A RESOURCE BASED AND REAL OPTIONS PERSPECTIVE ON IT INFRASTRUCTURE INVESTMENTS AIMING FOR STRATEGIC FLEXIBILITY

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Abstract

Today's turbulent environment increases the degree of uncertainty organizations can experience. Organizations differentiate and develop a repertoire of competencies to respond to, and to influence this environment. The degree to which organizations can respond to the competing demands is a measure of an organization's strategic flexibility. The business imperative of strategic flexibility is posing new requirements on the IT capabilities to deliver applications that facilitate responsiveness to customer demands and provide cost-effective, scalable infrastructures that enable enterprise-wide business processes. In literature, IT infrastructure is regarded as a major resource for attaining competitive advantage. We present a model using resource based theory and real option theory. The presented model lays a theoretical foundation that can be used as a basis for future empirical research. In this research we will try to answer how firms, in a turbulent environment, structure their IT infrastructure resources and capabilities and how they capture the value of managerial flexibility of IT infrastructure investment opportunities in their aim for strategic flexibility.

Keywords: IT infrastructure, strategic flexibility, real options theory, resource based theory

1 INTRODUCTION

The fascination and challenges associated with electronic business environments[1] coincides with an increasing turbulent and competitive business landscape, in which the intensity, unpredictability and diversity of change accelerates to create a condition of constant flux (D'Aveni 1994). Confronted by this complex and turbulent environment, organizations strive for strategies to be able to respond flexible to the complex and volatile environment, while at the same time being in control (Volberda 1998). As IT operates at the core of electronic business environments, the efficiency and flexibility with which IT capabilities - applications, infrastructures, skills and expertise- are developed and embedded in the organizational design becomes business critical (Bharadwaj 2000).

It has been recognized that IT infrastructure, which makes feasible both innovation and continuous improvement of information systems, can be either a potential enabler of change or a potential constraint or inhibitor, particularly when the organization's IT infrastructure is 'inappropriate' or 'inflexible'(Duncan 1995). The IT infrastructure underpins a firm's competitive position by enabling initiatives such as cycle time improvement, cross-functional processes and cross-selling opportunities (Sambamurthy and Zmud 1992; Weill and Broadbent 1998).

A potential framework for analysing how firms structure their IT infrastructure assets and resources when coping with a turbulent and complex environment is the resource based theory. Adopting a resource based view of IT infrastructure, it is argued that a firm's overall effectiveness is determined by the leverage of a firm's investments to create unique IT resources and skills that are firm-specific, rare and difficult to imitate or substitute (Barney 1991, Clemons 1991 , Mata et al. 1995). Another framework we will use is real options theory. Real options theory can be seen as an alternative to resource based theory in situation involving irreversible decisions under high uncertainty. Since the decision processes surrounding investment in IT infrastructure are complicated by uncertainty about expected payoffs and irreversibility in the costs of implementation, real option theory can be used to structure the evaluation and management of investment opportunities and can thereby capture the value of managerial flexibility (Fichman, 2003). Option thinking implies that managers should be more inclined to initiate uncertain investments in IT, and also be more likely to redirect or terminate uncertain projects. This may ask for different ways of structuring assets and resources than resource based theory does, since resource based theory favors investments that minimize the current level of uncertainty and performance variance (McGrath and Dubini, 1999).

In this paper we present a research model to analyse the relations between IT investments, IT infrastructure capabilities and IT option value favorability in the aim for strategic flexibility. In our research we use the two theories, resource based theory and real option theory, to better explain the relationship between the value of managerial flexibility of IT infrastructure investments and the way IT infrastructure assets and resources are structured when coping with a turbulent and complex environment.

The paper is structured as follows. We first define and analyse strategic flexibility in section two, IT infrastructure in section three and summarize resource based theory and real options theory in section four. In the fifth and final section we will define the research model and the research questions that we propose to evaluate using case study analysis.

[1] By electronic business environments we broadly refer to the automation of business activities, transactions, communication and interaction using computer and communications technologies for commercial purposes. The definition of e-business includes inter-organizational systems such as Internet and e-mail or internal computing which is in support of commercial online exchange (Jarvenpaa et al, 1999).

2 STRATEGIC FLEXIBILITY AND IT INVESTMENTS

D'Aveni (1994) metaphorically describes the contemporary business environment as 'hypercompetitive'. The confluence of complex and dynamic environments, through the intermediate variables of (low) predictability, (low) comprehensibility, (high) diversity and (high) flexibility increases the degree of uncertainty organizations can experience (Mintzberg 1978, Daft 1998). According to Volberda (1998), the turbulence of a firms environment, and thereby their needed degree of organizational flexibility, is formed by its competitive forces. These forces range from financiers, markets, knowledge and resources, suppliers and product-market combinations to competitors, customer groups and products or services. On the basis of these forces, he defines a high degree of environmental turbulence in terms of (1) high dynamism, the degree to which competitive forces remain basically static over time or are in a continual process of dynamic change, (2) high complexity, which depends on the number of factors within a competitive force and their relatedness, and can range from simple to complex, and (3) high unpredictability, which reflects the extent to which cause-effect relationships concerning competitive forces are incomplete.

Confronted by a complex and turbulent environment, organizations differentiate and develop a repertoire of competencies to respond to, and to influence their external environment (Hitt et al. 1998). The degree to which organizations can achieve the competing demands is a measure of an organization's strategic flexibility, i.e., developing differentiated capabilities to pro-act in an integrated manner to unanticipated changes (Hitt et al 1998). Volberda (1998) defines strategic flexibility as the highest form of organizational flexibility, where strategic flexible firms have a high variety of dynamic capabilities related to the goals of the organization or the environment and a high speed of response. Firms that strive for strategic flexibility can respond to a highly unpredictable, uncertain and complex environment and can change the nature of organizational activities, thereby shaping the ability to control outside environments effectively. The more control an organization has over its competitive environment, the better its potential for a favorable competitive position (Volberda 1998). Firms that build their capability of strategic flexibility internally dismantle current strategy, take on new tasks while sharing scarce information and knowledge resources, develop human resources, apply new technologies, fundamentally renew products and attain company wide synergies. Strategically flexible firms externally focus on adaptability and responsiveness to new and unexpected market demands, build competencies to influence consumers, use market power to control competitors e.g. by building partnerships) and engage in political activities to influence regulation (Buenger et al. 1996, Volberda 1998, Quinn et al. 2000). Lawrence and Lorsch (1967) indicate that in successful organizations operating in a dynamic environment, innovation in products and processes and responsiveness to customer demands is the dominant competitive issue. In this research, we define a strategic flexible firm as a firm that can quickly implement its core products in new markets while providing for local innovation and local customer responsiveness.

Advancements in information technologies are enabling organizations to attain the requisite dynamic stability for integrating the differentiated organizational capabilities needed for strategic flexibility. IT has become an integral part of the organizational design, wherein the market and technology strategy are intimately interwoven requiring seamless integration of the competences and capabilities of each (Boynton 1993, Sambamurthy 2000). Subsequently, the strategic planning process of today's successful firms involves discussions about the opportunities which are presented by the firm's IT capabilities – applications, infrastructures, skills and expertise- (Ross 2003). The business imperative of strategic flexibility is posing requirements on the IT capabilities to deliver applications that facilitate business responsiveness to customer demands in a rapid and efficient manner and provide cost-effective, scalable infrastructures and operations that enable cycle time improvement and streamlined, enterprise-wide business processes (Information Week, 1999). These IT capabilities would include being able to access specific data for new applications, integrate data from related processes or replicate systems in new locations. The arising IT-enabled business opportunities can provide agility and introduce the challenge of strategic experiments and are experienced as unanticipated sources of value (Ross, 2003).

