Inside the Adaptive Enterprise: An Information Technology Capabilities Perspective on Business Process Agility

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ABSTRACT

Recent innovations in utility computing, web services, and service-oriented architectures, combined with a growing array of IT skills, have improved firms' ability to be more agile in responding to change. Using the resource-based view of the firm, research suggests that IT resources, in isolation, are unlikely to yield superior performance and so as firms try to boost their agility, the question becomes how to configure IT resources to prepare for, or react to, change. In this paper, we posit that managerial IT capabilities based on IT-business partnerships, strategic planning, and ex-post IT project analysis lead to the development of technical IT capabilities associated with a flexible IT infrastructure which in turn drives agility or a firm's ability to react to changes in its products or markets. Using data from matched surveys of IT and business executives in 241 firms, we find that managerial and technical capabilities affect agility. In further testing our model for firms in stable settings, we find that technical IT capabilities are more important for agility than managerial IT capabilities, whereas in volatile settings, the opposite is true. Accordingly, for firms in volatile markets, effective models of IT governance are of vital importance for agility or adaptiveness.

Keywords
IT Capabilities, IT Infrastructure Flexibility, Process Agility, IT Governance, Environmental Dynamism

Introduction

At a time when firms are struggling to succeed in a world defined by globalization, fickle consumer tastes and growing uncertainty, there is widespread recognition among executives that information technology (IT) is a key ingredient in a firm's ability to detect and respond to market change [32]. Research has also identified the potential for IT to affect firm performance through IT capabilities or firm-specific resources that create options for responding to change [54]. At the same time, legacy systems can be inflexible or unresponsive to change to the point where rigidity traps emerge. IT could, therefore, become a limiting factor in a firm's ability to react to threats or opportunities [5,31,63]. For firms in industries such as electronics or fashion retail where change is both expected and routine, an absence of agility in key business processes – defined as the ease and speed with which firms can alter their processes to respond to threats or opportunities in their markets [17,54] – could seriously limit short-term performance. The need for agility is especially critical in fashion where IT has enabled firms such as Zara to move new concepts from designers to store racks inside a two-week window, while the Gap and other traditional retailers continue to wrestle with inflexible IT and a more restrictive nine-month design-to-delivery window [35,66].

Notwithstanding a rash of recent technological innovations in areas such as web services, utility computing and service-oriented architectures, a question remains as to whether an absence of agility or adaptiveness is primarily a technology rigidity issue or whether there are broader IT managerial issues that allow inflexible IT to persist and agility in turn to suffer. Recent interest in IT governance has identified the risks of ineffective IT management whether in the form of weak cost control or project oversight, ineffective strategic planning, mistrusting end-user relationships or a lack of standards – factors that can result in IT rigidity [5,28,62]. As such, it could be argued that agility is as much a managerial issue as a technical issue for IT flexibility is only truly useful

when firms know how and when to take advantage of the options that a flexible IT infrastructure has to offer [54]. This idea of performance being attributable to a duality of capabilities is echoed in the literature on the resource-based view where research finds that differences in performance are less a result of hardware or software resources alone – resources that are increasingly open to replication [15] – but how well they are combined with non-IT resources such as tacit knowledge to create distinct capabilities that can support a firm's strategic goals[1] [6,34,45,47,48,60].

In this research, we build on prior conceptual and empirical research to develop and test a model relating managerial and technical IT capabilities to agility. Set against the resource-based view, the aim of the model is to identify the extent to which each set of capabilities contributes to agility and, more importantly, to examine this relationship for different degrees of environmental turbulence. For firms operating in turbulent markets marked by rapid product obsolescence, short product lifecycles, high customer turnover, and price volatility, agility is a vital factor in a firm's survival [26]. In more stable settings where product lifecycles, customer turnover and pricing are relatively predictable, agility and any underlying IT resources that foster increased flexibility are largely unnecessary. Flexibility can still be used for strategic differentiation in these firms but the cost can be prohibitive. Thus while the conceptual literature sees the environment as a moderator of the link between IT capabilities and firm performance [54,60], this study is among the first to empirically test this link. Accordingly, our study focuses on two research questions: first, is there a positive link between managerial and technical IT capabilities and process agility and, second, to what extent does environmental dynamism positively moderate the link between each of these IT capabilities and business process agility?

To answer these questions, we first provide a theoretical evaluation of how IT capabilities impact firm performance. The result of this discussion is a conceptual model where technical IT

capabilities involved in the creation of a flexible IT infrastructure (hardware, software, networks, and skills) mediate the link between managerial IT capabilities and agility. We also theorize as to how this mediating relationship will behave under stable and turbulent environmental conditions. To test the model, we use data from matched surveys of business and IT executives in 241 firms. After construct validation and data analysis with Partial Least Squares (PLSGraph v3), we assess our results and their implications for both research and practice. Lastly, we note the limitations in our study, identify areas for future research, and provide a general conclusion.

1. Theoretical Overview

Researchers have used the resource-based view to argue that beyond hardware, software, and similar IT resources – much of which can be replicated by competitors [34] – it is ultimately the unique capabilities engendered by IT that form the basis for competitive advantage [5,45]. IT capabilities are defined as an ability to, "mobilize and deploy IT-based resources in combination or copresent with other resources and capabilities" [5, p.171]. The literature further subdivides IT capabilities into several dimensions, consistent with their unique orientation. For example, Wade and Hulland [60] use a typology developed by Day [18] to divide IT capabilities into three areas: outside-in, inside-out, and spanning. Outside-in capabilities represent external relationships with customers, environmental monitoring and understanding the dynamics of the market. In contrast, inside-out capabilities are more internal in nature, focusing on skills, technical abilities around IT infrastructure, operations and IT deployment. Finally, spanning capabilities focus on information systems (IS) planning, business partnerships, and alignment between IT and firm strategy. While Bharadwaj et al. [6] did not use this typology in a formal sense, they found that capabilities such as IS management, IT-business partnerships, business process integration, IT infrastructure, and IT vision were jointly representative of an overall IT capabilities construct. Elsewhere, Marchand

et al. [33] note that IT capabilities around application and infrastructure deployment, information management, and the establishment of behaviors conducive to the innovative use of information, support a firm's agile use of information which in turn can lead to improved firm performance.

While the three categories suggested by Wade and Hulland [60] may appear independent, research has begun to explore how they may be related. Thus, Ravichandran and Lertwongsatien [47] indicate that IT human capital, IT infrastructure flexibility, and IS partnership quality have a positive impact on broader IS capabilities around planning, development and operations. In other research, Mithas et al. [40] find that IT infrastructure capabilities have a positive impact on other capabilities around customer, process, and performance management. Similarly, Byrd and Turner [13] show that technical capabilities involved in the integration or modularity of IT infrastructure mediate the link between IT skills capabilities and competitive advantage. Therefore, while there may be many examples of technical, managerial or human resources that fit within the definition of IT capabilities, researchers are increasingly of the view that such capabilities are interrelated.

As with Byrd and Turner [13], we use this sense of interrelatedness among capabilities to develop our research model. In particular, we argue that business process agility – an outside-in capability that shows how firms react to change by altering how they perform business activities – is affected by spanning or managerial capabilities involving IT governance and by inside-out or technical capabilities around IT infrastructure. As such, managerial capabilities affect the design of a flexible IT infrastructure using hardware, software, networking, and IT skill-based resources to minimize the downside risk of rigidity traps that might otherwise damage or restrict agility.

1.1 Leveraging Managerial IT Capabilities

Feeny and Willcocks [21] identify nine different managerial IT capabilities for exploiting IT that subdivide into three groups: business and IT vision, delivery of IT services, and design of

IT architecture. Shared vision, it emerges, is both a core mechanism for IT governance and a key predictor of alignment between IT and business strategy [34,51,62]. Mata et al. [34] further argue that managerial IT capabilities such as strategic foresight and relationship building are immobile, socially complex and causally ambiguous, and as such can yield a competitive advantage in ways that competitors cannot easily replicate. This argument is later verified by Jarvenpaa and Leidner [28] who, in a case study of a Mexican news corporation, found that "the dynamic capabilities of strategic foresight and strategic flexibility … allowed them to achieve and sustain the position of an undisputed leader in the local information provider sector" (p. 354). Other research shows that foresight and flexibility are tied to IT governance and managerial attitudes towards IT [7,21,28].

Firms that adopt an IT governance model in which business and IS executives collaborate on setting strategic goals for IT and that work together to solve business problems through IT are more likely to be prepared for change [62,63]. Closer collaboration allows executives to be better informed of how change affects IT. For example, IT executives can probe vulnerabilities or areas of rigidity in their IT portfolios and so proactively move ahead of the market to reduce the risk of being caught out by unexpected market events. Similarly, an IT governance model that promotes ongoing learning and greater use of best practices allows firms to better prepare for change [62]. Closer IT-business partnerships also foster trust between groups that tend to be distrusting of one another, allowing IT to be a facilitator rather than an inhibitor of agility [4,42,54]. Hence:

H1. Managerial IT capabilities have a positive impact on business process agility.

