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Business Value of Information Technology Capabilities: An Institutional Governance Perspective

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Abstract. Prior research has differentiated intrafirm information technology (IT) capabilities that reduce internal coordination costs and interfirm IT capabilities that reduce external transaction costs. However, the influence of developing these capabilities on business value has not been explored in the realm of institutional governance—the regulatory context that defines the rules of the game for firms. We suggest that the value of a firm's investments in different types of IT capabilities development (ITCD) is evaluated by the financial market contingent on the firm's regulatory context. Our study is situated in the U.S. electric utility industry undergoing a market restructuring process to understand the impacts of intrafirm and interfirm ITCD on market value conditional on a firm's regulatory context characterized by the extent to which its business is located in states that allow consumer choice (i.e., deregulation), as well as the extent to which its business is located in states that deliberate regulations regarding price control, value chain configuration, and information control (i.e., regulatory uncertainty). We find that intrafirm ITCD for enhancing efficiency is rewarded in a firm's market valuation under a high level of deregulation. We further find that under a high level of regulatory uncertainty, interfirm ITCD for fostering flexibility can hedge against regulatory uncertainty and increase firm value. A key contribution of our work is demonstrating external institutional governance can influence the market value that firms accrue from different types of ITCD, thereby elaborating the complementarity in theoretical explanations of IT capabilities and institutional governance.

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Introduction

Information technology (IT) capabilities have been evolving in scope to more comprehensively encompass the coordination of a firm's assets and internal processes (Weill and Ross 2004, Banker et al. 2006) and their interfirm transactions and relationships (Bala and Venkatesh 2007, Tiwana 2008). Consequently, firms are investing significantly in developing IT capabilities for a variety of activities (Aral and Weill 2007, Mithas et al. 2011, Chae et al. 2014), ranging from production systems for coordinating distributed production resources and processes to transaction systems for aligning real-time supply with demand (Bharadwaj et al. 2007, Rai et al. 2015, Saldanha et al. 2017). Although firms have been expanding IT capabilities to encompass diverse intrafirm and interfirm activities, their investments in specific IT capabilities development (ITCD) could be more or less valuable depending on various circumstances (Dewan and Ren 2011, Ho et al. 2017). The choices to allocate investments in different IT capabilities, alongside the consideration that firms' investments in specific ITCD are not necessarily valuable, make it important to understand how *context* shapes the business value of ITCD (Hong et al. 2014, Rai et al. 2015). In particular, the institutional governance context of an industry (i.e., regulations) in which a firm conducts business has substantial implications for how the firm should develop specific IT capabilities to coordinate internal assets and activities and to organize interfirm transactions and relationships (Majumdar and Marcus 2001, Walker et al. 2002, Delmas and Tokat 2005). Furthermore, regulatory changes require a firm to make strategic decisions on how to effectively develop IT capabilities that are suitable for addressing challenges and seizing opportunities stemming from the regulatory context in which the firm conducts business (Delmas et al. 2007, Kim 2013, Weigelt and Shittu 2016). Despite its importance, how the regulatory context of a firm shapes the business value of its investments in ITCD is far from clear.

Prior information systems (IS) research has elaborated our understanding of the performance impacts of a firm's IT capabilities (Bharadwaj et al. 1999, Aral and Weill 2007) and more recently has considered contextual aspects related to governance of the firm's activities. Although internal governance contexts (e.g., sourcing decisions by the firm) have been shown to affect the impacts of ITCD on accounting-based performance (e.g., return on assets (ROA); Rai et al. 2015), the literature has not addressed how a firm should align its ITCD with external governance contexts (e.g., regulations) in which the firm conducts business to improve market-based performance (e.g., Tobin's Q). In particular, an *institutional governance perspective* is missing in our understanding of the relationship between IT capabilities and firm value. This is an important gap in our knowledge as transaction cost economics have stressed that internal and external governance are both important for firms' strategic decisions for capability development (Jacobides and Winter 2005). In formulating the precise gap in understanding related to the role of institutional governance, we focus on the regulatory context as a firm needs to develop specific IT capabilities to comply with regulatory requirements and capitalize on opportunities arising from the enactment of, and uncertainty in, regulations (Kim 2013, Weigelt and Shittu 2016). Particularly, the regulatory context has not been integrated into our understanding of the market value that firms gain from their investments in ITCD. Without considering how specific IT capabilities address challenges and seize opportunities stemming from the regulatory context in which a firm conducts business, the value of its investments in certain ITCD cannot be fully understood.[1] Our overarching research objective is to evaluate the market valuation of a firm's investments in different types of ITCD contingent on the regulatory context.

We situate our study in the U.S. electric utility industry (EUI), which has experienced significant market restructuring (Borenstein and Bushnell 2018). We focus on two regulatory characteristics: deregulation of consumer choice and regulatory uncertainty of market restructuring. As a firm's regulatory context can be unique based on its business locations, we consider deregulation and regulatory uncertainty at the firm level.

Deregulation with respect to choices afforded to wholesalers and consumers was a major regulatory change in the EUI, which opened untapped opportunities, allowing firms to enter new geographical markets, differentiate, and compete (Kim 2013, Weigelt and Shittu 2016). Although policy regarding wholesale choice was implemented nationally in the same way, policy on consumer choice varied by state. This led firms to be able to sell electricity beyond their home state and in multiple states that may differ in consumer choice, motivating the need to contrast firms with respect to deregulation based on their business locations (Delmas et al. 2007, Kim 2013). Accordingly, we define *deregulation* at the firm level as the extent to which a firm's business is located in states that allow consumer choice at a specific time in the market restructuring process.[2] Deregulation shifts the competitive landscape of the EUI by allowing consumers to choose their providers, potentially across state lines. A firm needs to compete on price and service reliability based on capabilities to reduce internal coordination costs of production activities (Weigelt and Shittu 2016). In the meantime, the firm may also need capabilities to agilely cope with demand shifts via market exchange activities to compete on service reliability (Delmas and Tokat 2005).

Market restructuring for consumer choice in the EUI was not one-shot but evolved. Different states were characterized by varying regulatory uncertainty, as their respective regulatory authorities (e.g., state governments and utility commissions) deliberated on regulations in key domains. These include the following: *price control*, pertaining to price thresholds and cost recovery that affect how firms create and appropriate value from consumers (Maloney et al. 1997, Borenstein and Bushnell 2018); *value chain configuration*, such as unbundling wholesale power generation from transmission (Cook et al. 1983)[3]; and *information control*, involving information disclosure requirements by firms for oversight (Cohen and Santhakumar 2007, Evans et al. 2009). In characterizing regulatory uncertainty for a firm, as with deregulation, it is important to consider not only the regulatory uncertainty in the firm's home state but also in other states where the firm operates that may differ in regulatory uncertainty. Thus, we define *regulatory uncertainty* at the firm level as the extent to which a firm's business is located in states that deliberate on market restructuring regarding changes to price control, value chain configuration, and information control.[4] When regulations are uncertain, a firm in the EUI with capital-intensive production resources needs to address the uncertainty using market exchanges in an agile manner. This will require the firm to constantly adapt to the changing regulatory context based on its capabilities to hedge against uncertainty by coordinating transactions with suppliers and customers to reduce transaction costs of market exchange activities (Jacobides and Winter 2005).

To address our research objective, we draw on the IT capabilities and institutional governance literatures to propose a model on how intrafirm and interfirm ITCD will be valued by the market according to a firm's regulatory context (i.e., deregulation and regulatory uncertainty) in the market restructuring process. We construct a panel data set from firms in the EUI over 10 years (1994–2003) for their investments in ITCD and regulatory contexts. This timeframe is well suited for our research objective as the entire industry was undergoing

tumultuous market restructuring that has since settled down. We find the market value of different types of ITCD in affected by the regulatory context. Our results show that intrafirm ITCD is valued to a greater extent in a more deregulated context, whereas interfirm ITCD is valued to a greater extent in a more uncertain regulatory context. They also suggest that intrafirm ITCD is not valued by the market in a less deregulated context, whereas interfirm ITCD is not valuable in a more deregulated context and may even incur market valuation penalties in a less uncertain regulatory context.

