



Enterprise agility and the enabling role of information technology

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Abstract

In turbulent environments, enterprise agility, that is, the ability of firms to sense environmental change and respond readily, is an important determinant of firm success. We define and deconstruct enterprise agility, delineate enterprise agility from similar concepts in the business research literature, explore the underlying capabilities that support enterprise agility, explicate the enabling role of information technology (IT) and digital options, and propose a method for measuring enterprise agility. The concepts in this paper are offered as foundational building blocks for the overall research program on enterprise agility and the enabling role of IT.

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Introduction

As strategic and operating conditions become increasingly turbulent due to factors such as hyper-competition, increasing demands from customers, regulatory changes, and technological advancements, the ability to sense relevant change and respond readily becomes an important determinant of firm success. The term 'agile' is commonly used to describe firms that are able to adapt to and perform well in rapidly changing environments (Dove, 2001; Weill *et al.*, 2002; Sambamurthy *et al.*, 2003; Gartner, 2004). Agility builds upon other concepts in management theory that pertain to firm success in turbulent environments, including dynamic capabilities (Teece *et al.*, 1997), strategic flexibility (Ansoff, 1980; Hitt *et al.*, 1998), market orientation (Kohli & Jaworski, 1990; Narver & Slater, 1990), and absorptive capacity (Cohen & Levinthal, 1990; Zahra & George, 2003).

Enterprise agility is commonly broken down into two components: sensing and responding. In this paper, we build on this decomposition to make several contributions. First, we present a definition of enterprise agility and distinguish it from similar concepts in management theory. Second, we provide a framework to illustrate the different combinations of firm capabilities for sensing and responding. This facilitates an exploration of the underlying firm-level capabilities that support enterprise agility. Third, we discuss how firm investments in information technology (IT) enable enterprise agility. Drawing on prior work in digital options (Sambamurthy *et al.*, 2003), we explain how IT enables both the sensing and responding components of agility by extending the reach and richness of firm knowledge and processes. Fourth, we discuss directions for future research and offer a starting point for empirical research on enterprise agility and the role of IT by proposing a method to measure enterprise agility.

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The paper is conceptual and seeks to provide a foundation for research on enterprise agility and the role of IT in enabling agility. Defining enterprise agility; delineating it from related concepts; delving into its enablers, with a specific focus on the direct and indirect effects of IT; and proposing a measurement schema are important components of this overall program. As research on agility proliferates, conceptual work of this nature is needed to help structure the overall investigation.

Definition and distinction from similar concepts

Enterprise agility is defined as the ability of firms to sense environmental change and respond readily. As such, enterprise agility consists of two components: sensing and responding. These two components appear in multiple definitions of agility culled from prior academic and business literature. For example, Dove (2001) referred to the responding component as ‘response ability’, which he defines as the physical ability to act, and to the sensing component as ‘knowledge management’, which he defines as the intellectual ability to find appropriate things to act on. We consider environmental change to encompass changes precipitated by competitors’ actions, consumer preference changes, regulatory or legal changes, economic shifts, and technological advancements. This broad conceptualization of environmental change allows enterprise agility to apply to a wider range of change drivers as compared to similar concepts, such as technological opportunism (Srinivasan et al., 2002), that deal with a specific change driver. Figure 1 illustrates the components of enterprise agility and its relationship to prior literature.

Enterprise agility builds upon other concepts in management theory that pertain to firm success in turbulent environments, including dynamic capabilities (Teece et al., 1997), market orientation (Kohli & Jaworski, 1990; Narver & Slater, 1990), absorptive capacity (Cohen & Levinthal, 1990; Zahra & George, 2003), and strategic flexibility (Ansoff, 1980; Grewal & Tansuhaj, 2001). However, enterprise agility is distinct from these concepts in important ways.

Dynamic capabilities are a firm’s ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments (Teece et al., 1997). A basic tenet is that firms must continuously adapt their capabilities in order to maintain competitiveness (and perhaps competitive advantage.) Although the concept of dynamic capabilities shares many of the same concepts with enterprise agility – particularly its relevance to rapidly changing environments – dynamic capabilities is a much broader concept. The dynamic capabilities concept is relevant to all types of firm processes, whereas enterprise agility includes only those processes relevant for sensing and responding to environmental change. In a sense, enterprise agility can be thought of as being enabled by a specific subset of dynamic capabilities.

The *market orientation* of a firm is reflected in the organization-wide generation of market intelligence pertaining to current and future customer needs, dissemination of the intelligence across departments, and organization-wide responsiveness to it (Kohli & Jaworski, 1990). Market intelligence includes information about customers, competitors, and other factors such as technology and regulatory developments. As such, the market orientation concept includes all of the drivers of ‘environmental change’ encompassed in the definition of enterprise agility. Similarly, both concepts explicitly include responsiveness to market intelligence and environmental change. However, there are slight differences between the two concepts. For example, market orientation is heavily rooted in information processing: information is gathered, disseminated across departments, and acted upon. Conversely, enterprise agility is not necessarily as reliant on information processing. For example, it is possible for firms to act with agility without disseminating information across departments. In addition, it is possible that disseminating information across departments may actually delay response and make firms less agile.

