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Managing Information Systems and Technologies for Agility: Case Studies in Supply Chain Management.

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MANAGING INFORMATION SYSTEMS AND TECHNOLOGIES FOR AGILITY: CASE STUDIES IN SUPPLY CHAIN MANAGEMENT

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Abstract

This research examines how information systems and technologies enable supply chain agility. The research was performed through the field study method involving 18 organizations representing the OEMs, suppliers, and IT vendors within the aerospace, automotive, electronics, healthcare, and fast moving consumer goods industries. Interviews were undertaken with managers from the IT and supply chain departments. The interviewees conceptualize supply chain agility with respect to the level of agility (internal or external) and the directions of agility (upstream or downstream). While supply chain agility is essentially regarded as the capability to rapidly match demand requirements and supply constraints by sensing and responding to change in the environment, form IT perspective, it means offering products and services that could increase transparency and improve relationships between trading partners. These are exemplified through the use of emergent IS/IT services, such as Supplier Portal, Vendor-Managed Inventory, E-Marketplace, and Web-based EDI, as well as industry-wide standards and solutions.

1.0 Introduction

Achieving agility has for many years been the main priority in many organizations (Greis & Kasarda, 1977). The long and winding road to agility challenges companies to continue shaping and reshaping their strategies and resources to be readily adaptable to the challenging and changing environment. Previous research has illustrated the importance of agility in different parts of the organization, such as in manufacturing (Calvo et al, 2008), information technology (Swafford et al, 2008), and supply chain (Swafford et al, 2008). However, even though previous research has shown how IS/IT increases the efficiency of supply chains (Alkadi et al, 2003), aligns supply chain strategy and business strategy (Williams et al, 1997), and contributes to the overall growth and profitability (Byrd & Davidson, 2003), there is an apparent gap in understanding in what ways information systems and technologies enable supply chain agility.

This paper reports on how practitioners conceptualize supply chain agility and how information systems and technologies have been used to increase the agility of supply chain. To do this, we would first offer the extant literature on supply chain agility and information systems and technologies in supply chain and provide the conceptual framework relates to the research. After discussing the method used for this research, we summarise and analyse our findings and its implications to practice.

2.0 Literature Review

Supply chain management can be defined as "connected series of activities that are concerned with planning, coordinating and controlling of materials, parts and finished goods from suppliers to customers" (Stevens, 1989) or "the management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole" (Christopher, 1998). Supply chain management acknowledges that buyer-supplier relationships need to be managed beyond logistics and procurement functions (Lambert et al, 1998). In recognizing that a supply chain often involves more than a dyadic relationship, Menzter et al. (2001) defined it as "a set of three or more entities (organizations or

individuals) who are directly involved in the upstream and downstream flows of one or more of products, finances and/or information, from a source to a customer".

Supply chain agility refers to the capability required in coping, managing, and mastering change related to supply chain operation and management. Agility in supply chain was defined by Lee (2002) as "the capability to be responsive to the changing, diverse, and unpredictable demands of customers on the front-end, while minimizing the back-end risks of supply disruption" (p.114). Many ways could be used to increase supply chain agility, such as: timely sharing of information (Li et al, 2006), utilizing virtual teams (Bal et al, 1999), having time compressed business processes (Mason-Jones & Towill, 1999), communicating real-time market data across the network (Christopher & Towill, 2001), making use of contract manufacturers (Mason et al, 2002), facilitating high levels of speed of change for throughput, destinations and volumes (Prater et al, 2001), and utilizing an inventory policy in seeking to dampen the effects of market related variance through the creation of slack resources and appropriate order management activities (Caridi & Cigolini, 2002).

Agility, as stated by Goldman et al (1994, p.42), "is not about improving efficiency, cutting costs, or battening down the business hatches to ride out fearsome competitive 'storms'…". Whereas efficiency is concerned about producing more with less effort within a relatively predictable environment, agility, termed by Ghemawat and Costa (1993) as "dynamic efficiency", is often linked to operating and competing in a dynamic environment. Efficiency assumes that change is pretty much predictable and therefore organisations would seek to design its processes in such a way that it could optimally fulfil a predetermined demand. On the other hand, agility assumes that change is practically rampant and therefore organisations would leave enough rooms for flexibility to cater for unpredictable demand. Efficient enterprises often follow make-and-sell model, while adaptive enterprises follow sense-and-respond model (Haeckel, 1999).

Essentially, agility means to have sufficient capability to rapidly adapt to changing environment. Goldman et al (1994) wrote that, "an agile company is organized in a way that allows it to thrive on change and uncertainty … to apply all the resources

that may be necessary to exploit changing market opportunities profitably" (p.74). Changing environment adds to uncertainty and complexity, at least while companies are trying to comprehend them. Complexity in the supply chain may be caused by the volume of information and material flowing in the chain, supply chain that interlinks with other supply chains, and uncertainty of demand, planning and manufacturing, and multitude of partners within a supply chain with different objectives and priorities (Blackhurst et al, 2004). Uncertainty in supply chains, on the other hand, is caused by deterministic chaos, parallel interactions, and demand amplification (Wilding, 1998) that reduces supply chain performance (Milgate, 2001).

Agile capability in supply chain can be conceptually divided into two: to sense and to respond (Haeckel, 1999). *Sense* refers to the capability to scan changes in environment while *respond* refers to the capability to rapidly react to these external changes within the current capacity such as in production volume, product design, machine set up, distribution routing, and manufacturing process (Sethi & Sethi, 1990; Vokurka & O'Leary-Kelly, 2000; D'Souza & Williams, 2000). Achieving agility in all these areas, which covers structure, process, and infrastructure, is critical in today's supply chain. According to Metes et al (1998), "reconfigurable processes will be hamstrung when tied to unconfigurable infrastructure". Agile structure, process and infrastructure would allow organizations to effectively master change while continually cooperate with trading partners, leverage resources, and enrich customers, as a response to dynamic market condition. Sensing and responding could be in terms of speed and scope of the changes required. This is illustrated in the research framework in Figure 1.

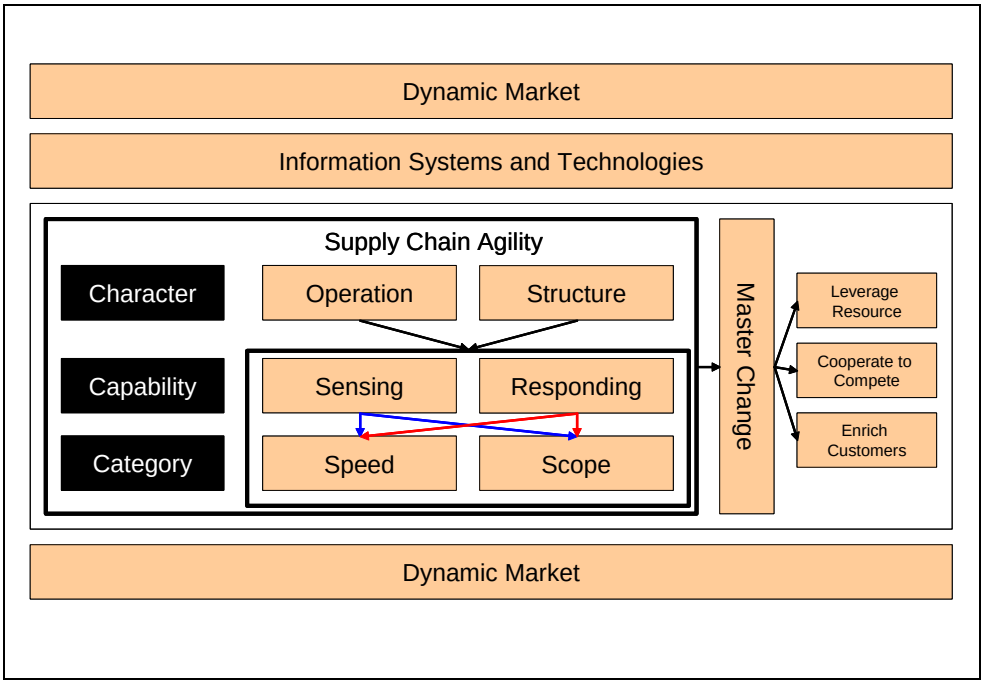

Figure 1: Supply Chain Agility Framework

The important roles that information systems and technology play in the operations and management of supply chain have repeatedly been highlighted in the literature. Previous research has indicated, for example, the impact of information systems and technology in increasing the efficiency of supply chains (Alkadi et al, 2003), in facilitating innovation (Holmqvist & Pessi, 2006), in aligning supply chain strategy and business strategy (Williams et al, 1997), and in improving overall growth and profitability (Byrd and Davidson, 2003). On a more operational level, the adoption of information systems and technology has been linked to: an increase in product offerings and customer service levels (Kincade et al, 2001) and quality and timeliness of production information (Brandbyberry et al, 1999). Even the perception about trading partners' technology adoption, according to previous research, could improve the supply chain relationship between both parties (Kent & Mentzer, 2003).

Another important role played by information systems in supply chain is in terms of facilitating the integration between these different systems as well enabling collaboration with trading partners (Swafford et al, 2008). Supply chain collaboration has been defined as an attempt to achieve integrative settlements between transacting parties through integrations of behavioural, communicational, and interactive flows

(Morash & Clinton, 1998). Computer Science Corporation (CSC), in their survey, noted that there has been a steady increase in the amount of inter-organizational transactions done electronically, and that "connecting to customers, suppliers, and/or partners electronically" is one of the top ranked global management issues (CSC, 2001). From IS/IT standpoint, supply chain collaboration refers to the linkages between different systems that enable transacting parties to perform inter-organizational processes seamlessly. IS/IT often plays the roles as both supporter and enabler to this collaboration (Kumar & van Dissel, 1996). IS/IT collaboration is often achieved through the use of inter-organizational systems (IOS) such as Vendor Managed Inventory (VMI) and Supplier Management Systems (SMS). In this research, we examine how the use of these information systems can increase supply chain agility in terms of sensing and responding to changes in the environment.

3.0 Methodology

The current study involves 18 organizations including OEMs, suppliers, and IT vendors representing the automotive (5 companies), aerospace (6 companies), electronics (2 companies), healthcare (1 company) and fast moving consumer goods industries (4 companies) and operating in Europe (15 companies), US (2 companies) and Asia (1 company). The research was carried out based on the interpretive tradition through the field study method. The main instruments used to gather evidence were interviews. Interviews, according to Burgess (1982, p.107), give the "opportunity for the researcher to probe deeply to uncover new clues, to open up new dimensions of a problem and to secure vivid, accurate inclusive accounts that are based on personal experience". The criteria for selecting the interviewees include: their role in IS and the supply chain, their knowledge about IS and the supply chain, and their willingness to participate in the research. The interviewees were selected among the responsible managers within IT and the supply chain with a total number of 40 interviewees.

36 interviews were done face-to-face and 3 through telephone. The interview questions consist of a combination of open-ended and semi-structured questions, though a large number of the questions were semi-structured. The open-ended

questions were used primarily for exploratory purposes such as when discussing the definition and measurement of agility as well as issues and problems faced by the interviewees in relation to supply chain management. The semi-structured questions were mainly used to obtain responses that could describe, rate and explain the dimensions and constructs that are important in understanding this topic. With prior permission from the interviewees, all interviews were tape recorded. The interview tapes were transcribed into texts and imported into QSR NVivo (Richards, 2002). The software was used to store and edit the data, to build and use a coding system, to build a model based on concepts and to analyze the data.

Analysis was performed using thematic content analysis which identifies the dimensions or issues that were most frequently cited and heavily stressed by the interviewees. Weber (1990, p.9) defined content analysis as "a research methodology that utilizes a set of procedures to make valid inferences from text" and Patton (1990, p.391) defined it as "the process of identifying, coding, and categorizing the primary patterns in the data". Using QSR NVivo, words and phrases that could be attached to a particular topic, theme, or code were retrieved, brought together, and displayed in a tabular format. This enabled the evidence to be analyzed in a more structured way and analyses to be performed in a more systematic manner. The analysis was first carried out independently by both researchers, followed by rigorous comparative analysis of the separate findings, when differences were reconciled, in an attempt to increase reliability.

4.0 Analysis of Findings

In this section, we will present the findings on (1) concept of supply chain agility, (2) transparency and visibility of information, and (3) factors hindering supply chain agility.

4.1 Conceptualizing Supply Chain Agility

The interviewees conceptualize supply chain agility in terms of the level of agility (external or internal) and the direction of agility (upstream or downstream). Internal

agility refers to the capability to rapidly respond to changes in the internal processes or decisions, while external agility, to changes in the demand or supply market. Upstream agility refers to the capability to rapidly respond to changes in the inbound operations, while downstream, to outbound operations. Briefly, external-upstream agility refers to responding to change in the supply market, external-downstream agility refers to responding to change in the demand market, internal-downstream agility refers to responding to change in the outbound processes, and internal-upstream agility refers to responding to change in the inbound processes. This is illustrated in Figure 2.

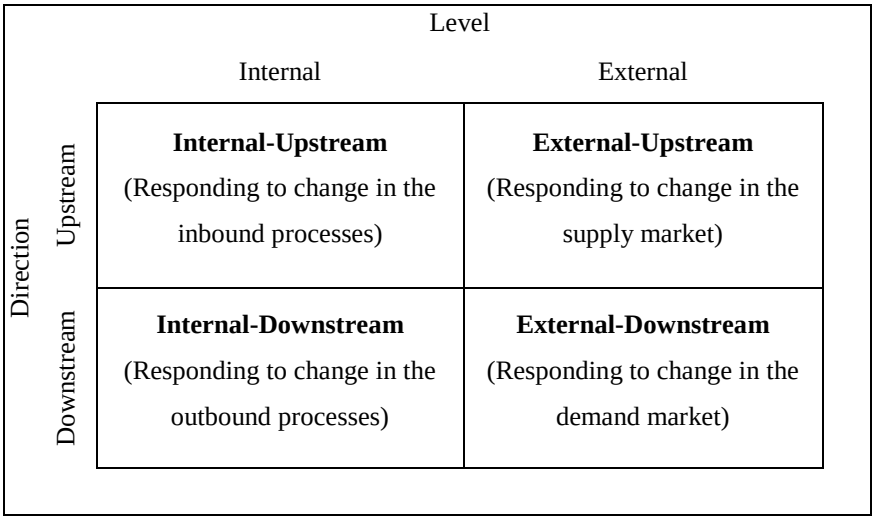

Figure 2: Types of Supply Chain Agility

The four types of supply chain agile capabilities just discussed are interrelated. For example, when the British Government decided to change its vehicle registration procedure from August to March and September that has caused a sudden surge in demand for right-hand-drive cars for these months (External-Downstream), it affected the manufacturing side particularly on part supplies for right-hand-drive cars (Upstream). For a contrasting example, due to increasing concerns about minimizing costs, automotive OEMs have increased sourcing and built factories in the Far East (Internal-Upstream) for cars to be sold in Western Europe. This move, though helped reduce costs and maximize tax incentives offered by these countries, has affected delivery performance (Downstream) in many companies.

In general, there are two sides of agility: (1) to rapidly adjusting strategic sourcing to meet the variable customer and business requirements; as well as (2) to rapidly adjusting channel and customer expectations, such as through demand conditioning, with respect to supply constraints. For example, according to one of the interviewees, *"there are two things involved: (1) you need to rapidly adjust strategic sourcing and supply because customer and business requirements change and (2) you need to be able to handle customer expectations because supply constraints naturally evolve".*

Change is not only generated by the external market but often come from inside the organization. According to a Supply Chain Manager we interviewed, *"We force the wholesale and we do that to meet our profit forecast. Generally that's what happens. It's not external consequences - it's one that is caused by us"*. This, according to him, requires an agile capability: *"Agility comes from making sure that everybody who is going to feel a consequence of a change can react and respond ... it is the responsiveness to a change, either self-induced or as a result of some external consequences"*.

Figure 3 illustrates how the interviewees conceptualize supply chain agility from their distinct perspectives.

UPSTREAM	VERSUS	DOWNSTREAM
"Flexibility and capability of suppliers to deliver the right product at the right quality at the right time at the right place"	"Rapidly adjust the strategic sourcing to meet the variable customer and business requirements and to rapidly adjust channel and customer expectations with respect to supply constraints"	"To be able to build what the customers want, when they want, it without manufacturing and suppliers limiting my capability to do what the customers want"

INTERNAL	VERSUS	EXTERNAL
"We force the wholesale and we do that to meet our profit forecast. Generally that's what happens. It's not external consequences - it's one that is caused by us"	"The responsiveness to change, either self-induced or as a result of some external consequences"	"To be able to respond to market demand at the lowest cost"

Figure 3: Conceptualizing Supply Chain Agility

4.2 Transparency and Visibility of Information

The systems being studied vary amongst different organisations and ranging from proprietary in-house-developed systems, web-based interfaces and linkages (e.g. web-based EDI), industry-wide solutions (e.g. Supplier Portals, Vendor-Managed Inventory, e-Marketplaces). The key role played by these emergent information systems is to provide transparency and visibility of information in the supply network. For example, according to a major tier-1 supplier in the automotive industry when discussing about the advantage of using a Supplier Portal, "*This is almost a perfect world because then there is transparency on his capabilities and we can tell him this information is what you need to work with us, you have the request for quotation, you have to follow our norms and standards, you have to do the billing electronically, this is where you get the drawing and this is how to do the logistics information exchange for delivery forecast, advance shipping notes etc. Use them.*"

The use of these technologies would in future change the landscape of information systems use in the industry from the more traditional enterprise-wide information systems to industry-wide supply chain systems, as illustrated in Figure 4. Such change would ensure a more seamless exchange of information systems between trading partners within the industry and hence increase agility of supply chain.

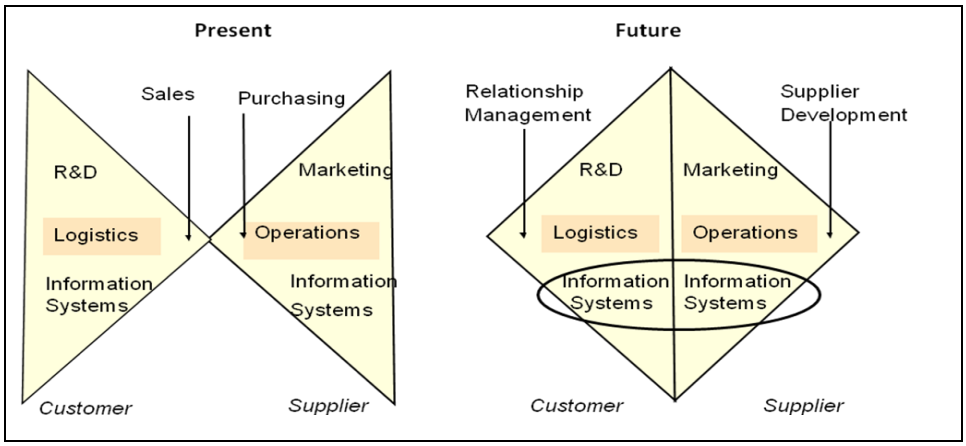

Figure 4: Enterprise-wide Information Systems versus Industry-wide Supply Chain Systems

Agility could also be achieved through the use of standard data formats across the industry. This includes, for example, the use of European Network eXchange (ENX) as the standard for communications network of the European automotive industry. To achieve this, companies also form B2B-consortiums to provide multi-company process management using agreed standards. These consortiums include Converge and E2open for the IT industry, Covisint and SupplyOn for automotive industry, Elemica and ChemConnect for chemicals industry, and Global Healthcare Exchange (GHX) for healthcare industry. According to one of the interviewees, "*The more plug and play or the more industry standard component you use in B2B, the more quickly you can decouple and re-couple with another supplier. The more you use conventional or readily recognizable system and technology in supplier relationship, the more readily you can establish supply-purchase related agreement.*"

4.3 Factors Hindering Supply Chain Agility

Our fieldwork reports several factors that act as hindrances to achieving transparency and visibility of information and thus agility of supply chain. Two of the key factors discussed here are segmentation within the industry and distinct internal complexity of individual companies.

Firstly, though visibility of information within the supply network acts as one of the core dimensions of agility and a prerequisite for an effective sensing capability, there is an apparent segmentation within the industry in the use of these inter-organizational systems (IOS) - IOS often offers visibility across not more than two echelons of the industry (e.g. between OEM, Tier-1, or Tier-2). This, in part, is due to organizations' hesitation in sharing corporate information and lack of trust between members within the supply network.

In the automotive sector, according to the Sales Manager of an IT Vendor, "*The OEMs actually want to have a transparency and visibility through the whole value chain down to the tier-n supplier but the tier-1s don't want to have that because should that be the case the OEM would have more power in the whole game, even more than they already have … Should the whole supply chain be connected, if there*

would be transparency and visibility throughout the whole supply chain from the OEM to the tier-n, then I think it could be very, very agile. But I think that would never happen because, as I said, the tier-1 would block that". This is confirmed by Tier-1 suppliers. The Supply Chain Manager of a Tier-1 Supplier we interviewed said, "*I'm responsible for my supply chain and I do not want to have the OEM seeing into it. I want to cover my supply chain as my area of responsibility but this is something where the transparency is working a little bit against.*" Similarly, as mentioned by one of the interviewees from the aerospace sector, "*If you see that I don't have any in the inventory, then I'm not going to have this business. All sorts of games are being played like that, people will not provide visibility. They won't provide prices; they won't provide any visibility*".

Secondly, change, uncertainty, and complexity can exist internally or externally. Externally includes events in the environment in which organisations have less or no control on, whereas, internally includes events in which organisations have more or sole control on. