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Franck Soh
University of North Carolina at Greensboro, f_sohnoume@uncg.edu

Pankaj Setia
Indian Institute of Management, Ahmedabad, pankajsetia@iima.ac.in

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The Impact of Dominant IT Infrastructure in Multi-Establishment Firms: The Moderating Role of Environmental Dynamism

Franck Soh,[1] Pankaj Setia,[2]

[1] Bryan School of Business & Economics, University of North Carolina at Greensboro, USA, f_sohnoume@uncg.edu
[2] Indian Institute of Management (IIM), Ahmedabad, India, pankajsetia@iima.ac.in

Abstract

Multi-establishment firms (MEFs) rely on digitized processes enabled by advanced IT infrastructure; however, environmental dynamism is a major influence on their operations. Environmental dynamism threatens the efficacy of current operations, requiring firms to evolve their processes. Firms' IT infrastructure may catalyze or hinder their endeavors and performance as they respond to environmental dynamics. Little previous research has examined which IT infrastructure types are high-performing and whether their effects vary across environments. We investigate the impacts of IT infrastructure, examining microlevel implementation—the constitution of technical and human assets—across the establishments of a multi-establishment firm (MEF). Specifically, we use the notion of a dominant IT infrastructure to unravel the heterogeneity of IT infrastructure across establishments. We explore dominant IT infrastructures—technology, human, or both—and assess their impacts across environmental conditions. To test our hypotheses, we used a panel dataset from 2007 to 2009 comprising 355 unique firms. Our findings reveal that the impact of establishment-level IT infrastructure types on MEF performance is contingent on environmental dynamism. A technology-dominant IT infrastructure leads to greater MEF performance in less dynamic environments, while a human-dominant IT infrastructure leads to greater MEF performance in more dynamic environments. The MEF performance is enhanced through a combination of technology- and human-dominant IT infrastructures in more dynamic environments. We conclude by discussing the theoretical insights and managerial implications of our findings.

Keywords: IT Infrastructure, Firm Performance, IT Business Value, Dynamism

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1 Introduction

Increasing environmental dynamism challenges large multi-establishment firms (MEFs), and IT infrastructure may catalyze or inhibit their ability to respond to such dynamism. While digital processes are crucial to such responses, they often vary across firms. For example, the COVID-19 pandemic made the business environment more fragile, transforming consumer behavior, logistics, and product demand. While about 10,000 US retail stores closed in the first half of 2020, some retailers saw huge opportunities with the growing trend toward online purchases (Berliner & Kotlyar, 2020). Such digitally enabled responses often leverage the firm's IT infrastructure as a foundation. For example, Nike's advanced IT infrastructure comprising IT talent (e.g., in-house data scientists) and technical capabilities (e.g., data centers, analytics software) enabled several IT initiatives (e.g., live workouts, digital fitness challenges, and customer direct offense) that were effective during the COVID-19 pandemic (Biswas, 2020; Fioravanti, 2020).

Similarly, Macy's dominance in terms of technologies and IT skills in its IT infrastructure enabled the creation of several initiatives (e.g., search & send, and Beauty Spot[1]), allowing for effective responses to consumers' accelerated shift toward online shopping during the COVID-19 pandemic (Johnston, 2020).

However, leveraging IT infrastructure is not easy. The International Data Corporation (IDC) predicted that 70% of spending on digital transformation would fail in 2018 due to undeveloped IT infrastructure (Rivkin & Keyworth, 2015). Much previous academic research has bolstered the claim that a firm's existing IT infrastructure forms the foundation helping the firm improve its business performance (Lu & Ramamurthy, 2011; Melville et al., 2004; Ray et al., 2005; Weill et al., 2002). However, IT infrastructure may either facilitate or impede firm performance (Broadbent & Weill, 1997; Byrd & Turner, 2000; Mithas et al., 2012; Subramani, 1999; Subramani & Walden, 2001; Weill et al., 2002). In particular, it is unclear which IT infrastructure type may be the best in unstable times. The gap in our understanding of the effects of IT infrastructure on MEF's performance is crucial—even more so when the business environment is unstable.

IT infrastructures are often essential for responding effectively to dynamic environments (Chen et al., 2010). However, effective responses are not easy for multi-establishment firms (MEF), as they must coordinate across business units. IT infrastructure can enable (or inhibit) responses in dynamic environments, significantly influencing the performance of MEFs. Indeed, environment dynamism has crucial impacts on firm dynamics, as it has been found to influence relationships across different contexts—for example, relationships between software patent stock and firm value (Chung et al., 2019), CEO future focus, and the rate of new product introduction (Nadkarni & Chen, 2014), strategic alignment and firm performance (Yayla & Hu, 2012), and future-oriented market scanning and the willingness to cannibalize and explore new products (Danneels & Sethi, 2011). Previous IS research has highlighted how environmental impacts can moderate the influence of IT—for instance in the context of new product development capabilities (Pavlou & El Sawy, 2006). Broadly, the focus on IT infrastructure has been an important domain of IS research (Armstrong & Sambamurthy, 1999; Fink & Neumann, 2007; Ray et al., 2005). The gap in the understanding of how IT infrastructure influences MEF's performance in dynamic environments is important, as the relationship between IT infrastructure and environment is intuitive and theoretically well-founded. For example, the structure-conduct-performance (SCP) paradigm emphasizes the intricate linkages between the firm's internal structure and the external environment (e.g., Domowitz et al., 1986; Porter, 1980).

Therefore, it is a bit surprising that the gap has not been addressed so far, given that the role played by IT infrastructures in the performance of contemporary firms is quite evident. This research gap is also important to address because environmental dynamism can adversely influence firm performance (Xue et al., 2011). One reason for the difficulty in addressing the gap may be problems related to conceptualizing and assessing IT infrastructures across MEFs. Multiple business units are organized in a complex fashion and IT assets vary across them. Such heterogeneity is complex to model conceptually and empirically. Not surprisingly, much of the previous research has made the broad assumption that the firm is a monolithic and homogenous entity in order to examine the business value of IT (Mithas & Rust, 2016; Xue et al., 2012) or the impacts of IT infrastructure (Bharadwaj, 2000; Lu & Ramamurthy, 2011). This assumption limits the understanding of the dynamics underlying complex IT infrastructures. Therefore, we address the following research question: How do IT infrastructures vary across MEFs' establishments, and do the performance impacts of infrastructure types depend on the environment's dynamism? We answer this question by using novel theoretical and empirical means to conceptualize and measure IT infrastructures and compare their performance impacts across less dynamic (stable) versus more dynamic (unstable) environments.

To unravel the heterogeneity in IT infrastructure across establishments, we focus on the *dominance* of IT infrastructure types—a concept that reveals the infrastructure type that is prominent across most establishments of the firm. By focusing on heterogeneity in IT infrastructure types, we highlight that the MEF's ability to implement digital initiatives depends on the relative dominance of a specific IT infrastructure type across its establishments. Conceptually, we underline that the dominant IT infrastructure may vary based on the relative implementation or constitution of different subcomponents, which are notably categorized as two major components: *technical assets* (e.g., PCs, servers, and databases) and *human assets* (e.g., technical skills). Across establishments, the relative dominance of these two components may lead to three different dominant IT infrastructures for the MEF—technology,

[1] The features allow customers to search and select cosmetic products across various brands.

human, or both. The three dominant IT infrastructures (i.e., technology dominant, human dominant, and technology and human dominant) influence digital initiatives differently. Indeed, firms may generate different IT returns depending on their IT emphasis (Mithas & Rust, 2016; Subramani, 2004). Following this logic, we assess the moderating effect of environmental dynamism on the relationship between MEFs' dominant IT infrastructure and their performance.

We empirically tested these relationships using a three-year panel dataset from 2007 to 2009 composed of 904 firm-year observations. Our findings indicate that MEFs with a technology-dominant IT infrastructure perform better in less dynamic environments, whereas MEFs with a human-dominant IT infrastructure perform better in more dynamic environments. Finally, compared to other dominant IT infrastructures, MEFs with a technology- and human-dominant IT infrastructure perform the best in more dynamic environments. Our study contributes to the literature on the impact of IT infrastructure on firm performance (Bharadwaj, 2000; Hitt et al., 2002). First, we unravel the role of IT infrastructure in influencing MEFs' operations. While prior research has highlighted the impact of various types of IT investments, we focus on arrangements between IT infrastructure components that adopt a disaggregated view of the IT construct and provide more richness about the development of IT infrastructure across establishments.

Second, we explore the linkages between environmental characteristics and IT infrastructure types contributing to prior literature about the role of environmental characteristics in understanding the impact of IT. We extend prior literature by demonstrating that the way IT infrastructure is configured across establishments influences MEF performance differently based on environmental dynamism. Hence, while prior research has ignored the types of IT infrastructure (Xue et al., 2012), our study increases the understanding of how IT infrastructure should be configured across establishments in different environments.

Third, our granular dataset enables exploring IT infrastructure heterogeneity across establishments, providing a more robust way to assess the effects of IT infrastructure in MEFs. Prior studies on multibusiness firms have indicated the importance of examining granular levels (Queiroz et al., 2020). Our granular analysis accommodates the role of each establishment in the aggregate IT infrastructure, to influence the MEF performance. Specifically, the concept of dominance offers a fresh view of IT infrastructure, as it outlines the significance of a dominant and coordinated response related to IT infrastructure.

2 Theoretical Background

2.1 Environmental Dynamism

Environmental dynamism is a facet of environmental uncertainty that focuses on the unpredictability and volatility of changes in the external environment (e.g., customers, competitors, and technology) in which a firm operates (Keats & Hitt, 1988). For example, in dynamic environments, firms face unpredictable changes in customers' tastes and preferences (Bourgeois & Eisenhardt, 1988). Unpredictability in the external environment can emerge from firms' efforts to leverage component IT innovations and architectural IT innovations (Nan & Tanriverdi, 2017). Prior literature has highlighted the role of environmental dynamism for understanding the impact of IT. Sabherwal et al. (2019) indicated that strategic IT alignment reinforces the positive effect of IT on firm performance in dynamic environments while reducing it in less dynamic environments, and Xue et al. (2012) found that IT investments influence efficiency and innovation differently based on the level of environmental dynamism.

In dynamic environments, firms usually focus their IT initiatives on responding to market changes (Chakravarty et al., 2013). In dynamic environments, the firm puts a greater focus on exploration processes (Xue et al., 2012). However, in less dynamic environments, firms focus on pursuing efficiency through the creation of exploitative processes (Xue et al., 2012). Building on this literature, this study underlines that the impact of MEF's dominant IT infrastructures depends on the level of environmental dynamism.

2.2 IT Infrastructure

IT infrastructure represents the base and shared technological foundation across the organization that supports the development of digitized business services and processes (McKay & Brockway, 1989). Across MEF establishments, different components underlie the IT infrastructure. Notably, previous research has identified two main IT infrastructure components: technical and human (Broadbent & Weill, 1997). While the former includes applications, data, and technology (Duncan, 1995; Henderson & Venkatraman, 1992), the latter represents the knowledge and skills required to manage the IT infrastructure (Henderson & Venkatraman, 1992; Lee et al., 1995). Using this categorization of IT infrastructure components, we emphasize that an MEF's establishments may have a specific IT infrastructure type based on the greater relative implementation or constitution of the technical or human component, in comparison to the implementation or constitution of these components by industry peers. That is, based on the greater implementation or constitution of the two components, an establishment may have greater implementation or constitution of the technical, human, or both components, leading to three respective IT infrastructure types: (1) a technology IT infrastructure type (i.e., only the technical component is above industry average value), (2) a human IT infrastructure type (i.e., only the human component is above industry average value), and (3) a technology and human IT infrastructure type (i.e., both the technology and human components are above industry average value).

