Resolving paradoxes in IT success through IT ambidexterity: the moderating role of uncertain environments

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ABSTRACT

As information technology (IT) success is both essential and elusive, researchers and practitioners are faced with an ongoing challenge to determine what IT capabilities should be developed to ensure IT success. Drawing on the paradox and ambidexterity theory, we highlight paradoxes in IT success and propose that firms manage these paradoxes by developing an IT ambidexterity capability. We hypothesize that IT ambidexterity capability enhances IT success, and that uncertain environments strengthen this relationship. Our hypotheses find support in a sample of 292 British high-tech firms. This research advances the theory for a more comprehensive understanding of the impacts of IT ambidexterity capability.

Keywords: IT ambidexterity, IT success, paradox and ambidexterity theory, environmental dynamism, environmental complexity.

INTRODUCTION

Information Systems (IS) frameworks and capabilities are inherently complex as their fundamental features and outcomes are often more emerged than planned, due to frequent changes in plans, strategies, structures, and environments (Butler and Gray 2006). Despite this unreliability, individuals and firms increasingly rely on information technology (IT) resources (e.g., IT infrastructure, technical and managerial IT skills, technical knowledge assets, synergy, etc.) to provide core services and gain business benefits. Where IT is both essential and imperfect (due to reliability issues), firms are faced with the challenge of developing the right IT capabilities[1] that can successfully and reliably deliver IT outcomes (Butler and Gray 2006).

[1] To distinguish between resource and capability, this study understands resources to be the inputs of production processes that are tradable and nonspecific firm assets, whereas capabilities refer to the capacity to

The proliferation of IT tools and the notorious reputation of IT frameworks (due to frequent delays, misalignment, failures, and reliability issues) has reinforced the need for firms to know what IT capabilities can deliver IT success and avoid wasting investments (Nambisan 2013). IT success is critical to understanding the value and efficacy of IT management efforts and IT investments, as well as to realize the business value of IT resources; thus, it cannot be ignored (Petter and McLean 2009), particularly in the present-day global trend toward IT transformations (Gregory et al. 2015). Although the IS literature provides a good understanding of operationalizing IT success (i.e., DeLone and McLean (1992) IS success model), research on IT capabilities that influence and ensure IT success remains limited (Petter et al. 2013).

Drawing on the theory of paradox and ambidexterity[2], we highlight paradoxes in IT success and argue that firms resolve such paradoxes by developing an ambidexterity capability (Gregory et al. 2015; Smith and Lewis 2011). The paradox resolution requires firms to pursue disparate things at the same time, associating ambidexterity capability to resolve paradoxical tensions (Gibson and Birkinshaw 2004). Therefore, we argue that the paradoxes in IT success may require a dual capacity to explore and exploit a firm's IT resources. Recent studies on IT capabilities have recognized IT ambidexterity – "the dual capacity to explore and exploit IT resources and practices" (Lee et al. 2015; p. 398) – as one of the critical capabilities for competitive IT performance (Subramani 2004). The high competitive intensity among present-day industries – due to globalization, frequent technological disruptions, and volatile market demands – has made IT ambidexterity an imperative capability that firms have to develop for long-term survival, particularly in the high-tech industry (Chandrasekaran et al. 2012). For instance, Merrill Lynch's IT utility model – that exploited existing IT resources by centralizing

deploy resources using organizational processes, and which are nontradable, firm-specific abilities to integrate, deploy, and utilize other resources within the firm (Amit and Schoemaker 1993; Wang et al. 2012).

[2] Ambidexterity, defined as the ability to manage two distinct things at the same time (Gibson and Birkinshaw 2004), is associated with resolving paradoxes, or "contradictory yet interrelated elements that exist simultaneously" (Smith and Lewis 2011; p. 382). The theory of paradox and ambidexterity refers to the ability of a firm in resolving paradoxical tensions by developing an ambidexterity capability (Gregory et al. 2015).

them and developed an innovative IT mechanism of cost transparency – resulted in an effective IT sensation, offering informational accuracy, technical reliability, and flexibility (Levinson 2004). Similarly, the Haier group exploited existing IT resources to integrate sales, procurement, and supply chain partners at the local levels, and implemented a novel IT system (IT exploration) called Global Value System (GVS). GVS allowed Haier group to synchronize information between the requirements and constraints of different departments across global supply chain partners, thereby, ensuring that the outcomes of planning were accurate and feasible (Huang et al. 2012). Haier's ability to simultaneously pursue both IT exploration and exploitation demonstrated a successful IT initiative, realizing higher informational quality, better response time, and greater reliability (Huang et al. 2012).

Despite the necessity of the simultaneous pursuit of IT exploration and exploitation activities in the present-day industry, research on IT ambidexterity capability is extraordinarily scant (Lee et al. 2015). In particular, our understanding of whether IT ambidexterity is the right capability to resolve the paradoxical determinants and realize IT success is lacking. It is important because developing IT ambidexterity capability is both challenging and risky, requiring firms to invest a significant amount of resources and time (Benner and Tushman 2003; Raisch and Birkinshaw 2008; O'Reilly and Tushman 2008). However, apart from anecdotal evidence and case examples (i.e., Merrill Lynch's IT utility model), IS literature lacks generalizable results to assure IS practitioners that their investments in IT ambidexterity capability will deliver successful IT outcomes. Therefore, the significance of IT ambidexterity capability in the present-day industry and the absence of evidence about delivering IT success, drive our empirical research in this area.

In a more nuanced understanding of the link between IT ambidexterity capability and IT success, we also check for the role of uncertain environments that may enable or inhibit the performance implications of an IT ambidexterity capability. This expectation is broadly grounded in the notion of strategic fit (Hambark 1983), which defines the appropriateness of an organizational strategy based on its congruence with the environmental contingencies. Uncertain environments often dictate the type of IT capability that firms need to acquire and the way to apply it, besides affecting the extent of value generation (Aral and Weill 2007; Chae et al. 2014; Chae et al. 2018). Prior research also suggests that environmental uncertainty may underlie the performance implications of an ambidexterity capability (Cao et al. 2009; De Clercq et al. 2014; Jansen et al. 2006; Li et al. 2013; O'Reilly et al. 2009), and such a focus may uncover critical boundary conditions for the IT ambidexterity–IT success relationship. Therefore, we moderate for uncertain environments to determine if uncertain conditions cause variations in the relationship between IT ambidexterity capability and IT success. Thus, two research questions that motivate this research are: (1) Does IT ambidexterity capability influence IT success? (2) Do uncertain environments influence the IT ambidexterity–IT success relationship?

The significance of determining the right capabilities to realize IT success grows more crucial in the context of high-tech small and medium enterprises (SMEs). SMEs, with limited resources, do not have the leverage to experiment with capabilities (Oke et al. 2007) and because of high survival stress and competition, any technological failures may result in market extinction (Jamali et al. 2015). Moreover, uncertainty is one of the key characteristics of SME environments (Neirotti and Raguseo 2017), thereby, providing appropriate context to investigate our research questions.

This study contributes to IS literature in the form of theoretical development and empirical test of the link between IT ambidexterity capability and IT success. Drawing on the theory of paradox and ambidexterity, we highlight underlying paradoxes in IT success and provide evidence of IT ambidexterity capability delivering IT success. We advance the contingent view of the organizational environment by showing its influence on the performance impacts of an ambidextrous capability. In other words, this research reinforces the critical need to consider a firm's external factors when measuring the implications of an IT capability. Finally, our research seeks to open up a discussion and advance theory for a more holistic and comprehensive understanding of the impacts of IT ambidexterity capability.

The remainder of this paper is structured as follows: first, we discuss the relevant literature, followed by our research framework, and hypothesis development. Next, we describe our research methodology for hypothesis testing, which relied on survey data collected from a large-scale field survey of high-tech SMEs and secondary data. We then present data analysis and results using partial least square (PLS) path modeling. Finally, we discuss the implications of our findings for both research and practice, limitations, and directions for future research.

THEORETICAL BACKGROUND

IT success operationalization

Recognizing the limitations and complexity in measuring IT success, Delone and Mclean (1992) proposed an IS success model. This proposed model has been refined over the years to include the dimension of service quality due to the changing nature of IT use (Delone and Mclean 2003). The updated Delone and Mclean model for IS success now encompasses system quality, information quality, and service quality singularly and jointly to operationalize IT success in net organizational benefits (Petter and Mclean 2009). The details of information quality, system quality, and service quality factors that inform the updated Delone and Mclean model of IS success are detailed in Table 1. This study adopts the three determinants as our measures to operationalize IT success; mainly because these factors are thoroughly validated and have been consistently used for operationalizing IT success (Petter et al. 2013).