Among the managerial IT capabilities reported by Feeny and Willcocks [21], architecture planning is a byproduct of relationship building. Architecture planning allows firms to formulate flexible plans for how IT will support critical business activities. Allen and Boynton [2] note that "the two criteria of greatest importance in choosing IS architecture are overall and simultaneous

efficiency and flexibility" (p. 436), criteria that are of particular relevance to firms in turbulent or unstable environments. For firms with effective IT governance practices embedded in managerial IT capabilities, responding to change means building an IT infrastructure that is both flexible and scalable and that is supported by a broad range of technical IT skills [5,21,34]. If business and IS executives expect change but worry that rigidity traps could be a limiting factor in their ability to react in time, there will be greater awareness of the need to have technical IT capabilities that can achieve the necessary redesign or architecting of the IT infrastructure. This might necessitate, for example, a utility computing approach to data processing as used by firms such as John Hancock or JP Morgan. It could also mean using middleware to foster interoperability across applications, operating systems, and potentially even across organizational boundaries.

Technical IT capabilities span a diverse set of resources around physical IT infrastructure (hardware, software, and networks) and human expertise. For example, Ross et al. [52] refer to a strong IT staff and a reusable technology base as resources that, together with a close IT-business partnership, provide a means for IT to deliver a sustainable competitive advantage. Ravichandran and Lertwongsatien [47] offer empirical evidence to show that these three types of IT capabilities impact firm performance. Elsewhere, in a series of analyses, Byrd and Turner [12,13,14] develop the notion of a flexible IT infrastructure based on flexible or integrated hardware and networking resources, reusable software, and IT expertise that can be leveraged to change IT infrastructure to suit the evolving needs of the firm. Byrd and Turner [13] also find that technical IT skills in such areas as programming, operating systems, database and network support, data warehousing, and web design allow IT to have a greater impact on firm performance. The scale of the impact of IT skills is in marked contrast to other studies that consider technical IT skills a commodity and, as such, an unlikely source of sustainable competitive advantage [34,45,49,60].

Managerial IT capabilities, as noted in prior studies by Feeny and Willcocks [21], Ross et al. [52], and Weill et al. [63], generates value by improving firms' ability to sense and respond to change. Agile-seeking firms try to avoid rigidity traps at all costs and so the resource-based view would suggest that firms will use insight, expertise and strategic planning to develop technical IT capabilities to give firms an ability to move in different directions. Depending on what market or product scenarios arise, a firm will be able to adapt its hardware, software, networks and IT skills to ensure that IT can continue to support the firm's business strategy. This argument implies that managerial IT capabilities affect business process agility through technical IT capabilities, and so we propose the following hypothesis as the first step in evaluating this mediation argument:

H2. Managerial IT capabilities have a positive impact on technical IT capabilities.

1.2 Leveraging Technical IT Capabilities

There is already some evidence in the IS literature that technical IT capabilities correlate with agility [61,63]. Applying the resource-based view, it is not difficult to see how using rare or causally ambiguous technical IT capabilities might create an advantage in how a firm responds to change. While competitors may be able to glean some details on the IT resources in use in a firm – for example, using media reports or perhaps by hiring some of their IT staff – it is seldom clear how firms have created technical IT capabilities from their resources and so any advantage might remain beyond the reach of competitors, at least in the short term.

Sambamurthy et al. [54] argue that IT competence – an inside-out capability signifying "a firm's capacity for IT-based innovation by virtue of the available IT resources and the ability to convert IT assets and services into strategic applications" (p. 244) – is a critical factor behind the range and intensity of competitive actions in a firm. Where IT infrastructure can flex in response to a change in the market or where technical skills can adapt to an urgent business need, a firm is

more likely to realize increased agility. Thus, for example, Zaheer and Zaheer [67] found that in foreign currency markets, banks with greater reach across their information networks were more responsive to change. In a practical sense, innovation around utility computing, service-oriented architecture, and web services are ways to expand the reach and range of IT infrastructure (often with a reduced need for capital spending) with the expectation that firms will be proactive rather than reactive [30]. From the viewpoint of IT skills, firms with a significant investment in training could find it easier to move personnel into new positions of responsibility. It is paradoxical that training is often the first item to suffer when IT budgets are cut, yet if viewed through the lens of real options, IT skills can have significant options value when combined with other aspects of IT infrastructure such as hardware or software [22,23]. This leads to the following hypothesis which completes the mediation argument that was presented in the last section:

H3. Technical IT capabilities have a positive impact on business process agility.

1.3 Environmental Change

Although the resource-based view is successful at explaining how capabilities shape firm performance, the theory has been criticized for failing to identify how capabilities might perform under varying environmental conditions [31,53,58]. The theory of dynamic capabilities attempts to address this oversight by noting that the performance implications of a firm's capabilities may be conditional on the environment [20,58]. For example, as conditions become more volatile, a firm may find itself straddled with capabilities that are best suited to a stable market but that are less than ideal in a volatile market. Similarly, a firm that devotes a great deal of time, money, and effort to creating IT capabilities that allow it to react quickly to change may see little return on its investment in a stable market when change is rare or largely predictable. This does not mean that firms in stable sectors such as chemicals, metals or construction should not bother with investing

in IT capabilities that facilitate agility; it simply means that under the resource-based view, firms in volatile markets are more likely to use their capabilities to greater effect than firms in stable or predictable markets. Thus, as environmental dynamism grows, defined by Miller and Friesen as the "amount or unpredictability of change in customer tastes, production or service technologies, and the modes of competition in the firm's principal industries" [37, p. 233], IT capabilities can have an even greater impact on agility. We capture this argument in the following hypotheses, to reflect the role of environmental turbulence as a moderating variable in each part of our model:

H4. Environmental turbulence positively moderates the link between managerial IT capabilities and business process agility.
H5. Environmental turbulence positively moderates the link between managerial IT capabilities and technical IT capabilities.
H6. Environmental turbulence positively moderates the link between technical IT capabilities and business process agility.

Combining these moderating hypotheses with our earlier hypotheses leads to the model in Figure 1. As shown in the model, managerial IT capabilities have both a direct and indirect effect on agility; the indirect effect arises from the mediating effects of technical IT capabilities. In the next section, we examine the measures used to operationalize the constructs shown in Figure 1.

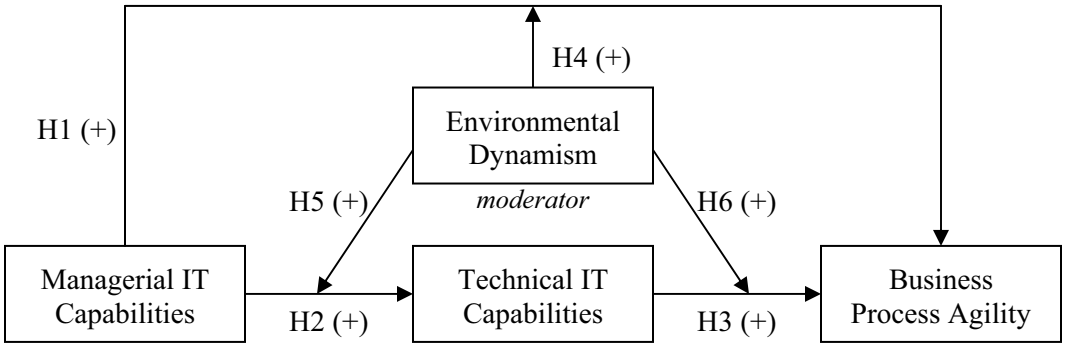

Figure 1. Conceptual Model and Hypotheses

2. Operationalizing the Model

In order to operationalize the primary constructs in our model: managerial IT capabilities, technical IT capabilities, business process agility, and environmental dynamism, we turned to the

extant IS literature. Consistent with the description of spanning capabilities in Wade and Hulland [60], we operationalize managerial IT capabilities in terms of partnerships between business and IS executives [21,50], strategic IT planning [52,57], and the use of post-implementation reviews [57]; details of all constructs are in Table 1. Technical IT capabilities were operationalized using prior research by Byrd and Turner [12,14] where IT infrastructure flexibility is shown in terms of hardware compatibility, software modularity, network connectivity, and IT skill adaptability.