For each MEF, a *dominant* IT infrastructure emerges based on the IT infrastructure of the majority of its establishments. That is, MEFs may have a technology-dominant (i.e., the majority of an MEF's establishments have a technology IT infrastructure type), a human-dominant (i.e., the majority of an MEF's establishments have a human IT infrastructure type), or a technology- and human-dominant IT infrastructure (i.e., the majority of an MEF's establishments have a technology and human IT infrastructure type). A technology-dominant IT infrastructure indicates that the MEF relies on greater capabilities inbuilt into technologies, while a human-dominant IT infrastructure indicates that the MEF relies mainly on human skills rather than the predefined technology algorithms and processes. MEFs with a technology- *and* human-dominant IT infrastructure rely on coordinated technology and human assets for creating and leveraging digital innovations.

3 Performance Impact: Conceptual Model and Hypotheses

We argue that the performance of MEFs depends on the establishment's dominant IT infrastructure. Previous research has outlined that the IT infrastructure type may play a crucial role in the transformation of business processes (Allen & Boynton, 1991; Kettinger et al., 2010). A larger number of establishments with a specific IT infrastructure type determines the landscape of digital business processes within the MEF. In other words, a dominant IT infrastructure shapes the culture and ethos of how managers leverage IT and what types of digital innovation they create. The dominance of a specific type influences how much value is realized by the firm. Further, the dominance of an IT infrastructure type is based on environmental dynamism, i.e., its impact is moderated by environmental dynamism (or the lack thereof). Figure 1 illustrates our conceptual model.

3.1 The Role of a Technology-Dominant IT Infrastructure

In less dynamic environments, a technology-dominant IT infrastructure is sufficient for increased performance. Specifically, such an infrastructure type represents firms that have invested money in technologies and adopted standard digitized processes but lack the human IT skills to customize them. That is, establishments across such MEFs rely on the technical infrastructure to enhance the scope and scale of the deployment of digitized processes through greater standardization of work processes. For example, such establishments may use third-party providers that help them set up the digital work processes, as they have limited access to in-house IT skills. Standardization becomes the norm, as third-party IT vendors provide off-the-shelf IT systems (e.g., enterprise applications) or set up standardized processes customized at the client's discretion at the onset. That is, such MEFs may use third-party IT vendors that implement the built-in logic of off-the-shelf IT systems (such as Salesforce) by adopting standards and best practices in the industry. However, these establishments do not have the skills necessary to customize these systems to their organizational needs. Such standardized processes are appropriate for firms operating in less dynamic environments.

For example, in the less dynamic environment of the oil and gas industry, Exxon Mobil Corp puts greater importance on deploying industry-best practices and creating common global processes, notably through the adoption of off-the-shelf applications and state-of-the-art business processes (Mitchell, 2006) (see Appendix A for more details on this example). In summary, the technology-dominant IT infrastructure enables the creation of state-of-the-art but standardized and stable digitized business processes. This is valuable in less dynamic environments.

The standardized infrastructure engenders greater value by facilitating the integration of business processes across establishments—for example, in the case of commercial off-the-shelf enterprise solutions (such as the SAP's R/3 system). Notably, standardized digitized business processes improve coordination and information sharing, enabling the seamless integration of information flows across the firm's establishments. Moreover, operational efficiency increases because of integration across organizational units (Barua et al., 1995; Subramani, 2004). The integration of complementary IT resources across establishments enables firms to exploit cross-establishment synergies (Saraf et al., 2013). Different establishments might adopt common standards for the technical IT infrastructure. Prior research has indicated that IT relatedness through common software, hardware, and communications standards drives subadditive cost synergies (Tanriverdi, 2005, 2006).

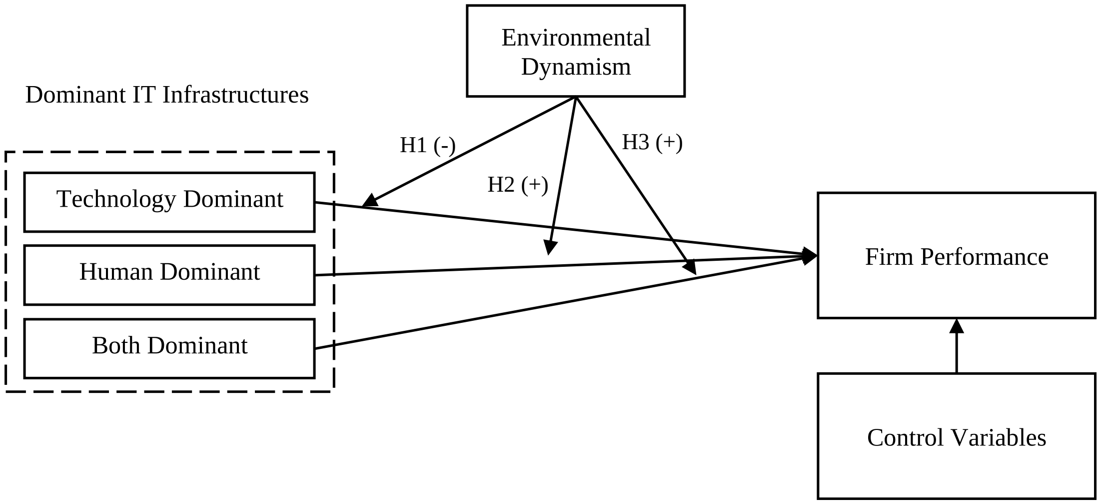

Figure 1. Conceptual Model

Further, in less dynamic environments, firms compete for customers less in terms of differentiation or innovation and more in terms of costs (Xue et al., 2012). By facilitating cross-unit integration in less dynamic environments, a technology-dominant IT infrastructure enhances MEF efficiency, leading to superior MEF performance, as cost leadership is valuable in less dynamic environments. Indeed, standardized IT resources are associated with cost-effective operations (Wade & Hulland, 2004). Additionally, in less dynamic environments, firms may compete without the costly human resources required to manage IT assets. MEFs with a technology-dominant IT infrastructure perform better in less dynamic environments as there is little need for adapting business processes, thus alleviating the role of human IS resources for managing the IT infrastructure. For example, Exxon Mobil Corp significantly reduced its staff by about 15,000 after the merger between Exxon and Mobil by leveraging standardized processes. This enabled Exxon Mobil Corp to achieve cost savings through economies of scale in a stable industry. In general, the technology-dominant IT infrastructure leverages synergies across establishments, due to the standardization of technologies and processes. Such cross-unit synergies are known to enhance performance (Tanriverdi, 2006). Therefore, we hypothesize:

H1: MEFs with a technology-dominant IT infrastructure realize greater performance as the environmental dynamism decreases.

3.2 The Role of a Human-Dominant IT Infrastructure

The human-dominant IT infrastructure enables MEFs to focus on business process adaptation, which is valuable in more dynamic environments. Specifically, such an infrastructure offers the MEF the ability to leverage in-house IT skills (notably technical and IS management skills) to quickly deploy tailored IT systems. An increase in firm IT skills improves the firm's focus on improving business processes by modifying existing business applications (Shaft & Vessey, 2006). In-house IT skills intervene in the selection, implementation, deployment, and management of IT systems that fit the MEF's unique business context. Notably, having in-house IT skills enables MEFs to either tailor off-the-shelf IT systems or write proprietary IT systems to suit the business. The greater human assets in this type of infrastructure enhance the MEF's ability to adapt digital business processes, as in-house human infrastructure assets combine business and customer-related knowledge with knowledge about the firm's internal and technical processes.

Such adaptability of digitized business processes enables MEFs to react locally to market changes, a dynamic seen clearly at Delta Airlines, for example. Operating in a highly dynamic industry, Delta relies on its high number of highly skilled IT employees in-house to build tailored business processes on a few strategic aspects of the business (Hub, 2014; Rice, 2014). This has likely contributed to Delta's strong performance over the past years (Sean, 2015) (see Appendix A for more details on this example).

In general, more dynamic environments call for adaptations, and the emergence of a human-dominant IT infrastructure enables such adaptations. Further, across establishments, there are synergies in recruiting, training, and retaining IT talent (Tanriverdi, 2006). That is, different establishments might have related IT knowledge, creating additional value for the firm. A dominance of human IT assets in a firm's IT infrastructure across establishments helps it harness such synergies by tapping into cumulative knowledge across establishments. Greater knowledge relatedness across establishments drives corporate performance (Tanriverdi, 2005; Tanriverdi & Venkatraman, 2005). That is, the human-dominant IT infrastructure enhances the firm's adaptability, which is valuable in dynamic environments. Therefore, we hypothesize:

H2: MEFs with a human-dominant IT infrastructure realize greater performance as environmental dynamism increases.

3.3 The Role of Technology- and Human-Dominant IT Infrastructure

The technology- and human-dominant IT infrastructure enable MEFs to make comprehensive changes to the digital business model throughout the firm. While the human-dominant IT infrastructure enables MEFs to adapt to changes, MEFs realize greater performance when they make comprehensive business model changes. In more dynamic environments, firms survive competition by increasing the number of competitive actions such as introducing new products and services (Sambamurthy et al., 2003). By definition, the human-dominant IT infrastructure has fewer technical assets, compared to industry peers, in the majority of its establishments. Therefore, the scale and scope of digital business infrastructure are limited. That is, in MEFs with human-dominant IT infrastructure, the reduced reach of the technical infrastructure limits its scale (i.e., number of employees that can access IT systems across establishments) and scope (i.e., number of business processes being digitized across different business activities). For example, when implementing and deploying tailored IT systems, firms (e.g., JetBlue Technology Ventures) might target specific departments while building momentum for other departments. While this enables the firm to adapt to changes in the environment, the performance effects are greater when the firm has a dominant position, in terms of both technology and human assets, in its infrastructure.

Such MEFs do not just adapt a subset of digital processes but unleash a set of responses that are aligned with the changes in the environment. That is, the firm's response to change in the environment is carried out across the firm's digital business processes, as in-house human IT assets transform the digital process landscape, aligning the transformation with environmental changes. MEFs achieve greater competitiveness in more dynamic environments by facilitating such aligned responsiveness. For example, in highly dynamic industries, such as the electronic computer manufacturing industry, because of rapid technological changes, price competition, and introductions of new technologies, products, and services by competitors, the ability to forecast changes in demand is crucial to effectively respond to industry dynamism. Compaq transitioned its business model from build-to-stock to build-to-order and built proprietary applications, instead of relying on commercial enterprise systems, to support its ordering and demand forecasting processes. The benefits of customization outweighed those of standardization because Compaq realized that improving its ordering and demand forecasting processes would confer a competitive advantage to the company (Davenport et al., 1998).

Macy's is another example of a firm leveraging its human and technical assets to offer a response to environmental changes that were aligned with the overall business model. To respond to frequent changes in consumer needs in the retailing industry, Macy's relies on its human and technical assets to build business processes with a wide scale and scope that are customized to business-model changes. All these initiatives have allowed Macy's to be responsive to changes in consumer needs and increase sales (see Appendix A for more details on this example).

Further, the dominance of the IT infrastructure with both technology and human assets enables the collection of data about a greater number of digitized business processes, forming the backbone for business model-based transformations responding to environmental changes. That is, a widespread technical infrastructure strengthens internal innovation when combined with human assets. For example, General Electric (GE) relies on advanced technical and human resources to create and manage hundreds of different mobile apps as well as several online channels (e.g., Vine, Twitter, and Instagram) while continuously experimenting with new technologies, such as augmented reality (Dua et al., 2018). Since consumers are always looking for novel solutions, these digital innovations are crucial, enabling GE to respond to more effectively to environmental dynamism (see Appendix A for more details on this example).

In general, firms with high levels of IT skills and technical infrastructure are more flexible (Byrd & Turner, 2000). This flexibility gives them the ability to align with changes that happen continually in more dynamic environments. MEFs with a high degree of establishment that have a technology- and human-dominant IT infrastructure sense and seize market opportunities through the creation of innovative products and services, thus realizing enhanced performance. Hence, we hypothesize:

H3: MEFs with a technology- and human-dominant IT infrastructure realize greater performance as environmental dynamism increases.