3 IT INFRASTRUCTURE AS A MAJOR BUSINESS RESOURCE

Research shows that a firm's IT infrastructure is a major business resource and a key source for attaining long-term competitive advantage (Keen 1991, Weill and Broadbent 1998, Venkatramann 1994, Davenport and Lindner 1994). IT infrastructure (figure 1) can be shared across boundaries and enable better business processes (Caron et al. 1994). The IT infrastructure is the choices pertaining to 'the shared IT resources consisting of the technical physical base of hardware and software, communications technology, data, core applications and a human component of skills. The human IT infrastructure includes human and organizational skills, expertise competencies, knowledge commitments, values, norms and organizational structures to plan, build and use the IT infrastructure.

Sauer and Willcocks (2003) note that there is a lack of any definitive distinction between infrastructure technologies and non-infrastructure technologies, and that any part of a company's technology investment can both enable and constrain business initiatives. They prefer to talk about technology investment, technology base, platform or IT assets. Although we use the term IT infrastructure we are well aware of the fact that IT infrastructure is a context-bound, layered notion which implies that what is considered to be infrastructure on one level, can be local for a higher level, depending on the level of analysis.

Many business strategies depend on specific underlying technology capabilities. The IT infrastructure of the organization is an important consideration in its ability to design and implement new business process applications to respond to emerging business opportunities. It can not only reduce time delays along the value chain but also enable the organization to source and distribute its products and services anytime, anywhere. An enabling infrastructure provides architectures and platforms for new applications and new businesses and permits a number of as-yet-unspecified business strategies to be implemented more rapidly than in firms with a less enabling infrastructure (Weil and Broadbent 1998). An analysis of projects in manufacturing firms identified IT infrastructure as providing increased flexibility, improved communication and integration of different functions and organizations. Weill and Broadbent (1998) showed that when firms have developed a high level of IT infrastructure capabilities, they were able to implement extensive changes to their business processes over relatively short time frames.

Weill, Subramani and Broadbent (2002) define IT infrastructure as a collection of reliable, centrally coordinated services and comprising both technical and human capability. They identified ten clusters of IT infrastructure services (see figure 1).

The first six clusters comprise the *physical* layer of IT infrastructure capability: (1) channel management, electronic channels firms need to link to customers and partners, (2) security and risk-management services, which provide protection for the firm's brand, reputation, data, equipment and revenue stream, (3) communication services, through which electronic interactions with customers and partners occurs, (4) data-management services, which provide for management of data assets, (5) application infrastructure services, applications that are standard across the firm, (6) IT facilities management services, which coordinates and spans the physical infrastructure layers and adds value by integrating the five other physical layers. In addition to the six clusters that constitute a firm's physical IT infrastructure capabilities, there are four clusters representing *management-oriented* capabilities: (7) IT management services, which coordinate the integrated infrastructure and manage its relationships with the business units, (8) IT architecture and standards services, which comprises the core policies that govern the use of information technology and that determine how future business will be done, (9) IT-education services, which includes training in the use of specific technologies and education for management on IT investment to create business value, and (10) the IT Research and Development services, which includes the firm's search for new ways to use IT to create business value.

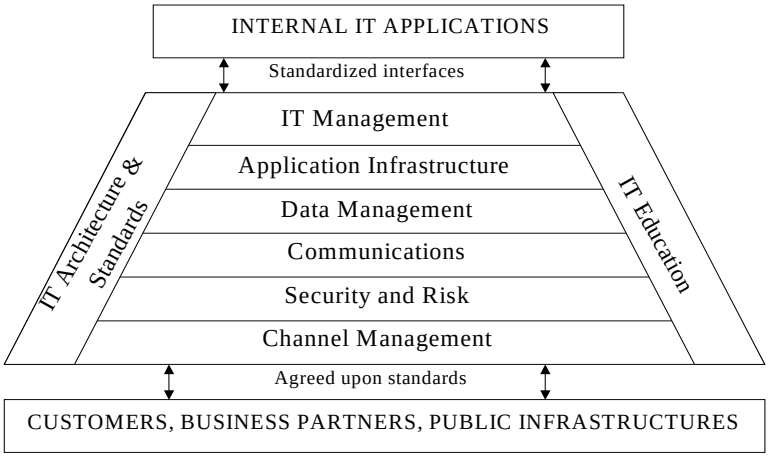

Figure 1. *An integrated IT infrastructure with 10 capability clusters according to Weill, Subramani and Broadbent (2002)*

Recent research (Duncan 1995, Barhadwaj 2000, Byrd and Turner 2001, Ross 2003) has focused on how to structure the IT infrastructure assets and resources. Duncan (1995) has defined the 'flexibility' of the IT infrastructure, which is measured by its (1) modularity, the ability to add, modify, and remove any software, hardware or data components with ease and with no major overall effect, its (2) connectivity, the ability of any technology component to attach to any of the other components inside and outside the organizational environment and its (3) compatibility, the ability to share any type of information across any technology component.