Table 1. Research Constructs and Survey Measures

Constructs	Description / Definition	Num. Items	Supporting Literature
1. Managerial IT Capabilities:			
IT-business partnership	Cooperation between business and IT executives in championing greater use of IT, cross-participation in shaping business and IS strategic plans, shared vision for IT	10	[4,6,21,50]
Strategic plans for IT use	Planned use of IT for greater operational excellence (low cost provider, quality, errors, and speed) and strategic positioning (market reach, changing de facto industry practices)	4	[44,52,57]
Post-implementation reviews	Post-hoc evaluation of IT performance at specified intervals for major IS projects	3	[57]
2. Technical IT Capabilities:			
Hardware compatibility	Systems interoperability and integration, seamless access via common user interface	4	[12,19]
Software modularity	Rapid software development, reusable code, software portability across systems, ability to handle different data formats	4	[12,19]
Network connectivity	Ability to expand or contract network reach, remote access to shared date pools, adaptable links to internal and external parties	4	[12,19]
IT Skills Adaptability	Ability of IT personnel to acquire and apply a broad range of IT skills covering a diverse programming methodologies & IT platforms	4	[11,12,13]
3. Environmental Dynamism:			
Industry clockspeed	Rate of change in products and markets	3	[24,36]
4. Business Process Agility:	Responsiveness to changes in demand, new product development, change in product mix, product pricing, market expansion, supplier selection, IT adoption and diffusion	8	[10,29,54]

Note: a full list of all survey items is shown in the appendix.

Following Sambamurthy et al. [54] and Johnson et al. [29], agility was operationalized in terms of responsiveness to customer needs, process development, process efficiency, and product innovation. Finally, environmental dynamism was operationalized using research by Mendelson and Pillai [36] on industry clockspeed [24]. Clockspeed offers a way to assess the rate of change in a firm by determining the rate of new product innovation, customer turnover, and the lifecycle duration for a product or service manufactured or sold by the firm. Since the design of our model spans technical and managerial domains, it was decided that in order to reduce respondent bias or common method bias, measures would be spread across two respondent groups: business and IS executives [43]. We next review the measures and supporting literature used for each construct.

2.1 Managerial IT Capabilities

To evaluate the extent of IT-business partnership, we devised ten items (a list of all items appears in the appendix). Recognizing that partnerships are a two-way relationship, we felt it was necessary to obtain information on the strength of the partnership from two perspectives, namely, how IT executives rate the involvement of business executives in IT decision making, planning or analysis, and correspondingly, how business executives view the involvement of IS executives in solving business issues and strategic planning. To build these measures, we reviewed research by Bassellier et al. [4], Reich and Benbasat [50], and Jarvenpaa and Ives [27] with an emphasis on collaborative efforts at solving mutual IT and business problems, fostering strategic use of IT, shared vision for IT, and cross-participation in IS and business planning. In this way, five items were targeted at IS executives to reflect actions by business peers, while five items were targeted at business executives in order to evaluate the opposite side of the dyad. Respondents were asked to identify the extent of their agreement with each item on a seven-point Likert scale anchored on ‘do not agree’ and ‘agree completely’; all items were tested and validated in prior research [55].

To identify a firm's strategic intent for IT, four measures were adopted from research by Tallon et al. [57]. These items reflect Porter's argument that firms can boost firm performance by pursuing strategic goals around operational excellence or strategic positioning [44]. Accordingly, these four items – targeted at IT executives – evaluate current goals for IT around cost reduction, quality, speed and efficiency, effectiveness of business performance, expanded market reach, and use of IT as a way to alter market practices. Respondents were asked to rate their agreement with each item on a seven-point Likert scale anchored on 'do not agree' and 'agree completely'. Prior research has also validated these four items, finding them to be accurate and reliable [55,57].

Three items on post-implementation reviews were adopted from Tallon et al. [57]. These items assess whether post-implementation IT reviews are formal, informal or only undertaken on an ad-hoc basis. IT executives were asked to assess their use of each post-implementation review item on a seven-point scale anchored on 'never used' and 'use is mandatory'. These four survey items were also found to be valid and reliable in prior research [57].

2.2 Technical IT Capabilities

Measures of technical IT capabilities focused on the flexibility and adaptability of the IT infrastructure. Keen [30] views IT infrastructure flexibility in terms of reach and range. Byrd and Turner [12] operationalize reach and range as network connectivity and hardware compatibility. A further element of IT infrastructure flexibility is software modularity, attesting to the way that applications can be reconfigured or customized with minimal effort or to an absence of legacy IT or proprietary systems that are commonly linked to rigidity. Lastly, IT skills provide an essential element of adaptability enabling firms to leverage whatever degree of flexibility is given by their physical IT infrastructure. These hardcore IT skills contrast with the softer managerial skills used for planning or to collaborate with business executives in setting a strategic direction for IT [13].

Byrd and Turner [12] have previously created a 74-item survey instrument to measure IT infrastructure flexibility: 33 items assess the flexibility of the physical IT infrastructure, namely hardware, software, and networks. The remaining 41 items cover technical and managerial skills, knowledge sharing, understanding of business issues, and interpersonal skills. From this broader instrument, we created a subset of 16 items in order to measure hardware compatibility, network connectivity, software modularity, and IT skills adaptability (four items relate to each construct). IT executives were chosen as the most suitable respondents given the technical nature of many of these items. Respondents were asked to identify their agreement with each item on a seven-point Likert scale anchored on 'do not agree' and 'agree completely'.

2.3 Business Process Agility

Eight measures of business process agility were developed based on previous research by Johnson et al. [29] and conceptual arguments offered by Sambamurthy et al. [54] and Brown and Sambamurthy [10]. These items highlight the ease and speed with which firms can undertake key business actions such as responding to changes in aggregate demand, customizing a product to a specific customer or market cluster, reacting to new product or service launches by competitors, changing prices or product mix, moving into or retrenching from markets, adopting new process IT, and redesigning the supply chain. These items were targeted at business executives who were s could be a limiting factor in their ability to react in time, there will be greater awareness of the need to have technical IT capabilities that can achieve the necessary redesund evidence of a single factor with high reliability and validity and so all eight items were used in this study.

2.4 Environmental Dynamism

While previous research has used perceptual measures as a surrogate or proxy for market volatility [37,38], we relied instead on objective measures of industry clockspeed [24] that speak

to the actual rate of change in a firm's products and markets. When we objectively determine the factors that create market volatility, critical differences between industries become apparent in a way that perceptual measures often overlook.[2] Using research by Mendelson and Pillai [36], we created three items to capture the essence of market change within a firm: the percentage of sales from new products or services launched in the last two years, the lifecycle duration (in months) of a flagship product or service produced or sold by the firm, and the rate of customer turnover in the last year. While firms may participate in multiple markets and offer a wide range of products or services, focusing these three items on a flagship offering tries to capture data on the dominant forces facing a firm – forces that in turn call for agility or perhaps instead hint at market stability.

3. Data Collection and Analysis

In order to test our model, during 2002 we mailed surveys to a sample of IT and business executives in 1,600 firms, randomly drawn from a population of 2,826 publicly-traded firms with revenues (in 2001) of $100 million to $3 billion. IT respondents were identified through the 2002 directory of Top Computer Executives compiled by Applied Computer Research, while business executives were identified through Hoovers.com, a subscription-based website that reports senior management by area-level responsibility. Preference was given to executives with responsibility for strategic planning or development; CFOs were used as default respondents if other executives with strategy oversight could not be identified. From this sample, matched surveys were received from 241 firms, indicating a 13% response rate. A summary of our sample appears in Table 2.

Based on S&P Compustat data, an analysis of variance on total assets, sales and net profit finds that the firms in our sample are representative of our overall population. We also contacted a sample of 100 firms whose executives had not responded after a second mailing. Reasons given for not replying to the survey included travel commitments, corporate policy or time pressures.

Table 2. Sample Characteristics (N=241)

	Frequency	Percent
Revenues (2001)		
Less than $100 million (M)	15	6.2
$100 M – $250 M	75	31.1
$250 M – $500 M	54	22.4
$500 M – $1 billion (B)	44	18.3
$1 B – $2 B	36	14.9
More than $2 B	17	7.1
Industry Categories		
Electronics and Computing Machinery	65	27.0
Wholesale and Retail	46	19.1
Financial Services	43	17.8
Software Services	25	10.4
Metals and Plastics	17	7.1
Pharmaceuticals and Health Care	12	5.0
Other	33	13.6
Respondents (matched surveys)		
IT Executive Survey		
Chief Information Officer	116	46.2
IT Director	50	20.7
SVP / VP, Information Technology	49	20.3
IT Manager	26	10.8
Business Executive Survey		
SVP / VP Corporate Development	113	46.9
Business Development Officer	60	24.9
VP Strategic Planning	37	15.3
Chief Financial Officer	31	12.9

3.1 Construct Validation

In order to validate the measures used across both surveys, we performed a confirmatory factor analysis within PLS. All items had been evaluated in previous research and so there was a basis for specifying an a-priori factor structure. Factor loadings, together with descriptive data on all survey items, appear in Table 3; loadings are sufficiently high to validate our factor structure. As a safeguard, we used principal components analysis and varimax rotation to do an exploratory analysis. Using the eigenvalue rule, an eight factor structure emerged (64% variance explained) that, upon further review, was found to be largely consistent with the a-priori factor structure.