4 Research Method

4.1 Data Collection

The data used in this research were retrieved from three sources: the CI Technology Database from Harte-Hanks, Compustat, and the Bureau of Labor Statistics (BLS). First, the Harte-Hanks' CI Technology Database was used to obtain data about the IS budget and the dominant IT infrastructure. This database provides a detailed description of the IT infrastructure, including hardware, software, services, and IT staff for over 400,000 establishments[2] in North America. Moreover, the Harte-Hanks database provides information about establishments' annual IS budgets for hardware, software, and services. The data, which are provided at the establishment level, can be aggregated to the MEF level. The Harte-Hanks database is considered a reliable source of information about MEFs (e.g., Mcelheran, 2014) and has been used in prior research (Dewan & Ren, 2011; Tambe et al., 2012). Second, the Compustat database was used to obtain control variables and firm-level financial data. Third, the measure of IS budget related to IT staff was derived using BLS (Xue et al., 2012). This complemented the measure of IS budget obtained from the Harte-Hanks database, which does not include IS budget for IT staff. The final sample is a panel dataset that covers 3 years 2007-2009 and contains 355 unique firms for which we have complete data on key variables of interest during the period 2007-2009. Of the 355 firms, 194 had three annual observations and 161 firms had two annual observations. In total, we collected 904 firm-year observations.[3] The average sales made at the MEF level was $16.26 billion during the 2007-2009 period. Of the 355 firms, 7 were in the trade industry, 196 were in the manufacturing industry, 80 were in the financial and professional services industry, and 72 were in the remaining industries.

4.2 Measures

4.2.1 IT Infrastructure Types

The components of IT infrastructure are measured using the Harte-Hanks CI Technology Database. On the one hand, the technical component was assessed using indicators of the establishment's platform, storage, network, telecommunications, and applications (Duncan, 1995). The measures of the platform, storage, network, telecommunications, and applications were standardized, and the average *z*-scores were used to measure the technical component (see Equation 1 below). In contrast, the human component was assessed using indicators of the establishment's technical skills and business knowledge (Lee et al., 1995). The measures of technical skills and business knowledge were standardized, and the average *z*-scores were used to measure the human component (see Equation 2 below). Table 1 summarizes the variables used as indicators to measure the technical and human components (Forman, 2005; Xue et al., 2011; Zhu, 2004; Zhu & Kraemer, 2002).

We used the industry (using the four-digit North American Industry Classification System—NAICS) average to categorize the technical and human dimensions into low and high, thus controlling for across-industry differences and practices such as cloud computing and IT outsourcing that could influence the establishment's IT infrastructure type.

For each MEF, we created three continuous variables as ratios. Each variable has the same denominator—the total number of employees in the firm—and the numerator represents the number of employees in the firm's establishments that have an above-industry average implementation of technical infrastructure (technology-dominant IT infrastructure TDI), an above-industry average constitution of human infrastructure (human-dominant IT infrastructure HDI), and an above-industry average implementation or constitution of technical and human infrastructure (technology- and human-dominant IT infrastructure BDI), respectively. Compared to business units, establishments provide a more accurate representation of the firm because firms have some establishments that are not counted as business units. MEFs have several establishments of different sizes based on the number of employees.

Equations (1) and (2)

$$TECHNICAL_{COMPONENT} = (Z_{total\ PCs\ per\ employee} + Z_{total\ servers\ per\ employee} + Z_{total\ printers\ per\ employee} + Z_{sum\ of\ applications} + Z_{total\ storage\ per\ employee} + Z_{total\ routers\ per\ employee} + Z_{total\ switches\ per\ employee} + Z_{total\ phone\ systems\ per\ employee} + Z_{total\ cellulars\ per\ employee} + Z_{total\ telecallers\ per\ employee})/10 \quad (1)$$

$$HUMAN_{COMPONENT} = \frac{(Z_{IT\ staff\ per\ employee} + Z_{number\ of\ Enterprise\ Application\ users\ per\ employee})}{2} \quad (2)$$

[2] An establishment represents an economic unit of a firm associated with a single location. A firm's establishments produce and/or sell goods or services.

[3] The sample size is 904, representing all the observations for whom we have data on all the key variables.

Table 1. IT Infrastructure Measurement

IT Infrastructure	Elements	Indicators	Literature
Technical component	Platform	Number of PCs per employee Number of servers per employee Number of printers per employee	Forman, 2005; Zhu, 2004; Zhu & Kraemer, 2002
	Storage	Total storage per employee	
	Network	Number of routers per employee Number of LAN switches per employee	
	Telecommunication	Number of phone extensions per employee Number of tele-callers per employee Number of cellular phones per employee	
	Applications	Total number of applications installed	
Human component	Technical skills	Number of IT employees per employee	Xue et al., 2011
	Business knowledge	Number of enterprise applications (EA) users per employee	

We created the three continuous variables to reflect such differences in establishments' sizes by weighting each establishment by size.

$$TDI = \frac{\sum Employees_{TI}}{\sum Total\ Employees_{MEF}} \quad (3)$$

$$HDI = \frac{\sum Employees_{HI}}{\sum Total\ Employees_{MEF}} \quad (4)$$

$$BDI = \frac{\sum Employees_{BI}}{\sum Total\ Employees_{MEF}} \quad (5)$$

Where $\sum Employees_{TI}$ represent the number of employees in establishments with an above-industry average implementation of technical infrastructure, $\sum Employees_{HI}$ represent the number of employees in establishments with an above-industry average constitution of human infrastructure, $\sum Employees_{BI}$ represent the number of employees in establishments with an above-industry average implementation or constitution of technical and human infrastructure and $\sum Total\ Employees_{MEF}$ is the total number of employees in the MEF.

4.2.2 Firm Performance

We define firm performance as the market value of the MEF in the stock market. We used Tobin's Q to measure MEF's market value. Tobin's Q is a market-based measure of IT contribution to firm performance. This measure captures the long-term and intangible business value of IT (Bharadwaj et al., 1999). Tobin's Q is measured as the MEF's market value divided by the replacement cost of assets. The market value of a firm is measured as the sum of the market value of its common equity, the liquidated value of the preferential stock, and total debt. Total assets measure the replacement cost of assets (Mithas & Rust, 2016). Greater firm performance corresponds to higher values of Tobin's Q.

4.2.3 Environment Dynamism

We measured environment dynamism by calculating the volatility of industry sales associated with the industry (four-digit NAICS) (Xue et al., 2011). Highly dynamic environments have an unpredictable sales growth rate (Xue et al., 2011). Hence, we obtained the volatility of industry sales using a two-step approach. First, we regressed the natural logarithm of the four-digit NAICS industry total sales against an index variable of years for the past five years. Second, we calculated the antilog of the standard error of the regression coefficient. This measure represents the environment's dynamism.

4.2.4 Control Variables

We considered different control variables previously used in the literature (Bharadwaj et al., 1999). We controlled for year-fixed effects because our dataset is spread out over three years from 2007 to 2009. An example of a year-fixed effect would be the 2008 financial crisis, which more than likely affected the market value of firms that could not adjust to the changes in the economy (Reinhart & Rogoff, 2008). We examined the unobserved year-fixed effects using two binary dummy variables. Moreover, we controlled for industry-specific factors, including industry average Q, and industry capital intensity.

Industry-average Q reflects the capital market structure. Industries with higher average Q have more valuable growth opportunities (e.g., Lang et al., 1996). Therefore, there is a positive association between the industry-average Q and Tobin's Q. Following previous studies, industry-average Q was measured as the average value of firms' Tobin's Q in a specific industry (four-digit NAICS) (e.g., Chung & Pruitt, 1994; Mithas et al., 2012). Industry capital intensity can constitute a barrier to entry into the market. It requires higher costs to be able to enter industries with high capital intensity. This results in a small number of incumbents, and low competition. Hence, it is expected that firms in industries with high capital intensity are associated with higher Tobin's *Q*. We measured industry capital intensity as physical capital divided by value added at the industry level (four-digit NAICS) (Mithas et al., 2012; Waring, 1996). We used three dummy variables to control for other industry-specific unobserved variables such as industry regulation, which could influence the firm's Tobin's Q (e.g., Bharadwaj et al., 1999). The three dummy variables represent four industry sectors, including trade, manufacturing, financial and professional services, and other industries. Such classification is established based on the NAICS code (Mithas et al., 2012).

Finally, we considered firm-specific factors as control variables. Firm-level variables such as R&D intensity, advertising intensity, firm size, and IS budget have an impact on the firm's Tobin's *Q* (Bharadwaj et al., 1999). Therefore, we included those variables in our model. Advertising intensity is an important factor in an effective marketing strategy. Several studies in the fields of marketing, and economics have found that advertising intensity is positively associated with firm performance (e.g., Comanor & Wilson., 1974; Park et al., 1986). Advertising intensity is measured as the firm's advertising expenditures divided by the firm's sales (Bharadwaj et al., 1999; Mithas & Rust, 2016). R&D intensity is an important factor for competition in the market. Several studies in the field of economics have found that R&D intensity is positively associated with firm performance (e.g., Oster, 1999; Ravenscraft & Scherer, 1982). R&D intensity is measured as the firm's R&D expenditures divided by the firm's sales (Bharadwaj et al., 1999; Mithas & Rust, 2016).

Firm size also constitutes an important factor for competition in the market. Prior research has shown that firm size is positively associated with firm performance (e.g., Pervan & Višić, 2012; Vijayakumar & Tamizhselvan, 2010). Firm size is measured as the natural logarithm of the firm's total number of employees (Bharadwaj et al., 1999; Xue et al., 2012). In Appendix B, we provide a detailed explanation of the measurement of IS budget. By dividing the MEF's IS budget by its sales, we obtained the level of the MEF's IS budget as a percentage of the sales. Table 2 summarizes the variables used in this study. Table 3 provides the repartition of the dataset across four IT infrastructure types at the establishment level. Table 4 summarizes the descriptive statistics of the sample and provides the pairwise correlations among the key variables.

4.3 Empirical Model and Econometric Considerations

In Equation 6, we specify the following econometric model for our panel data:

$$Y_{i,t} = X_{i,t}\beta + \varepsilon_{i,t} \, , \tag{6}$$

where Y represents the dependent variable, which is the firm's performance; X represents a vector of variables, including dominant IT infrastructures, and control variables; β represents a vector of parameters to be estimated; the subscripts i and j indicate respectively firms and years; and ε represents the error term associated with each observation i.

We develop robust models to examine the effect of dominant IT infrastructures on firms' performance. Similarly, we account for firm-level and industry-level factors such as firm size, market share, R&D intensity, advertising intensity, industry concentration, and industry average capital intensity. Moreover, we account for any unobserved year-fixed effect or industry-fixed effect by using year dummies and industry dummies. In Equation 7, we specify the empirical models that we use to test our hypotheses:

$$\begin{aligned} & FirmPerformance_{i,t} \\ & = \beta_0 + \beta_1 TDI_{i,t-1} + \beta_2 HDI_{i,t-1} + \beta_3 BDI_{i,t-1} \\ & + \beta_4 Dynamism_{i,t-1} \\ & + \beta_5 Dynamism_{i,t-1} \times TDI_{i,t-1} \\ & + \beta_6 Dynamism_{i,t-1} \times HDI_{i,t-1} \\ & + \beta_7 Dynamism_{i,t-1} \times BDI_{i,t-1} \\ & + \sum Firm\ Controls_{i,t-1} + \sum Year\ Dummies_t \\ & + \sum Industry\ Dummies_i + \varepsilon_{i,t} \end{aligned} \tag{7}$$

The error term is likely to create first-order autocorrelation AR1 meaning that for each firm, the error term ε_{it} is serially correlated across time (Mithas et al., 2016). We tested to detect the presence of first-order autocorrelation (Wooldridge, 2015). The results reject the null hypothesis ($p < 0.001$) implying that there is a first-order autocorrelation of the error term. Further, the use of a panel dataset implies the possibility of having a first-order panel-specific autocorrelation (PSAR1) of the error term. The first-order autocorrelation can be nested at the MEF level, meaning that within multi-unit firms there is the first-order autocorrelation and that the first-order autocorrelation coefficient is specific to each multi-unit firm. The results indicate that the model with first-order panel-specific autocorrelation (PSAR1) presents a higher model fit than the model with first-order autocorrelation (AR1). Thus, in our GLS model, we allow for PSAR1 variations.

In addition to autocorrelation, because our panel is imbalanced, we tested for heteroscedasticity, using a modified Wald test. The results reject the null hypothesis ($p < 0.001$), indicating the presence of heteroscedasticity. Similarly, we expect the variance of errors to change across establishments and to be specific to each multi-unit firm. This means that heteroscedasticity could be panel specific.

Table 2. Variable Definitions and Data Sources

Variable name	Variable definition	Source	Literature
Tobin's *Q*	The market value of a firm is divided by its replacement cost of assets. The market value of a firm equals the sum of the market value of its common equity, the liquidated value of the preferential stock, and total debt. The replacement cost of assets equals total assets.	COMPUSTAT	Mithas & Rust, 2016
IS budget	IS budget divided by the firm's sales	Harte-Hanks, COMPUSTAT, Bureau of Labor Statistics (BLS)	Bharadwaj et al., 1999; Mithas & Rust, 2016
TDI	The percentage of the number of employees in the MEF's establishments with above-industry average implementation of technical IT infrastructure compared to the total number of employees in the MEF	Harte-Hanks	This study
HDI	The percentage of the number of employees in the MEF's establishments with above-industry average constitution in human IT infrastructure compared to the total number of employees in the MEF	Harte-Hanks	This study
BDI	The percentage of the number of employees in the MEF's establishments with above industry average technical and human IT infrastructure compared to the total number of employees in the MEF	Harte-Hanks	This study
Environment dynamism	The volatility of industry sales associated with the industry (four-digit NAICS).	COMPUSTAT	Xue et al., 2011
Weighted industry average Tobin's *Q*	Sum of multiplications between MEF's proportion of sales in a four-digit NAICS industry* and the industry-average Tobin's *Q*	COMPUSTAT	Bharadwaj et al., 1999
Weighted industry capital intensity	Sum of multiplications between the MEF's proportion of sales in a four-digit NAICS industry and the industry average capital intensity. Capital intensity equals gross property, plant, and equipment divided by the sum of labor and operating income before depreciation	COMPUSTAT	Bharadwaj et al., 1999; Mithas et al., 2012
Weighted industry concentration	Sum of multiplications between MEF's proportion of sales in a four-digit NAICS industry and the industry concentration.		Bharadwaj et al., 1999
Advertising	Total advertising expenditures divided by the firm's sales	COMPUSTAT	Bharadwaj et al., 1999
R&D	Total R&D expenditures divided by the firm's sales	COMPUSTAT	Bharadwaj et al., 1999
Firm Size	The logarithm of the number of employees (in thousands)	COMPUSTAT	Bharadwaj et al., 1999
Weighted market share	Sum of multiplications between MEF's proportion of sales in a four-digit NAICS industry and the MEF's market share in that industry.	COMPUSTAT	Bharadwaj et al., 1999
Firm diversification	Entropy defined at the four-digit NAICS level minus entropy defined at the two-digit NAICS level	COMPUSTAT	Bharadwaj et al., 1999
Regulated industry	Dummy variable indicating if the MEF is in a regulated industry. Following Ciccone and Rocco (2005), regulated industries include (sic codes in parentheses) communications (4810-4899), gas and electric (4910-4924 and 4930-4939), water (4940-4941), and financial (6020-6062; 6140-6141; 6310-6321 and 6330-6331).	COMPUSTAT	Bharadwaj et al., 1999

*Proportion of sales in a 4-digit NAICS industry = total sales in the 4-digit NAICS industry divided by total sales across all four-digit NAICS industries. We use historical segments from Compustat to measure "proportion of sales in a 4-digit NAICS industry." The dataset contains firms' sales across industries. We calculate the denominator by summing a firm's sales across all the industries. The fields used are sales, NAICSS1, datadate, and gvkey.

Table 3. Description of the Dataset

	Establishments			
	Base group	**Technology dominant**	**Human dominant**	**Technology and human dominant**
2007	4547	1433	935	656
2008	2797	1337	484	682
2009	1896	1374	316	493

Table 4. Pairwise Correlations among Variables

		Mean	**SD**	**Min**	**Max**	**1**	**2**
1	Tobin's *Q*	1.1	.8	.06	7.2	1	
2	IS budget	.03	.046	3.9e-5	.73	-0.02	1
3	TDI	.14	.3	0	1	-0.01	.015
4	HDI	.12	.3	0	1	-0.03	0.16*
5	BDI	.06	.2	0	1	0.11*	0.05
6	Env dynamism	1.02	.013	1	1.1	-0.09*	-0.003
7	Weighted industry avg. Tobin's *Q*	1.21	.32	.8	5.34	0.007	-0.008
8	Weighted industry capital	.9	2.79	-14.38	19.56	0.006	0.002
9	Weighted industry concentration	.08	.08	0	1	-0.05	0.03
10	Advertising	.02	.022	1.8e-4	.308	0.02	-0.05
11	R&D	.05	.07	2e-4	.440	0.14*	-0.02
12	Size	2.46	1.88	-2.96	7.65	-0.17*	-0.003
13	Weighted market share	.1	.17	0	1	-0.1*	-0.02
14	Firm diversification	.09	.24	0	1.36	-0.03	-0.03
15	Regulated industry	.06	.24	0	1	-0.09*	-0.04
Note: *significant at 5%. *N* = 904							

		3	**4**	**5**	**6**	**7**	**8**
3	TDI	1					
4	HDI	-0.15*	1				
5	BDI	-0.1*	-0.09*	1			
6	Env dynamism	-0.07*	0.09*	0.002	1		
7	Weighted industry avg. Tobin's *Q*	-0.006	-0.025	-0.02	0.036	1	
8	Weighted industry capital	0.045	-0.03	-0.01	-0.08*	0.02	1
9	Weighted industry concentration	0.006	0.04	-0.004	0.026	0.01	-0.002
10	Advertising	-0.01	-0.05	0.016	-0.06*	0.026	0.09*
11	R&D	0.02	-0.05	-0.002	-0.19*	-0.026	-0.02
12	Size	-0.06*	0.009	-0.09*	-0.04	-0.01	0.08*
13	Weighted market share	0.008	0.026	-0.03	-0.006	-0.002	-0.02
14	Firm diversification	0.02	-0.05*	-0.02	-0.05	-0.02	0.03
15	Regulated industry	-0.02	-0.03	0.02	0.05	-0.01	0.03
Note: *significant at 5%. *N* = 904							

		9	**10**	**11**	**12**	**13**	**14**
9	Weighted industry concentration	1					
10	Advertising	-0.02	1				
11	R&D	-0.09*	-0.007	1			
12	Size	0.1*	0.03	-0.26*	1		
13	Weighted market share	0.37*	0.006	-0.15*	0.44*	1	
14	Firm diversification	-0.06	0.05*	-0.06*	0.19*	0.22*	1
15	Regulated industry	-0.1*	0.01	-0.03	0.003	-0.04	0.04
Note: *significant at 5%. *N* = 904							

We used the likelihood ratio test to detect the presence of panel-specific heteroscedasticity. The results reject the null hypothesis ($p < 0.001$), meaning that there is panel-specific heteroscedasticity in the dataset. We accounted for first-order panel-specific autocorrelation and panel-specific heteroscedasticity using GLS because it leads to reliable and robust estimation under the conditions (e.g., Mithas et al., 2012).

To reduce multicollinearity, we mean-centered the value of dynamism in all the interaction terms. Considering that firm performance can influence IT infrastructure (i.e., firms that perform well might tend to implement information technologies), it can be argued that there is a reverse causality between IT and firm performance. We mitigate the threat of endogeneity by using lagged values of firm performance (Mithas et al., 2016). Following prior studies (e.g., Xue et al., 2012), we considered the fact that IT infrastructure might be endogenous. We used Luan and Sudhir's (2010) two-stage model with instrumental variables to assess the endogeneity issue (see Saldanha et al., 2017).

We confirm the validity of the instruments by indicating their exogeneity and relevance. Following Xue et al. (2012), we used industry-level and previous year firm-level variables to ensure the exogeneity of the instruments. We also ensured that the variables could influence firm-level IT infrastructure implementations. Our final list of instruments includes the four-digit NAICS industry-average dominant IT infrastructure, and prior year net property, plant, and equipment (PPE). We selected industry-average dominant IT infrastructure because establishments may try to mimic other establishments in the industry. Also, we selected prior year PPE because Im et al. (2013) used PPE to measure non-IT stock and indicated that non-IT capital may influence IT capital. The results of the first stage (see Table 5) show that the two instruments are relevant. Both instruments satisfy the exclusion restriction because their impact on the outcome was indirect through their influence on MEF-level dominant IT infrastructure. Following Im et al. (2013), we also included prior year selling, general, and administrative (SG&A) expenses (excluding R&D). SG&A (excluding R&D) is marginally relevant.

Luan and Sudhir's (2010) model handles situations in which there are multiple endogenous variables. In the first stage, we regressed the variables TDI, HDI, and BDI on several variables, including log PPE, four-digit NAICS industry-average dominant IT infrastructure, and log SG&A expenses (excluding R&D) (see Table 5). Moreover, we used panel data models to estimate the first-stage model. We saved the residuals $\eta_{TechDomInfra}$, $\eta_{HumDomInfra}$, and $\eta_{TechHumDomInfra}$ from the first stage. We included the residuals $\eta_{TechDomInfra}$, $\eta_{HumDomInfra}$, and $\eta_{TechHumDomInfra}$ and the interaction terms $\eta_{TechDomInfra}$ × TDI, $\eta_{TechDomInfra}$ × HDI, $\eta_{TechDomInfra}$ × BDI, $\eta_{HumDomInfra}$ × TDI, $\eta_{HumDomInfra}$ × HDI, $\eta_{HumDomInfra}$ × BDI, $\eta_{TechHumDomInfra}$ × TDI, $\eta_{TechHumDomInfra}$ × HDI, and $\eta_{TechHumDomInfra}$ × BDI in the second stage to correct for endogeneity. The residuals accounted for selection bias and the interaction terms between the residuals and the endogenous regressors accounted for unobserved heterogeneity over the range of the regressors.

4.4 Results

The results support our main hypotheses. The first hypothesis, which suggests that MEFs with a technology-dominant IT infrastructure perform better in less dynamic environments, is supported. The interaction between a technology-dominant IT infrastructure and dynamism is negative and statistically significant for the dependent variable Tobin's *Q* (Table 6; $\beta = -1.98$, $p < 0.001$). Moreover, the second hypothesis, which posits that MEFs with a human-dominant IT infrastructure perform better in more dynamic environments, is also supported. The interaction between the human-dominant IT infrastructure and dynamism is positive and statistically significant for the dependent variable Tobin's *Q* (Table 6; $\beta = 0.43$, $p < 0.001$). Finally, the third hypothesis, which proposes that MEFs with a technology- and human-dominant IT infrastructure perform better in more dynamic environments, is also supported. Indeed, the interaction between the technology- and human-dominant IT infrastructure and dynamism is positive and statistically significant when the dependent variable is Tobin's *Q* (Table 6; $\beta = 4.81$, $p < 0.001$). Moreover, a Wald test indicated that the interaction between the technology- and human-dominant IT infrastructure and dynamism is statistically greater than the interaction between the technology-dominant IT infrastructure and dynamism. Similarly, the technology- and human-dominant IT infrastructure is statistically greater than the interaction between the human-dominant IT infrastructure and dynamism. We plot the moderating effect of dynamism on the association between the dominant IT infrastructure and firm performance (as illustrated in Figures 2-4).