Table 1: Determinants of IT success adopted from Delone and Mclean (2003) and Petter and Mclean (2009)

Determinants	Conceptualization	Dimensions of IT success

Information quality	Information quality conceptualizes the accuracy and efficiency of the IT capability in conveying the intended meaning	Semantic dimension of IT success
System quality	System quality conceptualizes the technical reliability, functionality, and flexibility of the IT capability	Technical dimension of IT success
Service quality	Service quality conceptualizes the responsiveness, reliability, and satisfaction of the users with IT capability	Effectiveness dimension of IT success

Theory of paradox and ambidexterity

Paradoxes, defined as contradictory yet interrelated elements that exist simultaneously, are argued to be one of the most common types of contradictions that appear in IT and organizational management (*cf.* Gregory et al. 2015). Ambidexterity, derived from the ability of an individual to work with both hands with equal ease, has been increasingly used in organizational settings to represent a firm's ability to resolve paradoxes by simultaneously balancing contradictory activities (Smith and Lewis 2011). Gregory et al. (2015) highlight the relationship between paradoxes and ambidexterity to define the theory of paradox and ambidexterity as an integrative view of recurrently resolving paradoxical tensions and developing an ambidexterity capability.

This study adopts information quality, system quality, and service quality, the three determinants of Delone and Mclean model, together to conceptualize IT success. However, at the root level, the conceptualization features of these IT success determinants create paradoxical demands that firms have to manage for realizing IT success. For instance, conceptualization features such as information efficiency, information accuracy, system reliability, service reliability, and service satisfaction require efficient use of existing IT resources, i.e., IT exploitation. At the same time, conceptualization features such as system functionality, service responsiveness, and system flexibility require continuous experimentation and adaptation of new IT solutions and applications, i.e., IT exploration. The former features require an internal focus of the firm's efforts and resources on existing IT resources, while the latter requires an external focus of the firm's efforts and resources to create more novel and robust IT solutions (Lee et al. 2015; Syed et al. 2019b). This presents the IT success paradox as both activities compete for similar organizational resources and the excessive focus on one adversely affects the other. Therefore, firms require a dual capacity (i.e., IT ambidexterity capability) to deliver IT success determinants simultaneously and realize IT success. Drawing on the theory of paradox and ambidexterity, the underlying paradoxes in IT success make it well suited to examine the influence of IT ambidexterity capability – which involves a combination of IT exploitation and IT exploration activities. Moreover, we recognize and complement the multifaceted nature of IT ambidexterity impacts by examining various dimensions of IT success (i.e., technical, semantic, and effectiveness).

IT ambidexterity capability

There is an emerging literature that extends the theory of paradox and ambidexterity in the IS context, defining IT ambidexterity capability as the ability of a firm to exploit its existing IT resources (IT exploitation) and, at the same time, explore new IT solutions (IT exploration) (Lee et al. 2015; Syed et al. 2019b). IT exploitation represents the continuous refinement, modification, and reconfigurations of existing IT resources, while IT exploration represents innovating, experimenting, and creating new IT solutions and IT practices (Lee et al. 2015; Mithas and Rust 2016; Syed et al. 2019a). IT exploration and IT exploitation, although highly interrelated, draw on different processes, resources, and structures generating significantly different performance outcomes over time (He and Wong 2004; Syed et al. 2019a).

To manage IT exploitation and IT exploration together, prior research suggests to separate them structurally – using a different structure or department for each (structural ambidexterity) (O'Reilly and Tushman 2004), temporally – one after the other in tandem (temporal/sequential ambidexterity) (Tushman and O'Reilly 1996), or to combine them within the same firm (contextual ambidexterity) (Gibson and Birkinshaw 2004). While the approach to structural ambidexterity may be effective, organizations (e.g., SMEs) may lack the resources or stability required to create different subunits dedicated to each activity (Lubatkin et al. 2006). In a tandem or temporal approach, the shift of balance and momentum from one activity to another becomes challenging and may lead firms to a "failure trap," in which exploration drives out exploitation, or a "competency trap," in which exploitation drives out exploration (Levinthal and March 1993). The contextual ambidexterity in which both exploitation and exploration are balanced within a firm seems to be the most suitable for the IS context. With the frequent technological breakthroughs and demand changes, IT exploitation and IT exploration can benefit when they coexist as learning mechanisms that can complement one another (Chandrasekaran et al. 2012; Napier et al. 2011).

While prior studies have articulated the criticality of organizational approaches for both IT exploitation and exploration (i.e., Subramani 2004), the explicit conceptualization and empirical analysis of the dual pursuit of these two IT activities remain scant. Except for the study of Lee et al. (2015) and Syed et al. (2019b), prior studies have primarily focused on a distinct aspect of IT activities, e.g., IT spending and technical IT skills (Ray et al. 2005) or the flexibility of IT infrastructure (Benitez et al. 2018c). Some studies adopted a case study approach to identify the paradoxical nature of IT activities (i.e., Gregory et al. 2015), while others have highlighted their moderating effect (i.e., Mithas and Rust 2016; Chi et al. 2017). Table 2 presents a comprehensive overview of the existing studies on IT ambidexterity capability. While prior studies have demonstrated operational benefits, such as fostering agility (Lee et al. 2015), new product development speed (Syed et al. 2019a), or governance strategy (Chi et al. 2017), they suggest that IT ambidexterity capability may act as a distinct IT capability that allows firms to manage paradoxes and implement IT resources in a competitive manner (i.e., Mithas and Rust 2016). This informs our understanding to validate whether IT ambidexterity is the right capability to deliver IT success.

Table 2: A comprehensive overview of prior research on IT ambidexterity capability

Author	Theoretical lens	Definition of IT ambidexterity	Focus on IT ambidexterity	Methodology	Key finding(s)
Gregory et al. (2015)	Paradox and ambidexterity theory	Capability to resolve paradoxical tensions associated with IT transformation programs	Identification of various dimensions of IT ambidexterity	Case examination of an IT transformation program in a commercial bank	Identified six areas of paradoxes that managers face in IT transformation programs. These areas include IT portfolio decisions, IT platform design, IT architecture change, IT program planning, IT program governance, and IT program delivery.
Lee et al. (2015)	Capability-building perspective	Dual capacity to explore and exploit IT resources and practices	IT ambidexterity as an enabler to organizational agility	Matched-pair field survey of 178 business and IT executives	IT ambidexterity enables operational ambidexterity to facilitate organizational agility. Moreover, the mediating effect of operational ambidexterity depends upon the level of environmental dynamism.
Mithas and Rust (2016)	Resource-based view and strategic IT orientation	Dual emphasis on IT resources in revenue expansion and cost reduction	IT ambidexterity as a moderator	Analysis of secondary dataset from more than 300 US firms	Dual emphasis on IT resources in revenue expansion and cost reduction moderates the influence of IT investments on market value. This IT–profitability relationship is stronger for the firms with either revenue- or cost-emphasis strategy.
Chi et al. (2017)	IT governance	Simultaneous pursuit of IT flexibility and IT standardization	IT ambidexterity as a moderator	Field survey of 200 senior executives	IT ambidexterity influences the choice of governance strategies such that firms with low IT ambidexterity prefer using a balancing governance strategy. While high IT ambidexterity can reduce the risks of an unbalancing strategy.
Syed et al. (2019b)	Ambidexterity theory	Simultaneous pursuit of IT exploration and IT exploitation	IT ambidexterity as an enabler to new product development speed	Matched-pair field survey of 292 NPD and IT executives	IT ambidexterity enables operational agility to facilitate NPD speed. The mediating effect of operational agility

					depends on the level of market complexity.

Uncertain environment

For any particular firm with specialized technological capabilities, changes in the environment may significantly change the prominence of its IT capabilities (Aral and Weill 2007; Chae et al. 2014). Therefore, the value and performance impact of the firm's strategic IT capabilities must be evaluated within an environment external to that in which the firm operates (Tsai and Yang 2013). Prior IS studies (i.e., Pavlou and El Sawy 2006; Mithas et al. 2013) have also emphasized the need to include the effects of external environments that may influence the value of their strategic IT capabilities, such as IT ambidexterity, to uncover the boundary conditions for underlying relationships. Table A-1 (Appendix) lists a sampling of research in the areas of IT constructs, environmental factors, and performance outcomes. It is not intended to serve as an exhaustive set of references on our key constructs, but merely to highlight some of the key articles in these areas and to suggest that uncertain conditions interplay with IT capabilities both positively and negatively. Thus, this emphasizes the need to moderate uncertain environments that may influence IT ambidexterity – IT success relationship.

Consistently, our model posits that uncertain environments are likely to modify the impact of IT ambidexterity capability. While prior research characterizes uncertain environments in multiple ways, our research model includes two constructs – dynamism and complexity – that are widely accepted to characterize uncertain environments in the existing literature that studies IT, environmental factors, and performance outcomes (Table A-1, Appendix). Table 3 presents the details of environmental dynamism and complexity constructs. Firms operating in higher environmental dynamism and complexity are likely to perceive greater uncertainty and require greater information processing than the firms facing simpler markets (Anderson and Tushman 2001; Simsek 2009; Cao et al. 2009).