Investigative Context

The EUI is an ideal setting for our study. It enables us to control for product heterogeneity as electricity is a unique commodity with standardized characteristics. Because it cannot be efficiently stored, supply must match demand at any time period to avoid blackouts or oversupply. As a functional product, electricity can be traded in volume and can experience price volatility in the spot market (Fisher 1997). There are also regulatory standards that must be adhered to on service reliability (e.g., safeguards against brownouts/blackouts). The EUI has a three-stage value chain: power generation to transmission (long-haul transmission from generation facilities to distribution sites) to distribution (distribution sites to consumers). We focus on investor-owned power generation firms.[5] Because of the structure of this industry, firms are not allowed to make excess profits, and thus, the competitiveness of power generation firms primarily resides on their production efficiency, as hedge inventory or purchase via transactions can be very costly and pull down already thin margins (Delmas and Tokat 2005, Kim 2013).

The EUI is governed at two institutional levels in the United States—federal and state.[6] At the federal level, the Energy Information Administration (EIA) collects, analyzes, and publicizes energy information that promotes policymaking, and the Federal Energy Regulatory Commission (FERC) regulates interstate transmission of natural gas, oil, and electricity. Interstate sales of electricity in the wholesale market and by public utilities (e.g., investor-owned utilities, power marketers, independent power producers, and nonexempt electric cooperatives) are subject to regulations by the FERC. Deregulation with respect to wholesale choice was also implemented nationally by the FERC (Kim 2013). In 1996, the FERC issued Order 888/889 with the objective of restructuring the retail market and allowing consumer choice by promoting competition in the power generation market. The order allowed utilities to recover stranded costs (price control), required all public utilities that own, control, or operate transmission facilities to have on file an open access nondiscriminatory transmission tariff and investor-owned utilities to unbundle wholesale generation and power marketing from transmission services and reconfigure their exchange linkages (value chain configuration), as well as created independent system operators and information release guidelines (information control). This was the FERC's first broad sweeping effort to eliminate discriminatory and unfair practices in the control of the EUI.

Although FERC Order 888/889 was issued nationally, state utility commissions were given broad regulatory authority to ensure that utilities in their jurisdictions provided fair, just, and reasonable services to customers. In particular, state utility commissions were given authority over various aspects of power generation, transmission, and distribution of electricity. Yet not all states moved at the same speed in deregulating or even allowed for consumer choice (see the e-companion, Figure EC-1a). Thus, the market restructuring process is distinct across states with deregulation and regulatory uncertainty varying within and across states over time. Because states were given broad regulatory authority, we see significant temporal variations in the degree to which they implement deregulation for consumer choice and debate regulations related to price thresholds and cost recovery (price control), configurations of value chain such as unbundling incumbents (value chain configuration), and information to be disclosed and overseen (information control). We also observe that even after deregulation, in some states, debates continue on price thresholds, value chain configurations, and information needs, reflecting continuation of regulatory uncertainty (see the e-companion, Figure EC-1b).[7] In the EUI, firms may conduct business not only in their home states but also across states with differences in deregulation and regulatory uncertainty. Accordingly, above and beyond the home state of a firm, the regulatory context of the firm needs to be characterized based on the extent of its business across states and considered in examining the impacts of intrafirm and interfirm ITCD on market value.

Theory Development

Research Model

We draw on the literature on IT capabilities (Piccoli and Ives 2005, Bharadwaj et al. 2007, Rai and Tang 2010) and institutional governance (Joskow 1997, Bushnell et al. 2017) to develop our core claim that during market restructuring, the market value of a firm's ITCD is conditional on characteristics of its regulatory context. Figure 1 presents our research model of the market value (Tobin's Q) of a firm's intrafirm and interfirm ITCD based on deregulation and regulatory uncertainty where it operates. Table 1 provides the definitions of ITCD and regulatory context constructs that we focus on in our research model.

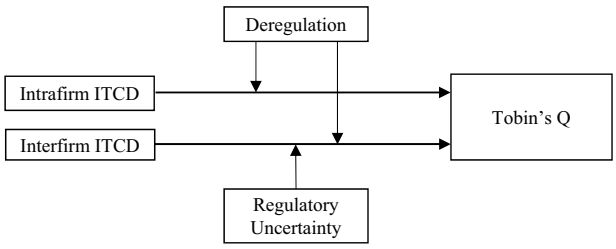
We focus on understanding how firms in the EUI receive differing market valuations by developing certain

Table 1. Definitions of Key Constructs

Construct	Definition	Examples
Intrafirm IT capabilities development	IT investments directed at digitally coordinating internal assets and activities (e.g., planning, monitoring, and/or controlling) (Bharadwaj et al. 2007, Rai and Tang 2010, Rai et al. 2015, Saldanha et al. 2017, Khuntia et al. 2019)	• Supervisory control and data acquisition system • Integrated automated mapping and facilities management system • Energy generation control system • Energy management system
Interfirm IT capabilities development	IT investments directed at digitally coordinating market transactions with suppliers and customers (Saraf et al. 2007; Rai and Tang 2010; Rai et al. 2012, 2015; Cui et al. 2020)	• Integrated supply chain planning system • Supply chain materials management system • Supplier contract management system • Customer service system • Client development system • Electronic data interchange system
Deregulation	The extent to which a firm's business is located in states that allow consumer choice at a specific time in the market restructuring process	• In 2000, a firm based in Maryland conducting business in three states: Delaware, Maryland, and Virginia. • Maryland had deregulated and allowed consumer choice, but Delaware and Virginia had not.
Regulatory uncertainty	The extent to which a firm's business is located in states that deliberate on market restructuring regarding changes to price control, value chain configuration, and information control	• In 2000, a firm based in Maryland conducting business in three states: Delaware, Maryland, and Virginia. • Delaware: no meetings in 2000 • Maryland: "The Maryland Court of Appeals ruled to *delay* the beginning of retail access … *complained* that the standard offer *rate* set in BG&E's territory was too low to attract competitive suppliers … " [italics added for emphasis] • Virginia: "*Pilot* programs in Virginia … participants have switched to *competitive* suppliers … " [italics added for emphasis]

IT capabilities based on their regulatory contexts in the market restructuring process.[8] This is in line with an institutional governance perspective that integrates the role of the material-resource (e.g., inputs, technologies, and outputs) and institutional (e.g., cultures, norms, and regulations) environment in which firms create economic and social value (Scott 2001). Firms within an industry do *not* exhibit isomorphism in their developments of intrafirm and interfirm IT capabilities. As firms formulate and enact IT strategies, they can differentiate themselves in how they enmesh IT in core production and market exchange processes. Thus, variations in ITCD can occur in an industry.[9] The industry may influence firm-level development of IT capabilities and their impacts (Chiasson and Davidson 2005), as industries exhibit heterogeneity in not only the material-resource environment but also in the institutional environment that establishes the regulatory context in which firms must cope to create value (Scott 2001, Chiasson and Davidson 2005, Rai et al. 2015). In a given industry, especially major ones (e.g., utilities, healthcare, education), the institutional environment is complex and requires delineation of the levels of the heterogeneity that characterize it. In the EUI, although there is federal-level governance, the public utility commission (PUC) at the state level has significant discretion in defining the rules of the game. Thus, the EUI has witnessed considerable differences in the regulations across states, providing a unique opportunity for examining a firm's regulatory context, which is defined by the locations where it conducts business. As such, to characterize its regulatory context, we consider deregulation and regulatory uncertainty of all states where the firm conducts business. These characteristics are particularly relevant to the market restructuring process in the EUI and likely to be critical in the market valuation of the firm's strategic investments in developing IT capabilities (Delmas et al. 2007, Weigelt and Shittu 2016). Firms in a regulatory context have the discretion to differentiate themselves in their capabilities to manage the material-resource environment, specifically with regard to coordinating assets and processes and executing transactions (Jacobides and Winter 2005). Accordingly, we theorize market value creation results from a firm's ITCD interacting with deregulation and regulatory uncertainty in its regulatory context.

Figure 1. Research Model



Our focus on intrafirm and interfirm ITCD is particularly suitable for two reasons. First, there are salient characteristics of the EUI that make both intrafirm and interfirm ITCD important for a firm to manage its intrafirm and interfirm activities in the underlying material-resource and institutional environment, which are pertinent for market valuation (Rai et al. 2015). Firms invest in intrafirm IT capabilities to control their assets and processes and reduce internal coordination costs,[10] given that production resources in the EUI setting are highly capital-intensive and a variety of internal activities are involved in production. Moreover, large investments[11] in interfirm IT capabilities can allow firms to function as flexible organizations by reducing external transaction costs and reshaping the transactional environment. Thus, both intrafirm and interfirm ITCD are especially important in the EUI. Second, research has examined intrafirm and interfirm IT capabilities in various settings, ranging from manufacturing (Bharadwaj et al. 2007) to equipment (Rai and Tang 2010) to logistics (Ray et al. 2005) to utilities (Rai et al. 2015) and to hi-tech industries such as solar energy and electronics (Cui et al. 2020). The IT capabilities literature has concluded that these two types of capabilities are critical for value creation and appropriation from IT investments in these industries, as intrafirm IT capabilities reduce internal coordination costs whereas interfirm IT capabilities reduce external transaction costs. Thus, findings on intrafirm and interfirm IT capabilities are generalizable across these industries. Although the literature has examined these capabilities in different industries, the influence of developing intrafirm and interfirm capabilities on market valuation has not been explored in the realm of a firm's regulatory context, particularly during market restructuring. Next, we develop the logic for our hypotheses on market valuation of intrafirm and interfirm ITCD based on regulatory context characteristics in the market restructuring process. It is worth noting that we assume "market efficiency" in which the financial market efficiently processes information about a firm to reflect it in a timely manner in the market valuation of the firm (Fama 1998).

Table 2 summarizes our theoretical logic underlying the research model. We suggest that intrafirm ITCD enhances a firm's *efficiency* via developing the IT capabilities to coordinate internal assets and activities, reduce internal coordination costs, and increase production efficiency, which are more valuable for the firm to compete on price and service reliability in a deregulated context with consumer choice. Additionally, interfirm ITCD increases a firm's *flexibility* in agilely coping with demand shifts via developing the IT capabilities to coordinate market exchange activities, which are more valuable for the firm to compete on service reliability in a deregulated context with consumer choice. The deregulation context can change for a firm as states can reverse its regulation on consumer choice (e.g., California) or firms can conduct business in different states such that the overall regulatory context where they operate is more or less skewed toward consumer choice.

Furthermore, market restructuring is an uncertain process where states debate changes in price control, value chain configuration, and information control over time. This renders the uncertainty of regulatory context as varying across states based on the potential changes that are debated in different states. In a more uncertain regulatory context, we suggest that interfirm ITCD increases a firm's *flexibility* in appropriating value by developing the IT capabilities to reshape the firm's transactional environment, reduce external transaction costs, and hedge against uncertainty. Intrafirm ITCD increasing a firm's *efficiency* is not relevant in this context because addressing regulatory uncertainty requires flexibility of adjusting supply to match unpredictable demand, rather than efficiency of production. In the EUI, production resources are capital-intensive and cannot be quickly adjusted (Delmas and Tokat 2005).

Deregulation and Market Valuation of IT Capabilities Development

With a high level of deregulation for consumer choice, consumers have choices in their electric utility providers among competitors in the industry. It has been documented that deregulating industries, ranging from airlines to banking to utilities, results in better customer services with decreased price (Winston 1998, Fabrizio et al. 2007). If a firm's services are considered expensive or unreliable when consumers have choices, the firm lacks a competitive advantage. As electricity is a homogeneous commodity across firms in the EUI (Delmas and Tokat 2005, Delmas et al. 2007, Kim 2013), the market should reward a firm based on its capabilities to compete on price and service reliability as such capabilities align creating value in a competitive environment following deregulation. Deregulated consumer choice defines a competitive landscape, urging power generation firms to develop capabilities that reduce internal coordination costs and improve the control of internal production processes for greater efficiency and reliability (Fabrizio 2012).

Although research has shown that intrafirm IT capabilities have a positive relationship with firm performance (Banker et al. 2006, Ayabakan et al. 2017), we suggest that this relationship is contingent on the level of deregulation for consumer choice. We argue that intrafirm ITCD can enhance a firm's *efficiency* required to win the competition in a more deregulated context. Investments in production systems (e.g., supervisory control and data acquisition (SCADA)) can develop intrafirm IT capabilities to control production assets cost-efficiently and coordinate internal production processes reliably. Moreover, a firm's internal production

Table 2. Market Valuation of IT Capabilities Development Based on the Regulatory Context

	Hypothesis 1a	Hypothesis 1b	Hypothesis 2
Regulatory context	High deregulation of consumer choice characterizes institutional governance of a firm's business		High regulatory uncertainty of market restructuring characterizes institutional governance of a firm's business
ITCD type	Intrafirm ITCD	Interfirm ITCD	Interfirm ITCD
Theoretical logic	Market rewards intrafirm ITCD to increase a firm's *efficiency*. Intrafirm IT capabilities enable the firm to cost-efficiently coordinate internal assets and reduce agency costs and risk in distributed production processes, thereby reducing costs and increasing service reliability in a more deregulated context for consumer choice.	Market rewards interfirm ITCD to increase a firm's *flexibility*. Interfirm IT capabilities enable the firm to leverage market exchanges to agilely cope with demand shifts in its customer base, thereby increasing service reliability in a more deregulated context for consumer choice.	Market rewards interfirm ITCD to increase a firm's *flexibility*. Interfirm IT capabilities enable the firm to: (1) rapidly identify and adjust to suitable suppliers and customers for cost recovery to address regulatory uncertainty regarding *price control*, (2) agilely realign with supply chain partners and hedge against inventory or purchase to address regulatory uncertainty regarding *value chain configuration*, (3) readily extract and report information about value chain activities in the market restructuring process to address regulatory uncertainty regarding *information control*.

processes are likely to be distributed over plants within or across states, leading to information asymmetry within the firm that may increase internal coordination costs and harm production efficiency. Investments in intrafirm ITCD can also improve the efficiency of production by reducing this information asymmetry and corresponding agency costs and risk of opportunism in the firm's distributed production processes. When a firm is not equipped with such coordination capabilities via intrafirm ITCD, there could be excess or shortage of production. For functional products like electricity, the rates are close to the cost recovery basis with a thin margin (Fisher 1997), and excess production can lead to high costs for storage, maintenance, and ad hoc transmission and distribution, eating all profits or resulting in a high price (Delmas et al. 2007). Similarly, shortage of production must be minimized as the costs of spot purchase from other firms may exceed the firm's thin margin or lead to inevitable high price. Thus, functional products require coordination capabilities to be competitive (Fisher 1997).

Intrafirm ITCD aligns with a high level of deregulation, as it bolsters the firm's ability to produce and deliver homogenous outputs cost-efficiently and reliably. Under the assumption of market efficiency (Fama 1998), investors, especially large ones, are likely to monitor and learn from financial analysts about a firm's investments in intrafirm ITCD and evaluate these investments based on their alignment with the level of deregulation, which will guide their stock purchase decisions manifested in market valuation. Therefore, we expect that intrafirm ITCD will be rewarded in market valuation under a high level of deregulation, as these investments can reduce a firm's internal coordination costs and price and increase its service reliability. However, intrafirm ITCD will not be as valuable when the level of deregulation is low, because consumers do not have a choice and a monopoly firm does not have to reduce costs and compete on efficiency. Hence, we propose the following.

Hypothesis 1a. *Intrafirm IT capabilities development creates greater market value under a high level of deregulation for consumer choice than under a low level of deregulation for consumer choice.*

With expanding consumer choice under an increasing level of deregulation, we further argue that interfirm ITCD can strengthen a firm's *flexibility* required to win the competition. Although power generation firms primarily compete on efficiency in a deregulated market (Fabrizio 2012), there could be unpredictable demand shifts. Although demand for functional products like electricity can be anticipated with high accuracy (Fisher 1997), the customer base may dynamically change and be difficult to predict after deregulation that allows consumer choice (Delmas and Tokat 2005, Delmas et al. 2007). Investments in interfirm ITCD allow a firm to adjust to suppliers and customers and agilely cope with

unpredictable shifts in consumer demand using market exchanges for spot purchase, which is aligned with a high level of deregulation by ensuring reliable customer services. Investors are also likely to reward such alignment via stock purchase manifested in market valuation. Thus, we expect that interfirm ITCD will be rewarded in market valuation under a high level of deregulation, as these investments can increase a firm's agility to provide reliable services under demand fluctuations. Hence, we further propose the following.