4.5 Robustness Checks and Additional Analyses

We conducted robustness checks and additional analyses to ensure the robustness of our findings and strengthen our theoretical contributions. We incorporated the multi-industry footprint of MEFs into the measure of environmental dynamism by weighting the volatility of industry sales by the proportion of the MEF's sales in that industry in each year. The formula is given below:

$$Environment\ Dynamism_{ijt} = \sum V_{it} P_{ijt},$$

where V_{it} is the volatility of industry *i*'s sales in year *t*, and P_{ijt} is the proportion of MEF *j*'s sales in industry *i* in year *t*. The multiplication is summed across all four-digit NAICS industries. The results (see Table 7) are consistent with the main findings, indicating that the findings are robust to this alternative measure of environmental dynamism.

Table 5. First-Stage Results of Luan and Sudhir's (2010) Approach

	First-stage results (mean)			
	Base group	Technology dominant	Human dominant	Technology and human dominant
Log net property, plant, and equipment	-.0321* (.0155)	.028* (.0119)	-.0506* (.0227)	-.0261** (.01)
Industry average base group	.989** (.345)			
Industry average technology dominant		1.09* (.496)		
Industry average human dominant			2.5* (1.09)	
Industry average technology and human dominant				1.32* (.538)
Log SG&A expenses (excluding R&D)	-.0229 (.0216)	-.0096 (.0175)	.0221 (.02)	.0217* (.0099)
Firm diversification	.0469 (.047)	.0188 (.0449)	-.051 (.0331)	-.0269 (.0294)
IS budget	-2.95*** (.413)	.884* (.414)	1.17+ (.617)	1.21* (.473)
Logarithm employees	.0904*** (.0224)	-.0467** (.0175)	.0345 (.0249)	-.03* (.015)
Advertising intensity	.46 (.706)	-.227 (.49)	-.671 (.441)	.54 (.849)
R&D intensity	.0785 (.053)	.0944** (.0346)	-.177 (.123)	-.0712** (.0266)
Market Share	-.51+ (.265)	.391+ (.214)	.278 (.312)	.0948 (.163)
Environmental dynamism	-1.35 (1.28)	.4 (.803)	3.94* (1.82)	-.0338 (.659)
Environmental munificence	.0539 (.337)	-.114 (.279)	.652 (.434)	.252 (.186)
Environmental concentration	.768* (.334)	-.653* (.267)	2.06 (1.35)	-.0124 (.218)
Industry average capital intensity	-.003 (.0028)	.0012 (.0027)	.0019 (.0034)	5.4e-04 (.0017)
Industry average Tobin's *Q*	3.9e-04 (7.9e-04)	6.2e-04 (8.4e-04)	4.4e-04 (6.8e-04)	-6.8e-04+ (3.7e-04)
Regulated industry	.0338 (.0591)	-.01 (.0479)	-.145 (.131)	.0527 (.0752)
Constant	1.36 (1.52)	-.157 (.971)	-5.39* (2.2)	-.669 (.714)
Chi Squared	83.93***	92.78***	77.93***	75.32***

Note: +significant at 10%, *significant at 5%, **significant at 1%, ***significant at 0.1%. N = 904, robust standard errors are reported in parentheses. The model includes year and industry dummies. The results are consistent after using weighted market share, and weighted measures (e.g., weighted concentration) for the industry-level variables.

Table 6. Second-Stage Results of Luan and Sudhir's (2010) Approach

	Tobin's *Q*		
Regulated industry	-.125*** (.0052)	-.147*** (.0026)	
Firm diversification	-.0521*** (.0017)	-.0496*** (.0012)	
Logarithm employees	-.0093*** (1.9e-04)	-.0102*** (1.9e-04)	
Advertising intensity	.501*** (.0308)	.485*** (.0171)	
R&D intensity	.571*** (.0044)	.429*** (.0039)	

Weighted industry average Tobin's *Q*	.826*** (.0023)	.802*** (.0017)	
Weighted industry average capital intensity	-.0144*** (1.6e-04)	-.0154*** (1.2e-04)	
Weighted market share	.0945*** (.0036)	.117*** (.0027)	
IS budget	.0572*** (.0085)	.0279*** (.0027)	
Weighted industry concentration	.383*** (.0043)	.435*** (.0065)	
$\eta_{TechDomInfra}$	-.125*** (.0027)	-.112*** (.0029)	
$\eta_{HumDomInfra}$	.114*** (.009)	-.0931*** (.0071)	
$\eta_{TechHumDomInfra}$	-1.52*** (.0118)	-1.84*** (.0157)	
Technology-dominant IT infrastructure	.0908*** (.0081)	.095*** (.0055)	
Human-dominant IT infrastructure	.0386*** (.0097)	.197*** (.0087)	
Technology- and Human-dominant IT infrastructure	1.66*** (.0151)	1.95*** (.0174)	
$\eta_{TechDomInfra}$ × Technology-dominant IT infrastructure	.138*** (.0118)	.11*** (.007)	
$\eta_{TechDomInfra}$ × Human-dominant IT infrastructure	.444*** (.008)	.407*** (.0044)	
$\eta_{TechDomInfra}$ × Technology- and human-dominant IT infrastructure	-.0173 (.0307)	.105*** (.0148)	
$\eta_{HumDomInfra}$ × Technology-dominant IT infrastructure	-1.78*** (.0593)	-1.8*** (.0482)	
$\eta_{HumDomInfra}$ × Human-dominant IT infrastructure	-.0694*** (.0046)	-.0164*** (.0043)	
$\eta_{HumDomInfra}$ × Technology- and human-dominant IT infrastructure	-1.6*** (.0455)	-1.42*** (.0301)	
$\eta_{TechHumDomInfra}$ × Technology-dominant IT infrastructure	2.59*** (.102)	2.81*** (.0615)	
$\eta_{TechHumDomInfra}$ × Human-dominant IT infrastructure	1.4*** (.0315)	1.43*** (.0302)	
$\eta_{TechHumDomInfra}$ × Technology- and human-dominant IT infrastructure	-.294*** (.0045)	-.222*** (.0087)	
Environmental dynamism		-3.73*** (.0368)	
Technology-dominant IT infrastructure × Environmental dynamism		-1.98*** (.224)	
Human-dominant IT infrastructure × Environmental dynamism		.432*** (.102)	
Technology- and human-dominant IT infrastructure × Environmental dynamism		4.81*** (.169)	
Constant	-.46*** (.0139)	-.598*** (.0135)	
Chi squared	9.12e+06***	6.36e+07***	

Note: +significant at 10%, *significant at 5%, **significant at 1%, ***significant at 0.1%. N = 904, the model includes year and industry dummies.

	Tobin's *Q*		
Regulated industry	-.152*** (.0019)	-.151*** (.0022)	-.148*** (.0031)
Firm diversification	-.0474*** (.0011)	-.0466*** (9.1e-04)	-.0476*** (6.8e-04)
Logarithm employees	-.009*** (1.4e-04)	-.0088*** (1.4e-04)	-.0102*** (1.5e-04)
Advertising intensity	.466*** (.0126)	.473*** (.0128)	.501*** (.0195)

R&D intensity	.446*** (.0034)	.457*** (.0045)	.445*** (.0048)
Weighted industry average Tobin's *Q*	.799*** (.0013)	.801*** (.0012)	.801*** (.0018)
Weighted industry average capital intensity	-.0154*** (1.2e-04)	-.0155*** (1.3e-04)	-.0154*** (1.3e-04)
Weighted market share	.113*** (.0023)	.111*** (.0015)	.116*** (.0011)
IS budget	.0166*** (.0017)	.0248*** (.0031)	.023*** (.0027)
Weighted industry concentration	.425*** (.0046)	.422*** (.0051)	.43*** (.0041)
$\eta_{TechDomInfra}$	-.113*** (.0022)	-.112*** (.0022)	-.103*** (.0024)
$\eta_{HumDomInfra}$	-.0746*** (.0053)	-.086*** (.0055)	-.104*** (.0063)
$\eta_{TechHumDomInfra}$	-1.87*** (.0091)	-1.86*** (.0097)	-1.85*** (.0123)
Technology-dominant IT infrastructure	.098*** (.0043)	.102*** (.0068)	.0966*** (.0073)
Human-dominant IT infrastructure	.186*** (.0064)	.182*** (.0068)	.2*** (.0077)
Technology- and human-dominant IT infrastructure	2.01*** (.0159)	2.02*** (.0137)	1.96*** (.0149)
$\eta_{TechDomInfra}$ × Technology-dominant IT infrastructure	.113*** (.0052)	.118*** (.0053)	.12*** (.0041)
$\eta_{TechDomInfra}$ × Human-dominant IT infrastructure	.41*** (.0036)	.408*** (.0036)	.397*** (.004)
$\eta_{TechDomInfra}$ × Technology- and human-dominant IT infrastructure	.0138 (.0123)	5.2e-04 (.0105)	.083*** (.0215)
$\eta_{HumDomInfra}$ × Technology-dominant IT infrastructure	-1.72*** (.0427)	-1.73*** (.0475)	-1.67*** (.047)
$\eta_{HumDomInfra}$ × Human-dominant IT infrastructure	-.0222*** (.0028)	-.0073* (.0033)	-.008*** (.0015)
$\eta_{HumDomInfra}$ × Technology- and human-dominant IT infrastructure	-1.47*** (.0219)	-1.47*** (.0192)	-1.4*** (.028)
$\eta_{TechHumDomInfra}$ × Technology-dominant IT infrastructure	2.76*** (.0639)	2.78*** (.0447)	2.79*** (.0479)
$\eta_{TechHumDomInfra}$ × Human-dominant IT infrastructure	1.42*** (.0208)	1.4*** (.0203)	1.44*** (.0256)
$\eta_{TechHumDomInfra}$ × Technology- and human-dominant IT infrastructure	-.297*** (.0149)	-.305*** (.0106)	-.216*** (.0066)
Environmental dynamism	-3.43*** (.0195)	-3.67*** (.0217)	-3.93*** (.0249)
Technology-dominant IT infrastructure × Environmental dynamism	**-2.3*** (.183)**		
Human-dominant IT infrastructure × Environmental dynamism		**.239** (.0804)**	
Technology- and human-dominant IT infrastructure × Environmental dynamism			**5.11*** (.134)**
Constant	-.611*** (.014)	-.615*** (.0118)	-.606*** (.0125)
Chi squared	3.83e+07	3.28e+07	6.64e+06
Note: +significant at 10%, *significant at 5%, **significant at 1%, ***significant at 0.1%. *N* = 904, the model includes year and industry dummies.			

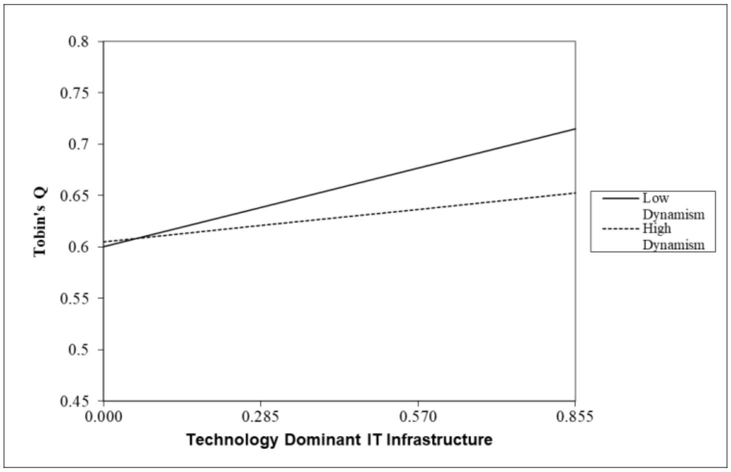

Figure 2. Impact of the Interaction between Technology-Dominant IT Infrastructure and Dynamism on Tobin's *Q*

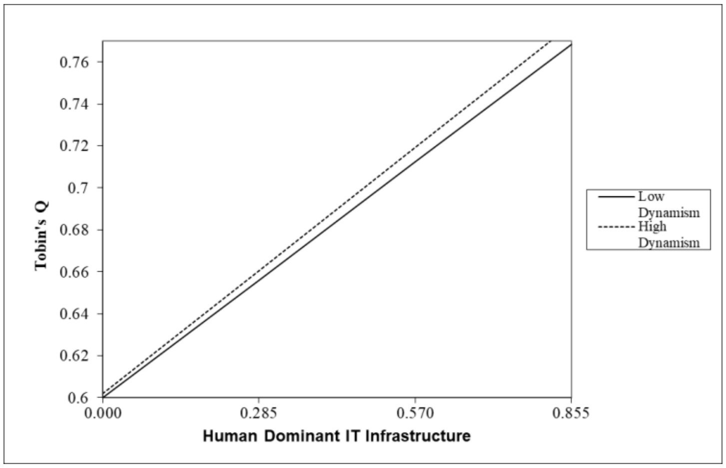

Figure 3. Impact of the Interaction between Human-Dominant IT Infrastructure and Dynamism on Tobin's *Q*

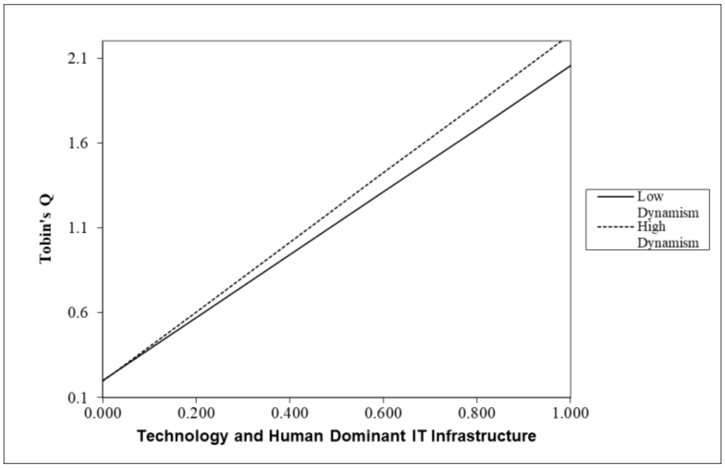

Figure 4. Impact of the Interaction between Technology- and Human-Dominant IT Infrastructure and Dynamism on Tobin's *Q*

Table 7. Second-Stage Results (weighted dynamism)

	Tobin's *Q*
Regulated industry	-.114*** (.0021)
Firm diversification	-.044*** (.0015)
Logarithm employees	-.0112*** (3.2e-04)
Advertising intensity	.187*** (.0183)
R&D Intensity	.482*** (.0075)
Weighted industry average Tobin's *Q*	.78*** (.0026)
Weighted industry average capital intensity	-.0043*** (1.0e-04)
Weighted market share	.193*** (.0124)
IS budget	.0973*** (.0053)
Weighted industry concentration	.26*** (.0082)
$\eta_{TechDomInfra}$	-.0088** (.0029)
$\eta_{HumDomInfra}$	.199*** (.0116)
$\eta_{TechHumDomInfra}$	-1.23*** (.0151)
Technology-dominant IT infrastructure	.072*** (.004)
Human-dominant IT infrastructure	.205*** (.0118)
Technology- and human-dominant IT infrastructure	1.42*** (.0227)
$\eta_{TechDomInfra}$ × Technology-dominant IT infrastructure	.205*** (.0046)
$\eta_{TechDomInfra}$ × Human-dominant IT infrastructure	.22*** (.0202)
$\eta_{TechDomInfra}$ × Technology- and human-dominant IT infrastructure	.0306 (.0324)
$\eta_{HumDomInfra}$ × Technology-dominant IT infrastructure	-.566*** (.0197)
$\eta_{HumDomInfra}$ × Human-dominant IT infrastructure	-.0847*** (.0083)
$\eta_{HumDomInfra}$ × Technology- and human-dominant IT infrastructure	-1.18*** (.06)
$\eta_{TechHumDomInfra}$ × Technology-dominant IT infrastructure	1.82*** (.0248)
$\eta_{TechHumDomInfra}$ × Human-dominant IT infrastructure	1.6*** (.0373)
$\eta_{TechHumDomInfra}$ × Technology- and human-dominant IT infrastructure	-.283*** (.0186)
Environmental Dynamism	-3.27*** (.0375)
Technology-dominant IT infrastructure × Environmental dynamism	**-1.25*** (.16)**
Human-dominant IT infrastructure × Environmental dynamism	**.183** (.067)**
Technology- and human-dominant IT infrastructure × Environmental dynamism	**4.9*** (.316)**
Constant	.0808*** (.0031)
Chi squared	3.25e+07***

Note: +significant at 10%, *significant at 5%, **significant at 1%, ***significant at 0.1%. *N* = 904, the model includes year and industry dummies.

Next, we used an alternative measure of firm performance. We replaced Tobin's *Q* with sales per employee. We report the results of the base model and interactions in Table 8. Overall, the results are consistent with the main findings. Thus, our findings can be generalized to alternative dependent variables.

We used an alternative measure of establishments' IT infrastructure types. Instead of comparing establishments' technical and human components of IT infrastructure to the industry average, we used the industry median. We report the results of the first stage and second stage in Tables 9 and 10. The results confirm the main findings, indicating that both the industry average and median can be used to identify establishments' IT infrastructure types.

We conducted split samples analyses to test the moderating effect of environmental dynamism on the relationship between dominant IT infrastructure and firm performance. We create three quantiles based on environmental dynamism. The first-quantile (mean = 1.01), second-quantile (mean = 1.015), and third-quantile (mean = 1.04) groups correspond to groups of low, medium, and high environmental dynamism, respectively. We compared the effects of dominant IT infrastructures across groups of low and high environmental dynamism. The results (see Table 11) confirm the main findings.

5 Discussion

5.1 Theoretical Contributions

The theoretical contributions of our work punctuate the role played by IT infrastructure in MEFs' digital business processes. Notably, IT infrastructure is the biggest category of IT investment for most firms (Kappelman et al., 2018; Peter Weill & Broadbent, 1998). The importance of IT infrastructure for a firm's digital business processes cannot be underemphasized, as it plays a crucial role in providing the foundation that enables IT-based business initiatives (Weill et al., 2002). Previous research has examined the impact of IT capabilities (Bharadwaj, 2000), IS spending (Brynjolfsson & Hitt, 1996), and specific application technologies, such as enterprise resource planning (Hitt et al., 2002), computerized reservation systems (Banker & Johnston, 1995), and ATM networks (Banker et al., 1988). We extend the inquiries beyond the application level to reveal the role of IT infrastructure, offering a robust conceptualization of the construct in an MEF. Specifically, we contribute by differentiating the relative development of two components in building the IT infrastructure and their efficacy in different environments.

Previous research has underlined the role of the environment in IT impacts (Xue et al., 2012). In general, various aspects of IS have interactions with the environment. For example, the environment has an influence on the impacts of IT capabilities (Chen et al., 2014) and IT alignment (Yayla & Hu, 2012). Contributing to this research highlighting the impacts of the environment, we unravel the effects of environmental dynamism on the firm's ability to leverage its IT infrastructure. Notably, we explore how the effect of the environment differs when an MEF has greater relative development of one of the two—technical or human—components of IT infrastructure, which are characterized as the basic pillars of IT infrastructure by the classical theoretical IS research (Broadbent & Weill, 1997; Henderson & Venkatraman, 1992). By examining the relative implementation or constitution of different subcomponents of the two major IT infrastructure components, our research shows how unique types of IT infrastructures may manifest in establishments and when are they most efficacious.

Further, by pointing out the notion of the dominance of IT infrastructures, we unravel the complexity involved in assessing the effects of IT infrastructure in an MEF and propose a unique way of assessing the infrastructure. Within large multi-establishment organizations (MEFs), IT infrastructure implementation differs across establishments. Although there is a recognition of the commonalities and synergies across business unit IT infrastructure technologies and IT management processes in the research examining organizational-level effects of IT infrastructure (Tanriverdi, 2006), very little research has examined granular IT infrastructure at the establishment level. Our conceptualization of dominance contributes to the domain of works by highlighting heterogeneity in IT infrastructure at the establishment level. The need to investigate such heterogeneity in IT infrastructure is well known (Chen & Forman, 2006). Because little previous research has explored such granular level impacts, our research contributes by addressing the calls for examining granular levels of analysis notably differentiating between corporate and business unit levels of analysis (Queiroz et al., 2020). That is, we contribute by addressing the necessity of disaggregating the IT construct to better assess the impact of IT (Melville et al., 2004). The concept of dominance helps present a nuanced analysis of granular effects, as it helps to reveal the aggregate effects of the granular level yet accommodates the variance in IT infrastructures across establishments.

Notably, the focus on the dominance of a type of IT infrastructure extends the recent research that has started to differentiate corporate and business unit levels of analysis (see Queiroz et al., 2020). The notion of dominance highlights how firm-wide digital business processes are contingent upon the underlying IT infrastructure.

Table 8. Second-Stage Results with an Alternative Dependent Variable

	Sales per employee	
Regulated industry	.0026*** (4.6e-04)	.0015** (5.9e-04)
Firm diversification	.0012* (5.7e-04)	.0025*** (5.9e-04)
Logarithm employees	7.3e-04*** (6.9e-05)	5.6e-04*** (1.2e-04)
Advertising intensity	.0774*** (.0108)	.089*** (.0112)
R&D intensity	.0618*** (.0029)	.0631*** (.0031)
Weighted industry average Tobin's *Q*	.881*** (9.3e-04)	.883*** (.0011)
Weighted industry average capital intensity	-6.7e-04*** (4.8e-05)	-5.2e-04*** (2.7e-05)
Weighted market share	.0136*** (.0016)	.0098*** (.0011)
IS budget	-.0056*** (.0013)	-.0031** (.001)
Weighted industry concentration	-.0684*** (.0032)	-.0682*** (.0024)
$\eta_{TechDomInfra}$	.0278*** (.0014)	.0321*** (.0015)
$\eta_{HumDomInfra}$	-.0638*** (.0025)	-.0688*** (.002)
$\eta_{TechHumDomInfra}$	-.0762*** (.0043)	-.0771*** (.0022)
Technology-dominant IT infrastructure	-.005** (.0017)	-.0017 (.0014)
Human-dominant IT infrastructure	.0337*** (.0022)	.0288*** (.0018)
Technology- and human-dominant IT infrastructure	.107*** (.0061)	.0982*** (.0058)
$\eta_{TechDomInfra}$ × Technology-dominant IT infrastructure	-.0657*** (.0077)	-.0821*** (.0076)
$\eta_{TechDomInfra}$ × Human-dominant IT infrastructure	-.0562*** (.007)	-.0864*** (.01)
$\eta_{TechDomInfra}$ × Technology- and human-dominant IT infrastructure	-.323*** (.0433)	-.403*** (.0415)
$\eta_{HumDomInfra}$ × Technology-dominant IT infrastructure	.0448*** (.0083)	.0418*** (.0065)
$\eta_{HumDomInfra}$ × Human-dominant IT infrastructure	.0347*** (.0028)	.0462*** (.0022)
$\eta_{HumDomInfra}$ × Technology- and human-dominant IT infrastructure	.142*** (.009)	.134*** (.0101)
$\eta_{TechHumDomInfra}$ × Technology-dominant IT infrastructure	-.224*** (.0151)	-.192*** (.0139)
$\eta_{TechHumDomInfra}$ × Human-dominant IT infrastructure	.102*** (.0105)	.0972*** (.0091)
$\eta_{TechHumDomInfra}$ × Technology- and human-dominant IT infrastructure	-.0196** (.0067)	-.0102 (.0072)
Environmental dynamism		.102*** (.0112)
Technology-dominant IT infrastructure × Environmental dynamism		**-.188**** **(.071)**
Human-dominant IT infrastructure × Environmental dynamism		**.0877*** **(.0373)**
Technology- and human-dominant IT infrastructure × Environmental dynamism		**.567***** **(.0793)**
Constant	.0305*** (8.7e-04)	.03*** (8.2e-04)
Chi squared	9.12e+06***	6.36e+07***

Note: +significant at 10%, *significant at 5%, **significant at 1%, ***significant at 0.1%. *N* = 904, the model includes year and industry dummies.

Table 9. First-Stage Results of Luan and Sudhir's (2010) Approach (median)

	First-stage results (mean)			
	Base group	**Technology dominant**	**Human dominant**	**Technology and human dominant**
Log net property, plant, and equipment	-.041** (.0151)	.0377** (.0128)	.0233 (.019)	-.0418* (.021)
Industry average base group	1.06** (.372)			
Industry average technology dominant		.812*** (.183)		
Industry average human dominant			1.07* (.425)	
Industry average technology and human dominant				.937+ (.562)
Log SG&A expenses (excluding R&D)	-.0423+ (.0237)	.0123 (.0102)	.0448* (.021)	.0035 (.0263)
Firm diversification	.0247 (.0625)	.0864 (.0618)	-.0633 (.0536)	-.0166 (.0497)
IS budget	-3.02*** (.496)	2.27*** (.661)	.282 (.472)	2.61*** (.552)
Logarithm employees	.112*** (.0238)	-.0602*** (.0167)	-.0465+ (.0267)	-.059 (.036)
Advertising intensity	1.13 (.711)	-.192 (.255)	-.387 (.673)	.756 (.808)
R&D intensity	.103+ (.0556)	-.12*** (.0344)	-.0767+ (.0399)	.0362 (.0444)
Market share	-.0866 (.305)	-.135 (.209)	-.656* (.302)	.464+ (.277)
Environmental dynamism	-2.08+ (1.25)	.373 (.792)	1.08 (1.34)	.823 (1.31)
Environmental munificence	.109 (.347)	.274 (.202)	-.501 (.379)	-.101 (.345)
Environmental concentration	-.107 (.371)	-.0783 (.262)	.337 (.442)	-.233 (.355)
Industry average capital intensity	.002 (.0041)	-3.1e-04 (.0026)	-.0032 (.0048)	5.1e-05 (.0026)
Industry average Tobin's *Q*	3.6e-04 (7.5e-04)	-9.0e-04 (7.7e-04)	.0011 (.0012)	-3.1e-04 (6.9e-04)
Regulated industry	.0468 (.0698)	.0067 (.0426)	-.101 (.078)	.0126 (.0952)
Constant	2.32 (1.46)	-.922 (.948)	-.198 (1.59)	-.932 (1.45)
Chi squared	99.88***	102.73***	43.69***	115.32***

Note: +significant at 10%, *significant at 5%, **significant at 1%, ***significant at 0.1%. *N* = 904, environmental concentration and industry concentration are used interchangeably. Robust standard errors are reported in parentheses. The model includes year and industry dummies. The results are consistent after using weighted market share, and weighted measures (e.g., weighted concentration) for the industry-level variables.

Table 10. Second-Stage Results: Moderation of Dynamism (median)

	Tobin's *Q*	
Regulated industry	-.128*** (.002)	-.129*** (.002)
Firm diversification	-.107*** (.0016)	-.109*** (.0017)
Logarithm employees	-.0076*** (1.4e-04)	-.0093*** (3.0e-04)
Advertising intensity	.526*** (.0188)	.585*** (.0196)
R&D intensity	.488*** (.0057)	.512*** (.0087)
Weighted industry average Tobin's *Q*	.821*** (.0018)	.796*** (.0031)

Weighted industry average capital intensity	-.0123*** (1.4e-04)	-.0125*** (1.3e-04)
Weighted market share	.138*** (.0043)	.14*** (.0027)
IS budget	.0248** (.009)	.0588*** (.0063)
Weighted industry concentration	.348*** (.0061)	.337*** (.0101)
$\eta_{TechDomInfra}$	-.173*** (.0029)	-.178*** (.0049)
$\eta_{HumDomInfra}$	.256*** (.0029)	.243*** (.0056)
$\eta_{TechHumDomInfra}$	-.956*** (.0153)	-.948*** (.0271)
Technology-dominant IT infrastructure	.0583*** (.0037)	.0319*** (.0051)
Human-dominant IT infrastructure	.21*** (.0021)	.219*** (.0023)
Technology- and human-dominant IT infrastructure	.202*** (.0013)	.242*** (.0026)
$\eta_{TechDomInfra}$ × Technology-dominant IT infrastructure	.204*** (.0034)	.207*** (.0064)
$\eta_{TechDomInfra}$ × Human-dominant IT infrastructure	.421*** (.0067)	.443*** (.009)
$\eta_{TechDomInfra}$ × Technology- and human-dominant IT infrastructure	.342*** (.0067)	.424*** (.0069)
$\eta_{HumDomInfra}$ × Technology-dominant IT infrastructure	-.391*** (.0132)	-.392*** (.0147)
$\eta_{HumDomInfra}$ × Human-dominant IT infrastructure	.0834*** (.0053)	.133*** (.0068)
$\eta_{HumDomInfra}$ × Technology- and human-dominant IT infrastructure	-.122*** (.0169)	-.103*** (.0153)
$\eta_{TechHumDomInfra}$ × Technology-dominant IT infrastructure	.586*** (.0452)	.46*** (.0624)
$\eta_{TechHumDomInfra}$ × Human-dominant IT infrastructure	1.5*** (.0239)	1.52*** (.0295)
$\eta_{TechHumDomInfra}$ × Technology- and human-dominant IT infrastructure	1.02*** (.0161)	1.03*** (.0275)
Environmental dynamism		-2.35*** (.0669)
Technology-dominant IT infrastructure × Environmental dynamism		**-2.67*** (.318)**
Human-dominant IT infrastructure × Environmental dynamism		**.172** (.0651)**
Technology- and human-dominant IT infrastructure × Environmental dynamism		**11.8*** (.16)**
Constant	-.311*** (.0105)	-.309*** (.0104)
Chi squared	5.70e+06***	3.23e+07***
Note: +significant at 10%, *significant at 5%, **significant at 1%, ***significant at 0.1%. *N* = 904, the model includes year and industry dummies.		

Table 11. Second-Stage Results: Split Samples

	Tobin's *Q*	
	Low dynamism	**High dynamism**
Regulated industry	-.255*** (.0034)	-.264*** (.0212)
Firm diversification	-.135*** (.0057)	.0263** (.0095)
Logarithm employees	.0119*** (6.7e-04)	-.0515*** (.0048)
Advertising intensity	.375*** (.0753)	.532 (.499)

R&D Intensity	.811*** (.0167)	.259 (.193)
Weighted industry average Tobin's *Q*	.765*** (.007)	.868*** (.0288)
Weighted industry average capital intensity	.0039*** (3.5e-04)	-.0568*** (.002)
Weighted market share	-.0978*** (.0071)	.515*** (.0312)
IS budget	.319*** (.0137)	2.97*** (.424)
Weighted industry concentration	-.121*** (.0097)	-.458** (.174)
$\eta_{TechDomInfra}$	.119*** (.0118)	.772*** (.052)
$\eta_{HumDomInfra}$	.107*** (.0043)	.438*** (.0533)
$\eta_{TechHumDomInfra}$	-1.52*** (.0565)	-1.64*** (.147)
Technology-dominant IT infrastructure	**.0664*** (.0104)**	**.0228 (.235)**
Human-dominant IT infrastructure	**.0034 (.0099)**	**.385*** (.0855)**
Technology- and human-dominant IT infrastructure	**.286*** (.043)**	**3.19*** (.441)**
$\eta_{TechDomInfra}$ × Technology-dominant IT infrastructure	.487*** (.0508)	.393 (.369)
$\eta_{TechDomInfra}$ × Human-dominant IT infrastructure	1.17*** (.0633)	-.764** (.286)
$\eta_{TechDomInfra}$ × Technology- and human-dominant IT infrastructure	.0356 (.0864)	3.93** (1.21)
$\eta_{HumDomInfra}$ × Technology-dominant IT infrastructure	-.0617*** (.0145)	.325 (.301)
$\eta_{HumDomInfra}$ × Human-dominant IT infrastructure	-.468*** (.0157)	.0693 (.0892)
$\eta_{HumDomInfra}$ × Technology- and human-dominant IT infrastructure	.811*** (.0248)	1.81+ (.988)
$\eta_{TechHumDomInfra}$ × Technology-dominant IT infrastructure	2.11*** (.215)	4.94*** (1.2)
$\eta_{TechHumDomInfra}$ × Human-dominant IT infrastructure	2.46*** (.0749)	4.52*** (.796)
$\eta_{TechHumDomInfra}$ × Technology- and human-dominant IT infrastructure	1.93*** (.0411)	.689 (.788)
Constant	.0335*** (.0063)	-.235*** (.0392)
Chi squared	1.62e+07***	1.39e+07***

Note: +significant at 10%, *significant at 5%, **significant at 1%, ***significant at 0.1%. *N* = 301, the model includes year and industry dummies.

Dominant IT infrastructures enable the development and evolution of digitized business processes. The three different dominant IT infrastructures studied could catalyze standardization, adaptation, or comprehensive business-model transformation. Future research could build on our early findings to build the nomological linkages between these concepts. That is, we contribute to a nascent but growing domain of IS research that links IT to different emphases such as revenue generation and cost savings (Mithas & Rust, 2016), and goals such as exploration and exploitation (Xue et al., 2012).

Our study also lays a foundation for future research on the topic. However, more research is required to develop a comprehensive theory that captures the diversity and impacts of IT infrastructures; our study contributes by offering a conceptual and empirical foundation to build such a theory. First, our research offers a unique methodology to assess dominance as an aggregate concept. Building on the foundation of this research, future research could examine how dominant IT infrastructure enhances the competitive advantage and performance of MEFs. For example, future research could study contextual and moderating influences that influence the performance effects of dominant IT infrastructures (Melville et al., 2004; Wade & Hulland, 2004). Second, future research could go beyond external factors to explore how the impact of dominant IT infrastructure is influenced by internal factors such as IT governance or IT planning. Third, future research could investigate additional external factors, including partner characteristics (e.g., IT intensity and knowledge management). Finally, future research could also examine the relationship between dominant IT infrastructures and IT capabilities. IT capabilities are key to resolving important managerial issues such as enterprise alignment (Fonstad & Subramani, 2009). Future research could also contribute by examining the relationship between dominant IT infrastructures and IT capabilities.

5.2 Practical Implications

Beyond making a theoretical contribution, our findings have important managerial implications. Notably, we punctuate the role of dominance in IT infrastructure—a dynamic that may be understood only through an establishment-wide analysis of the relative development of technology and human assets. Because it is a latent factor that may catalyze or inhibit digital business initiatives, the dominant IT infrastructure is an important aspect for MEF managers to focus on. Especially for firms operating in more dynamic environments, our findings indicate that, collectively, the choice of an IT infrastructure type across its establishments should be in sync with the external environmental conditions and in line with the dominant IT infrastructure configuration. Because these have indirect implications for digital business initiatives the firm can undertake, a strategic and careful assessment of how the dominant IT infrastructure is emergent across the firm is crucial for the firm to realize superior performance.

We recommend that managers develop metrics and methods to assess the dominance of different IT infrastructure types across their establishments, based on our research findings. Such an approach is crucial for MEFs because normal business activities can transform their IT infrastructures. In particular, several business practices—such as IT outsourcing or mergers and acquisitions (M&A)—can cause a shift in the MEF's dominant IT infrastructure. Because such business events may have a positive or negative influence on firms' valuations, based on the effectiveness with which the firm manages its digital business processes after the event, the active management of the dominant infrastructure can shape appropriate digital business processes.

5.3 Limitations and Future Research

Our study has certain important limitations. First, our measure of the human component is based on the size of the IT staff. This measure has been used in prior research assessing IT knowledge (Xue et al., 2011). However, future research could use alternative operationalizations that focus on richer indicators of the human component, such as technology management, business knowledge, management knowledge, and specific technical skills (Byrd & Turner, 2000). Further, we measure the telecommunications technical infrastructure as the number of tele-callers per employee because tele-calling is an important aspect of modern IT infrastructure. However, one may think of tele-callers as representing a human component and future research may be able to use them to represent the human component, especially by linking the measure with employees' business knowledge (e.g., knowledge about their day-to-day business routines, rules, heuristics, opportunities and threats, and strategy—Tiwana & Kim, 2015) or technical skills (e.g., knowledge about systems design, database structures, programming languages, IT project methodologies, and application development tools, among others—Tiwana & Kim, 2015).