Table 3. Confirmatory Factor Analysis and Descriptive Statistics

Item	Mean	S.D.	IT-Bus. Partner.	Strategic IT Plan	Post IT Eval.	Hard. Comp.	Soft. Mod.	Net. Con.	IT Skill Adapt.	Bus Pr. Agility
ITBP1	4.86	1.44	**0.74**	0.40	0.43	0.26	0.35	0.31	0.47	0.43
ITBP2	5.43	1.21	**0.82**	0.50	0.47	0.37	0.39	0.44	0.48	0.43
ITBP3	4.74	1.51	**0.79**	0.49	0.48	0.38	0.42	0.39	0.50	0.43
ITBP4	4.93	1.41	**0.82**	0.48	0.49	0.36	0.37	0.40	0.52	0.44
ITBP5	4.95	1.37	**0.88**	0.52	0.50	0.37	0.36	0.40	0.55	0.44
ITBP6	4.52	1.60	**0.72**	0.45	0.35	0.35	0.36	0.31	0.50	0.29
ITBP7	5.46	1.33	**0.77**	0.47	0.37	0.41	0.35	0.37	0.47	0.44
ITBP8	5.26	1.41	**0.74**	0.42	0.37	0.37	0.28	0.36	0.52	0.32
ITBP9	5.12	1.42	**0.86**	0.43	0.47	0.32	0.32	0.31	0.54	0.43
ITBP10	4.70	1.47	**0.89**	0.50	0.49	0.44	0.43	0.41	0.54	0.43
SITP1	5.98	1.13	0.31	**0.65**	0.27	0.29	0.29	0.29	0.24	0.35
SITP2	5.73	1.14	0.45	**0.78**	0.30	0.34	0.26	0.33	0.41	0.38
SITP3	4.35	1.67	0.47	**0.72**	0.33	0.36	0.37	0.37	0.37	0.36
SITP4	3.92	1.78	0.42	**0.74**	0.35	0.33	0.44	0.33	0.41	0.33
Post1	3.99	1.58	0.47	0.34	**0.82**	0.29	0.33	0.32	0.38	0.33
Post2	4.35	1.47	0.48	0.40	**0.86**	0.31	0.42	0.38	0.38	0.42
Post3	4.72	1.42	0.43	0.34	**0.83**	0.27	0.32	0.30	0.36	0.41
HC1	5.32	1.47	0.41	0.42	0.22	**0.84**	0.48	0.60	0.49	0.40
HC2	5.00	1.60	0.34	0.37	0.31	**0.83**	0.49	0.62	0.38	0.33
HC3	5.06	1.66	0.32	0.30	0.28	**0.77**	0.56	0.61	0.34	0.32
HC4	3.96	1.83	0.38	0.39	0.32	**0.78**	0.60	0.64	0.33	0.41
SM1	3.74	1.69	0.37	0.37	0.36	0.49	**0.85**	0.57	0.37	0.33
SM2	4.09	1.76	0.34	0.34	0.34	0.62	**0.87**	0.66	0.38	0.36
SM3	4.83	1.70	0.32	0.35	0.28	0.47	**0.69**	0.47	0.26	0.41
SM4	3.95	1.60	0.38	0.42	0.36	0.45	**0.69**	0.50	0.38	0.41
NC1	4.27	1.52	0.35	0.37	0.31	0.59	0.57	**0.77**	0.38	0.39
NC2	4.22	1.93	0.30	0.32	0.30	0.58	0.58	**0.83**	0.37	0.38
NC3	4.41	1.54	0.41	0.40	0.34	0.70	0.60	**0.91**	0.45	0.44
NC4	4.07	1.59	0.46	0.43	0.37	0.66	0.59	**0.80**	0.45	0.45
ITSA1	5.12	1.18	0.43	0.34	0.32	0.39	0.32	0.37	**0.79**	0.29
ITSA2	4.08	1.49	0.53	0.44	0.39	0.36	0.38	0.35	**0.83**	0.31
ITSA3	4.15	1.50	0.50	0.37	0.40	0.39	0.35	0.44	**0.81**	0.44
ITSA4	4.76	1.25	0.60	0.46	0.34	0.43	0.40	0.47	**0.84**	0.42
BPA1	4.73	1.28	0.45	0.37	0.44	0.32	0.35	0.35	0.45	**0.65**
BPA2	5.04	1.57	0.21	0.20	0.17	0.23	0.23	0.30	0.11	**0.58**
BPA3	4.48	1.17	0.38	0.37	0.36	0.33	0.37	0.42	0.39	**0.79**
BPA4	5.33	1.28	0.37	0.29	0.25	0.33	0.24	0.30	0.27	**0.59**
BPA5	4.59	1.57	0.19	0.30	0.27	0.30	0.30	0.31	0.16	**0.63**
BPA6	4.55	1.35	0.37	0.32	0.30	0.32	0.31	0.37	0.30	**0.72**
BPA7	4.29	1.32	0.42	0.42	0.44	0.36	0.41	0.40	0.41	**0.76**
BPA8	4.78	1.42	0.29	0.33	0.22	0.21	0.27	0.21	0.22	**0.59**

Note: all survey items are listed in the appendix.

We next reviewed all items for convergent and discriminant validity. Convergent validity identifies if the indicators of a factor correlate higher among themselves than with indicators of a different factor, while discriminant validity tests if the indicators of a specific factor load higher on that factor than on another factor. To show that each form of validity is upheld, the correlation

between each pair of factors must be less than the square root of the average variance extracted by the items loading on each factor in that pair. As shown in Table 4, all factor pairs pass this test showing that the factor structure is valid. We also reviewed composite reliability for each factor. In each case, composite reliability exceeds a suggested minimum of 0.80 [41,64].

Table 4. Construct Validity and Reliability (including correlations)

Constructs	Composite Reliability	1.	2.	3.	4.	5.	6.	7.	8.
1. IT-Business Partnership	0.949	**0.81**							
2. Strategic IT planning	0.813	0.58	**0.72**						
3. Post-implementation reviews	0.873	0.55	0.43	**0.83**					
4. Network Connectivity	0.881	0.45	0.46	0.35	**0.81**				
5. Hardware Compatibility	0.859	0.45	0.47	0.43	0.66	**0.78**			
6. Software Modularity	0.897	0.46	0.46	0.40	0.77	0.71	**0.83**		
7. IT Skills Adaptability	0.887	0.63	0.49	0.45	0.48	0.44	0.50	**0.81**	
8. Business Process Agility	0.862	0.51	0.49	0.47	0.45	0.47	0.50	0.45	**0.67**

Constructs 1–3 above are reflective of managerial IT capabilities, while constructs 4–7 are reflective of technical IT capabilities. Data in bold along the main diagonal represent the square root of the average variance extracted (AVE) or the variance shared between each construct and its indicators. Off-diagonal elements are the correlation between each pair of constructs. All correlations are significant at $p<0.01$.

3.2 Model Estimation

In order to formally test our model and hypotheses, we first created second order factors for managerial IT capabilities comprising three first order factors: IT-business partnership, post-implementation IT reviews, and strategic planning for IT, and for technical IT capabilities whose four first order factors were: hardware compatibility, software modularity, network connectivity, and IT skills adaptability. To build a second order factor, we first created a weighted average or composite score for all first order factors in each firm as the product of PLS outer model weights and standardized item measures, summed over all items to give a single score for each factor [1].

Since our model specifies environmental dynamism (clockspeed) as a moderator, we next needed to add these three clockspeed measures to our model. Moderation can be accomplished in either of two ways. First, interaction terms can be constructed for all independent and moderator

variables (*mxn* items are needed if the independent and moderator variables are modeled using *m* and *n* items, respectively). Second, subgroups can be formed based on distinct differences in the level of the moderator; median sample splits by a criterion variable are among the most common approach. The model is then estimated independently for each subgroup and the path coefficients compared across all groups. While both approaches must necessarily yield similar results, the use of interaction terms is often criticized for reasons of interpretation [16]. This can be particularly vexing if the independent or moderator variable is measured using different scales as is the case in this study: our independent measures use seven-point Likert scales while clockspeed measures are continuous [59]. We, therefore, decided to apply the second approach using k-cluster analysis (k=2) on the three clockspeed measures to divide our sample into two subgroups, reflecting firms in relatively stable markets and those in more volatile or unstable markets.[3]

Table 5. Environmental Dynamism Subgroups (ANOVA)

Clockspeed Measures	Firms in Stable Environments (N=134)	Firms in Unstable Environments (N=107)	F (sig.)
Rate of annual customer turnover (%)	9.9	17.0	14.882***
Revenues from newly launched products and services (%)	24.6	50.0	44.682***
Length of product or service lifecycle (months)	70.7	28.2	9.733***

Significance: *** $p<0.001$

Descriptive details on the resulting two subgroups or clusters appears in Table 5. The first group contains firms in stable markets (low rate of customer turnover, low rate of sales from new products and services, long product lifecycles) while the second group contains firms in turbulent markets (customer turnover is higher, product lifecycles are shorter, and with a higher percentage of sales from new products or services launched inside the last two years). A one-way analysis of variance (ANOVA) on each clockspeed measure shows statistically significant differences across both clusters ($p<0.001$), as shown in Table 5. Descriptively, the data in Table 5 are revealing. For example, firms in stable environments encounter much little pressure to innovate continuously as

less than 10% of sales come from new products and services. Firms in turbulent markets report a rate that is almost twice as high. Similarly, the average lifecycle duration for a product or service in stable markets is almost six years compared with only two years for firms in volatile markets.