Ross (2003) distinguishes four IT architecture stages which differ in the logical design infrastructure, including data and applications, the IT capabilities they provide, the strategic opportunities they present and the IT management and governance they demand. The term architecture and infrastructure are sometimes used interchangeably, with architecture seen as the plan for the next infrastructure. The four stages are (1) the application silo architecture, which consists of architectures of individual applications, (2) the standardized technology architecture, which becomes enterprise-wide and provides efficiencies through technology standardization, (3) the rationalized data architecture, which expands to include standardization of data and processes, and (4) a modular architecture, which builds onto enterprise-wide global standards with loosely coupled applications, data and technology components to preserve the global standards while enabling local differences.

This last modular architecture stage introduces the challenges of componentisation, customisation, strategic experiments and reuse. This last stage creates the opportunity for strategic agility through customized or reusable modules so that a firm can quickly implement its core products. In this stage, top management has defined and standardized the core of the business and by ensuring the predictability of core processes, has leveraged the firm's distinctiveness. With a wired core, agility can be provided in two ways: (1) by creating reusable modules and allowing business units to select customer-oriented processes from a menu of options, and (2) by giving business units greater discretion in their local processes as long as they can connect to the wired core processes. By enabling local customisation, innovation and customer responsiveness can be encouraged. According to Ross (2003), to benefit from modular architectures, firms need to learn how to quickly identify strategic opportunities that best leverage their core and then quickly develop or reuse modules that extend that core. Ross' view is in line with today's move towards grid computing, standardization of components

(e.g. web services) and open systems that provide a stable platform to build on and offer new ways of differentiation, either by costs, products or services that meet unknown future needs.

4 THEORETICAL FRAMEWORKS

To help underpin the research on strategic flexibility and IT infrastructure, we draw insight from two theoretical frameworks, resource based theory and real option theory. Using resource based theory, one can explain how organizations structure their technological assets and resources to take advantage in a competitive market environment. Options theory suggests how firms can capitalize on their strategic options in a fast and changing business environment (Amran and Kulatilaka, 1999). The so obtained combined approach will be suited to the study of how organizations structure their IT infrastructure assets and resources given the uncertainty and irreversibility of their IT infrastructure investments in a highly uncertain and turbulent market environment.

4.1 Resource based theory and IT infrastructure capabilities

The resource based theory addresses the question of why some organizations achieve and sustain a competitive advantage, while others don not succeed in achieving their goals. The resource based view is the dominant theoretical perspective in strategic management literature and posits that firms compete on the basis of 'unique' corporate resources that are valuable, rare, difficult to imitate and non-substitutable by other resources (Barney 1991). It operates under the assumptions that these resources tend to survive competitive imitation because time is needed to acquire the resource, the resource is unique due to for example distinctive location or first mover advantage or the resource is inexplicably linked to another complementary resource (Barney 1991, Dierickx and Cool 1989).

Grant (1991) distinguishes between resources and capabilities. While resources serve as basic units of analyses, firms create competitive advantage by assembling, integrating and deploying valued resources that work together to create organizational capabilities. Resources can be classified into tangible, intangible and personnel-based resources. Tangible resources include the financial capital and physical assets of the firm. Intangible resources encompass assets such as reputation and product quality. Personnel based resources include technical know-how and other knowledge assets including dimensions such as organizational culture or loyalty (Bharadwaj 2000).