Hypothesis 1b. *Interfirm IT capabilities development creates greater market value under a high level of deregulation for consumer choice than under a low level of deregulation for consumer choice.*

Regulatory Uncertainty and Market Valuation of IT Capabilities Development

Although interfirm IT capabilities have been found to improve firm performance (Rai et al. 2012, Cui et al. 2020), the contingency of this effect at varying levels of regulatory uncertainty has not been examined. Regulatory uncertainty suggests that there are deliberations among those responsible for formulating policy or "rules of the game" for an industry. In our case, this would involve discussions about regulations for market restructuring in a local region by the PUC. As mentioned earlier, the goal of this regulatory policy (FERC Order 888/889) was to foster competition in the EUI and debates on how the market restructuring process in states should unfold in the domains of price control (e.g., price thresholds and cost recovery), value chain configuration (e.g., unbundling and reintegrating value chain), and information control (e.g., information disclosure and oversight). When a firm's regulatory context is highly uncertain, we suggest that the market will reward the firm based on its capabilities to hedge against uncertainty by rapidly and agilely responding to unpredictable regulatory changes. Thus, interfirm ITCD aligns with regulatory uncertainty, as it strengthens the firm's *flexibility* in a more uncertain regulatory context along three aspects.

When there is high regulatory uncertainty regarding *price control*, the market favors a firm's capabilities to rapidly reshape its transactional environment with suppliers and customers in response to unpredicted price protocols (Smith and Grimm 1987, Weigelt and Shittu 2016). Because it is difficult to predict whether and when price protocols may be revised, it is challenging for the firm to quickly coordinate capital-intensive production assets for cost recovery (Kim 2013). Interfirm IT capabilities can more flexibly address this uncertainty by reducing external transaction costs, because investments in transaction systems (e.g., electronic data interchange (EDI) and supply chain management (SCM)) allow the firm to quickly identify and adjust to suitable suppliers and customers with higher cost efficiencies (Majumdar and Marcus 2001, Saraf et al. 2007). Thus, interfirm ITCD will be rewarded by investors by enabling a rapid response to high uncertainty regarding price control but could be viewed as unnecessary investments that are not rewarded and even penalized when this uncertainty is low.

When there is high regulatory uncertainty regarding *value chain configuration*, a firm needs to agilely reshape its transactional environment by increasing or decreasing its reliance on external suppliers or customers in response to the unknown changes of value chain structure (Walker et al. 2002, Delmas and Tokat 2005), requiring hedging capabilities via interfirm ITCD (Rai et al. 2015). Investments in transaction systems (e.g., EDI and SCM) foster a firm's hedging capabilities to flexibly realign with supply chain partners for transactions (Rai and Tang 2010, Rai et al. 2015), allowing the firm to readily work with supply chain partners to hedge against inventory or purchase in short time windows when it is difficult to predict and match supply and demand as value chain structure is subject to possible changes (Jung et al. 2004). Thus, interfirm ITCD will be rewarded by investors as interfirm IT capabilities enable an agile response to high uncertainty regarding value chain configuration but could be seen as a waste of financial resources that are penalized in market valuation when this uncertainty is low.

When there is high regulatory uncertainty regarding *information control*, a firm needs to readily extract and report information about its transactional environment according to changing regulatory requirements (Delmas et al. 2010, Marshall et al. 2016). In the market restructuring process, such requirements primarily concern the information about market transactions along value chains, rather than internal production assets. Investments in transaction systems (e.g., EDI and SCM) provide real-time, transparent information on value chain transactions (Rai et al. 2006), allowing the firm to readily disclosure transactional information as policy changes. Thus, interfirm ITCD will be rewarded by investors as interfirm IT capabilities enable a prompt response to high uncertainty regarding information control but could be seen as unnecessary investments that are not rewarded and even penalized when this uncertainty is low. In summary, we propose the following.

Hypothesis 2. *Interfirm IT capabilities development creates greater market value under a high level of regulatory uncertainty with market restructuring than under a low level of regulatory uncertainty with market restructuring.*

Methodology

Data Collection

Our data set is composed of firm- and state-level data from 1994 to 2003 collected from the EIA and FERC. The

FERC requires all major electric utilities in the United States to annually file Form 1, from which we draw our data.[12] Form 1 is a comprehensive financial and operating report. The firms that file Form 1 produce approximately 80% of electricity in the United States and are required to disclose all major investments (defined by the FERC as investments that are greater than 5% of the total construction-work-in-progress or greater than $100,000) undertaken in a year. Minor investments are grouped together as a single entry. We extracted Form 1 data filed with the FERC from 1994 to 2003, with 6,685 major IT investments. Although each firm is required to annually file Form 1, we found that there was little uniformity of IT investment descriptions. We clarified these discrepancies via phone interviews with conformity officers at various firms. Any missing accounting or financial information, including the information to calculate Tobin's Q, for firms was obtained from the Wharton Research Data Service (WRDS). Combining the data and removing missing values in all variables allowed us to develop a unique panel data set of 729 firm-year observations from 128 firms from 1994 to 2003.[13]

Coding Scheme for IT Investments of a Firm

We adopted the two-stage coding process of IT investments from Rai et al. (2015), as described later, to classify if an IT investment was to develop either intrafirm or interfirm IT capabilities. We use a firm's investments as a proxy for a firm's development of IT capabilities based on the logic that the size of investments is a proxy for the emphasis and resources that it allocates on a corresponding type of ITCD (Argyres 2011).

Phase 1: Initial Classification of IT Investments. This phase involved starting by deciding if an investment was either in IT infrastructure or in IT-enabled process coordination, which entails digitally coordinating intrafirm activities and resources in the firm or coordinating interfirm transactions with suppliers and customers (Rai et al. 2015). The coding scheme was that IT infrastructure investments pertained to the foundational technologies (e.g., hardware, networking, communication, operating systems, and databases). The coding scheme for IT-enabled process coordination was that the investments were directed at digitally coordinating activities and resources within a firm (e.g., SCADA) or with partners (e.g., EDI and SCM). These coding schemes were iteratively refined through phone and personal interviews with IT industry experts, utility industry professionals, and conformity officers from various utilities that filed the FERC reports. After the coding schemes were developed, two graduate students from a major research university were trained on the scheme and independently coded IT investments for 1994–1995. Their initial interrater reliability for the first two years of IT investments was 94.5%. Differences that arose in the coding were discussed with plant engineers at a large utility firm to obtain clarity on the characteristics of certain systems. In light of this meeting, the coders recoded the 1994–1995 IT investments and attained a 96.7% interrate reliability. The coding of remaining IT investments for 1996–2003 was then divided evenly between the coders. After this initial classification, IT infrastructure was retained as a control variable whereas IT-enabled process coordination was further classified.

Phase 2: Classification of Intrafirm vs. Interfirm IT Capabilities Development. We decomposed investments in IT-enabled process coordination into intrafirm ITCD—which are investments directed at digitally coordinating internal assets and activities—and interfirm ITCD—which are investments directed at digitally coordinating market transactions with suppliers and customers. The devised coding scheme was applied to a 10% sample of IT investments ($n = 700$) and further honed. The coding scheme was then validated by inspecting the completed coding for the first two years of IT investments ($n = 1{,}400$), which revealed only a few minor discrepancies (1%). Furthermore, a random sample as 20% of the remaining IT investments was coded with only a few minor discrepancies, and we concluded that the coding was accurate. Finally, one of the coders was trained and applied the scheme to all remaining IT investments, and 20% of the finally coded data were inspected to ensure quality.

Coding Scheme for Regulatory Uncertainty of a State

A two-stage coding process of regulatory uncertainty was applied to the yearly summary reports of a state's PUC meetings on the market restructuring process, as curated and reported by the EIA as "status of state electric industry restructuring activity." The reports, detailing the deliberations by the PUC (those responsible for defining the "rules of the game" at the state level) about the market restructuring process in the EUI, were used to create a text corpus after applying a text cleaning procedure to remove unicode characters and stopwords, normalize text, and exclude sentiment words. The cleaning process yielded 3,631 words to code regulatory uncertainty for states by year.

