrant future research. First, given the cross-sectional nature of our study, causality, as understood in the variance-based tradition, cannot be inferred. As a result, the delayed effects of the capability configurations on service innovation performance cannot be ascertained.

Second, our measure of service innovation performance is an aggregate proxy (i.e., percentage of sales attributed to new or modified services) that does not differentiate between incremental (i.e., modified services) and radical innovation (i.e., new services) performance.⁹ As exploitative activities may possibly be associated with incremental innovation performance and explorative activities with radical innovation performance (Brem et al., 2016), future research could differentiate between the two types of innovation and test the extent to which IT capabilities for exploitation and IT capabilities for exploration are associated to incremental and radical innovation performance.

Third, the industrial service SMEs studied here operate mostly in high-knowledge and technical/functional support service sectors (i.e., engineering, computing, machinery/equipment supply services, etc.). As there is great heterogeneity among SMEs with regard to their sector of activity and the markets in which they operate, future research could focus on exploring the digital ecodynamic configurations of SMEs in industries whose knowledge requirements and technical intensity vary more than in the industrial services sector.¹⁰

Fourth, we looked at two types of capabilities (i.e., innovation and networking capabilities) that only cover partially the broad dynamic capability concept. For instance, the innovation capability encompasses activities that partly refer to the DCs' underlying processes, such as sensing (via analysis of customer information, competitor's offerings and economic

⁹ We thank an anonymous reviewer for this insight.

¹⁰ We thank an anonymous reviewer for this insight.

trends) and learning (via idea generation and prefeasibility analysis of ideas). As a result, future research could conceptualize and operationalize a broader dynamic capability construct, i.e. a construct that covers more of its multiple dimensions such as sensing, learning, coordinating and integrating (Mikalef & Pateli, 2017; Pavlou & El Sawy, 2011).

Finally, there are limitations that stem from the analytical technique utilized in this study, namely fsQCA. For instance, decisions regarding the calibration of our measures could affect our results (Glaesser & Cooper, 2014; Skaaning, 2011). Thus, besides following recommended guidelines for calibration (Dul, 2016; Glaesser & Cooper, 2014), we performed sensitivity analyses (e.g., Fiss, 2011; Glaesser & Cooper, 2014; Schneider & Wagemann, 2012). That is, we changed the calibration of conditions and the outcome, with the resulting configurations being similar to those reported here (e.g., Fiss, 2011). In addition, although fsQCA is much less sensitive than other QCA methods (e.g., crisp-set QCA) with respect to changes in the frequency of cases linked to the configurations and the choice of the consistency threshold (Glaesser & Cooper, 2014), these decisions may still affect the results. In this regard, it is important to note that we followed the recommended frequency threshold of 2 for samples smaller than 150 cases (Fiss, 2011; Ragin, 2006). With respect to consistency, although we used the recommended threshold of 0.75 for consistency (Liu et al., 2017; Pappas, 2018; Ragin, 2006, 2008a), we also performed analyses with other consistency thresholds with the resulting configurations being similar than those reported here.

5.3. Conclusion

In summary, our study has taken a configurational approach to unveil sets of equifinal causal configurations that characterize the digital ecodynamics of industrial service SMEs and that lead to the presence (and absence of) high levels of service innovation performance. These causal conditions included the sampled firms' environmental uncertainty, dynamic capabilities and, most importantly for IS research, IT ambidexterity in the form of IT capabilities for

exploration and exploitation. In so doing, we hope to have provided added knowledge and further insight on the extent to which and the manner in which SMEs may develop and deploy their IT resources and competences to fuel and manage service innovation.

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Appendix A: Elements of the questionnaire designed to measure the research variables

Environmental Uncertainty

Please indicate to what extent you disagree or agree with the following statements relative to your firm's business environment:

	Totally disagree			Totally agree	
	1	2	3	4	5
Our firm must change its marketing strategy very frequently.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Our services/products become obsolete very rapidly.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The actions of our competitors are unpredictable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The demand for our services/products is very difficult to predict.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Our service delivery processes are often subject to important changes.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Innovation Capability

Please indicate the frequency with which your firm uses the following practices to improve its existing services or develop new ones:

	Never			Always	
	1	2	3	4	5
Idea generation (brainstorming) sessions among the firm's employees.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Analysis of a new idea's commercial potential (pre-feasibility study).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Encouragement of employees to express new ideas.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Consultations of employees during informal work sessions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Analysis of information provided by customers (suggestions or complaints).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Networking Capability

Please indicate the extent of your firm's formal collaborations with various organizations in terms of the domains of collaboration and the type of partners.

	<u>Partners</u>	<u>Manufacturing</u> customers	<u>Non-manufact.</u> customers	Universities/ colleges	Consultants	Suppliers	Research centers
Collaboration domains							
Personnel training	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Service delivery	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Purchasing/procurement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Design/R&D	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Marketing/sales	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Improvements in service and delivery process	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

IT Infrastructure Capability

Please check if your firm uses any of the following technologies and systems.

[for exploration]

CAD / CAM (computer-aided drafting, design and manufacturing)	<input type="checkbox"/>
Modeling / Simulation	<input type="checkbox"/>
Rapid Prototyping	<input type="checkbox"/>
Customer Relationship Management (CRM)	<input type="checkbox"/>
Mobile Communication (e.g. mobile computing, smartphone)	<input type="checkbox"/>

[for exploitation]

Logistics / Optimization (e.g. routing, loading, distribution)	<input type="checkbox"/>
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- Computer-Aided Maintenance
- Computer Numerical Control (CNC)
- Automated Handling
- MRP / MRP II / ERP (enterprise resource planning)
- External Communication Network (Internet, Extranet, EDI)
- Internal Communication Network (Intranet)

e-Business Capability

Among the following activities, indicate those realized by your firm through e-business applications, the Internet and the Web.

[for exploration]

- e-Business intelligence
 - Prospecting for new customers in Canada
 - Prospecting for new customers abroad
 - Developing business intelligence

e-Collaboration

- Interacting with business partners to design new products/services

e-HRM

- Recruiting personnel

[for exploitation]

e-Commerce

- Ordering supplies online
- Selling products/services online
- Interacting with customers to improve products/services