Absorptive capacity, as recently re-conceptualized, is a set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit

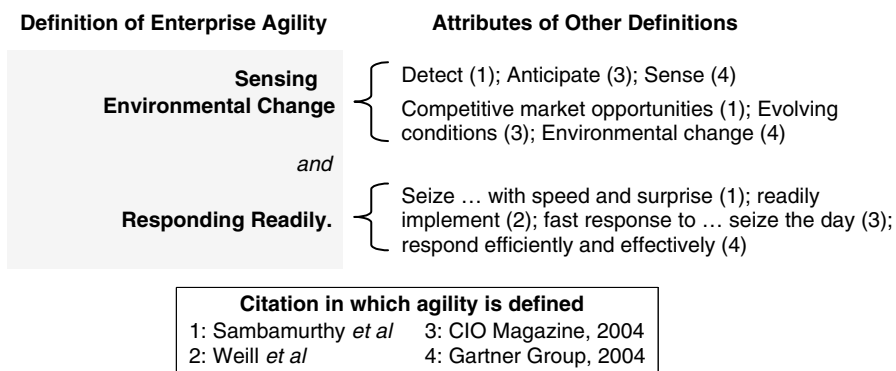


Figure 1 Attributes of enterprise agility.

knowledge to produce a dynamic organizational capability (Zahra & George, 2003). The acquire and assimilate dimensions of absorptive capacity refer to firms' ability to gather and make sense of externally generated knowledge. This is similar to the sensing component of enterprise agility. The transform and exploit dimensions are similar to the responding component of enterprise agility in that they pertain to firms' ability to use the newly acquired and assimilated knowledge. The main difference between absorptive capacity and enterprise agility is that absorptive capacity refers predominantly to firms' ability to manage *knowledge* (i.e., by acquiring, assimilating, transforming, and exploiting it), whereas enterprise agility refers predominantly to firms' ability to manage *change* (i.e., by sensing and responding to it.). As a result, enterprise agility is best viewed as applying to episodic events precipitated by environmental change, whereas absorptive capacity operates on a more continuous basis.

Strategic flexibility has been defined as the organizational ability to manage economic and political risks by promptly responding in a proactive or reactive manner to market threats and opportunities (Grewal & Tansuhaj, 2001). Firms possessing strategic flexibility tend to have flexible resource pools and diverse portfolios of strategic options, which allows them to practice effective 'surprise management' (Ansoff, 1980). As reflected in its name, strategic flexibility refers to strategic issues, that is, those that affect the businesses that a firm is in and how it creates competitive advantage in those businesses (Porter, 1987). Strategic issues are distinct from operational or tactical issues (Porter, 1996). Enterprise agility, on the other hand, applies to both strategic and operational issues. For example, firms may need to be agile to handle strategic issues such as those created by competitor moves or changing customer preferences. In addition, firms may also need to be agile to handle operational issues such as those created by new regulations. For example, consider a new federal law that increases firm liability for worker's compensation claims. Agile firms must be able to sense how this change affects their operations and implement any needed safety improvements in a timely manner. Thus, because firms can be agile in both strategic and operational issues, enterprise agility envelops and extends strategic flexibility.

In addition to applying to both strategic and operational moves, enterprise agility can also apply to both proactive and reactive moves (Dove, 2001). To illustrate, consider two competing firms, A and B. Assume that firm A has sensed a pending technological or regulatory change such as the FDA's approval of sucralose sweetener (marketed as Splenda) and launched a new line of low-calorie foods. Firm B, which does not track regulatory and technological developments as closely as does Firm A, senses the change in market demand created by firm A and quickly responds to launch its own line of low-calorie foods made with sucralose. Note that both firms have sensed and responded to environmental change: firm A

has behaved proactively in the face of regulatory and technological change, while firm B has behaved reactively due to a competitor's move.

Enterprise agility applies to sensing and responding capabilities for the entire firm. Thus, it is distinct from forms of agility that apply to specific processes (e.g., software engineering agility) or that operate at different levels of analysis such as a network of firms (e.g., supply chain agility).

The sensing and responding components of enterprise agility

We present a framework for the different combinations of sensing and responding capabilities that firms may possess. The framework presented here is based on an integration of perspectives from the academic literature as well as field-based perspectives from practicing managers. We drew on the works of Dove (2001), as well as others (e.g., Bradley & Nolan, 1998; Weill et al., 2002) who have identified sensing and responding as the critical elements of enterprise agility, to develop our preliminary conceptualization. We subsequently conducted three in-depth interviews and a focus group session to refine our thinking. The interviews were carried out by one of the authors and involved facilitated discussions with the CIO of a large multinational company, an IT consultant, and an academic expert who researches and consults with firms on enterprise agility. The focus group was conducted as a half-day face-to-face session that brought in six experts (four academic experts along with two business/IT consultants) for discussions with the authors. The primary objective of this session was to explore the characteristics of agile firms and delineate the components of enterprise agility. Transcripts of the interviews and the focus group session were analyzed and integrated with the academic literature to develop the framework and other elements presented herein.

The framework, shown in Figure 2, consists of a 2×2 matrix with sensing capability on the x -axis and responding capability on the y -axis. Each cell contains a stylized profile of a firm that displays the relevant combination of sensing and responding capabilities.

In order to explore the framework, we further decomposed our definition of agility to examine (1) the types of environmental change that firms must be able to sense and (2) the types of responses that firms can implement. A summary of this decomposition appears as Table 1.