We next estimated three models within PLS: the first used the entire sample of 241 firms, while the second and third used subgroup data for firms in stable (N=134) and turbulent (N=107) markets, respectively. Reflective measures were used in all cases. Controls for firm size (small vs. large based on median 2001 sales) and industry (based on sector data shown in Table 2) were added to each model. Statistical significance of path coefficients and item loadings was compiled on the basis of 1,000 bootstrap samples. The results of all three models appear in Table 6.[4]

Table 6. Model Results (Standardized Estimates)

	All Firms N=241	Stable Environment N=134	Unstable Environment N=107	Moderation Path Differences Stable vs. Unstable
Path Estimates:				
H1. Mgt. IT Capabs. → Agility	0.337***	0.235***	0.462***	**H4.** 0.227*
	(0.071)	(0.071)	(0.076)	(0.104)
H2. Mgt. IT Capabs. → Tech. IT Capabs.	0.642***	0.642***	0.681***	**H5.** 0.039 NS
	(0.038)	(0.055)	(0.046)	(0.070)
H3. Tech. IT Capabs. → Agility	0.320***	0.451***	0.257***	**H6.** –0.194*
	(0.067)	(0.045)	(0.075)	(0.087)
Second Order Factor Loadings:				
Managerial IT Capabilities				
IT-business Partnership	0.853***	0.827***	0.892***	
Strategic Planning for IT	0.800***	0.815***	0.801***	
Post-investment Evaluation	0.773***	0.774***	0.766***	
Technical IT Capabilities				
Hardware Compatibility	0.877***	0.815***	0.845***	
Software Modularity	0.916***	0.885***	0.885***	
Network Connectivity	0.886***	0.872***	0.828***	
IT Skills Adaptability	0.723***	0.681***	0.774***	
Variance Explained: R^2				
Technical IT Capabilities	41.2	41.2	46.4	
Business Process Agility	36.7	37.4	48.9	

Standard errors are shown in parentheses. All control variables for industry sector and firm size were insignificant.
Significance: ns: not significant * $p<0.05$ ** $p<0.01$ *** $p<0.001$

3.3 Overview of Results

An analysis of the results in Table 6 finds support for each of our three main hypotheses, confirming that both managerial and technical IT capabilities influence business process agility,

and that technical IT capabilities in turn mediates the link between managerial IT capabilities and agility. The importance of this mediation result is confirmed when the mediator and its paths (H2 and H3) are removed from the model leaving only the direct path representing H1 and the model is re-estimated. The explained variance in agility declines from 36.7, 37.4 and 48.9 to 31.2, 26.3 and 46.3 for the three models shown in Table 6. Consequently, technical IT capabilities are only a partial mediator of the link between managerial IT capabilities and agility [3]; this is especially so for firms in stable markets where ΔR^2 between the mediated and unmediated or direct models is more pronounced. This suggests that managerial IT capabilities can indirectly influence agility through technical IT capabilities or by more direct means. The significance of a direct link could be due to the effects of other variables such as end user training, IT absorptive capacity, learning, structure, and culture, or any number of other mediation variables not contained in our model [5].

Several interesting findings come to light with a review of how environmental dynamism affects the link between IT capabilities and agility. We noted earlier that market volatility would allow technical and managerial IT capabilities to play a more important role in shaping process agility. We also noted that managerial IT capabilities would have a greater effect on technical IT capabilities under conditions of heightened volatility. Yet for H5, we observe that environmental dynamism has no impact on the link between managerial and technical IT capabilities – all firms, regardless of the extent of environmental flux, are equally adept at using managerial practices to enhance the adaptability of their IT infrastructure. For H4, we find that environmental dynamism has a positive effect on how managerial IT capabilities translate into improved agility, consistent with our argument that firms in volatile settings have a greater need for agility. However, for H6, a very different result occurred than had been predicted. We had argued that increased turbulence would allow technical IT capabilities to have an even greater impact on agility but our analysis

indicates an entirely opposite result: firms in stable markets realize a higher boost in agility from enhanced technical IT capabilities than firms in more volatile settings. The result for H6 is all the more interesting when viewed in the context of H4, for it implies that not all capabilities perform equally well under different degrees of volatility. The next section examines why this might be.

4. Discussion

Within our resource-based model, we show that firms effectively have two choices when it comes to boosting business process agility: they can turn either to managerial IT capabilities or to technical IT capabilities. In a stable setting, technical IT capabilities appear more beneficial (a 0.451 coefficient for technical IT capabilities is greater than a 0.235 coefficient for managerial IT capabilities). One could argue that the higher value of technical capabilities is due to the fact that firms in stable markets are less likely to have a flexible IT infrastructure – a fact confirmed by an analysis of variance comparing both subgroups on each dimension of IT infrastructure flexibility (see Table 7). For firms with an already inflexible infrastructure, adopting an integrated approach to hardware, pursuing modular software design or extending networks to bridge different parts of the firm, has a greater impact at the margin than IT-business partnerships or post-implementation IT reviews – practices that Table 7 identifies as more prominent among firms in stable markets.

Table 7. Subgroup Comparison (ANOVA)

	Firms in Stable Markets (N=134)		Firms in Volatile Markets (N=107)		
	Mean	S.D.	Mean	S.D.	F (sig.)
Managerial IT Capabilities					
IT-business Partnership	5.15	0.97	4.80	1.27	5.926 *
Strategic IT Planning	4.90	1.06	5.11	0.97	0.116 NS
Post-investment IT Evaluation	4.41	1.18	4.29	1.31	0.442 NS
Technical IT Capabilities					
Hardware Compatibility	4.54	1.30	5.20	1.24	15.705 ***
Software Modularity	3.96	1.29	4.39	1.29	6.792 **
Network Connectivity	4.00	1.36	4.54	1.29	9.785 **
IT Skills Adaptability	4.51	1.09	4.54	1.10	0.046 NS

Data for all items above are determined by taking an average of the items loading on each factor in Table 3.
Significance: ns: not significant * $p<0.05$ ** $p<0.01$ *** $p<0.001$

In a stable environment, a close working relationship between IT and business executives may be helpful in environmental scanning or in the creation of long-term strategic plans or goals for IT. However, when change is more the exception that the norm, those plans may give little or no consideration to agility or ways to deal with change more broadly. It is possible that firms in a stable market might seek agility in order to be proactive, moving ahead of competitors in order to steal marketshare. In any case, our results show that agility comes from enhancing IT capabilities around a flexible, adaptable or scalable IT infrastructure. If a firm sees little prospect for market change, rigidity traps may naturally arise if IT become more focused in how it is used to resolve business problems [5,39]. Several researchers have in the past spoken of the tradeoff between IT flexibility and the pursuit of efficiency [2,46]. Ironically, it seems that market stability lulls firms into a false sense of security, blinding them to the possibility that IT decisions taken today could have adverse consequences if markets shift abruptly. Firms in stable settings must also be fearful of fear rigidity traps and so those that engineer their IT infrastructure to be flexible stand to gain more in terms of enhanced process agility and overall preparedness for change if it should occur.

Meanwhile, for firms in volatile markets that already have a flexible IT infrastructure, it makes sense to use managerial IT capabilities to directly impact process agility or to leverage the options embedded within a flexible IT infrastructure to indirectly enhance agility [54]. What this means is that while IT has long been regarded as a useful tool in the search for greater agility and adaptiveness, especially in volatile markets where firms feel most threatened by a lack of agility, IT governance and its attendant managerial capabilities are perhaps more important than research may have previously noted [9,62]. To the extent that Table 7 shows that firms in volatile markets are less inclined to use post-implementation reviews or to foster closer IT-business partnerships, sudden change may be forcing IT managers to devote considerable time and effort to *putting out*

fires rather than reaching across the executive divide. IT executives may also perceive little value in reviewing sunk IT investments to learn what could be done differently in future as an evolving market may render obsolete any lessons learned. Equally, there may simply not be sufficient time to devote to such reviews with the result that IT value assessment becomes a matter of faith.

There is another argument that one might draw from our results which is to recognize that if firms in volatile markets already possess a flexible IT infrastructure, the trigger for leveraging this infrastructure must come from environmental scanning and high level planning on the part of business and IS executives. While an adaptable, scalable or flexible IT infrastructure can enable increased agility as seen by our results for H3, it is still the case that managers must know how or when to react to change or indeed when not to react. Research on alignment or the fit between IT and business strategy can help to explain what is happening here. In a volatile market where both IT and business strategy are susceptible to change, firms can expect to encounter problems when trying to maintain tight fit. The presence of IT flexibility can allow firms to redirect IT resources in a way that ensures ongoing support for the business strategy [47,56]. A flexible or adaptable IT infrastructure will enable continuous alignment but managerial capabilities are still the trigger that align IT with the business strategy. This argument is echoed by Broadbent [8] who notes that "the ability to integrate [or align] business and IT can exist only when clear and robust systems of IT governance also exist, systems that will allow you to make well-informed decisions faster" p. 29. Thus, IT can positively affect agility but only insofar as managerial IT capabilities are able to leverage a firm's technical capabilities, directing IT resources to where they are needed most.