Phase 1: Initial Identification of Uncertainty Keywords. Two authors independently coded the 3,631 words corpus to identify uncertainty keywords manifested as (1) concepts describing uncertainty in general (e.g., fear, indefinite), (2) concepts characterizing uncertainty in our research context (e.g., pilot, developing), and (3) processes to deliberate views connoting uncertainty (e.g., debate, comment). Any differences in the

coding results were discussed and reconciled among all authors and the coding scheme was refined. High consistency of coding was achieved between the two coders, with an interrater reliability of 93%. After lemmatization, we identified 75 uncertainty keywords from the text corpus.

Phase 2: Cross-Validation and Refinement of Uncertainty Keywords. We further refined our coding scheme to incorporate context-specific terms that reflect uncertainty that were not identified in Phase 1. A 10% random sample of the meetings ($n = 100$) was selected for (1) automated coding based on the 75 uncertainty keywords from Phase 1 and (2) manual coding by two authors independently to identify if meetings manifested uncertainty or not, and the keywords reflecting uncertainty (this enabled discerning context-specific keywords not identified in Phase 1). High consistency of manual coding was achieved between two coders, with an interrater reliability of 94%. However, the consistency of the automated coding and the manual coding was 66%, revealing that there were context-specific uncertainty keywords being considered in the manual coding above and beyond the 75 keywords used in the automated coding. The discrepancies between the manual coding and the automated coding were discussed among all authors. Based on the discussion, 10 additional uncertainty keywords were identified as capturing uncertainty in the EUI regulatory context (e.g., appeal, shift), yielding a total of 85 uncertainty keywords (see the e-companion for a full list of the keywords). Applying the updated uncertainty keywords to the random sample of 100 meetings, an acceptable consistency of 85% was achieved between the automated coding and the manual coding. We then applied the automated protocol based on the final 85 uncertainty keywords to code the summary reports of the PUC meetings to identify the meetings in which regulatory uncertainty manifested.[14] Table 3 provides examples of the manifestation of regulatory uncertainty in deliberations of PUC meetings.

Operationalization of Constructs

Market Value. We use *Tobin's* Q_{t+1} to evaluate market value of a firm in the subsequent year. Tobin's Q has been widely used in past research to examine business value of IT (Bharadwaj et al. 1999, Bardhan et al. 2013).

IT Capabilities Development. We aggregated a firm's specific IT investments in a year to determine intrafirm and interfirm ITCD ($Intra_t$ and $Inter_t$), respectively. We scaled these investments by work-in-process (WIP) value. In the EUI, as electricity is not stored, WIP represents the total value of all development projects undertaken by the firm in that year. Our scaled measures capture the relative emphasis and resources placed by the firm in developing specific types of IT capabilities versus other development projects.

Deregulation. We first defined deregulation for each state in a year as a binary variable indicating one for consumer choice and zero for no consumer choice. Consumer choice is defined as the ability of customers to choose their own suppliers of power services in a state (Delmas et al. 2007, Kim 2013). A firm may conduct business across state lines and is exposed to a unique regulatory context across states. In our sample, approximately 40% of firms conduct business in more than one state. Following Delmas et al. (2007), we measured $deregulation_t$ at the firm level by weighting the binary measure of deregulation for a state in a year with the percentage of electricity sold by the firm in the state and summing these values across the states where the firm conducts business in that year. For example, in 2000 if firm i sold 60% of its electricity in state A that was deregulated and 40% in state B that was regulated, $deregulation_t$ takes on the value of $1 \times 60\% + 0 \times 40\% = 0.6$.

Regulatory Uncertainty. Consistent with the approach to measure deregulation, we first coded regulatory uncertainty for each state in a year based on the summary reports of the PUC meetings on the market restructuring

Table 3. Examples of Regulatory Uncertainty Manifestation in the PUC Meetings

Quote from the PUC summary report	Interpretation of regulatory uncertainty	Uncertainty keywords
"CILCO and IL Power conducted retail wheeling *pilot programs* in 1995-1996. IL *pilot* included only large customers; CILCO *pilot* included all classes of customers." [italics added for emphasis]	Pilot programs can be viewed as feasibility studies or trials. They are not a guarantee that consumer choice will be adopted. When utilities initiate pilot programs around consumer choice, uncertainty is introduced as the results of the program are unknown.	Pilot
"The Louisiana Public Service Commission *recommended* that all industrial customers with loads greater than five megawatts be given the *choice* to select their power provider." [italics added for emphasis]	The recommendation by the Public Service Commission signals that the regulatory environment may be changing in the future. Although the summary report provides no more information, the support of the commission is necessary for any change to happen.	Recommend, choice

process. Using the 85 uncertainty keywords, we created a binary variable indicating one if any uncertainty keyword was present in a meeting and zero otherwise and then summed up the number of meetings involving uncertainty by state and year. Again, as firms may sell electricity across state lines, we measured *Regulatory Uncertainty*$_t$ at the firm level by weighting the number of meetings involving uncertainty for each state in a year with the percentage of electricity sold by a firm in the state and then summing the values across all states where the firm conducts business in that year. For example, in 2000 if a firm sold 60% of its electricity in state A that had four meetings involving uncertainty and 40% of its electricity in state B that had five meetings involving uncertainty, our measure takes on the value of $4 \times 60\% + 5 \times 40\% = 4.4$.

Control Variables. We controlled for firms' investments in *IT Infrastructure*$_t$, as this variable has been discussed as influencing firm value (Ross et al. 2006, Aral and Weill 2007). Here again, we scaled the investments by WIP value to capture the emphasis and resources on IT infrastructure relative to other development projects undertaken by the firm. As major capital assets in the EUI (e.g., power plants, power generating equipment, and infrastructure) require significant advance planning and have a natural useful lifetime (Taylor and Fuller 1986), we controlled for *Firm Age*$_t$ as years elapsed since the founding year. As a firm's market value can be influenced by its size, we controlled for *Firm Size*$_t$ as the natural logarithm of revenue. We controlled for *Net Generation*$_t$ to account for the influence of output a firm on its value, and for *Depreciation Expense*$_t$ as it may influence firm value (Rai et al. 2015). As purchased power and resale contracts can influence supply and demand and therefore market value of the firm, we controlled for *Purchased Power*$_t$ as the total amount that a firm spent on all power purchased in a year and *Resale Contracts*$_t$ as the total amount that a firm sold to purchasers other than ultimate consumers in a year. We controlled for firm ownership as *Public*$_t$ (value = 1 for public utilities and 0 otherwise) and *Investor*$_t$ (value = 1 for investor-owned utilities and 0 otherwise), as ownership structure may also influence firm value (Hill and Snell 1989).

We developed a composite measure to control for a firm's home state's *Experience of Deregulation*$_t$ by aggregating years of experience since each of the following was enacted: consumer choice, net metering, and community choice aggregation.[15,16] Last, we controlled for *Wholesale Choice*$_t$. Originally part of FERC Order 888/889, wholesale choice was implemented at the federal level by establishing Independent Systems Operations (ISO) and refined with Order 2000 proposing Regional Transmission Organizations (RTO) across states. Following Kim (2013), we created an ordered categorical variable that takes the value of one for 1994–1995, two for 1996–1999, and three for 2000–2004 to indicate the changing levels of wholesale choice in the EUI.

Descriptive statistics and correlations are reported in Table 4 (see the e-companion, Table EC-2, for an overview of variables).

Results

We specified a two-level model to estimate the impacts of ITCD on market valuation. Level 1 includes the study and control variables as well as firm fixed effects, whereas Level 2 includes home-state random effects. We chose a random intercept model at the state level because firms are nested in different home states. We standardized the variables before calculating the interaction terms.