Second, our conceptualization of IT infrastructure type is limited to the technical and human components of IT infrastructure (Byrd & Turner, 2000). Future research could expand our conceptualization to include aspects of IT architecture, including processes, policies, or culture, in order to address broader research questions, such as those linking dominant IT culture with firm performance. Third, the study timeframe (2007-2009) coincides with the US financial crisis. Although we are less concerned about its effects in our design because we control for temporal effects using time-fixed effects, future work could explore the impact of different dominant IT infrastructures in other periods. Finally, our study would have benefitted from additional empirical assessments focusing on our theoretical arguments. For example, although we mention standardization and adaptability as theoretical arguments for the hypotheses, we do not have measures of MEF's standardization and adaptability. Future research could empirically assess how different dominant IT infrastructures enable MEFs' standardization and adaptability, in turn influencing their performance. Also, future studies could hypothesize about the moderating effects of other dimensions of environmental uncertainty (e.g., munificence and complexity).

6 Conclusion

To conclude, this study explores how environmental dynamism moderates the impact of dominant IT infrastructures on MEFs' performance. We unravel the differences in effects of the three different dominant IT infrastructures across environments with different dynamism. The findings provide an empirical and theoretical foundation to study IT infrastructures. Overall, our findings offer a basis for new groundbreaking research about dominant IT infrastructures and their effects.

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Appendix A: Detailed examples

Hypotheses	Claim	Example
H1	MEF can use third-party IT vendors that implement the built-in logic of the off-the-shelf IT systems (such as, Salesforce) by adopting standards and industry-best practices. Such a strategy is appropriate for firms operating in less dynamic environments	For example, in the less dynamic environment of the oil and gas industry—characterized by low entry and exit rates (Dunne et al., 1988; Klapper et al., 2006) and low job reallocation rates, i.e., the sum of job creation and destruction across firms (Hathaway & Litan, 2014; Rob, 1995)—Exxon Mobil Corp (the largest US publicly traded oil company) relies on their technology infrastructure to pursue business process standardization (Mitchell, 2006). That is, Exxon Mobil Corp puts greater importance on deploying industry-best practices and creating common global processes, notably through the adoption of off-the-shelf applications. State-of-the-art business processes may follow. For instance, Exxon Mobil Corp implemented the "upstream suitcase" platform by integrating standard computing applications (e.g., for tracking personnel, monitoring equipment, and managing work permits) (Mitchell, 2006). Further, it was able to standardize most of the business operations parts of its chemical business by deploying a global SAP solution.
H2	The MEF's ability to adapt digital business processes enables it to react locally to market changes, a dynamic seen in the digital business strategy of Delta Airlines.	The airline industry is highly dynamic due to cost structure, demand volatility, and competition, and is characterized by highly volatile aircraft fuel prices. Moreover, demand is sensitive to multiple factors, including overall economic performance, accidents, technology failures, security threats (e.g., terrorist attacks), contagious illnesses, new regulation, disruption at major airports, seasonality, weather, and natural disasters. Finally, airlines face intense competition with respect to fares, routes, timing, frequency of flights, customer service, and frequent-flyer programs. The creation of well-funded alliances and new airlines continually increases competition in the industry. In such a dynamic industry, Delta relies on its human infrastructure to build tailored business processes on a few strategic aspects of the business (Hub, 2014; Rice, 2014). Notably, in contrast to most US airlines, Delta manages its reservations and operational systems in-house, differentiating itself in a highly competitive industry. Delta relies on its high number of highly skilled in-house IT employees to build greater flexibility and control over future technological improvements. Delta seeks to customize its reservations and operational systems to fit its mobile platforms, airport kiosks, and delta.com. This customization of business processes enables Delta to be responsive to competitors' moves, changes in customer needs, and in the external environment by creating innovative solutions (e.g., personalized promotions, customer targeting, and baggage tracking) that enhance operational performance and customers' travel experience. This approach likely contributed to Delta's almost fourfold increase in stock price from 2010-2015, as well as its multiple-year ranking as the most admired US airline (Sean, 2015).
H3	MEFs achieve greater competitiveness in more dynamic environments by facilitating strategically aligned responsiveness.	For example, in highly dynamic industries such as the electronic computer manufacturing industry, because of rapid technological changes, price competition, introduction of new technologies, products, and services by competitors, forecasting demand changes is crucial to effectively respond to industry dynamism. Compaq transitioned its business model from build-to-stock to build-to-order and built proprietary applications—instead of relying on commercial enterprise systems—to support its ordering and demand forecasting processes. The benefits of customization outweighed those of standardization as Compaq realized that improving ordering and demand forecasting processes confers a competitive advantage to the company (Davenport et al., 1998).
		Macy's is another example of a firm leveraging its human and technology assets to offer a response to environmental changes that were strategically aligned with the overall business model. Macy's operates in the fashion and retailing industry, which is a highly dynamic industry due to issues such as seasonality, weather conditions,

		pandemics, natural disasters, regulations, disruption in the supply chain, technology failures, and changes in consumer spending, fashion trends, and consumer preferences. Moreover, the fashion and retailing industry is characterized by high demand volatility, due to increasing numbers of retailers and retailer competition at different levels, including assortment, quality, service, price, advertising, reputation, location, and credit availability. The survival of retailers is linked to their ability to predict and respond to changes in consumer preferences and fashion trends. To respond to frequent changes in consumer needs in the retailing industry, Macy's relies on its human and technology assets to build business processes with a wide scale and scope that can be customized to respond to business model changes. Macy's implements digital initiatives by leveraging its technologies and IT skills. Notably, Macy's is ranked among the top retailers in terms of digital mastery and competency (Macy's Inc, 2011). For example, pursuing the goal of increasing sales, Macy's developed several technological solutions, both in-store and online, to support an omnichannel strategy. These solutions seek to enhance consumer engagement and experience, which are crucial in rapidly changing environments. Further, the company's infrastructure enables learning via the experimentation of new ideas. While not all ideas may be successful, the company is dedicated to leading in digital innovation by building tailored processes to satisfy ever-changing consumer needs. Macy's seeks to provide in-store consumers with an online-like shopping experience. Several examples highlight the scope and scale of Macy's digital initiatives. In particular, Macy's expanded their Search & Send initiative nationwide and several stores across the United States joined the initiative. The Search & Send initiative enables consumers at a Macy's location to access the volume and variety of inventory across many stores. Moreover, Macy's enhanced the fulfillment of orders allowing the shipping of products purchased in-store or online to be shipped to the consumer's home or workplace. Other Macy's digital initiatives include Beauty Spot—facilitating the consumer's search for cosmetics products—tablets and hand-held devices, digital receipts, and live chats. All these digital initiatives have allowed Macy's to be responsive to changes in consumer needs and grow sales. For example, Macy's was able to mitigate the volatility caused by the COVID-19 pandemic—which increased online shopping online and decreased in-store shopping—by expanding digital sales by 53% (Johnston, 2020).
	A widespread technical infrastructure strengthens internal innovation when combined with human assets.	For example, General Electric (GE) relies on advanced technical and human resources to create and manage hundreds of different mobile apps, and several channels (e.g., Vine, Twitter, and Instagram) while continuously experimenting with new technologies, such as emojis and augmented reality (Dua et al., 2018). The technical infrastructure provides the resources for the deployment of digital innovations (e.g., mobile apps) while human resources focus on designing, implementing, and aligning digital innovations in synch with the business strategy and model. As consumers look for novel solutions, these digital innovations are crucial and have enabled GE to respond to environment dynamism such as that arising due to fierce competition, pricing, and cyclical pressures.

Appendix B. Measurement of IS Budget

We measure the level of MEF's IS budget with respect to sales (Bharadwaj et al., 1999). The measure helps calibrate IS budget to the size (e.g., Mithas et al., 2016; Mithas & Rust, 2016). IS budget is calculated using the Harte-Hanks database, BLS, and Compustat following a two-step approach. First, we use the Harte-Hanks database to collect estimates of the establishment's budget for IT hardware, IT software, IT communication equipment, IT storage equipment, IT services, and outsourcing. The Harte-Hanks database does not provide an estimate of the establishment's budget for IT labor. Second, we calculate such estimates by multiplying the number of IT employees of the establishment by the IT wages obtained from BLS which provides industry-specific values of IT wages (Xue et al., 2012).

The establishment's IS budget is a sum of the establishment's budget for IT labor, IT hardware, IT software, IT communication equipment, IT storage equipment, IT services, and outsourcing. Because not all MEF establishments' IS budgets are reported by the Harte-Hanks database, we cannot obtain MEFs' IS budgets by summing their establishments' IS budgets.[4] Thus, we calculate the ratio of the IS budget per employee at the MEF level based on the available data on establishments' IS budgets. We multiply this ratio by the number of employees in the MEF to obtain the MEF's IS budget. By dividing the MEF's IS budget by its sales, we obtain the level of the MEF's IS budget as a percentage of the sales. To alleviate concerns about our measurement and the reliability of the Harte-Hanks database estimates, we compare the IS budget data descriptive statistics (i.e., mean and standard deviation) with those of previous studies that used the InformationWeek survey (e.g., Mithas et al., 2016; Mithas & Rust, 2016). We found that our descriptive statistics are comparable to previous studies.[5]

[4] If we sum the IS budget for all available establishments, we obtain the following statistics for IS budget (as a percentage of sales): mean = 0.003, *SD* = 0.006, years = 2007-2009.

[5] Our descriptive statistics are mean = 0.029, *SD* = 0.040, years = 2007-2009, and previous studies report the following descriptive statistics: mean = 0.041, *SD* = 0.068, year = 2003-2004 (Mithas & Rust, 2016);
mean = 0.028, *SD* = 0.026, year = 1999-2003 (Han & Mithas, 2013); mean = 0.029, *SD* = 0.027, year = 1994-1996, 1999-2006 (Mithas et al., 2016).

About the Authors

Franck Soh (PhD, University of Arkansas, 2020) is an assistant professor of information systems at the Bryan School of Business and Economics, The University of North Carolina at Greensboro. His research interests include the business value of IT, competition in mobile platform ecosystems, healthcare IT, customer service performance, open source, and social media. Dr. Soh has published in *Journal of Management Information Systems*, *Journal of Computer Information Systems*, and *Australasian Journal of Information Systems*. He has presented his research at several conferences and symposiums including International Conference on Information Systems (ICIS), Conference on Information Systems & Technology (CIST), Americas Conference on Information Systems (AMCIS), Interdisciplinary Symposium on Decision Neuroscience (ISDN), and Big XII.

Pankaj Setia (PhD, Michigan State University, 2008) is the institute chair professor, professor of information systems and strategy areas, and founding chair of the Centre for Digital Transformation at the Indian Institute of Management (IIM) Ahmedabad, India. He previously taught at Michigan State University and the University of Arkansas. He was also the executive director of the PhD program and an associate professor at the University of Arkansas, USA. His broader research interests include business analytics and artificial intelligence, IT strategy, digital innovations, neuroscientific theories, computational models of sentiment analysis and IT Governance, and open source innovations. He has published in top information systems and business journals, such as *MIS Quarterly*, *Information Systems Research, and Journal of Operations Management*, among others, in two domains: (1) IT strategy and governance, and (2) open source software. He has been featured among the top 100 researchers in the field of information systems worldwide, based on his publications in the top business journals (e.g., the Financial Times top 50 Journals). Also, he has been invited to give research talks and keynote speeches by universities in different countries, such as India, the US, Chile, and Singapore. He teaches graduate-level courses on strategic management of digital innovations and digital transformation at the Indian Institute of Management, Ahmedabad (IIMA).