Sensing environmental change

Recall that relevant forces of environmental change include competitors' actions, consumer preference changes, economic shifts, regulatory and legal changes, and technological advancements. Different firm capabilities may be required to sense each of these types of change. For example, a firm may need a strong *market intelligence* capability to track competitors' actions, consumer preference changes, and economic shifts.

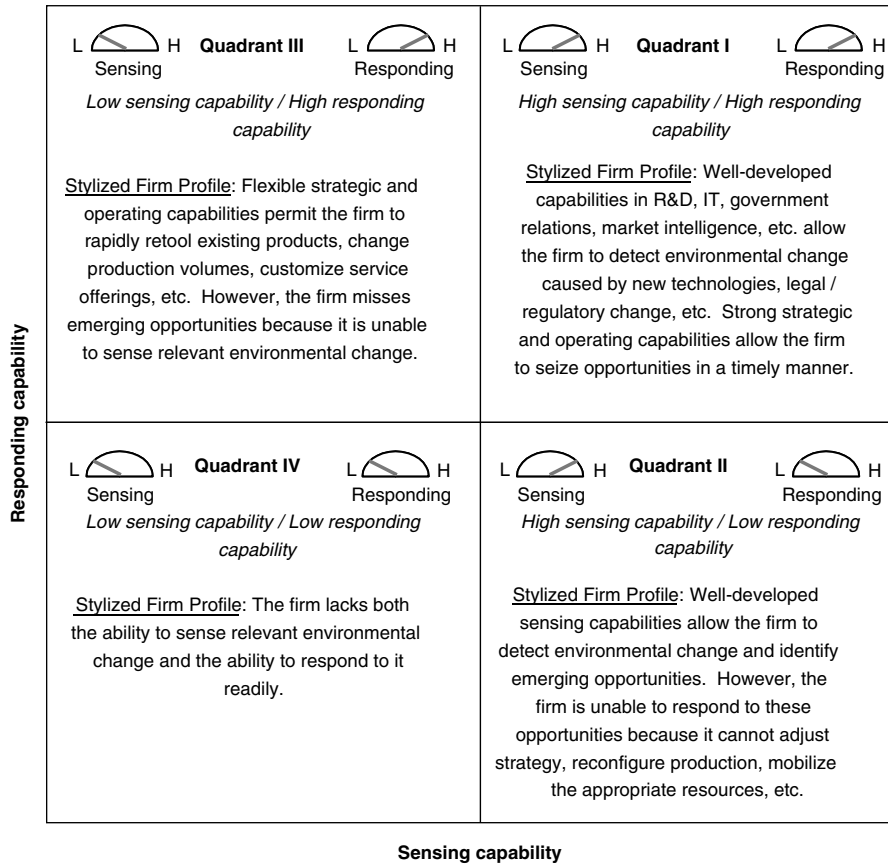


Figure 2 Framework of different combinations of sensing and responding capabilities.

Table 1 Decomposition of sensing and responding capabilities

	Relevant types	Examples of enabling capabilities
Sensing environmental change	<ul style="list-style-type: none"> • Competitors’ actions • Consumer preference changes • Economic shifts • Regulatory/legal changes • Technological advancements 	<ul style="list-style-type: none"> • Market intelligence • Government relations • Legal • Research and development • Information technology
Responding	<ul style="list-style-type: none"> • Embark on new venture (complex) • Adjust existing venture (simple) • No action 	<ul style="list-style-type: none"> • Product development • Systems development • Supply chain • Production • Resource utilization

Similarly, a strong *government relations* or *legal* department may be required to sense impending regulatory and legal changes of relevance to a firm. Last, strong *research and development* and *IT* capabilities may be needed to sense technological advancements and the ways in which a firm might leverage them to gain advantage.

The relative importance of each of these forces of change (and the corresponding firm capabilities needed to detect them) will vary across industries and across time. For example, technological advancements may be very important early in the life cycle of products

in industries such as consumer electronics. However, as technology stabilizes, competitors’ actions in the form of price reductions or product bundling may become the more salient driver of environmental change. Despite fluctuation in their relative importance, most (if not all) of these forces are likely to be relevant to contemporary firms.

Responding to environmental change

Upon sensing environmental change, there are a variety of responses that a firm can make, ranging from (1) a

complex move such as embarking on a new venture, (2) a *simple move* such as adjusting an existing venture, to (3) *no move* (Ferrier et al., 1999). In other words, the scope of responses can differ (Dove, 2001). The first response classification, complex move, encompasses such responses as launching a new product, creating a new distribution channel, or targeting a new customer segment. For example, Apple's launch of the iTunes music store in 2003 is an example of a firm responding to environmental change (technological advancements in music distribution) by embarking on a new venture (Apple Computer, 2003). The second classification, simple move, encompasses such responses as making a price change, increasing or decreasing production of an existing product, or adjusting product features. For example, consider The New York Times Company's production of hundreds of thousands of extra copies of *The Boston Globe* (which it publishes) to sell to New England Patriots fans in Houston, TX, U.S.A. during the 2004 Super Bowl (Prewitt, 2004). This is an example of a firm responding to a market opportunity (thousands of additional *Globe* readers in Houston, TX, U.S.A. for a few days) by adjusting an existing venture (the Houston – area production, distribution, and sale of the *Globe*). The last classification, no move, presents a paradox of sorts: can doing nothing be considered a response? We argue that the answer is yes, as long as the inactivity is calculated and not merely an artifact of a failure to sense an opportunity. In this sense, it is possible for a firm to be agile but not necessarily display its agility at every opportunity.