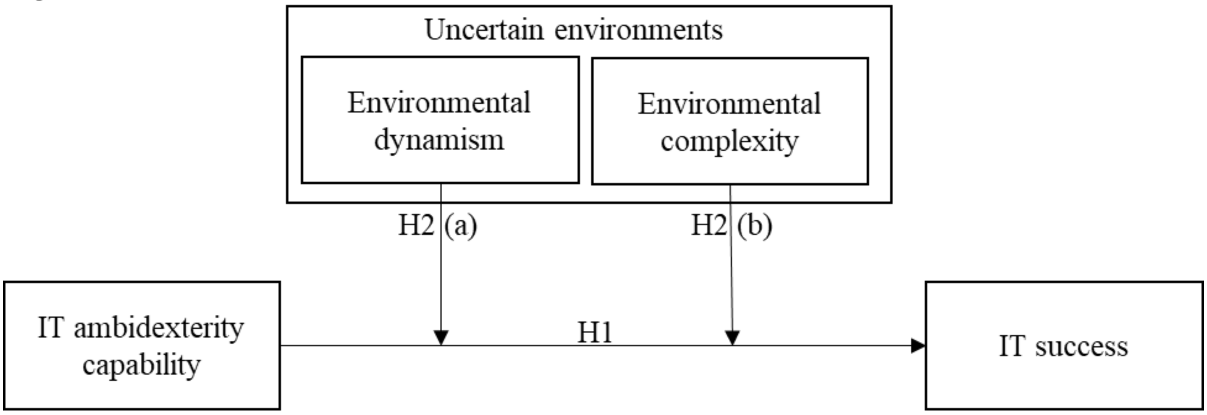
Table 3: Operationalization of uncertain environments

Construct	**Conceptualization**	**Supporting references**
Environmental dynamism	The extent of unpredictable change in an industry characterized by inconsistent customer preferences or demand fluctuations as well as the volatility in technological breakthroughs	(Anderson and Tushman 2001; Dess and Beard 1984; Melville et al. 2007)
Environmental complexity	The extent to which a firm has to consider its range of activities, heterogeneous actors, linkages, and interconnectedness outside its boundaries in making strategic decisions	(Anderson and Tushman 2001; Dess and Beard 1984; Stoel and Muhanna 2009; Chen et al. 2014)

RESEARCH MODEL AND HYPOTHESES

This study draws on the paradox and ambidexterity theory to propose that IT ambidexterity capability positively influences IT success. To develop a nuanced understanding of the IT ambidexterity – IT success relationship, we investigate the moderating influence of uncertain environments – characterized by environmental dynamism and complexity – in this relationship. Figure 1 presents the conceptual model and highlights the proposed hypotheses.

Figure 1: Research model



IT ambidexterity and IT success

The paradoxical features trigger managerial responses to develop an ambidexterity capability to accommodate conflicting demands (Gregory et al. 2015). Grounding our research in the theory of paradox and ambidexterity, we argue that firms develop IT ambidexterity capability by simultaneously exploring and exploiting their IT resources to effectively realize IT success outcomes of information quality, system quality, and service quality.

The dual pursuit of IT exploitation and exploration can significantly enhance the accuracy and efficiency of the IT capability to convey the intended meaning. For instance, IT exploitation encourages refinement and reconfiguration of existing systems in a way to enforce data and process integration (Subramani 2004). Such integrated systems make it possible to gather and share comprehensive information timely and accurately (Sambamurthy et al. 2003), allowing users to make well-informed decisions. Repeated use of existing technologies increases the experience and builds confidence among users to generate digital options that enhance the knowledge base for synthesizing and providing accurate information (Lu and Ramamurthy 2011). IT exploitation reinforces continuous refinement through standard operating procedures and recurrent use, which are deemed to reduce errors and unwanted variations, ensuring service reliability (Butler and Gray 2006). For example, in a global trading industry where price changes are frequent and critical, efficient use of existing IT systems integrates real-time information to provide an accurate and reliable perception of price trends to spot market opportunities (Zaheer and Zaheer 1997).

IT exploration, on the other hand, enables a proactive stance to innovate and to quickly identify emerging technologies, practices, and IT skills (Lee et al. 2015). This enables a continuous process of learning and knowledge renewal that mindfully manages the adoption, assimilation, and implementation of new IT solutions to avoid firms falling into lock-in technology rigidity (Swanson and Ramiller 2004). In other words, IT exploration reduces the risk of core technology becoming obsolete by reinforcing existing systems with innovative technical reconfigurations (Lu and Ramamurthy 2011). The extensive scanning for innovative initiatives generates market intelligence that develops the ability to anticipate changes in customer needs, competitors, and technology in time, allowing for the modification of existing

IT resources to adapt to changing environments (Lee et al. 2015; Subramani 2004). Thus, IT exploration augments the system quality by inducing the flexibility to adapt to technological developments and to implement better IT applications.

IT ambidexterity capability, with the simultaneous pursuit of IT exploitation and IT exploration, makes it possible to resolve the paradoxes underlying IT success; for example, as information efficiency, information accuracy, system reliability, service reliability, and service satisfaction is delivered through the repeated use and continuous refinement of existing technology, whereas adaptations and modifications with novel technologies and experimentation augment system functionality, service responsiveness, and system flexibility. Consequently, firms with a higher level of IT ambidexterity capability are expected to be better able to resolve paradoxical features of IT success and generate opportunities for business development. For instance, IBM has been able to compete in mature as well as new business technologies through simultaneous exploitation and exploration of their technological resources (O'Reilly et al. 2009). Therefore, we hypothesize that:

Hypothesis 1 (H1): Firms high in IT ambidexterity capability will be higher in IT success.

The moderating effect of environmental dynamism and environmental complexity

Environmental dynamism represents the instability of environmental change (Dess and Beard 1984; Simsek 2009). The instability is commonly conceptualized into market instability and technical instability (Anderson and Tushman 2001). The former is linked to the unpredictability in customer preferences or demand for certain products, while the latter is related to volatility in technological breakthroughs. The unpredictability and volatility in the market seek higher information processing that makes the management of IT success paradoxes more challenging. We expect that environmental dynamism can moderate the influence of IT ambidexterity capability on IT success, such that IT ambidexterity capability is more influential in dynamic environments.

Higher dynamism for firms seeks greater information collection and processing to ensure the reliability, efficiency, and responsiveness of IT systems continuously. Under conditions of high dynamism, firms face higher risks of technologies becoming obsolete, i.e., incompatible with new business requirements or new technological developments that uncover new IT solutions (Chandrasekaran et al. 2012; Mithas et al. 2013). Consequently, the average industry IT capability may be perceived as a less reliable route for IT success (Wang et al. 2012) compromising the ability to deliver IT success determinants. It is therefore expected to have a detrimental direct effect of environmental dynamism on IT success. However, such environmental instability triggers a managerial response for a stronger focus on IT exploitation activities to integrate, build, and reconfigure internal technologies for incremental improvements as well as on IT exploration for technological breakthroughs and radical improvements (Lee et al. 2015). IT ambidexterity capability is, therefore, propelled to higher levels in both IT exploitation and exploration, strengthening the impacts on delivering IT success determinants.

This expectation is broadly grounded in the arguments of Levinthal and March (1993), that environmental turbulences tend to emphasize dynamic efficiency – which requires firms to not only refine existing systems but to explore new solutions (O'Reilly and Tushman 2008). Thus, IT ambidexterity capability is augmented under dynamic environments in influencing IT success. On the contrary, in low environmental dynamism, the competitive intensity pacifies, and the firms' approaches to their markets get simpler. Firms may afford greater confidence in exploiting and refining existing IT resources to achieve adequate levels of IT success, reducing IT exploration, and increasing the risk to lock-in stagnant technology (Swanson and Ramiller 2004). Consequently, IT ambidexterity capability may grow weak or may lead to an imbalance of exploitation and exploration activities under such environments, adversely affecting IT success. Therefore, we hypothesize that:

Hypothesis 2a (H2a): Firms high in IT ambidexterity capability that have high environmental dynamism will be higher in IT success than firms high in IT ambidexterity capability but lower in environmental dynamism.

Environmental complexity represents the extent to which a firm has to consider its range of activities, heterogeneous actors, linkages, and interconnectedness outside its boundaries in making strategic decisions (Dess and Beard 1984). The tacit coordination with other bodies enhances mutual awareness among industry actors (Mithas et al. 2013), but, at the same time, requires higher information processing. More interdependencies of firm actions and higher levels of heterogeneity in firm activities generate a need for higher information gathering and processing capabilities. The higher level of heterogeneity escalates the intricacy to manage the paradoxical demands of IT success determinants, compromising IT success. While the aforementioned arguments suggest that the direct effect of environmental complexity will be detrimental to IT success, we expect that environmental complexity will positively moderate the influences of IT ambidexterity capability on IT success, such that IT ambidexterity capability is more influential in complex environments.

A complex environment will be perceived as more uncertain and thus requires more information processing to achieve a given level of performance (Anderson and Tushman 2001; Dess and Beard 1984). To compete in complex environments, firms are expected to gather information about their surroundings and possess information-processing mechanisms to adapt and coevolve with the environment (Wade and Hulland 2004; Cao et al. 2009). Thus, firms are pushed to enhance the efforts in IT exploitation and are required to explore IT resources as well to stay ahead in delivering IT success. For instance, despite the dominance of Microsoft's Windows and comparable technology Blackbird, Sun Microsystem's Java 2.0 successfully developed conventional technology standards (Garud et al. 2002). In a complex environment of rapid growth in IT applications, Sun Microsystem was able to achieve this landmark through liaising with external actors to exploit what seemed to be an ambiguous IT code with available applications, while exploring a complete networking platform for new Java-based applications (Garud et al. 2002). Sun Microsystem's higher levels of interconnectedness outside firm boundaries, and greater information processing requirements, had driven an aggressive strategy in the exploitation and exploration of its IT resources to ensure that Java 2.0 becomes an IT success.

The likelihood of sustaining an advantage through existing technologies over an extended period is high under simple environments, and firms may not emphasize the need to continuously refine existing or explore new technological resources (Lee et al. 2015). On the other hand, in a more complex environment, firms may face intense pressures to exert increased efforts not only when refining existing technological resources, but also when introducing new technical solutions to sustain their competitive advantage (Wade and Hulland 2004). In particular, for the high-tech firms that tend to compete on their operational and technical flexibility, the higher complexity will require them to incorporate higher levels of IT exploitation and exploration activities, and give more attention to achieving IT success. Likewise, Wang et al. (2012) argue that simple IT resources may not suffice in highly uncertain and complex environments; the influence of such environments increases the emergence and heightens the performance implications of higher order IT capabilities, i.e., IT ambidexterity. Therefore, we hypothesize that:

Hypothesis 2b (H2b): Firms high in IT ambidexterity capability that have high environmental complexity will be higher in IT success than firms high in IT ambidexterity capability but lower in environmental complexity.

RESEARCH METHODOLOGY

Empirical Context

The sampling frame of this study consists of 1000 U.K. high-tech[3] SMEs (1-249 employees) that were randomly selected from the Financial Analysis Made Easy (FAME) database in November 2015. FAME database provides descriptive information of all major private and public U.K. firms in both the manufacturing and service sectors. The choice of SMEs is due to the fact that, in contrast to larger firms, SMEs are limited in their ability to create separate structures or buffers for exploration and exploitation activities that conceal performance problems (Voss and Voss 2013). Moreover, SMEs tend to adopt novel technologies more swiftly to remain competitive and emphasize the development of innovative products for survival (Oke et al. 2007). Thus, technological exploitation and exploration are their key forte, providing appropriate context to measure IT ambidexterity capability. Finally, little research on ambidexterity strategies and their influence on performance has focused on SMEs (De Clercq et al. 2014; Chang and Hughes 2012). The choice of the high-tech sector is well suited for three reasons. First, technological exploitation and exploration, which is imperative, is very strong in this sector and plays a crucial role in sustaining and enhancing its effectiveness (Oke et al. 2007). Thus, given that ambidexterity is more important in high-tech industries (Chandrasekaran et al. 2012), examining whether and when IT ambidexterity capability improves IT success in this sector potentially yields meaningful new insights. Second, the high-tech industry provides a rich context in which to examine the influences of uncertainty, complexity, and munificence, which are common characteristics of high-tech environments (*cf.* Tsai and Yang 2013). Finally, industry type differences may contribute to variance in IT success measures, and focusing exclusively on the high-tech sector can effectively minimize

[3] The high-tech firms in this study include several IT-related sectors, such as precision equipment manufacturers, computer and electronic product manufacturing, control instrument manufacturing, telecommunication, medical equipment and supplies manufacturing, and optics apparatus, all of which are included in NAICS 2012 industry classification under codes 33, 51, and 54.

the industry effects (Tsai and Yang 2013). Therefore, UK high-tech SMEs represent an appealing and critical context in which to examine our research questions and expand our understanding of IT ambidexterity capability.

Data collection efforts

The online questionnaire was designed to measure the key constructs in our conceptual model. To enhance the validity of our measures and response rate, the survey was designed by carefully following the procedural guidelines recommended by Podsakoff et al. (2003), such as mixing dependent and criterion variables, ensuring anonymity, and using well-established measuring scales. To avoid ambiguities, the questionnaire was then presented to and discussed with three senior IS researchers. After finalizing the data collection instrument, IT executives or project managers were contacted initially and were asked to identify appropriate respondents for completing other sections of the questionnaire within their firms – i.e., IT executives for IT exploration and IT exploration scales, and project managers for IT success and environments scales – as the projects would have a high use of IT department services within the firm.

Consequently, two respondents within the same firm completed this questionnaire. We included the specific criteria questions in the online questionnaire to allow access to relevant respondents only. Thus, we used multiple respondents for each questionnaire to minimize the risk of common method bias (Podsakoff et al. 2003). The key informants were contacted through e-mails and telephone calls to describe the research objectives and purpose of this study. The online questionnaire link was then directly e-mailed to the key informants who agreed to participate in this study. A follow-up reminder was sent with the questionnaire link to the firms that had not yet responded after the third and fifth weeks following the first email.

The questionnaires obtained were then screened for incomplete information, missing data values, outliers, and unengaged responses (evidenced by finding the exact same response for every item). Out of 314 initially received responses, 292 responses were found complete and valid for our variables of interest in this study. The collected dataset provided a diverse range of firms in terms of age, size, type, and industry. The collected sample covers a good and balanced representation of both service and manufacturing firms. Our initial respondents had worked for an average of 4.5 years in their respective firms and 70.4 percent of them had a university degree. Therefore, it was safe to assume that our respondents were able to understand all the items and respond accurately. Table 4 presents the characteristics of the firms.

Table 3: Key characteristics of the respondent's firms

Key characteristics	Frequency	Percentage
Industry details		
Computer and peripheral equipment	94	32.19
Communications equipment	47	16.09
Semiconductor and electronic components	78	26.71
Medical equipment and supplies	32	10.95
Industrial and precision equipment	41	14.04
Firm size		
Small (1-49 full-time employees)	160	54.79
Medium (50-249 full-time employees)	132	45.20
Firm age		
Up to 5 years	35	11.98
Between 6 and 10 years	71	24.31
Between 11 and 15 years	84	28.76
More than 15 years	102	34.93
Firm Type (Industry classification under NAICS 2012)		
Service	161	55.13
Manufacturing	131	44.86

We performed Cohen's statistical power analysis test to calculate the minimum sample size required to detect the significant effects in our analysis (Cohen 1988). Anticipated medium effect size ($f^2 = 0.150$), seven predictors (structural links on IT success), desired the statistical power of 0.95 and a confidence level of 0.05, the proposed model required a minimum sample size of 154. Thus, our sample size of 292 represented adequate statistical power to detect all significant effects (Benitez et al. 2018b; Cohen 1988).

To detect a potential effect of nonresponse bias, we examined differences between respondents and nonrespondents. T-tests showed no significant differences based on the number of full-time employees, firm type, and firm age. To check for late-response bias, we compared early respondents (those who submitted the questionnaire during the first week of data collection) and late respondents (those who submitted the questionnaire during the last week of data collection) in terms of construct variables. These comparisons revealed no significant differences between the two groups, indicating that nonresponse bias and late-response bias were not affecting this study.

Measures

We used the previously developed and tested scales in the literature to measure our constructs (Table 5 presents all measuring scales and items, with respective psychometric properties). Respondents were asked to indicate the extent to which they agreed with the scale items on a five-point Likert scale, with 1 indicating "strongly disagree" and 5 indicating "strongly agree." Following the classification of measurement types by Henseler (2017), i.e., (reflective, causal-formative, and composites), we discussed our constructs' measures with three senior IS academics and, with their consensus on the Henseler's criteria, operationalized all constructs of our proposed model as composite constructs at both first- and second-order levels. The operationalization as composites was preferred because, first, the constructs' respective measurement items met the criteria specifications[4] of formative constructs specified by Jarvis et al. (2003) and Petter et al. (2007); and second, the construct's respective measurement items could exhibit high correlation, making it problematic to retain multiple items due to multicollinearity. Therefore, mean manipulated scores, instead of factor scores, were used to

[4] The specified criteria for formative constructs are based on the assumption that the items are not interchangeable. It does not impose any restrictions on the covariance among indicators of the same construct, thereby relaxing the assumption that all the covariations among a block of indicators are explained by a common factor, i.e., indicators do not have to covary. Moreover, the direction of causality is from the items to the latent construct, and the items can be expected to have different predictors (*cf.* Keil et al. 2013; Syed et al. 2019b).

enhance the transferability of results across studies (Hair et al. 1995). We also note that all our results are robust to specifying the measures for all constructs at first- and second-order levels as composites instead of using reflective. Composites serve as representatives for the concept under investigation, which consists of more elementary components (Benitez et al. 2017).

Dependent variable

IT success: IT success is operationalized as a three-indicator composite second-order construct[5] that consists of three-indicator composite first-order constructs of information quality, three-indicator composite first-order constructs of system quality, and three-indicator composite first-order constructs of service quality. The scales for information quality, system quality, and service quality were directly adopted from the studies of Delone and McLean (2003) and Bernroider (2008). The three-indicator scale assesses informational quality by asking respondents about the integrality, quality, relevancy, and understandability of information provided by the IT department. The system quality is assessed through measuring the IT system adaptability, response time, and usability. The scale for service quality captures information related to IT service reliability, responsiveness, and improvements offered by the IT department.

Independent variable

IT ambidexterity. IT ambidexterity capability is operationalized as a two-indicator composite second-order construct composed of the four-indicator composite first-order construct of IT exploitation and five-indicator composite first-order construct of IT exploration. The scales for IT exploitation and IT exploration were adapted from the studies of Jansen et al. (2006) and

[5] To further elucidate on the second order composite construct, i.e., IT success, consider an example of a recipe (second-order composite), which is made through a mix of ingredients (first-order indicators). Although the correlations between amounts of ingredients in the recipe may be high, one would not conclude that the recipe causes ingredients. Rather, ingredients are combined to form the emergent variable we called recipe. Therefore, the temporal precedence of the ingredients (i.e., first-order constructs) also suggest that recipe (second-order construct) cannot be the common cause of ingredients (Benitez et al. 2019). Hence, first-order constructs develop the meaning and measurement of second-order constructs collectively.

Lee et al. (2015). The five items scale was developed for IT exploration by adopting the first three items from Lee et al. (2015) and adopting the remaining two items from Jansen et al. (2006). The four items scale for IT exploitation was developed by adopting the first three items from Lee et al. (2015) and adopting the remaining one item from Jansen et al. (2006). The developed scales provide a better understanding of each construct, validated through establishing higher construct reliability scores. The adapted scales for IT exploitation and IT exploration measure the extent to which a firm refines and extends existing technological resources, and the extent to which a firm explores new technical solutions, respectively.

Prior studies also operationalize ambidexterity through multiplicative interaction (Gibson and Birtkinshaw 2004), absolute deviation (He and Wong 2004), or the addition of scores (Lubatkin et al. 2006). We followed the methodological approach suggested by Edwards (1994) to compare F-values based on R^2 differences among these operationalization methods with an unconstrained model (also see prior studies on this approach, i.e., Lubatkin et al. 2006; Jansen et al. 2009). The comparison revealed a composite model operationalization to provide the most interpretable approach for measuring IT ambidexterity in our data. We validated our key findings with an alternate operationalization of IT ambidexterity construct as a robustness check to this approach.

Moderating variables

Environmental dynamism. Environmental dynamism is operationalized as a four-indicator composite first-order construct. The four-item scale for environment dynamism was adopted directly from the study of Chen et al. (2014). The developed scale captures the extent of unprecedented market behavior and technological progress in the industry.

Environmental complexity. Environmental complexity is operationalized as a four-indicator composite first-order construct. The scale for environment complexity was adopted directly from the study of Chen et al. (2014), which measures complexity in terms of the heterogeneity (diversity in customers' buying habits and product lines) and the range of an organization's activities resulting from a frequent change of suppliers and legal regulations.

Control variables

We included control variables in the form of industrial characteristics to regulate the potential impact on the degree of perceived environmental characteristics and IT success. Industrial characteristics (such as competitiveness, regulation, and clock speed) may shape how IT is applied within the focal firm (Chiasson and Davidson 2005; Aral and Weill 2007). Accordingly, three dummy variables for the industry type were included. Industry 1 was coded zero if the firms were service firms and one if the firms were manufacturing firms. Industry 2 was coded zero if the firms were public and one if the firms were private. Finally, Industry 3 was coded zero for the medical instrument industry and one for the electronics industry to regulate the influence due to the differences in the scope of the analyzed industries (Chiasson and Davidson 2005; Tsai and Yang 2013). We controlled the resource availability by including firm size and environmental munificence as two control variables. Because depending upon the availability of resources (i.e., workforce or growth opportunities in the industry), the challenges to manage exploration and exploitation activities simultaneously for realizing performance may change (He and Wong 2004; Jansen et al. 2006; Syed et al. 2019a). Firm size is measured by taking the natural logarithm of the number of full-time employees. Environmental munificence is measured by adopting a four-item scale from the study of Li et al. (2013), which assesses the degree of growth opportunities provided by the market. We also controlled for firm age, as the level of expertise may confound the benefits realization of an ambidextrous capability (Voss and Voss 2013), by taking the natural logarithm of the number of years since the firm has been in business.

EMPIRICAL ANALYSIS AND RESULTS

We conducted the empirical test of our proposed model using PLS path modeling, variance-based structural modeling (SEM) technique, using the statistical software package Advanced Analysis for Composites (ADANCO) 2.0.1 Professional (Henseler and Dijkstra 2015). The primary reason for the choice of PLS as an estimation method is because all the constructs in our research were operationalized as composites, and PLS is particularly well suited to provide consistent estimations for composite models (Benitez et al. 2017; Henseler and Dijkstra 2015; Henseler et al. 2014). Moreover, PLS offers an appropriate estimation in comparison to covariance-based SEM when estimating complex models (i.e., a combination of first- and second-order constructs) (Benitez et al. 2018a; Sarstedt et al. 2016). ADANCO is one of the current developments in PLS path modeling that offers robust analysis, goodness-of-fit tests, and facilitates causal and predictive modeling (Benitez et al. 2017; Benitez et al. 2018b; Henseler and Dijkstra 2015).

Measurement model analysis

The traditional validity methods (i.e., Cronbach's alpha, composite reliability, average variance extracted) may not apply well as all our constructs have been operationalized as composites (Petter et al. 2007). Therefore, we assessed the psychometric properties of our first- and second-order composite constructs by content validity, assessing multicollinearity, the significance of weights and loading, and evaluating the goodness of model fit with confirmatory composite analysis (Henseler et al. 2014; Benitez et al. 2019; Schuberth et al. 2018; Syed et al. 2019b).

We estimated the variance inflation factors (VIFs) to check for multicollinearity issues. The VIF scores ranged from 1.085 to 3.977, well below the cutoff score of 10, suggesting that multicollinearity is not a problem in our composite constructs (Benitez et al. 2018c).

We checked the significance level of indicator and dimension weights and loadings by performing a bootstrap analysis with 5000 subsamples. Composite indicator and dimension should be retained if its loading is significant, irrespective of the significance of weight (Benitez et al. 2017; Petter et al. 2007). The significance of indicator loading at a 5 percent level indicates that more than 50 percent of the indicator variance is explained by the latent variable (Benitez et al. 2019). Indicator weights vary based on random errors, such that indicators with a small random measurement error take greater weight than the indicators with a larger random measurement error. The 5 percent significance level of indicator weight indicates that the indicator contributes significantly to the emergent construct (ibid). The analysis yielded one indicator weight for environmental complexity as not significant, which was retained due to significant loading and to ensure construct validity (Rueda et al. 2017). The loadings were all significant at the 0.001 level for both first- and second-order constructs and respective items. Overall, the analysis suggests good properties for our composite measures (Benitez et al. 2018a, Syed et al. 2019b). Table 5 presents complete details for the psychometric properties of our constructs and respective items.

Table 4: Psychometric properties of constructs at first- and second-order levels

Construct/dimension/indicator	**Mean**	**S.D.**	**VIF**	**Weight**	**Loading**
IT ambidexterity (Lee et al. 2015; Jansen et al. 2006)	3.613	1.443			
IT exploration	3.589	1.361	2.652	0.439***	0.886***
Our firm experiments and develops unique IT applications	3.394	0.908	2.937	0.236**	0.874***
Our firm regularly searches for and acquires new IT resources (e.g., a new generation of IT architecture, potential IT applications, and critical IT skills)	3.615	1.080	3.635	0.194***	0.910***
Our firm experiments with new IT management practices	3.489	0.984	3.689	0.150**	0.901***
Our firm pursues innovative applications of IT	3.860	1.036	2.733	0.301***	0.863***
Our firm accepts demands that go beyond existing level of information services	3.477	1.197	3.977	0.261***	0.906***
IT exploitation	3.636	1.432	2.652	0.583***	0.983***
Our firm frequently refines the existing level of IT components, such as hardware and network resources	3.382	1.105	2.549	0.239***	0.926***
Our firm reuses existing IT skills	3.569	1.763	1.844	0.296***	0.683**
Our firm improves existing IT applications and services	3.863	0.971	2.295	0.195**	0.879***
Our firm continually expands existing IT services for existing clients	3.825	1.104	2.611	0.353***	0.857***
Environmental dynamism (Chen et al. 2014)	3.574	1.132			
Products and services in our industry become obsolete quickly	3.812	1.058	2.174	0.178***	0.803***
The product/services technologies in our industry change quickly	3.165	1.160	1.952	0.233***	0.797***
We can predict what our competitors are going to do next	3.554	1.185	2.752	0.365***	0.909***

We can predict when our products/services demand changes	3.763	1.160	2.225	0.380***	0.886***
Environmental Complexity (Chen et al. 2014)	3.220	1.041			
In our industry, there is considerable diversity in customer buying habits	3.261	1.275	2.087	0.381***	0.878***
In our industry, there is considerable diversity in product lines	3.366	1.238	1.979	0.209***	0.800***
There have been frequent changes in firm suppliers	3.065	1.360	3.116	0.365***	0.887***
The legal regulations have frequently changed the way our firm conducts business	3.189	1.256	2.931	0.195	0.883***
IT success (Delone and McLean 2003; Bernroider 2008)	3.364	0.893			
Informational quality	3.301	1.124	2.627	0.416***	0.917***
Integrated and better quality of information	3.114	0.833	1.119	0.439***	0.994***
Ease of understanding	3.418	1.287	1.085	0.301***	0.626***
Relevant and complete information	3.751	1.242	1.096	0.281***	0.640***
System quality	3.570	1.260	1.537	0.242***	0.736***
IT system adaptability	2.971	1.903	2.292	0.332***	0.794***
IT system response time	4.014	0.728	2.779	0.151***	0.773***
IT system usability	3.868	0.983	2.211	0.381***	0.828***
Service quality	3.196	1.083	2.532	0.474***	0.925***
IT service reliability	3.188	1.121	1.206	0.293***	0.855***
IT service responsiveness	3.261	1.164	1.288	0.358***	0.917***
Improved service level	3.301	1.223	1.109	0.340***	0.733***
Firm size: Natural logarithm of the total number of full-time employees	4.162	1.851			
Firm age: Natural logarithm of the number of years of the firm's operations	1.894	1.787			
Environmental Munificence (Li et al. 2013)	3.186	1.325			
Our firm is in the market with numerous profit opportunities	3.758	1.121	1.674	0.279***	0.865***
Our firm is in the market with sufficient capital (i.e., human, relational, etc.) supply	2.853	1.632	1.604	0.263***	0.619***
Our firm is in the market, which can easily access the needed resources for the operation and expansion	3.336	1.236	2.362	0.365***	0.894***
Our firm is in the market almost without an external threat to the survival and development of firms	2.969	1.339	1.791	0.254***	0.760***
Industry 1: Manufacturing vs. service	0.438	0.501			
Industry 2: Public vs. private	0.466	0.500			
Industry 3: Medical instrument vs. electronic	0.493	0.506			
Note: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$					

Before structural analysis, we performed the confirmatory composite analysis to evaluate the goodness of fit of our saturated model (a model that enables free correlation among the measurements) at first- and second-order levels (Schuberth et al. 2018). It checks the adequacy of the composite models by comparing the empirical correlation matrix with the model-implied correlation matrix of the saturated model, based on standardized root mean square residual

(SRMR), unweighted least squares (ULS) discrepancy (d_{ULS}), and geodesic discrepancy (d_G). The lower values suggest a better fit of the proposed model (Benitez et al. 2017). The evaluation of the overall model fit is useful to assess the validity of the measurement and the composite models because potential model misfit can be entirely attributed to misspecifications in the composite and/or measurement models (Benitez et al. 2019). The analysis revealed all values of the discrepancies were below the 95 percent quantile of the bootstrap discrepancies (HI_{95} values), suggesting that the measurement structure of our composite constructs is correct with a 5 percent level of probability. Table 6 presents the results for confirmatory composite analysis that provides empirical support for the structure of our composite constructs at first- and second-order levels.

Table 5: Confirmatory composite analysis of the saturated model

Discrepancy	First-order level			Second-order level		
	Value	HI_{95}	Conclusion	Value	HI_{95}	Conclusion
SRMR	0.033	0.056	Supported	0.022	0.031	Supported
d_{ULS}	0.789	1.901	Supported	0.031	0.050	Supported
d_G	0.487	1.343	Supported	0.023	0.045	Supported

Structural model evaluation

We performed a bootstrap analysis with 5000 subsamples to estimate the beta coefficient and the significance of our hypothesized relationships. The baseline model tests H1 (the direct effect of IT ambidexterity capability on IT success), including all control variables. Our analysis reveals a significant positive relationship between IT ambidexterity capability and IT success ($\beta = 0.314$, $p_{\text{one-tailed}} < 0.001$), validating H1.

Given that our independent and moderator variables were modeled as composites, and to avoid multicollinearity issues (Dijkstra and Henseler 2011), we adopted a two-stage approach suggested by Fassot et al. (2016) to estimate moderating effects for each of our moderators. In the first stage, path models comprising direct effects were run to calculate construct scores of the independent and moderating variables. In the second stage, the interaction terms were built as the product term of the extracted construct scores from the first step of each moderator with the independent variable. Model 1 introduces the additional direct effect of environmental dynamism on IT success, while Model 2 includes the interaction term to measure the moderating effect of environmental dynamism on the relationship between IT ambidexterity capability and IT success to test H2a. The results reveal that environmental dynamism positively moderates the IT ambidexterity–IT success relationship ($\beta = 0.129$, $p_{\text{one-tailed}} < 0.05$), confirming H2a. Model 3 presents the direct effect of environmental complexity on IT success, while Model 4 tests H2b by introducing the moderation effects of environmental complexity on the IT ambidexterity–IT success relationship. The direct impact of environmental complexity is significant and negative ($\beta = -0.080$, $p_{\text{one-tailed}} < 0.01$), which is consistent with the theoretical arguments that a higher level of heterogeneity in firm actions makes it tough to manage the paradoxical demands of IT success, consequently, compromising IT success. Our findings confirm H2b by indicating the positive moderating effect of environmental complexity ($\beta = 0.182$, $p_{\text{one-tailed}} < 0.01$). Model 5 presents the simultaneous effect of both external environmental moderating variables. The significance and influence of these relationships remain similar, bearing a slight decrease in beta values. Table 7 presents the results of our analysis.

Table 6: Results of the structural model analysis

	Baseline model	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
IT ambidexterity → IT success (H1)	0.314^{***} (7.279) [0.255, 0.561]	0.312^{***} (7.276) [0.256, 0.554]	0.311^{***} (7.276) [0.257, 0.556]	0.298^{***} (6.532) [0.265, 0.549]	0.294^{***} (6.383) [0.270, 0.529]	0.283^{***} (6.178) [0.274, 0.463]
Environmental dynamism (ED) → IT success		0.089 (0.917) [0.046, 1.298]	0.078 (0.898) [0.039, 1.265]			0.076 (0.897) [0.040, 1.261]
ED x IT ambidexterity → IT success (H2a)			0.129^{*} (1.267) [0.064, 0.293]			0.126^{*} (1.254) [0.058, 0.278]
Environmental complexity (EC) → IT success				-0.112^{**} (-2.473) [-0.368, 0.122]	-0.085^{**} (-2.117) [-0.346, 0.120]	-0.080^{**} (-2.113) [-0.335, 0.105]

EC x IT ambidexterity → IT success (H2b)					0.184^{**} (2.485) [0.160, 0.395]	0.182^{**} (2.482) [0.159, 0.389]
Industry 1 → IT success (CV)	-0.096 (-0.887)	-0.094 (-0.874)	-0.095 (-0.876)	-0.094 (-0.874)	0.095 (-0.876)	0.095 (-0.876)
Industry 2 → IT success (CV)	$0.109^{\dagger}$ (1.010)	$0.111^{\dagger}$ (1.016)	$0.112^{\dagger}$ (1.018)	$0.111^{\dagger}$ (1.016)	$0.113^{\dagger}$ (1.020)	$0.112^{\dagger}$ (1.018)
Industry 3 → IT success (CV)	0.043 (0.312)	0.041 (0.302)	0.041 (0.302)	0.042 (0.307)	0.042 (0.307)	0.041 (0.302)
Firm size → IT success (CV)	0.213^{***} (3.445)	0.212^{***} (3.441)	0.212^{***} (3.442)	0.214^{***} (3.448)	0.213^{***} (3.445)	0.212^{***} (3.442)
Munificence → IT success (CV)	0.223^{***} (3.658)	0.222^{***} (3.654)	0.222^{***} (3.655)	0.221^{***} (3.652)	0.222^{***} (3.654	0.222^{***} (3.654)
Firm age → IT success (CV)	0.081 (0.647)	0.074 (0.620)	0.068 (0.618)	0.069 (0.619)	0.068 (0.618)	0.068 (0.618)
Endogenous variable	**R^2** / **Adj. R^2**	**R^2** / **Adj. R^2**	**R^2** / **Adj. R^2**	**R^2** / **Adj. R^2**	**R^2** / **Adj. R^2**	**R^2** / **Adj. R^2**
IT success	0.421 / 0.405	0.438 / 0.414	0.446 / 0.420	0.439 / 0.417	0.464 / 0.441	0.480 / 0.459
SRMR value	0.040	0.036	0.032	0.033	0.028	0.027
SRMR HI_{95}	0.059	0.052	0.048	0.048	0.041	0.041
d_{ULS} value	0.072	0.087	0.098	0.086	0.099	0.103
d_{ULS} HI_{95}	0.158	0.181	0.213	0.181	0.195	0.205
d_G value	0.042	0.050	0.058	0.051	0.060	0.059
d_G HI_{95}	0.088	0.094	0.095	0.098	0.101	0.104
f^2						
IT ambidexterity → IT success (H1)	0.302	0.301	0.301	0.294	0.294	0.282
ED x IT ambidexterity → IT success (H2a)			0.126			0.124
EC x IT ambidexterity → IT success (H2b)					0.155	0.154
Note: t-values in parentheses. Bootstrapping 95% confidence interval bias corrected in square bracket (based on n = 4999 subsamples). $^{\dagger}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$ [based on n = 4999, one-tailed test]. CV= control variable						

The values of the beta coefficient, their significance levels, R^2 values, and f^2 values represent the individual measure of the explanatory power of the model in PLS estimation (Benitez et al. 2018a; Benitez et al. 2018b). The beta coefficients above 0.200 explain the good strength of the relationship and R^2 values above 0.200 suggest the good explanatory strength of endogenous variables (Chin 2010). Our significant path coefficients range from 0.126 to 0.314, suggesting medium to strong relationships for our hypothesized relationships and R^2 values of our endogenous variable range from 0.405 to 0.459, depicting good explanatory strength. f^2 values represent the effect size of each incremental relationship included in the model. The values below 0.020, above 0.150, and above 0.350 represent weak, medium, and strong effect sizes, respectively (Benitez et al. 2017; Henseler and Fassott 2010). The f^2 values in our hypothesized significant relationships ranged from 0.124 to 0.302 (Table 7). Overall, the findings indicate that our structural model shows good explanatory power.

We evaluated the goodness of fit of each model in our structural model analysis by examining the SRMR, d_{ULS}, and d_G (Rueda et al. 2017). All discrepancy values for each model were below the 95 percent quantile, and the bootstrap discrepancies and SRMR values are below the threshold of 0.800 (Table 6). Altogether, these findings suggest that the proposed theory of the structural model is correct (Benitez et al. 2018a; Henseler et al. 2014). Table 8 reports the correlation among all hypothesized and control variables in this study. The inter-factor correlations are well below the 0.65 threshold, providing further evidence that our estimations are not likely to be biased by multicollinearity problems (*cf*. Cao et al. 2009).

Table 7: Correlation matrix of constructs

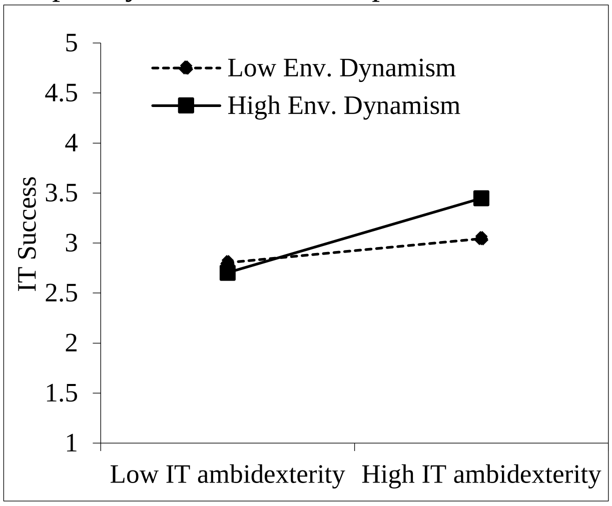
	Min	**Max**	**1**	**2**	**3**	**4**	**5**	**6**
1. IT ambidexterity	1.00	5.00	1.000					
2. Ln organizational age	1.39	4.74	0.036	1.000				
3. Ln organizational size	3.25	5.51	0.216**	0.370**	1.000			
4. Environment dynamism	1.00	5.00	0.207**	0.110*	0.328**	1.000		
5. Environment complexity	1.00	5.00	-0.113*	0.238**	0.376**	0.122*	1.000	
6. Environment munificence	1.00	5.00	0.484**	0.212*	-0.157*	0.027	0.145*	1.000
7. IT success	1.00	5.00	0.314**	0.094	0.320**	-0.163*	-0.188*	0.422**
7.1. Information quality	1.00	5.00	0.187*	0.063	0.369**	-0.201**	-0.324**	0.377**
7.2. System quality	1.00	5.00	0.260**	0.113*	0.144*	0.126*	0.201*	0.464**
7.3. Service quality	1.00	5.00	0.363**	0.091	0.341**	-0.103*	-0.151*	0.390**
8. Industry 1	0.00	1.00	-0.052	-0.094	0.260**	-0.039	0.135*	-0.029
9. Industry 2	0.00	1.00	-0.036	0.124*	0.069	0.012	0.038	-0.115*
10. Industry 3	0.00	1.00	0.116*	0.044	-0.032	0.087	0.109*	0.056

	7	7.1	7.2	7.3	**8**	**9**	**10**
7. IT success	1.000						
7.1. Information quality	0.618**	1.000					
7.2. System quality	0.642**	0.366**	1.000				
7.3. Service quality	0.591**	0.255**	0.543**	1.000			
8. Industry 1	-0.038	-0.064	0.029	0.138*	1.000		
9. Industry 2	-0.029	-0.04	-0.105*	-0.061	-0.113*	1.000	
10. Industry 3	0.091	0.185*	0.016	0.110*	-0.066	-0.012	1.000
Note: *p < 0.05, **p < 0.01							

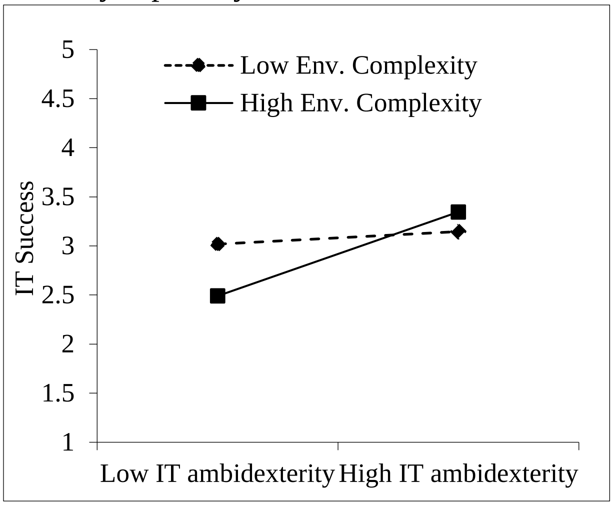
Test of robustness

Our structural model operationalized IT ambidexterity capability as the composite second-order construct. We also validated our hypotheses using a commonly adopted combination method of multiplicative approach, i.e., IT exploitation and IT exploration scores are multiplied to get IT ambidexterity capability score. The developed multiplicative construct of IT ambidexterity capability (min=1, max=25, mean=14.059, and SD = 6.524) was tested again in our structural models. The analysis yielded consistent results for all hypotheses with good model fits, i.e., H1 (β = 0.286 and $p_{\text{one-tailed}} < 0.001$), H2a ($\beta$ = 0.098 and $p_{\text{one-tailed}} < 0.05$), and H2b ($\beta$ = 0.156 and $p_{\text{one-tailed}} < 0.01$), thus providing credence to our previous findings. To validate our interaction effects, Figure 2 presents the interaction plots for the moderation links. Figure 2(a) shows the plot of the interaction effect between environmental dynamism and IT ambidexterity capability. Consistent with the arguments in H2a, this plot indicates that the influence of IT ambidexterity capability on IT success is significantly enhanced for firms facing higher environmental dynamism. Figure 2(b) presents the plot for the moderation effect of environmental complexity on the relationship between IT ambidexterity and IT success. The plot shows that higher environmental complexity drives higher IT ambidexterity in firms to realize better IT success. These plots provide further credence to our theoretical arguments and statistical results.

Figure 2. Moderating effects of (a) environmental dynamism and (b) environmental complexity on the relationship between IT ambidexterity capability and IT success.



(a)



(b)

DISCUSSION AND CONCLUSIONS

This study examined the impact of IT ambidexterity capability on IT success in a sample of 292 British high-tech firms. Building on the theory of paradox and ambidexterity, we identify the paradoxical demands of the IT success determinants and argue that firms manage the underlying paradoxes in informational quality, system quality, and service quality, and realize IT success through the dual pursuit of IT exploitation and IT exploration. To further explicate this relationship, we also examined the effect of uncertain environments within this relationship. In particular, we investigated the moderating roles of environmental dynamism and complexity in the IT ambidexterity–IT success relationship. The empirical analysis validated our hypothesized relationships, i.e., IT ambidexterity capability enhances IT success, and uncertain environments significantly moderate this relationship.

The proliferation of IT tools and IT investments may not necessarily provide differentiating IT outcomes due to imitability and transferability, and firms are required to know the right IT capabilities to rely upon for sustaining IT success. The foremost contribution of this study in IS scholarship is to theoretically hypothesize and empirically demonstrate that IT ambidexterity capability manages the paradoxical determinants to deliver IT success. Following the introduction of IT ambidexterity capability construct by Lee et al., (2015), this study is among the first (Table 2) to further validate and extend the significance of this IT capability. In doing so, we reinforce the theoretical arguments emphasized in contemporary IS research (i.e., Lu and Ramamurthy 2011; Mithas and Rust 2016), that firms should adopt a simultaneous approach in IT exploitation and exploration activities. Given that no firm is endowed with unlimited resources, the ability to engage in strategic thinking that integrates and establishes a synergy between IT exploitation and IT exploration helps firms to deploy scarce and limited IT resources in the right manner and manage the paradoxical demands in IT success. The resulting arguments create a promising path to expand and benefit future research when assessing the implications of IT ambidexterity capability.

While IT success models (such as DeLone and McLean success model) have developed an acute understanding of the determinants of IT success, the research on IT capabilities to achieve the determinants of IT success remains scant (Petter et al. 2013). Grounded on the theory of paradoxes and ambidexterity, our study contributes to highlight underlying paradoxes in the IT success determinants and theoretically develops and empirically tests an IT ambidexterity capability to manage these paradoxes. In doing so, this study also contributes to provide empirical evidence on the theoretical conjectures of the theory of paradoxes and ambidexterity (Gregory et al. 2015) by showing a positive and significant effect of IT ambidexterity capability on IT success. Such an understanding provides support not only to the claims of multidimensionality of IT success (Petter et al. 2013), but also serves to inform the debate about what IT strategy a firm should develop to realize IT success (Chae et al. 2014). We hope the developed understanding of IT success in this study will result in more conclusive and consistent findings in realizing IT success and will support a continued theory development in the area.

This study helps enrich technology management literature by investigating the impacts of uncertain environments on the performance outcomes of an IT capability. Aligned with the contingent view of external environments, our findings provide further credence to the long-standing theoretical arguments that higher-order IT capabilities, i.e., IT ambidexterity, can deliver better benefits in uncertain environments (Sambamurthy et al. 2003; Wade and Hulland 2004). More specifically, high levels of uncertain environments (technological unpredictability or volatile customer demand) create greater information deficit, making the management of paradoxes more challenging for firms, i.e., Figure 2 indicates lower IT success when ambidexterity is low for higher uncertainty. Consequently, firms are required to pursue high levels of IT ambidexterity to benefit in realizing IT success. This finding complements the significance of IT ambidexterity capability for high-tech firms. While the direct diminishing effect of the uncertain environment of IT success was expected, the empirical evidence provides a springboard effect for future research to explore how external environments may interplay with the paradoxes of IT success.

Our study provides practical implications for managers who have to deal with constant and accelerating waves of change, much of which is driven by advances in IT and e-business strategies. In contrast to previous beliefs – that managers should exploit IT capabilities in stable environments and switch to exploration in unstable environments – our results show the significance of the simultaneous pursuit of IT exploration and IT exploitation by evidencing IT success in high-tech firms. Managers should thus recognize that developing a diverse technological portfolio of IT exploitation and IT exploration successfully manages the differing IT success determinants. The significance of IT ambidexterity capability is particularly striking in high-tech industries because there is often a mismatch between a firm's technological capabilities and its environmental conditions. Our findings show that the positive impact of IT ambidexterity capability would amplify in uncertain environments. Finally, our results caution managers that, when seeking to benefit from the IT ambidexterity capability in high-tech SMEs, better performance implications reside in maintaining higher levels of IT exploration and IT exploitation.

Limitations and directions for future research

The limitations of this study are as follows. First, we investigate a static cross-sectional picture of IT capability and IT success. This makes it challenging to address the issue of how IT ambidexterity capability influences the underlying paradoxes of IT success over a run of several years. Second, although we collected data from multiple respondents who were knowledgeable in respective areas, and from the secondary database (FAME), the use of self-reported data may have limited the inferences among construct variables. The self-reported data may not essentially be flawed (Tsai and Yang 2013); however, the use of a mixed-method approach to collect independent and dependent variables data separately provides better methodological reliability (Jansen et al. 2006). Third, while Cohen's statistical power analysis test shows that our sample size has the power required to detect the significant effects in our analysis, a larger dataset can provide better precision with variance and reduce sampling errors. Finally, although the focus on a single industry (high-tech industry) enhanced internal validity and provided an appealing context for accurately assessing IT ambidexterity capability and IT success, this boundary condition pertains to the generalizability of our findings beyond the high-tech sector (Chiasson and Davidson 2005; Chae et al. 2018). Likewise, our focus on SMEs allows a better investigation of the IT ambidexterity–IT success relationship, in contrast to larger firms where separate structures may conceal performance problems (Voss and Voss 2013), and contributes to the limited existing research on ambidexterity strategies in SMEs (De Clercq et al. 2014; Chang and Hughes 2012). However, the generalizability of our findings may be limited to SMEs.

This study generates several potentially meaningful directions for future research. The emergent stage of literature on IT ambidexterity capability provides a fertile area of research. Perhaps qualitative ethnographic methodologies would be particularly useful to add more depth to our understanding of how firms create and leverage IT ambidexterity capability for successful IT outcomes. In other words, the extension of the inherently static character of this work toward the development of process-based (rather than variance-based) models focus on how IT capabilities are created and leveraged when managing paradoxes. Our investigation on IT ambidexterity capability may represent only one piece of the puzzle in achieving IT success, and future research can extend our research and examine socio-technical perspectives that interact for consistent organizational sensemaking (Garud et al. 2008), i.e., how other organizational elements such as culture, structure, process, or people interact/couple with IT ambidexterity capability when managing the paradoxes of IT success. An important extension of this work can investigate mechasnisms through which IT ambidexterity capability resolves the paradoxes in IT success to provide a more granular understanding of this relationship. Moreover, while our study identifies the significant influence of uncertain environments, we operationalize these environments through unpredictability in demand and technological/product uncertainty. Future research on more explicit uncertainty measures, i.e., specific industry mechanisms and standards would benefit managers.

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APPENDIX

Table A-1: Representative sampling of prior work on IT constructs with the environmental effect

Author	IT construct	Conceptualization of external environment	Approach	Dependent variable	Relevant findings
Li and Ye (1999)	IT investment	Dynamism as moderator and Munificence as a control variable	Secondary data analysis	Economic performance	Stronger relationship under high environmental dynamism
Wade and Hulland (2004)	IS resources typology of inside-out, outside-in, and spanning	Turbulence, Munificence, and Complexity as moderators	Conceptual	Firm performance	High turbulence supports outside-in and spanning resources, low munificence supports inside-out resources and high complexity supports all resources.
Pavlou and El Sawy (2006)	IT leveraging competence	Turbulence as a moderator	Survey	Competitive advantage in NPD	The more pronounced effect of IT leveraging competence in high turbulence
Melville et al. (2007)	IT artifact	Industry concentration and dynamism as moderators	Secondary data analysis	The elasticity of IT and regular capital	In contrast to regular capital, IT impacts are stronger in competitive industries and stable in dynamic industries.
Stoel and Muhanna (2009)	IT capabilities (internally and externally focused)	Dynamism, Munificence, and Complexity as moderators	Secondary data analysis	Accounting-based measures	For externally focused capability high dynamism and high complexity were supportive, while internally focused capability was only favorable in high complexity
Sila (2010)	Internet-based interorganizational systems	Hostility, Dynamism and Complexity as moderators	Survey	Firm performance	Complexity and hostility are not significant moderators. The effects of dynamism as a moderator are less clear.
Wang et al. (2012)	IT resources and IT capabilities	Dynamism as a moderator	Survey	Firm performance	IT resources more beneficial in stable environments, while IT capabilities more beneficial in dynamic environments
Xue et al. (2012)	IT asset portfolio	Dynamism, Munificence, and Complexity as moderators	Secondary data analysis	Operational efficiency and organizational innovation	Lower dynamism, complexity, and munificence increase the influence of IT assets on efficiency. Higher complexity supports greater innovation
Mithas et al. (2013)	Digital strategic posture (convergent and divergent)	Turbulence, Competition, and Growth as moderators	Survey	IT Investments and IT Outsourcing	High turbulence increases the divergent impact on IT investment. High competition enhances the convergent effect on outsourcing investment.

					High growth supports both dimensions.
Chen et al. (2014)	IT capability (infrastructure, partnerships, strategic thinking, process integration, management, and external IT linkage)	Hostility, Dynamism, and Complexity as moderators	Survey	Firm performance	High environmental hostility weakens the effect of IT capability, while high environmental complexity strengthens it. Environmental dynamism has an insignificant effect.
Lee et al. (2015)	IT ambidexterity	Dynamism as a moderator	Survey	Firm agility	Higher dynamism influences the mediation link between IT ambidexterity and agility.
Neirotti and Raguseo (2017)	IT-based external orientation	Dynamism and Munificence as moderators	Survey	Competitive advantage	High dynamism, as well as high munificence, reduce the impact of IT orientation

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