Lastly, with respect to IT skills adaptability, we note in Table 7 that there is no significant difference between firms in stable and volatile markets. In contrast to significant differences that exist in each of the others areas of infrastructure capabilities (hardware, software, and networks),

firms may have made a significant investment in building up their IT skills base in the hope that superior technical skills might carry the day if the more physical elements of IT infrastructure are resistant to change. Certainly, the role of IT skills cannot be ignored in any decision to develop a flexible, adaptable or scalable IT infrastructure. However, in contrast to the findings in Byrd and Turner [13] where technical IT skills had a positive affect on measures of competitive advantage, our results question whether IT skills have any direct affect on agility. To test this argument, we tested an alternative model with the four items identifying IT skills adaptability forming a single latent variable that was then linked to agility independently. The coefficient of the resulting path was insignificant; the variance explained in agility was also identical to that shown in Table 6.

4.1 Implications

The attraction of recent innovations in web services, utility computing or service oriented architectures may have prompted firms to apply IT fixes to what they perceive as an IT problem. If IT is considered to be at the root of rigidity traps, then it is reasonable to assume that removing these traps through more flexible forms of IT, extreme programming or similar rapid application development techniques will lead to greater agility. Our results would say that this assumption is largely correct (H3 is supported) but our results would also say that this is not the entire story.

Theoretically and empirically, managerial IT capabilities are a key variable in how a firm converts IT resources into capabilities and how those capabilities in turn are leveraged to deliver superior firm performance [5,34,45]. IT governance, which encompasses many of the managerial IT capabilities described in this study, is a key differentiator in firm performance [62]. Effective governance focuses in part on communicating the value and strategic intent for IT to end-users or other stakeholders, and in realizing that value through the creation of an IT architecture, policies and procedures that foster short-term efficiency and greater responsiveness to the evolving needs

of the business [2]. This argument is consistent with Westerman [65] who finds, on the basis of a Gartner survey of 1,400 firms, that four IT capabilities facilitate greater business process agility: service management (ongoing delivery of basic IT services), project delivery (successful project implementations), governance alignment (proper control and prioritization of IT projects), and IT business relationships (cross-participation and shared IT vision).

There may also be some question as to the appropriate level of IT governance if IT is to be an enabler of agility. For example, should IT governance be delegated to the level of a project manager with responsibility for IT development, hardware integration or network design, or is IT governance an issue that squarely resides within the CIO suite or the executive boardroom? Our research did not address this question directly but our results may sound a word of caution if IT governance is delegated to a function or business-unit level where IT decisions are divorced from the oversight that close IT-business partnerships provide. IT executives have long been criticized for being fixated on *speeds and feeds* and for failing to provide an adequate business justification for all IT investment. To the extent that IT executives decide to enhance the technical capabilities of the IS function by investing in new and more innovative IT – investments that, consistent with the speeds and feeds argument, add to the scalability and flexibility of the firm's IT infrastructure – our results show that agility will be favorably enhanced. What is less obvious, however, is that this form of capability enhancement may not be the only, or necessarily the best, solution to the problem of weak or inadequate agility. It may still be necessary to question whether IT rigidity is the reason behind a lack of agility but solving that issue alone is insufficient to solve the problem of weak agility in all cases. It may appear counter-intuitive that more effective IT governance or managerial IT capabilities more broadly could boost process agility more than a rip and replace strategy that is only directed at enhancing the physical IT artifact. Vendors of utility computing

or middleware solutions will not hesitate to sell technology as the answer to all rigidity problems but, as our results suggest, weak agility may still be an issue unless there is an attempt to correct an ineffective IT governance model that may indeed have contributed to the rise of rigidity traps.

4.2 Research Contribution and Limitations

This research contributes to the growing body of research on the resource-based view and IT capabilities in three respects. First, based on conceptual arguments in prior research [54], we develop and test a series of eight measures of process agility. The nomological validity of these items – collected as part of a matched survey methodology from business executives and CFOs with responsibility for strategic planning – is confirmed through their inclusion in our structural model. Second, we extend research on the resource-based view that argues that while there are many dimensions of IT capabilities such as human, technical, or relational [5], these dimensions are often interlinked in complex ways or structured in a hierarchical format [25,40,47]. Third, the mediation model outlined in this research not only allows us to see how different managerial and technical IT capabilities are related, or how they predict business process agility, but by virtue of the moderating impacts of environmental dynamism, we find that the path to enhanced agility or adaptiveness is not exclusively through technical IT capabilities. This is an important finding at a time when firms such as IBM, Cisco, HP and others are selling hardware, software, and network equipment as a way to improve agility. Our data would not dispute such claims but would, at the same time, call attention to the fact that enhanced managerial IT capabilities or more effective IT governance could have an even greater impact on agility than technical IT capabilities alone.

Our study is not without its limitations, however. Although data were collected through a matched survey methodology involving two respondents (a business executive and IS executive) per firm, there remains the question of whether a single respondent can realistically offer a valid

and accurate view of business process agility or other variables of interest in our study. Multiple respondents and the presence of high interrater reliability, particularly for measures of agility, are a necessary step to developing a stable set of measures for this concept. Our operationalization of both managerial and technical IT capabilities provides a mere snapshot of what are, in reality, an evolving set of measures. Notwithstanding the fact that each capability was measured in multiple ways, our constructs could be more inclusive and broadened to include other capabilities that are not considered in this research. Byrd and Turner [12], from whose research our sixteen measures of technical IT capabilities were derived, have a much broader instrument which could provide a basis for providing a more exhaustive set of capabilities measures.

The cross-sectional nature of our data limits our ability to observe firms in transition from a stable to an unstable market or vice versa. In the absence of longitudinal data, we are forced to define the conditions under which a firm operates as either stable or unstable. While this does not undermine our results, the nature of dynamic capabilities of which managerial and IT capabilities are quintessential forms due to their ability to respond to change [20,58,60], calls for longitudinal analysis. Case study analyses could yield useful insights and facilitate such data collection [28].

Finally, this study does not evaluate firm performance in any objective sense. As a result, it may be unsafe to assume that just because IT capabilities can enhance process agility, that firm performance as measured by profit, efficiency, market share or other objective criterion will also grow. At best, agility is a proxy for performance. Consistent with the arguments in Sambamurthy et al. [54], future research needs to test if improved agility leads to higher firm performance and to identify, if necessary, whether time lags might delay any financial gains from agility. Research could also review spending on hardware, software, and labor to see how quickly it takes to boost agility. Firms with limited budgets may have to be careful with how they invest their resources.

5. Conclusion

This research sought to answer two research questions regarding the affect of managerial and technical IT capabilities on agility and whether this was positively moderated by the degree of environmental change, as argued by the resource-based view of the firm. Our analysis strongly answers the first question in the affirmative – both managerial and technical IT capabilities have a positive impact on agility. As for the second question, it emerged that environmental dynamism or volatility did not uniformly translate into greater agility, contrary to what the theory predicted. Instead, we learn that volatility positively moderates the link between managerial IT capabilities and agility, showing that IT governance is vital for firms whose markets are in a constant state of change. While environmental change has no effect on the link between managerial and technical IT capabilities, it negatively affects the link between technical IT capabilities and agility. The net impact of this result is to show that the choices firms face in deciding how to enhance agility will largely depend on the extent of volatility. Managerial IT capabilities are more effective for firms in volatile markets, while technical IT capabilities are more effective for firms in stable markets.

Our research does not deny that recent innovation around web services, utility computing or other technologies will radically improve business process agility and market responsiveness. The concern, however, is that firms may become overly confident in the ability of the physical IT artifact to boost agility by itself. A belief in the ability of IT to restore or enhance process agility is understandable when the blame for lackluster agility is placed at the feet of IT and its attendant rigidity traps. Our results reveal, however, that the path to improved agility is not always through better, faster or cheaper technology. IT governance and managerial IT capabilities are as much a part of the search for agility as infrastructure enhancements. The human element, it seems, is still a key ingredient in a firm's success and in its ability to use IT to the fullest extent possible.

References

[1] R. Agarwal and E. Karahanna, Time Flies When You're Having Fun: Cognitive Absorption and Beliefs about Information Technology Usage, MIS Quarterly 24(4) (2000) 665-694.

[2] B.R. Allen and A.C. Boynton, Information Architecture: In Search of Efficient Flexibility, MIS Quarterly 15(4) (1991) 435-445.

[3] R.M. Baron and D.A. Kenny, The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic and Statistical Considerations, Journal of Personality and Social Psychology 51 (1986) 1173-1182.

[4] G. Bassellier and I. Benbasat, Business Competence of Information Technology Professionals: Conceptual Development and Influence on IT-Business Partnerships, MIS Quarterly 28(4) (2004) 673-694.

[5] A. Bharadwaj, A Resource-based Perspective on Information Technology Capability and Firm Performance: An Empirical Investigation, MIS Quarterly 24(1) (2000) 169-196.

[6] A. Bharadwaj, V. Sambamurthy and R. Zmud, Firmwide IT Capability: An Empirical Examination of the Construct and its Links to Performance, Working Paper (Emory University, 2002).

[7] A.C. Boynton, R.W. Zmud and G.C. Jacobs, The Influence of IT Management Practice on IT Use in Large Organizations, MIS Quarterly 18(3) (1994) 299-318.

[8] M. Broadbent, Why Governance Matters, CIO Insight 60 (2005) 29-30.

[9] M. Broadbent, P. Weill and D. St. Clair, The Implications of Information Technology Infrastructure for Business Process Redesign, MIS Quarterly 23(2) (1999) 159-182.

[10] C.V. Brown and V. Sambamurthy, *Repositioning the IT Organization to Enable Business Transformation* (Pinnaflex Educational Resources, Cincinnati, OH, 1999).

[11] T.A. Byrd, B.R. Lewis and D.E. Turner, The Impact of IT Personnel Skills on IT Infrastructure and Competitive IS, Information Resources Management Journal 17(2) (2004) 38-62.

[12] T.A. Byrd and D.E. Turner, Measuring the Flexibility of Information Technology Infrastructure: Exploratory Analysis of a Construct, Journal of Management Information Systems 17(1) (2000) 167-208.

[13] T.A. Byrd and D.E. Turner, An Exploratory Analysis of the Value of the Skills of IT Personnel: Their Relationship to IS Infrastructure and Competitive Advantage, Decision Sciences 32(1) (2001) 21-54.

[14] T.A. Byrd and D.E. Turner, An Exploratory Examination of the Relationship between Flexible IT Infrastructure and Competitive Advantage, Information and Management 39 (2001) 41-52.

[15] N. Carr, IT Doesn't Matter, Harvard Business Review 81(5) (2003) 41-49.

[16] T.A. Carte and C.J. Russell, In Pursuit of Moderation: Nine Common Errors and their Solutions, MIS Quarterly 27(3) (2003) 479-501.

[17] R.A. D'Aveni, *Hypercompetition: Managing the Dynamics of Strategic Maneuvering* (Free Press, New York, NY, 1994).

[18] G. Day, The Capabilities of Market-Driven Organizations, Journal of Marketing 58(4) (1994) 37-52.

[19] N. Duncan, Capturing Flexibility of Information Technology Infrastructure: A Study of Resource Characteristics and their Measure, Journal of Management Information Systems 12(2) (1995) 37-57.

[20] K.M. Eisenhardt and J.A. Martin, Dynamic Capabilities: What Are They?, Strategic Management Journal 21(10-11) (2000) 1105-1121.
[21] D.F. Feeny and L.P. Willcocks, Core IS Capabilities or Exploiting Information Technology, Sloan Management Review 39(2) (1998) 9-21.
[22] R.G. Fichman, Real Options and IT Platform Adoption: Implications for Theory and Practice, Information Systems Research 15(2) (2004) 132-154.
[23] R.G. Fichman, M. Keil and A. Tiwana, Beyond Valuation: Options Thinking in IT Project Management, California Management Review 47(2) (2006) 74-96.
[24] C.H. Fine, *Clockspeed: Winning Industry Control in the Age of Temporary Advantage* (Perseus Books, Reading, MA, 1998).
[25] R.M. Grant, The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation, California Management Review 33(3) (1991) 114-135.
[26] M. Hitt, B. Keats and S. DeMarie, Navigating in the New Competitive Landscape: Building Strategic Flexibility and Competitive Advantage in the 21st Century, Academy of Management Executive 12(4) (1998) 22-41.
[27] S.L. Jarvenpaa and B. Ives, Executive Involvement and Participation in the Management of IT, MIS Quarterly 15(2) (1991) 205-227.
[28] S.L. Jarvenpaa and D.E. Leidner, An Information Company in Mexico: Extending the Resource-based View of the Firm to a Developing Country Context, Information Systems Research 9(4) (1998) 342-361.
[29] J.L. Johnson, R.P. Lee, A. Saini and B. Grohmann, Market-Focused Strategic Flexibility: Conceptual Advances and an Integrative Model, Journal of the Academy of Marketing Science 31(1) (2003) 74-89.
[30] P. Keen, *Shaping the Future: Business Design through Information Technology* (Harvard Business School Press, Boston, MA, 1991).
[31] D. Leonard-Barton, Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development, Strategic Management Journal 13 (1992) 111-125.
[32] J.N. Luftman, Key Issues for IT Executives, MIS Quarterly Executive 3(2) (2004) 1-18.
[33] D.A. Marchand, W.J. Kettinger and J.D. Rollins, *Information Orientation: The Link to Business Performance* (Oxford University Press, New York, NY, 2001).
[34] F.J. Mata, W.L. Fuerst and J.B. Barney, Information Technology and Sustained Competitive Advantage: A Resource-based Analysis, MIS Quarterly 19(4) (1995) 415-433.
[35] A. McAfee, A. Sjoman and V. Dessain, *Zara: IT for Fast Fashion* (Harvard Business School Press 9-604-081, 2004).
[36] H. Mendelson and R.R. Pillai, Clockspeed and Informational Response: Evidence from the Information Technology Industry, Information Systems Research 9(4) (1998) 415-433.
[37] D. Miller and P. Friesen, Strategy-making and Environment: The Third Link, Strategic Management Journal 4(3) (1983) 221-235.
[38] D. Miller and P. Friesen, *Organizations: A Quantum View* (Prentice-Hall, Englewood Cliffs, NJ, 1984).
[39] D. Miller, T.K. Lant, F.J. Milliken and H.J. Korn, The Evolution of Strategic Simplicity: Exploring Two Models of Organizational Adaptation, Journal of Management 22(6) (1996) 863-887.
[40] S. Mithas, N. Ramasubbu, M.S. Krishnan and V. Sambamurthy, Information Technology Infrastructure Capability and Firm Performance: An Empirical Analysis, Working Paper (University of Maryland, R.H. Smith School of Business, 2006).

[41] J.C. Nunnally, *Psychometric Theory (Second Edition)* (McGraw-Hill, New York, NY, 1978).
[42] G. Piccoli and B. Ives, IT-Dependent Strategic Initiatives and Sustained Competitive Advantage: A Review and Synthesis of the Literature, MIS Quarterly 29(4) (2005) 747-776.
[43] P.M. Podsakoff, S.B. MacKenzie, J.Y. Lee and N.P. Podsakoff, Common Method Bias in Behavioral Research: A Critical Review of the Literature and Recommended Remedies, Journal of Applied Psychology 88(5) (2003) 879-903.
[44] M.E. Porter, What is Strategy?, Harvard Business Review 74(6) (1996) 61-77.
[45] T.C. Powell and A. Dent-Micallef, Information Technology as Competitive Advantage: The Role of Human, Business and Technology Resources, Strategic Management Journal 18(5) (1997) 385-405.
[46] C.K. Prahalad and M.S. Krishnan, The Dynamic Synchronization of Strategy and Information Technology, Sloan Management Review 43(4) (2002) 24-33.
[47] T. Ravichandran and C. Lertwongsatien, Effect of Information Systems Resources and Capabilities on Firm Performance, Journal of Management Information Systems 21(4) (2005) 237-276.
[48] G. Ray, J. Barney and W.A. Muhanna, Capabilities, Business Processes, and Competitive Advantage: Choosing the Dependent Variable in Empirical Tests of the Resource-based View, Strategic Management Journal 25(1) (2004) 23-37.
[49] G. Ray, W.A. Muhanna and J. Barney, Information Technology and the Performance of the Customer Service Process: A Resource-based Analysis, MIS Quarterly 29(4) (2005) 625-652.
[50] B.H. Reich and I. Benbasat, Measuring the Linkage Between Business and Information Technology Objectives, MIS Quarterly 20(1) (1996) 55-81.
[51] B.H. Reich and I. Benbasat, Factors that Influence the Social Dimension of Alignment between Business and Information Technology Objectives, MIS Quarterly 24(1) (2000) 81-113.
[52] J.W. Ross, C.M. Beath and D.L. Goodhue, Develop Long-Term Competitiveness through IT Assets, Sloan Management Review 38(1) (1996) 31-45.
[53] V. Sambamurthy, Business Strategy in Hyper-competitive Environments: Rethinking the Logic of IT Differentiation, in: *Framing the Domains of IT Management: Projecting the Future through the Past*, ed., R. Zmud (Pinnaflex, Cincinnati, OH, 2000) 245-261.
[54] V. Sambamurthy, A. Bharadwaj and V. Grover, Shaping Agility through Digital Options: Reconceptualizing the Role of Information Technology in Contemporary Firms, MIS Quarterly 27(2) (2003) 237-263.
[55] P.P. Tallon, A Process-oriented Assessment of the Alignment of Information Systems and Business Strategy: Implications for IT Business Value, Unpublished Ph.D. Dissertation (UC Irvine, 2000).
[56] P.P. Tallon and K.L. Kraemer, Leveraging IT Infrastructure for Firm Performance: Perspectives on IT Resource Positioning under Environmental Dynamism, Working Paper (CRITO, University of California, Irvine, 2006).
[57] P.P. Tallon, K.L. Kraemer and V. Gurbaxani, Executives' Perceptions of the Business Value of Information Technology: A Process-oriented Approach, Journal of Management Information Systems 16(4) (2000) 145-173.

[58] D. Teece, G. Pisano and A. Shuen, Dynamic Capabilities and Strategic Management, Strategic Management Journal 18(7) (1997) 509-533.
[59] N. Venkatraman, The Concept of Fit in Strategy Research: Toward Verbal and Statistical Correspondence, Academy of Management Review 14(3) (1989) 423-444.
[60] W. Wade and J. Hulland, The Resource-based View and Information Systems Research: Review, Extension, and Suggestions for Future Research, MIS Quarterly 28(1) (2004) 107-142.
[61] P. Weill and M. Broadbent, *Leveraging the New Infrastructure: How Market Leaders Capitalize on Information Technology* (Harvard Business School Press, Cambridge, MA, 1998).
[62] P. Weill and J.W. Ross, *IT Governance* (Harvard Business School Press, Boston, MA, 2004).
[63] P. Weill, M. Subramani and M. Broadbent, Building IT Infrastructure for Strategic Agility, Sloan Management Review 44(1) (2002) 57-65.
[64] C.E. Werts, R. Linn and K. Jöreskog, A General Method of Estimating the Reliability of a Composite, Educational and Psychological Measurement 38 (1978) 933-938.
[65] G. Westerman, *IT Leadership, Agility, and Financial Performance* (CISR, MIT Sloan School, 2005).
[66] Wikipedia, Zara Clothing, (2006), last accessed: December 27, 2006 at: http://en.wikipedia.org/wiki/Zara_%28clothing%29.
[67] A. Zaheer and S. Zaheer, Catching the Wave: Alertness, Responsiveness, and Market Influence in Global Electronic Networks, Management Science 43(11) (1997) 1493-1509.

APPENDIX

Business Executive / Strategic Planner / CFO Survey

1. To what extent do you agree that your firm can easily and quickly perform the following business actions?

Business Process Agility *(BPA 1 – 8)*	Do Not Agree						Agree Completely
Respond to changes in aggregate consumer demand.	1	2	3	4	5	6	7
Customize a product or service to suit an individual customer.	1	2	3	4	5	6	7
React to new product or service launches by competitors.	1	2	3	4	5	6	7
Introduce new pricing schedules in response to changes in competitors' prices.	1	2	3	4	5	6	7
Expand into new regional or international markets.	1	2	3	4	5	6	7
Change (i.e., expand or reduce) the variety of products / services available for sale.	1	2	3	4	5	6	7
Adopt new technologies to produce better, faster and cheaper products and services.	1	2	3	4	5	6	7
Switch suppliers to avail of lower costs, better quality or improved delivery times.	1	2	3	4	5	6	7

2. Please complete the following for a flagship product or service sold by your firm.

N= ___ Average length of the life cycle of the product or service (in months).
%= ___ What % of customers is turned over (i.e., lost or replaced) in a year?
%= ___ What % of sales comes from products or services launched inside the last 2 years?

3. Please indicate the type of relationship that exists between the business and IT executives in your firm.

IT-Business Partnership *(ITBP 6 – 10)*	Do Not Agree						Agree Completely
IT executives are active in shaping business strategy.	1	2	3	4	5	6	7
IT executives promote IT among business executives.	1	2	3	4	5	6	7
IT executives are called upon to help solve business problems.	1	2	3	4	5	6	7
Business and IT executives work closely together on IT issues.	1	2	3	4	5	6	7
Business and IT executives share a common vision for using IT.	1	2	3	4	5	6	7

IT Executive Survey

1. What are your firm's goals for current IT investments?

Strategic IT Planning *(SITP 1 – 4)*	Do Not Agree						Agree Completely
IT should reduce our costs, increase quality, speed and efficiency.	1	2	3	4	5	6	7
IT should enhance the effectiveness of our overall performance.	1	2	3	4	5	6	7
IT should extend our market and geographic reach.	1	2	3	4	5	6	7
IT should help us to change industry and market practices.	1	2	3	4	5	6	7

2. What processes do business and IT executives use to evaluate major IT investments?

Post Implementation Reviews *(Post 1 – 4)*	Never Used						Use is Mandatory
Formal post-implementation reviews.	1	2	3	4	5	6	7
Regular reviews by business units.	1	2	3	4	5	6	7
Ad-hoc, milestone reviews of projects.	1	2	3	4	5	6	7

3. Please indicate the type of relationship that exists between the business and IT executives in your firm.

IT-Business Partnership ***(ITBP 1 – 5)***	Do Not Agree						Agree Completely
Business executives are active in shaping IT strategy.	1	2	3	4	5	6	7
Business executives are openly in favor of using IT.	1	2	3	4	5	6	7
Business executives consider the competitive use of IT.	1	2	3	4	5	6	7
Business executives understand how IT supports business goals.	1	2	3	4	5	6	7
Business executives champion greater use of IT.	1	2	3	4	5	6	7

4. To what extent do you agree with the following statements on IT infrastructure in your firm?

Hardware Compatibility ***(HC 1 – 4)***	Do Not Agree						Agree Completely
Software applications can be easily transported and used across multiple platforms	1	2	3	4	5	6	7
Our user interfaces provides transparent access to all platforms and applications	1	2	3	4	5	6	7
Our firm offers multiple interfaces or entry points (e.g., web access) to external users	1	2	3	4	5	6	7
Our firm makes extensive use of middleware to integrate key enterprise applications	1	2	3	4	5	6	7
Software Modularity ***(SM 1 – 4)***	Do Not Agree						Agree Completely
Reusable software modules are widely used throughout our systems development unit	1	2	3	4	5	6	7
Legacy systems within our firm do not hamper the development of new IT apps.	1	2	3	4	5	6	7
Functionality can be quickly added to critical applications based on end-user requests	1	2	3	4	5	6	7
Our firm can easily handle variations in data formats and standards	1	2	3	4	5	6	7
Network Connectivity ***(NC 1 – 4)***	Do Not Agree						Agree Completely
Our company has a high degree of systems inter-connectivity	1	2	3	4	5	6	7
Our systems are sufficiently flexible to incorporate electronic links to external parties	1	2	3	4	5	6	7
Remote users can seamlessly access centralized data	1	2	3	4	5	6	7
Data is captured and made available to everyone in the firm in real time	1	2	3	4	5	6	7
IT Skills Adaptability ***(ITSA 1 – 4)***	Do Not Agree						Agree Completely
Our IT personnel are encouraged to improve their technical skills	1	2	3	4	5	6	7
Our IT personnel can quickly develop technical solutions to business problems	1	2	3	4	5	6	7
Our IT personnel are adept at multi-tasking	1	2	3	4	5	6	7
Our IT personnel are trained in a variety of programming methodologies and tools	1	2	3	4	5	6	7

Notes

[1] The distinction between resources and capabilities is subtle but important. While, resources are the basic building blocks of capabilities, capabilities are the primary source of competitive advantage [25]. Rather than focus on web services or other IT resource innovations, capabilities asks what these resources enable the firm to achieve.

[2] Environmental flux has most often been measured on the basis of perceptions of heterogeneity (differences in competitive tactics, customer tastes, product lines, distribution channels), hostility (variations in product pricing, technology competition, regulation, unfavorable demographic trends), munificence (abundance or scarcity of key resources), and dynamism (amount and unpredictability of change in customer tastes, technologies and modes of competition) [37,38].

[3] When using subgroup analysis to evaluate moderation in PLS, Carte and Russell [16] suggest the use of Box's M to test if item loadings are similar in each group. Significant differences in item loadings could complicate efforts to interpret and compare the path coefficients within each group. We find no significant differences in this study between item loadings for firms in stable and unstable markets.

[4] We also tested an alternative model to the one indicated in Figure 1 where interaction terms were used to model a moderation effect: managerial IT capabilities moderating the link between technical IT capabilities and agility or technical IT capabilities moderating the link between managerial IT capabilities and agility – product terms are identical in each case [59]. We then estimated this model for our entire sample and for both sub-samples. In each model, the moderator construct was insignificant, confirming that there is no interaction between both sets of IT capabilities and that they each influence agility independent of each another.