A range of operating and strategic capabilities is likely to be relevant to firm responses of all types. For example, *product development* capabilities will facilitate a firm's ability to embark on new ventures such as launching new products and to adjust existing ventures such as adding product features. *Systems development* capabilities will affect how quickly and efficiently firms can implement IT-enabled offerings, be they hardware or software products for firms in technology industries or IT-enabled ventures (such as electronic commerce) for firms in other industries. Axiom is an example of a firm that has invested in its systems development and product development capabilities. Specifically, their use of iterative methodologies and modular, re-usable code enables them to produce IT-based products rapidly to capitalize on emerging market opportunities (Levinson, 2004). *Supply-chain and production* capabilities enable firms to adjust existing ventures by shifting production to match a pending change in demand. For example, because of high supply chain visibility, firms such as DaimlerChrysler (Mayor, 2004) are able to sense changes in supply and demand and scale their operations accordingly. *Flexible resource utilization* allows firms to shift resources to areas of need, which will help them embark on new ventures or adjust existing ventures. For example, firms such as Merrill Lynch (Prewitt, 2004) have flexible budgeting and staffing

systems that permit them to reallocate resources to where they are most needed.

Quadrant I: high sensing, high responding

Returning to the framework, we can infer that several firm capabilities are reflective of quadrant I, including strong sensing capabilities supported by R&D, market intelligence, IT, legal, and government relations activities as well as strong responding capabilities supported by product development, systems development, supply chain, and resource utilization skills.

Wal-Mart provides an example of how a firm can exhibit well-honed sensing and responding capabilities. During a recent hurricane season in Florida, Wal-Mart was able to leverage its strong IT and data analysis capabilities to sense which disaster-related products were in the greatest demand, which included both predictable items such as flashlights and batteries and less predictable items such as beer and strawberry Pop-Tarts. Using its supply chain and distribution capabilities, Wal-Mart was able to deliver additional disaster-related inventory to stores in affected areas to respond to this unusual spike in demand (Hays, 2004).

Quadrant II: high sensing, low responding

It is conceivable that firms might be able to sense environmental change relevant to their business (high sensing) but fail to respond to it in an agile manner (low responding). For example, unnecessary bureaucracy or 'analysis paralysis' may slow down the strategic decision-making process, causing firms to fail to act on emerging opportunities. Risk aversion may cause firms to pass on an opportunity even when responding to it would be beneficial. Poorly integrated processes may slow down product development and systems development activities, causing firms to miss opportunities. Last, agency problems may create incentives for managers to fail to act on opportunities that would be beneficial to the firm as a whole.

Xerox's Palo Alto Research Center ('PARC') in the 1970s provides an example of how a firm can have strong sensing capabilities, but fail to respond to the opportunities it sensed. Xerox engineers sensed impending changes in the computing industry and developed multiple innovations such as the graphical user interface, the mouse, and Ethernet. However, due to multiple issues, including conflicting strategies and issues with the U.S. Justice Department, Xerox did not market these innovations. Thus, although Xerox was able to sense change in customer demand, it was unable to respond to it in a profitable manner (Alexander & Smith, 1988).

Quadrant III: low sensing, high responding

It is also conceivable for firms to have strong responding capabilities (high responding) but be unable to sense the correct opportunities to pursue (low sensing). This lack of a sensing capability may be due to several factors. For example, lack of integration may hinder information

flows within a firm, harming its overall sensing capability. Over-reliance on outsourced providers may cause firm expertise in the outsourced area (be it IT, legal, R&D, government relations or market intelligence) to atrophy, making it difficult for firms to sense relevant environmental change. This is consistent with the original conceptualization of absorptive capacity put forth by Cohen & Levinthal (1990), which suggests that firms must have a base of prior knowledge in an area in order to make sense of new developments in that area. Last, competitive complacency (Ferrier *et al.*, 1999) may cause firms to become comfortable in their current strategic positions, causing them to ignore signals of change.

Cisco Systems circa 2001 provides an example of how a firm can have strong responding capabilities, but fail to sense important environmental change. Cisco has frequently received accolades for its supply chain capabilities, which allow it to respond quickly to customer demands (Poirier & Bauer, 2001). However, Cisco failed to sense the downturn in the market for networking equipment in 2001, despite the existence of signals that caused competitors to downgrade their forecasts and reduce inventory (Berinato, 2001). This led to a \$2.2 billion inventory write-off for Cisco in the third quarter of 2001. Some commentators contend that Cisco's flexible responding capabilities may have even exacerbated the situation by streamlining Cisco's ability to acquire inventory in order to respond to demand that never materialized (Berinato, 2001).

Quadrant IV: low sensing, low responding

It is also possible for firms to lack not only the ability to sense environmental change but also the ability to respond readily. The deficiencies related to sensing and responding discussed with respect to quadrants II and III apply to quadrant IV. Woolworth's, in the several years leading up to its final U.S. store closings in 1997, provides an example of how a firm might be deficient in both sensing and responding capabilities. Initially, Woolworth's failed to sense how the growth of suburbs in the U.S. would cause its target market to shift its shopping activities away from the urban centers where most Woolworth's stores were located. This left Woolworth's with a mismatch between its merchandise and the needs of the customers who continued to shop 'downtown'. Eventually, Woolworth's recognized this shift and attempted to respond by converting its venerable lunch counters into coffee bars and adjusting its merchandise mix to include more high-volume items such as health and beauty aids (Zinn, 1991). However, lacking the marketing capability to rebrand itself, those responses were ineffective, ultimately leading to the store closures (Brancaccio, 1997).