Table 4. Descriptive Statistics and Correlations

Variable	Mean	Standard deviation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 *Tobin's* Q_{t+1}	0.81	0.48															
2 *Intra*$_t$[a]	0.11	1.13	0.00														
3 *Inter*$_t$[a]	0.10	1.26	0.04	−0.01													
4 *Deregulation*$_t$	0.19	0.39	**−0.06**	−0.04	−0.04												
5 *Regulatory Uncertainty*$_t$	2.43	2.64	−0.03	0.01	−0.02	**0.15**											
6 *IT Infrastructure*$_t$[a]	0.13	1.22	0.02	0.03	0.01	0.01	−0.02										
7 *Firm Age*$_t$[a]	0.04	0.97	**0.05**	**−0.11**	−0.02	**0.28**	**0.10**	**−0.05**									
8 *Firm Size*$_t$[a]	0.12	0.95	**−0.13**	**0.13**	**0.18**	**0.17**	**0.08**	**0.18**	**0.16**								
9 *Depreciation Expense*$_t$[a]	0.03	0.99	−0.01	**0.13**	**0.22**	0.01	**0.13**	**0.16**	0.02	**0.57**							
10 *Net Generation*$_t$[a]	−0.02	0.95	**−0.13**	**0.09**	**0.08**	**−0.06**	**0.10**	0.03	**−0.07**	**0.24**	**0.15**						
11 *Purchased Power*$_t$[a]	0.05	1.02	−0.04	**0.14**	0.04	**0.27**	**0.09**	**0.13**	**0.04**	**0.50**	**0.40**	**0.12**					
12 *Resale Contract*$_t$[a]	0.01	0.99	**−0.05**	0.04	−0.02	0.03	0.03	0.02	−0.01	**0.16**	**0.04**	**0.09**	**0.55**				
13 *Public*$_t$	0.69	0.46	**−0.10**	0.03	−0.04	**0.19**	**0.11**	**0.07**	**0.21**	**0.29**	**0.13**	0.00	**0.18**	**0.09**			
14 *Investor*$_t$	0.13	0.34	**−0.09**	0.03	−0.04	**−0.05**	−0.01	−0.04	**−0.19**	**−0.14**	−0.03	**0.11**	−0.03	**−0.05**	**−0.57**		
15 *Experience of Deregulation*$_t$	2.32	6.17	**−0.11**	0.01	**−0.05**	**0.27**	**−0.12**	**−0.08**	**0.15**	**−0.09**	**−0.11**	**−0.17**	0.02	−0.01	**0.14**	**−0.09**	
16 *Wholesale Choice*$_t$	2.33	0.74	**−0.10**	**−0.07**	**−0.05**	**0.37**	**0.05**	−0.04	0.03	0.01	**−0.04**	0.00	**0.21**	**0.08**	0.03	0.02	**0.22**

Note. Significant correlations at $p < 0.05$ are in bold.
[a]Variables are standardized into z-scores.

Table 5. Mixed Effects Random Intercept Model Results

Tobin's Q_{t+1}	A	B	C
Fixed effects at the firm level			
$Intra_t$		0.046	0.021
		(0.032)	(0.033)
$Inter_t$		−0.014	−0.077***
		(0.013)	(0.022)
$Deregulation_t$		−0.037	−0.033
		(0.053)	(0.052)
$Regulatory\ Uncertainty_t$		0.005	0.006
		(0.005)	(0.005)
Hypothesis 1a: $Intra_t \times Deregulation_t$			0.296**
			(0.109)
Hypothesis 1b: $Inter_t \times Deregulation_t$			−0.105
			(0.061)
Hypothesis 2: $Inter_t \times Regulatory\ Uncertainty_t$			0.024***
			(0.006)
$IT\ Infrastructure_t$	0.018	0.020	0.018
	(0.013)	(0.014)	(0.014)
$Firm\ Age_t$	0.003	−0.057	−0.062
	(0.019)	(0.035)	(0.034)
$Firm\ Size_t$	−0.187***	−0.192**	−0.218***
	(0.038)	(0.066)	(0.065)
$Depreciation\ Expense_t$	0.017	0.021	0.026
	(0.013)	(0.014)	(0.014)
$Net\ Generation_t$	−0.020	−0.000	0.001
	(0.015)	(0.022)	(0.021)
$Purchased\ Power_t$	0.039*	0.059**	0.057**
	(0.017)	(0.021)	(0.021)
$Resale\ Contract_t$	0.009	−0.002	−0.006
	(0.016)	(0.018)	(0.018)
$Public_t$	−0.132**	−0.106	−0.107
	(0.042)	(0.059)	(0.058)
$Investor_t$	−0.223*	−0.229	−0.154
	(0.091)	(0.122)	(0.122)
$Experience\ of\ Deregulation_t$	−0.007	−0.001	−0.001
	(0.005)	(0.007)	(0.007)
$Wholesale\ Choice_t$	−0.079***	−0.125***	−0.119***
	(0.018)	(0.032)	(0.032)
Constant	1.260***	1.348***	1.342***
	(0.070)	(0.105)	(0.104)
Random effects at the home state level			
Var(Constant)	0.086	0.122	0.116
Var(Residual)	0.131	0.133	0.130
Intraclass correlation coefficient	0.397	0.478	0.471
Wald chi-square	92.370***	49.620***	70.180***
Number of observations	1,112	729	729
Number of states	44	41	41
Number of firms	148	128	128

Note. Standard errors are in parentheses.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

The e-companion, Table EC-3, explains the details of the random intercept model that we used to test hypotheses. Table 5 presents our main results.

The Wald chi-square test indicates that including the interaction terms in the model significantly increases the model's explanatory power. In evaluating the full model (Model C), we found that $Intra_t \times Deregulation_t$ has a statistically significant and positive effect ($\beta = 0.296$, $p < 0.01$), supporting Hypothesis 1a. We also found that $Inter_t \times Deregulation_t$ is not statistically significant ($\beta = -0.105$, $p > 0.05$), not supporting Hypothesis 1b. Moreover, $Inter_t \times Regulatory\ Uncertainty_t$ has a statistically significant and positive effect ($\beta = 0.024$, $p < 0.001$), supporting Hypothesis 2. For completeness of model specification, we also included $Intra_t \times Regulatory\ Uncertainty_t$ in another model (see the e-companion, Table EC-4). However, it is not statistically significant and does not change our results. Simple slope tests for the significant interaction effects showed that the relationship between $Intra_t$ and *Tobin's* Q_{t+1} at a low level of

deregulation is not statistically significant ($\beta = -0.036$, $p > 0.05$), whereas it is statistically significant at a high level of deregulation ($\beta = 0.193$, $p < 0.001$). We also observed that the relationship between $Inter_t$ and *Tobin's* Q_{t+1} is statistically significant at a low level of regulatory uncertainty ($\beta = -0.082$, $p < 0.001$) and at a high level of regulatory uncertainty ($\beta = 0.046$, $p < 0.01$). The interaction plots are shown in Figure 2(a) and (b).

As shown in Figure 2(a), intrafirm ITCD to coordinate internal production assets and distributed production processes *increases* market valuation at a high level of deregulation for consumer choice, but not at a low level of deregulation for consumer choice. These findings imply that as firms in a less deregulated context expand their services to a more deregulated context, they need to make necessary adjustments in the development of intrafirm IT capabilities. With a low level of deregulation, intrafirm ITCD does not affect market value, because consumers do not have a choice and the monopoly firm does not have to leverage intrafirm IT capabilities and compete on efficiency (Delmas and Tokat 2005); thus, these investments are not rewarded. As shown in Figure 2(b), developing interfirm IT capabilities to hedge against high regulatory uncertainty regarding price control, value chain configuration, and information control *increases* market valuation. In contrast, interfirm ITCD *decreases* market valuation under low regulatory uncertainty. Finally, interfirm ITCD to create flexibility under low regulatory uncertainty could be viewed as inefficient allocation of financial resources, thereby exacting penalties in market valuation of the firm.

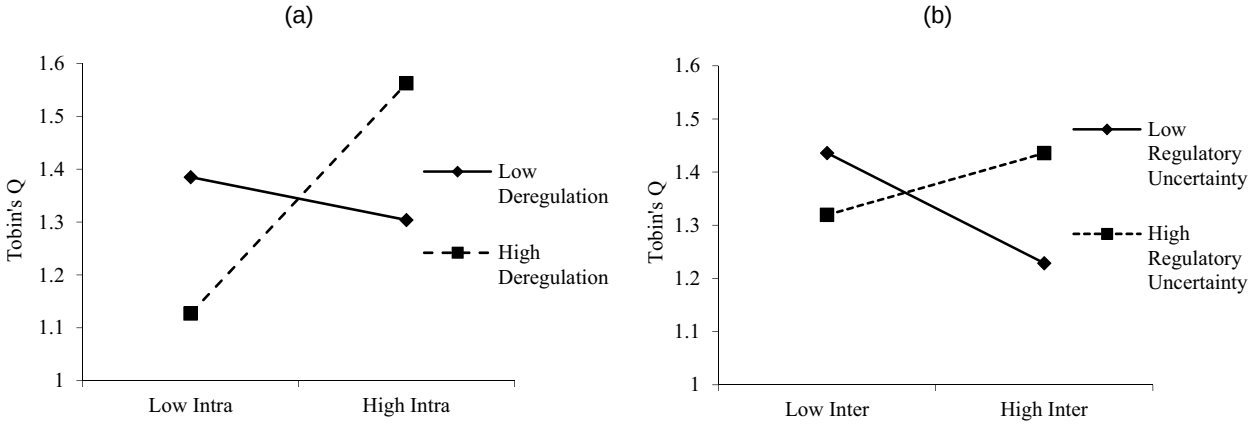
Robustness Checks

We conducted several robustness checks, as summarized in the e-companion, Table EC-5.

Endogeneity Tests. We first evaluated endogeneity by using a two-stage generalized method of moments (GMM) model with instrumental variables (see the e-companion, Table EC-6). The primary instruments were based on the average investments in intrafirm and interfirm ITCD made by firms from the same balancing authority. Grid operations are managed by balancing authorities who are responsible for real-time supply-demand balance of electricity within its region under mandatory reliability standards issued by the North American Electric Reliability Corporation and approved by the FERC (EIA 2016). Absent this balance, local or wide-area blackouts can result. Firms from the same balancing authority are likely to make similar investments in ITCD as they are facing the same demand in a region, whereas other firms' investments should not influence a focal firm's Tobin's Q. We also included two dummy variables representing FERC Order 888/889 in 1996 and the Oil Crisis in 2001, which were unannounced and unplanned shocks (Puller 2007). Additionally, we used the two-stage Heckman model by estimating the inverse Mills ratio (IMR) in the first stage and including the IMR in the second stage to account for endogeneity (see the e-companion, Table EC-7). Our results were robust in both endogeneity tests.

Alternative Measures and Additional Control. We computed two alternative measures for level of deregulation for a firm: percentage of revenue and the percentage of customers, instead of percentage of electricity sold, to weight the deregulation status (1 = consumer choice; 0 = no consumer choice) of the states in which the firm conducts business (see the e-companion, Tables EC-8 and EC-9). Following the procedure to measure regulatory uncertainty, we also developed three measures to capture regulatory uncertainty in each of the key domains: price control, value chain configuration, and information control (see the e-companion, Table EC-10 and Figures EC-2a, EC-2b, and EC-2c). We further measured regulatory uncertainty by (1) counting the total number of meetings in a year for a state as an indicator

Figure 2. Interaction Plots



Notes. (a) Interaction plot of intrafirm ITCD and deregulation. (b) Interaction plot of interfirm ITCD and regulatory uncertainty.

of regulatory deliberation and (2) using a binary variable that takes the value of one if an uncertainty keyword was expressed in any meetings in a year for a state and zero otherwise (see the e-companion, Tables EC-11 and EC-12). Furthermore, we included $PUC\ status_t$ to capture if the PUC in a firm's home state is elected or appointed as an additional control variable to our model (see the e-companion, Table EC-13). The results of using the alternative measures of deregulation and regulatory uncertainty and including the additional control were consistent with the main results.

Alternative Model Specifications. We also evaluated a random intercept random slope model and found consistent results (see the e-companion, Table EC-14). Last, as there may be synergies between intrafirm and interfirm ITCD in addressing regulation, we additionally added $Intra_t \times Inter_t$, $Intra_t \times Inter_t, \times Deregulation_t$ and $Intra_t \times Inter_t, \times Regulatory\ Uncertainty_t$, as well as $Intra_t \times Regulatory\ Uncertainty_t$, to our model (see the e-companion, Table EC-15). We did not find these interaction effects to be statistically significant.

Discussion and Conclusion

Implications for Theory

Departing from prior research on *internal* governance and business value of IT capabilities (Rai et al. 2015), a key contribution of our work is surfacing that *external* governance can shape the market value that firms accrue from developing IT capabilities. In line with research on business value of IT contingent on environmental factors (Xue et al. 2011, 2012; Mithas et al. 2013), we advance our understanding regarding market valuation of different types of ITCD across firms' regulatory contexts in terms of deregulation for consumer choice and regulatory uncertainty with market restructuring. This understanding contributes to the literature on IT capabilities (Bharadwaj et al. 1999, Rai et al. 2006, Bharadwaj et al. 2007, Rai and Tang 2010, Rai et al. 2015) and business value of IT (Bharadwaj et al. 1999, Aral and Weill 2007, Xue et al. 2011, Mithas et al. 2012, Chae et al. 2014). In particular, we show that different types of ITCD are rewarded in market valuation based on the characteristics of a firm's specific regulatory context. By bringing together two perspectives on IT capabilities and institutional governance from largely disconnected literature, our work extends past research on business value of IT capabilities (Bharadwaj et al. 1999, Aral and Weill 2007), as well as on how governance influences the relationship between IT capabilities and business value (Jacobides and Winter 2005, Tiwana and Konsynski 2010, Rai et al. 2015, Wang et al. 2018). We broaden past research on the influences of internal governance on the relationship between IT capabilities and business value by considering external governance, with a focus on the regulatory context. The regulatory context can change over time by dictating how a firm conducts business in different locations using various incentive and compliance mechanisms. Our results suggest that the firm needs to align its ITCD toward reducing internal coordination costs or external transaction costs based on its regulatory context in terms of deregulation and regulatory uncertainty.[17]

Specifically, we extend our understanding about business value of IT capabilities by showing that developing intrafirm IT capabilities for reducing internal coordination costs is only rewarded in a firm's market valuation when its regulatory context is characterized by a high level of deregulation. As the primary source of efficiency resides on cost-efficient and reliable production capabilities in the EUI and deregulation induces consumer choice, developing IT capabilities that expand the firm's abilities to coordinate its internal production assets and distributed production processes to provide cost-efficient, reliable services is valued by the market. Our findings further suggest that interfirm ITCD does not affect market value at different levels of deregulation, which may be because interfirm IT capabilities address demand shifts because of consumer choice with costly market exchanges that may hurt firm profit and thereby market value (i.e., cumulative profit in the long term). It implies that deregulation primarily requires firms to compete on efficiency with lower costs and price. Although the interorganizational systems literature has primarily focused on mechanisms to counter transactional uncertainty given the central role of transaction cost economics in the development of this literature base (Rai et al. 2006, Saraf et al. 2007), our findings suggest that high uncertainty with respect to regulations create conditions under which a firm's ability to redefine digital connections with suppliers and customers is rewarded with superior market value, as interfirm IT capabilities can reduce external transaction costs, reshape the transactional environment, and report the required information.

Overall, this study shows how a firm's development of IT capabilities and its regulatory context interact to explain market value. Integrating an institutional governance perspective to understand the market value of a firm's investments in developing different types of IT capabilities, which has been largely overlooked in prior research, can provide a more holistic picture on the conditions under which developing specific IT capabilities may create or hurt value, contributing to our understanding of the role that institutional governance plays in market valuation of IT capabilities. Our findings support the institutional governance perspective suggesting that institutional environment and regulatory changes have enormous influence on firm capability development and performance (Walker et al. 2002, Delmas and Tokat 2005, Delmas et al. 2007, Kim 2013, Weigelt and

Shittu 2016). In sum, this study integrates and elaborates the complementarity between the theoretical explanations of IT capabilities and institutional governance and offers an *institutional governance perspective on business value of IT capabilities*.

Implications for Practice

Our study suggests that firms should develop their IT capabilities, intrafirm and interfirm for internal coordination and market exchange, not only based on firm strategy or governance considerations at the firm level, but also on considerations of governance at the institutional level. Managers need to recognize that the business value for developing IT capabilities depends not only on the internal governance context but also on the external governance context. Consequently, firms need to align their IT investments within the regulatory context in which they conduct business, by investing in intrafirm IT capabilities in a more deregulated context and in interfirm IT capabilities in a more uncertain regulatory context. It depends on the locations where a firm operates and their relative importance for business, within a specific state or across states with possibly distinct regulatory characteristics.

Regulators need to recognize that the regulatory context that they shape, specifically deregulation for consumer choice and regulatory uncertainty in the market restructuring process, has consequences for the valuation of firms' development of IT capabilities as assessed by the financial market. When they deregulate the industry to provide consumer choice in a functional product market, they need to recognize and acknowledge the role of intrafirm IT capabilities in providing firms with the needed efficiency and service reliability to create value in this market structure. When regulators are extensively deliberating regulations for market restructuring, they need to recognize and acknowledge the role of interfirm IT capabilities in providing firms with the needed flexibility to create value in an alternative market structure. The market valuation of firms' development of IT capabilities is not static, but dynamic as the regulatory context evolves in terms of enactment and uncertainty of regulations. More broadly, regulators should also consider how to support firms in transitioning to a new regulatory context by designing incentives and penalties to motivate firms in developing such capabilities, which will be critical to value creation under a different market structure.

Limitations and Future Research

The power generation segment of the EUI has unique characteristics (e.g., characteristics of the value chain and electricity as a product) that should be considered in the interpretation of our findings. Yet, the findings provide compelling support to the perspective of Chiasson and Davidson (2005) that significant theoretical advances related to core IS phenomena (e.g., business value of IT capabilities) can be achieved by adopting an industry perspective, whereby characteristics of the institutional governance (e.g., regulatory context characteristics) and IT are considered together. Empirically, our focus on a single industry helps mitigate confounds from cross-industry differences, develop context-specific measures, and collect granular data for IT investments, as well as leverage the regulatory differences across states. Although it provides a strong basis for the validity of our results, future research can examine the development of IT capabilities in other industries with varying characteristics. We do not observe that interfirm ITCD is valuable under deregulation or intrafirm and interfirm ITCD have synergies in our study, but future research can explore in other settings.

As the EUI has witnessed major shift from regulation to deregulation, at distinct paces, across regions and over time, we identify deregulation and regulatory uncertainty as two key regulatory context characteristics in the market restructuring process that affect the valuation of ITCD. Future research can extend the types of regulations that are considered in illuminating the linkage between ITCD and business value, especially when other industries are studied. In particular, future work can examine enacting IT regulations such as the General Data Protection Regulation (GDPR) or the Personal Data Protection Act (PDPA) and how they affect the development of different IT resources and capabilities. Another avenue of research is evaluating the processes that firms can use to effectively develop their intrafirm and interfirm IT capabilities, specifically focusing on the adjustment costs incurred because of changes in integration and coordination (Kor et al. 2016, Karhade and Dong 2021), along with institutional governance.

Conclusion

Situated in the EUI, we investigate the influence of developing intrafirm and interfirm IT capabilities on market value in the realm of a firm's regulatory context. Bridging the IT capabilities and institutional governance literatures, we theorize and empirically test the impacts of intrafirm and interfirm ITCD on market value conditional on deregulation and regulatory uncertainty in the market restructuring process. We find that intrafirm ITCD is rewarded when consumer choice is expanded in a more deregulated context, whereas interfirm ITCD is rewarded in a more uncertain regulatory context. Overall, we demonstrate that an institutional governance perspective is useful to better understand the business value of IT capabilities.

Endnotes

[1] Although there are various measures of IT business value (e.g., return on assets, operational efficiency), we focus on market valuation

(i.e., Tobin's Q) as it provides the market's appraisal of IT investments made by a firm in a given context (Bharadwaj et al. 1999).

[2] We empirically control for other forms of deregulation (e.g., wholesale choice, net metering, and community choice aggregation).

[3] Value chain reconfiguration in the EUI could be much broader than introducing consumer choice in the market restructuring process, which involves mergers/divestitures of power generation from firms and establishing new forms of market structures.

[4] Deliberations on regulations in a state can remain ongoing after deregulation.

[5] Our data covers the period 1994–2003, in which 2000 is approximately the midpoint and thus an appropriate year to look at the status of the industry. In 2000, investor-owned electric utilities represent 7.6% of total electric utilities, approximately 38% of utility installed capacity, 42% of generation, 73.7% of sales, and 75.6% of revenue in the United States. The annual revenue from major U.S. investor-owned electric utilities was $260 billion (EIA 2011).

[6] Some firms conduct business across states (e.g., ConEdison sells electricity in New York and northern New Jersey). Others have a parent company that holds independent subsidiaries in a given state (e.g., Southern Company owns Georgia Power and Alabama Power Company, which sell electricity in Georgia and Alabama, respectively, and Duke Energy owns Duke Energy Indiana and Duke Energy Ohio, which sell electricity in Indiana and Ohio, respectively). These independent subsidiaries file their own reports and are independently responsible for following guidelines and complying with regulations in their own states.

[7] e-Companion, Table EC-1, reports year deregulated/re-regulated and regulatory uncertainty by state over time.

[8] Past IS research has recognized that the impacts of IT capabilities on productivity and other performance measures can differ across industries because of the differences in outputs, market structure, and the role of IT in production and market exchange (Devaraj and Kohli 2003). Although the market valuation of IT capabilities across the regulatory context has not been explicitly examined, past IS studies reveal the interdependencies of IT capabilities and market environments. For example, the ability of a firm to create value from the investments in developing IT capabilities depends not only on a firm's strategies, but also on the market structure as returns from IT investments are subject to market risks and regulation (Dewan and Ren 2011).

[9] For example, Christiaanse and Venkatramam (2002) describe how firms in the airline industry exhibited large heterogeneity in their ability to develop computerized reservation systems, resulting in considerable control over their distribution channels, leading to increased market share and return on investments. Similarly, Rai et al. (2015) find that intrafirm and interfirm IT capabilities are heterogeneously distributed across firms in the EUI and interact with a firm's sourcing choices in creating business value.

[10] For example, a supervisory control and data acquisition (SCADA) system costs $1.6 million on average, and for some firms upwards of tens of millions of dollars. Firms can invest in IT systems for control and coordination that can be integrated (Tanriverdi et al. 2010), enmeshed (Chiasson and Davidson 2005), or embedded (Kohli and Grover 2008) in production and sourcing processes.

[11] For example, installing an advanced meter reading system, on average, costs $3.3 million (EIA 2011).

[12] A major electric utility is defined as having at least (1) one million megawatt hours (MWh), (2) 100 MWh of annual sales for resale, (3) 500 MWh of annual power exchange delivered, or (4) 500 MWh of annual wheeling for others (deliveries plus losses).

[13] As our control model includes only the control variables, we used 1,112 firm-year observations from 148 firms in 1994–2003 to estimate it.

[14] Although the main measure of regulatory uncertainty captures overall regulatory uncertainty, we recognize that there are different domains that may be discussed from meeting to meeting. Accordingly, we also assessed regulatory uncertainty for each state in a year with respect to the domains of price control, value chain reconfiguration, and information control, respectively, and conduct robustness tests with these domain-specific measures. See the e-companion for a full list of domain-specific regulation keywords and the coding process.

[15] A firm's home state was determined by the address of principal office as reported in the FERC Form 1.

[16] Net metering is a mechanism to compensate system owners for distributed power generation (NREL 2021) and community choice aggregation allows local governments to procure power from alternative sources (EPA 2021).

[17] It is worth noting that we do not suggest that firms can only invest in either intrafirm or interfirm ITCD. Although a firm could invest in both intrafirm and interfirm ITCD, we show that each type of investment will be more or less valuable in market valuation based on the regulatory context. Intrafirm ITCD will be more valuable when the market is more deregulated for consumer choice and will not contribute to greater value in markets with a low level of deregulation. Interfirm ITCD will increase market value when regulatory uncertainty is high but will not affect market value across the levels of deregulation and even decrease market value when regulatory uncertainty is low. As such, a firm should consider its regulatory context under which its investments in intrafirm and interfirm ITCD will be valued.

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