The resource based view on IT argues that IT investments do not provide any sustained advantages. Rather, by investing in IT firms can create unique IT resources and skills that determine a firm's overall effectiveness (Clemons 1991, Mata et al. 1995). Thus, despite uniformly high investments in technology, IT resources and skills tend to be heterogeneously distributed across firms, leading to different patterns of IT use and effectiveness.

Bharadwaj (2000) extends the traditional notion of organizational capabilities to a firm's IT capabilities, which is defined as its ability to mobilize and deploy IT-based resources in combination or copresent with other resources and capabilities. Key IT-based resources which in combination create a firm-wide IT capability, are classified as (1) the physical IT infrastructure resource, (2) the human IT resources, comprising the technical and managerial skills, and (3) the intangible IT-enabled resources. Firms with high IT capabilities tend to outperform on a variety of profit and cost-based performance measures (Bharadwaj 2000).

We use resource based theory because it explains how organizations assign resources to strategic choices and more specifically how organizations structure their IT infrastructure assets and resources when dealing with a turbulent and complex environment.

4.2 Options theory and IT infrastructure investments

The resource based theory has been criticized for advocating over-investment in existing assets and competencies that support today's strategy, leaving firms prisoner of their past (Williamson 1999). Resource based theory favors investments that minimize the current level of uncertainty and performance variance (Peffer and Salancik 1978). Real options theory is seen as an alternative to resource based theory in situations involving irreversible decisions under high uncertainty and offers a framework for valuing incremental resource investments and choice processes under highly uncertain and volatile environments with complex asset structures. According to the real options theory, which is based on the assumption that 'people seek to keep options open', increased volatility of the underlying assets increases the value of the option because the potential gains of an investment are greater while the costs to access them remain the same (McGrath 1997). External uncertainty is transformed through the firm's assets to uncertainty about the value of the strategic investment. In the traditional view the firm's exposure to external uncertainty remains large. Real options in strategic investment processes allow managers to reduce exposure to bad outcomes and enhance exposure to good outcomes, modifying the exposure of the firm's assets to uncertainty and increasing the value of strategic investment (Amran and Kulatilaka 1999). The value of an option represents the potential benefit a firm may reap in the future beyond a value that can be estimated using the current organizational capabilities and knowledge. The option-theoretic perspective argues that option-potential is maximized when a firm can make investments that create new knowledge, generate information or utilize existing resources in new combinations that are not available to other firms. For example, say that a firm has the option to invest in a new telecom based non-proven technology. From the theory of real options it is known that the option value of waiting with investment increases with revenue uncertainty. This implies that increased uncertainty delays adoption of the current non-proven technology and the possible invention of more efficient technology raises the option value of waiting to invest in the current technology.

The real options approach argues for a highly flexible organizational form and assumes an integrative strategic vision (Jarvenpaa and Tiller 1999). Strategy is seen as a path of related options; there is no such thing as a well thought-through overall strategy. An option arises from the interplay of the organization's existing investments, its knowledge and capabilities and its environmental opportunities (Bowman and Hurry 1993). The firm must monitor continuously the value and risk of options and respond flexibly to what it has just learned about business conditions, competitors moves, governmental action and so forth.

Within information system research, option models have been shown to be applicable to making IT investments and shedding insight on the issues of timing and scaling up IT investments under changing market conditions. The three conditions which are prerequisite to using the real options concepts to structure the evaluation and management of technology or other uncertain investments are uncertainty regarding net payoffs, irreversibility in project costs and managerial flexibility regarding how projects are structured (Fichman 2003). Option thinking implicates that managers should be more inclined to initiate uncertain investments in IT (Tuades et al. 2000), and also be more likely to redirect or terminate uncertain projects (Keil et al. 2000). The value of an option depends on the payoffs of the contingent decision, the length of time to decision date and volatility. Higher volatility leads to a higher chance of a good outcome, and thus to a higher outcome.

There are limitations however in applying options theory to emerging technology investments, since the development costs and adoption and diffusion rates are unknown to both the depending firm and the industry at large (Benaroch and Kaufmann 1999). However, Fichman has developed a set of qualitative factors for valuing IT platform[2] investments, where quantitative estimation of option is not

[2] An IT platform is broadly defined as a general-purpose technology that enables a family of applications and related business opportunities, and includes computing platforms (e.g. Palm OS); infrastructure platforms (e.g. wireless networking); software development platforma (e.g. Java); and enterprise application platforms (e.g. ERP) (Fichman, 2003)

feasible. Fichman (2003) notes that certain characteristics of organizational IT innovation compound uncertainty and have implications for irreversibility or managerial flexibility. These four characteristics not only increase the salience of real options, but they also interact with more specific determinants of option value. He presents a model which proposes that IT platform investments will have a higher option value and thus an organization will be more likely to imitate such investments, when: (1) the processes and products affected have greater strategic importance, (2) the competitive advantages are more sustainable, (3) the organization possesses greater innovation-related capabilities and endowments, (4) the organization possesses greater learning-related capabilities and endowments, (5) the learning associated with the technology is less product-specific, (6) use of technology contributes to absorptive capacity in more exploitable domains, (7) the IT platform's technology class is better poised for dominance, (8) the technology instance within the class is better poised for dominance, (9) the organization has a greater opportunity to tailor the innovation to complementary assets and (10) the organization has a greater opportunity to pursue a more incremental deployment strategy.

We use real option theory because it helps organizations to value their managerial flexibility regarding irreversible and uncertain IT infrastructure investment decisions. Fichman's approach regarding real options theory for valuing IT investments will be used, since it supports a more qualitative analysis that does not involve often unknown IT development and adoption costs.

5 RESEARCH PROPOSAL AND CASE STUDY DESIGN

In the previous sections we have reviewed literature on IT investments, strategic context, and strategic flexibility. Two theories (resource based theory and real option theory) were summarized that have been proposed in information management literature to explain the relationships between strategic context and strategic flexibility. We now present a research model that combines the two theories.

The first part of the model (figure 2) connects strategic context (A), IT infrastructure resource investment (B), IT infrastructure capabilities (C) and strategic flexibility (E).

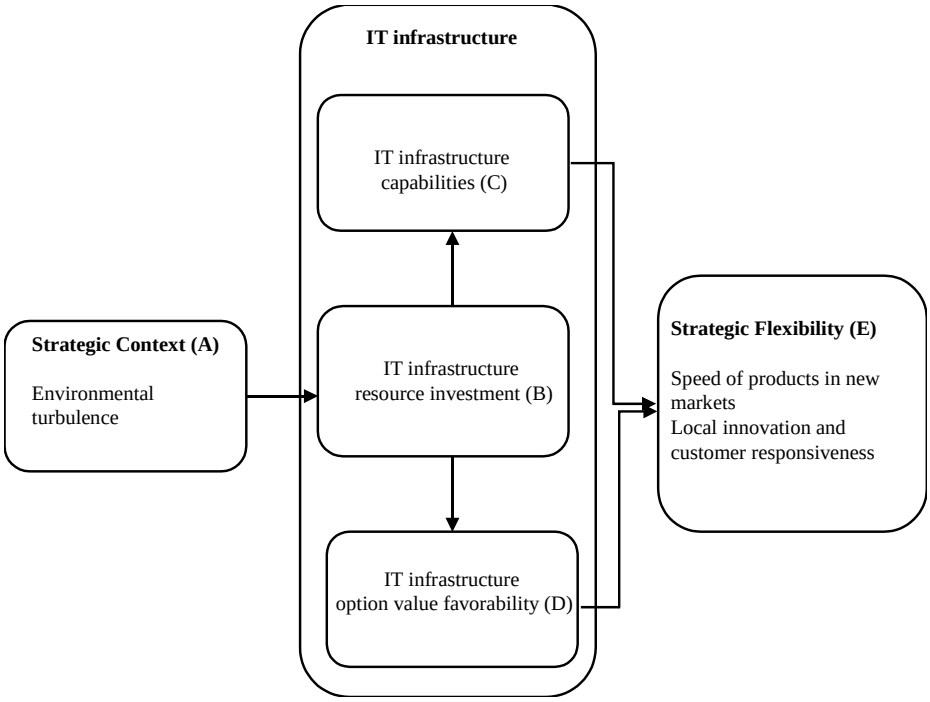

Figure 2. The research model

The strategic context (A) is defined as the degree of environmental turbulence. Environmental turbulence will be measured following Volberda (1998) in terms of (1) dynamism, (2) complexity and (3) unpredictability, which are all formed by the competitive forces an organization challenges.

The IT infrastructure related resources (B) will be classified following the categorization of Grant (1991) and Bharadwaj (2000) who distinguish between (1) the physical IT infrastructure resources, (2) the human IT resources, comprising the technical and managerial skills, and (3) the intangible IT-enabled resources. Also the IT infrastructure can be categorized following Ross (2003), who distinguishes between into (1) the application silo architecture, (2) the standardized technology architecture, (3) the rationalized data architecture and (4) a modular architecture.

The IT infrastructure capabilities (C) will be categorized using Weill, Subramani and Broadbent (2002) who define IT infrastructure as a collection of reliable, centrally coordinated services, which constitute of six clusters that comprise the *physical* layer of IT infrastructure capability: (1) channel management, (2) security and risk-management services, (3) communication services, (4) data-management services, (5) application infrastructure services, (6) IT facilities management services. In addition they distinguish four clusters representing *management-oriented* capabilities: (7) IT management services, (8) IT architecture and standards services, (9) IT-education services and (10) the IT Research and Development services.

As mentioned in part two of this paper, we define a strategic flexible firm (E) as a firm that can quickly implement its core products in new markets while providing for local innovation and local customer responsiveness. Since in a turbulent and volatile environment market and technology strategy require seamless integration of the competences and capabilities of each, firms respond to this environment by investing in IT infrastructure in order to provide architectures and platforms for speed and flexibility of new applications and new businesses and permit a number of as-yet-unspecified business strategies (A-> B). Combinations of these resources can produce capabilities, which can be beneficial in the aim for quickly implementing core products in new markets and providing for local

innovation and local customer responsiveness (B->C->E). The model in figure 2 raises the following *research question (1)*, which will lead our further investigation: How do strategically flexible firms (E) structure their IT infrastructure resources (B) and capabilities (C) when coping with a turbulent and complex environment (A)? And more specifically, how do the distinguished IT infrastructure capabilities (C) differ in the extent of strategic flexibility (E) they provide?

The second part of the research model connects strategic context (A), IT infrastructure resource investment (B), IT infrastructure option value favorability (C) and strategic flexibility (E).

The option value (D), where a high option value stands for greater managerial flexibility and a low option value stands for low flexibility, will be measured according to Fichman (2003) by (1) the strategic importance of processes and products affected, (2) the sustainability of competitive advantages, (3) the innovation-related capabilities and endowments the organization possesses, (4) the learning-related capabilities and endowments that the organization possesses, (5) the degree of product-specific learning associated with the technology, (6) the absorptive capacity in other exploitable domains that the use of technology contributes to, (7) the degree to which the IT platform's technology class is poised for dominance, (8) the degree to which the technology instance within the class is poised for dominance, (9) the degree to which the organization has the opportunity to tailor the innovation to complementary assets and (10) the degree to which the organization has the opportunity to pursue a more incremental deployment strategy. The IT infrastructure resource investment will lead to the estimation of a certain option value (B->D), where a high option value equals greater managerial flexibility and thus support for strategic flexibility (D->E). The model in figure 2 raises the following *research question (2)* that requires further investigation: How do strategically flexible firms (E) manage IT infrastructure resource investment opportunities (B) and capture the value of managerial flexibility (D) in a turbulent environment (A)?

In order to evaluate the above two questions, we will conduct an exploratory case study in a firm that fits our definition of strategic flexibility. A case study will be undertaken in an information intensive organization (e.g. banking). We will look at the IT infrastructure investments (in the organization over time), which will lead us to draw conclusions on the obtained IT infrastructure capabilities and option value favorability of the investments made. In this way, resource based theory and real option theory can be applied in practice. In a next step, this might lead to survey based analysis to compare IT infrastructure resource investment in flexible firms with those in non-flexible firms in a turbulent environment.

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