Positioning firms in the framework

Care must be taken when positioning individual firms in the framework. For example, enterprise agility cannot be assessed based on individual anecdotes. With respect to

the examples provided in the previous section, it is uncharitable to indict Xerox as having poor overall responding capability based on the specific situation related to PARC and thereby label them a quadrant II firm. Similarly, it is overly generous to anoint Wal-Mart as agile and place them in quadrant I on the basis of a single Florida storm season. The examples provided are merely instances of firms displaying different combinations of sensing and responding capabilities in a specific context. Additional measurement is required to determine if firms have the sensing and responding capabilities to enable them to be agile in a recurring, non-anecdotal sense. In addition, it is possible for firms that have the sensing and responding capabilities to support enterprise agility to act in non-agile ways in a specific situation. For example, although Wal-Mart may have appropriate enabling capabilities for both sensing and responding, there are undoubtedly opportunities it fails to sense or to which it does not respond. These missed opportunities do not make it a non-agile firm. As such, enterprise agility is best conceptualized as a matter of degree and not an on/off proposition.

The need for agility?

As the framework suggests, multiple operating and strategic capabilities support enterprise agility. Creating and maintaining these capabilities is a costly proposition, so it is important to consider the contexts in which agility is needed and those in which agility may represent a waste of resources. Referring back to the definition, enterprise agility applies to firms affected by environmental changes, which are reflective of turbulent and dynamic environments. It follows that enterprise agility is unlikely to be needed (and may actually represent wasted resources) in relatively stable environments. Given sufficient environmental stability, it may be appropriate or even advantageous for some firms to have capabilities reflective of quadrants II, III, and IV of the framework. Many firms operating in traditionally regulated industries such as the energy industry have enjoyed this type of environmental stability, although deregulation forces are increasing the need for such firms to become agile. We submit that as environmental conditions become increasingly turbulent for firms across industries, enterprise agility will be important for firm success.

Enabling enterprise agility: the role of IT

As described above, several firm capabilities enable the sensing and responding components of enterprise agility, including market intelligence, supply chain, production, and resource utilization. This section focuses on a specific enabler of enterprise agility: IT. IT plays an important role in enabling the sense and responding capabilities of firms (Bradley & Nolan, 1998; Weill & Broadbent, 1998; Sambamurthy *et al.*, 2003) in two ways: (1) directly and (2) indirectly through the creation of digital options.

Direct effect

In certain contexts, a firm's IT capability is directly related to both the sensing and responding components of enterprise agility. With respect to sensing, firms must have an adequate level of IT capability to be able to anticipate or sense changes relevant to their business that are brought about specifically due to advances in IT. Consider that firms that sensed the opportunities created by emerging technologies such as interactive HTML pages and the secure sockets layer protocol were able to implement electronic commerce strategies before many of their competitors (Kalakota & Robinson, 2001). With respect to responding, IT capability is critical for responding to opportunities in IT-driven industries such as financial services, retailing, telecommunications, and hardware/software (Sambamurthy *et al.*, 2003). IT capability is also important for firms in other industries who rely on IT to support customer and supplier channels (Bharadwaj, 2000). The changing dynamics of customer and supplier relationships often require frequent modification and enhancement to supporting information systems.

This is consistent with existing arguments that IT capability directly supports sensing and responding in contemporary environments (Haeckel, 1999). As the volume of information that firms must process outstrips human capacity to process it, IT systems enable firms to make sense out of what would otherwise overwhelm them. Similarly, responses in contemporary environments are often too complex for timely implementation without such IT support as communication infrastructure and automation. Haeckel & Nolan (1993) referred to managing in conditions so turbulent that sense making and action are impossible without IT as 'managing by wire'.

Indirect effect through digital options

While the direct relationship between IT and agility is important, the indirect relationship may be even more pronounced. Much of the business value of IT stems from its complementarities with business processes (Barua *et al.*, 1995). Under this theory, IT contributes to performance in business processes such as product development, manufacturing, and supply chain, which in turn contribute to firm performance. In effect, IT provides the infrastructure upon which other business

functions and processes depend (Lewis & Byrd, 2003). Thus, other firm processes mediate the effect of IT on performance, although IT may also have direct effects on performance in certain circumstances. We submit that this is also the case for enterprise agility.

Theory suggests that IT indirectly supports agility by providing firms with digital options (Sambamurthy *et al.*, 2003), which are defined as a set of IT-enabled capabilities in the form of digitized work processes and knowledge systems. A basic premise of this theory is that IT enhances the reach and richness of a firm's knowledge and its processes. Enhancements in the breadth of resources (reach) and quality of information (richness) available to a firm improve its ability to sense and respond to environment change, thereby making it more agile. The concept of 'digital options' encapsulates this ability of IT to make firms more agile. The term 'options' is used because a firm may apply its IT-related capabilities to emerging opportunities, or they may remain unused, depending on the firm's environment and strategy (Fichman, 2004). The graphic in Figure 3 illustrates how IT provides firms with digital options and how these digital options enhance enterprise agility. Figure 3 also displays the direct relationship between IT and enterprise agility described above.

Digital options are created through enhancements to the reach and richness of firm knowledge and processes. *Knowledge reach* refers to the comprehensiveness and accessibility of codified knowledge that is available to a firm. Well-architected IT systems can assist firms in accessing, synthesizing, and exploiting knowledge from a wide range of sources. IT also enhances *knowledge richness* by providing firms with high-quality information that is timely, accurate, descriptive, and customized to the recipient (Evans & Wurster, 2000). Information technologies such as decision support systems, data warehouses, and OLAP tools can help firms develop rich knowledge through real-time data monitoring, pattern recognition, and strategic scenario modeling. Knowledge reach and richness enhance firms' sensing capabilities by providing managers with high-quality information about the state of the business, which helps them identify emerging opportunities and threats. For example, rich knowledge related to customer purchase behavior can help managers to sense profitable new customer segments. Rich knowledge related to internal processes can

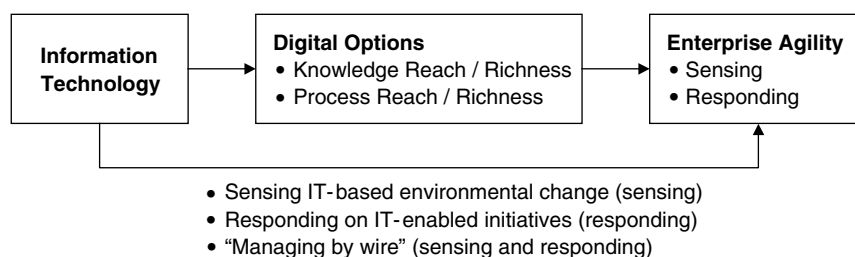


Figure 3 Relationship between IT, digital options, and enterprise agility.

help managers identify operational deficiencies such as fulfillment problems that are likely to be exposed as the competitive environment evolves.

Similarly, IT creates digital options by extending *process reach* so that firms are better integrated internally and with external customers, suppliers, and partners. For example, information technologies such as e-mail, intranets/extranets, supply chain systems, and groupware extend process reach by connecting internal and external stakeholders and increasing boundary-spanning activity (Merali, 2002). This is consistent with suggestions that IT enables the creation and sharing of boundary objects (Karsten et al., 2001) such as technical specifications and a technical grammar (Argyres, 1999), which, in turn, facilitate collaboration among individuals and firms. While process reach facilitates greater process participation among relevant stakeholders, *process richness* improves the quality of information available to process participants by making it more timely, accurate, relevant, and customized. Process reach and richness support firms' responding capabilities by improving coordination internal and external to the firm, which enhances responding-enabling capabilities such as product development, systems development, supply chain, and production.

Although individual information technologies can improve both a firm's knowledge and its processes, we submit that some technologies are more knowledge oriented and others are more process oriented. Further, we submit that knowledge-oriented IT is more directly supportive of a firm's sensing capability and that process-oriented IT is more directly supportive of a firm's responding ability. To illustrate, data warehouses, data mining, OLAP, and other reporting tools are examples of knowledge-oriented information technologies, as these technologies help firms identify patterns within and extract knowledge from data. Because these technologies can help firms make sense out of apparent noise (Haeckel, 1999), they directly support firms' sensing capability. Process-oriented IT systems are designed to help firms conduct business processes such as procurement, production, distribution, and billing. Examples of such systems include enterprise resource planning systems and supply chain systems. These technologies support firms' responding capability by facilitating process integration and visibility, which in turn enables processes to be adjusted quickly in order to meet changing environmental conditions. Process-oriented systems often provide the raw data to knowledge-oriented systems such as data warehouses, although knowledge-oriented functionality such as reporting is often built directly into the process-oriented IT (e.g., a reporting module in an ERP system.)

In terms of the framework, firms with capabilities reflective of quadrant III (low sensing, high responding) may have sophisticated process-oriented IT but sub-optimal knowledge-oriented IT. This is because strong process-oriented IT enables responding capabilities, but

deficiencies in knowledge-oriented IT may be one of the reasons that prevent some firms from sensing relevant environmental change. Similarly, firms with capabilities reflective of quadrant II (high sensing, low responding) may have strong knowledge-oriented IT but poor process-oriented IT. Knowledge-oriented IT can help firms sense environmental change, but a lack of process-oriented IT may hamper the ability to develop and implement responses, perhaps because firms cannot reach the relevant stakeholders or communicate with them in a sufficiently rich manner. Deficiencies in either knowledge- or process-oriented IT create an imbalance in the digital options 'platform', making it an unsteady base from which to launch agile moves. On the other hand, knowledge- and process-oriented IT can be key enablers of the sensing and responding capabilities needed for agility. They combine to provide firms with a stock of digital options that creates a solid platform from which to launch agile moves. Conversely, firms that lack both knowledge- and process-oriented IT cannot develop a digital options platform. Figure 4 maps firms' knowledge- and process-oriented IT capabilities to the enterprise agility framework and illustrates the concept of instability in the digital options platform.

How IT might hinder enterprise agility

Depending on how it is deployed and managed, IT may actually hinder enterprise agility. For example, monolithic IT architectures may hinder agility by limiting the range of responses available to a firm. Such architectures may make it difficult for the firm to adjust processes to changing conditions, creating high costs when the firm seeks to pursue new strategies (Daniel & Wilson, 2003). Other systems may limit information visibility by storing data in ways that make it difficult to retrieve and interpret. Also, some systems may limit process reach by being incompatible with systems adopted by customers and suppliers. These issues, however, are not endemic to IT in general, although some may be reflective of early generations of IT (e.g., monolithic, incompatible.) Rather, these issues stem from inappropriate investment in or management of IT, just as issues may stem from inappropriate investment in or management of other firm resources such as human resources or manufacturing equipment. This calls attention to the importance of firm-level IT planning, implementation, and maintenance (Weill & Broadbent, 1998; Bharadwaj, 2000).

A strategy for measuring enterprise agility

A fruitful avenue for future research is to conduct empirical work designed to test the antecedents and consequents of enterprise agility. Such work might involve testing how IT enables (or hinders) agility, the relative importance of IT capability compared to other firm capabilities in enabling agility, and the effect of agility on firm performance. These inquiries will inform research on firm strategy in turbulent environments and

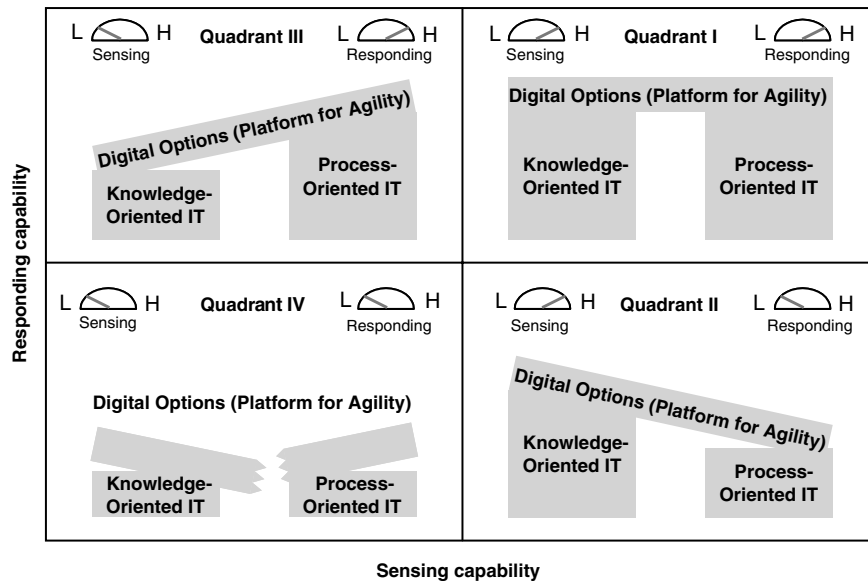


Figure 4 Relationship between digital options and the enterprise agility framework.

have managerial implications for affected firms. A common theme across each of these topics is a need to measure enterprise agility. In this section, we propose a measurement strategy.

Enterprise agility is composed of two main components: sensing and responding. Each of these components is needed for a firm to be agile. For example, a strong sensing capability may be wasted if a firm lacks the ability to respond to identified opportunities. Similarly, a strong responding capability may not help a firm if it is unable to identify opportunities on which to act. The symbiotic relationship between the sensing and responding components is at the heart of the measurement strategy proposed herein.

We suggest that enterprise agility be measured as a function of a firm's individual sensing and responding capabilities. In other words, enterprise agility should not be measured directly. Instead, the components of sensing and responding should be measured individually and then combined to create an overall measure of enterprise agility. The functional relationship linking the sensing and responding sub-scores to the overall agility score will depend on the alignment between a firm's sensing and responding capabilities. The following section presents an example of how to measure enterprise agility using this measurement strategy.

First, a firm receives a score on two components: Sensing and Responding. The Sensing score taps the firm's ability to sense environmental change, and the Responding score taps its ability to respond. Items from existing measurement scales such as those used to measure a firm's market orientation (Kohli *et al.*, 1993) or strategic flexibility (Grewal & Tansuhaj, 2001) may represent a good starting point for developing the Sensing and Responding measurement scales. In addi-

tion, the 'change factors' developed by van Oosterhout *et al.* (2006) to measure the gap between an environmental change and the agility required to respond to it are good candidates for the measurement scale. The Sensing and Responding scores should be measured on a scale from 0.00 to 1.00 (as opposed to the more commonly used 0 to 5 scale), the reason for which will be made clear below.

Second, a firm receives a score that measures the alignment between its sensing and responding capabilities, which we refer to as the Agility Alignment score. Agility Alignment is designed to answer the following question: does a firm sense opportunities in only those areas where it has the capability to respond, or does it sense opportunities beyond the range of its responding capabilities? An *aligned firm* senses only those opportunities to which it can respond; correspondingly, its responding capabilities are useful only for those opportunities it senses. Aligned firms do not waste their capabilities, either by sensing opportunities that cannot be seized or by having responding capabilities that lie unused. This is in contrast to a *non-aligned firm*, that is, a firm whose sensing and responding capabilities are not in synch. Non-aligned firms may sense a breadth of opportunities that they cannot respond to or have responding capabilities that do not apply to the opportunities they sense. The Agility Alignment of a given firm is a matter of degree and should be measured on a continuous, rather than a binary, scale. In other words, firms are not merely aligned or non-aligned; their alignment lies somewhere on a continuum between the two. Items drawn from existing scales such as those used to measure strategic alignment (Chan *et al.*, 1997) may be appropriate for inclusion in the Agility Alignment measurement scale.

The Agility Alignment score determines the functional form of the relationship between the individual Sensing and Responding scores and the overall measure of enterprise agility, which we will refer to as the Enterprise Agility score. For aligned firms, the Enterprise Agility score will be the minimum of the Sensing and Responding scores, as shown in the following equation:

$$\begin{aligned} \text{Enterprise Agility score}_{\text{Aligned}} \\ &= \min(\text{Sensing score}, \text{Responding score}) \end{aligned}$$

For non-aligned firms, the Enterprise Agility score will be the product of the Sensing and Responding scores, as shown in the following equation:

$$\begin{aligned} \text{Enterprise Agility score}_{\text{Non-aligned}} \\ &= \text{Sensing score} \times \text{Responding score} \end{aligned}$$

The following example illustrates the rationale behind these two functional forms. Recall that the Sensing and Responding scores are measured on a scale of 0.00 to 1.00. Assume, for the moment, that these scores can be interpreted as the proportion of available opportunities that a firm can sense or respond to (although they would not be measured as such.) For example, assume that a Sensing score of 0.50 suggests that a firm can sense approximately 50% of all relevant opportunities. Similarly, assume that a Responding score of 0.50 suggests the firm can respond to 50% of all relevant opportunities. The Enterprise Agility score of a firm with Sensing and Responding scores of 0.50, given alignment, would be 0.50, as shown below.

$$\begin{aligned} \text{Enterprise Agility score}_{\text{Aligned}} \\ &= \min(\text{Sensing score}, \text{Responding score}) \\ &= \min(0.50, 0.50) = 0.50 \end{aligned}$$

This reflects the notion that, although the firm can neither sense nor respond to all opportunities, it is equipped to respond to those that it senses (or *vice versa*). In other words, the firm's sensing and responding capabilities are in synch.

On the other hand, the Enterprise Agility score of the same firm if non-aligned would be 0.25, as shown below.

$$\begin{aligned} \text{Enterprise Agility score}_{\text{Non-Aligned}} \\ &= \text{Sensing score} \times \text{Responding score} \\ &= 0.50 * 0.50 = 0.25 \end{aligned}$$

In this case, although the firm can sense 50% of the overall opportunities, it can only respond to half of that 50% because its sensing and responding capabilities are not aligned. In other words, what the firm senses and what it can respond to do not always match up, thereby limiting the total number of opportunities it can seize.

The Enterprise Agility scores for alignment and non-alignment represent the end points in the range of

possible agility scores for a firm with a given set of Sensing and Responding scores. The actual Enterprise Agility score will lie somewhere within this range based on a firm's specific Agility Alignment score. For example, the Enterprise Agility score for a firm with a medium level of Agility Alignment will be approximately the midpoint between the aligned and non-aligned scores. For a firm with Sensing and Responding scores given in the example above, a medium Agility Alignment score would yield an Enterprise Agility score of 0.375, which is midway between the 0.50 score for an aligned firm and the 0.25 score for a non-aligned firm.

Discussion

A central theme throughout the paper is the decomposition of agility into its sensing and responding components. This decomposition and the framework based on it are useful at many levels. First, by breaking a complex construct into its constituent parts, the framework facilitates investigation of the enablers of enterprise agility. Rather than attempting to investigate how factors affect agility in general, we suggest that it is more fruitful to investigate how factors affect the individual components of sensing and responding. Second, the framework is useful for examining how IT supports the sensing and responding components of agility. Some IT applications create digital options by enabling both sensing and responding, while others are more specialized for one or the other. Last, the framework illustrates the symbiotic relationship between sensing and responding, which directly informs the proposed measurement strategy. Thus, a central contribution of the paper is in breaking down agility into its constituent parts of sensing and responding and exploring the insights that follow (e.g., the role of IT in enabling agility, measuring agility based on its components.)

Another theme of the paper lies in the definition of enterprise agility and the delineation of enterprise agility from similar concepts. By disentangling enterprise agility from dynamic capabilities, market orientation, absorptive capacity, strategic flexibility, and technological opportunism, we illustrate how these concepts inform, but yet are distinct from, enterprise agility. It is important to explicate these types of differences in order to limit the possibility of redundant lines of inquiry and to identify areas where efforts across topic areas may be synergistic.

Conclusion

By juxtaposing firm sensing and responding capabilities, this paper illustrates the enabling characteristics of enterprise agility, the specific influence of IT and digital options on enterprise agility, and a method for measuring enterprise agility.

Both the sensing and responding components are needed for agility. Thus, each of the components is a necessary, but not sufficient, condition for agility. However, the components are related, and they are likely to operate in a virtuous cycle. For example, a firm's ability to

sense environmental change can greatly increase its likelihood of being able to develop effective responses by giving it a head start on its competitors. In turn, strong responding capability can provide incentives for a firm to look for emerging opportunities, thereby improving its sensing capability. Effective use of IT is one method for firms to kick off and sustain this virtuous cycle, as IT enhances both sensing and responding capabilities. When investments in IT serve to increase the process and knowledge capabilities of a firm, they create a powerful platform of digital options that can enable the firm to sense and respond to rapidly changing environmental conditions.

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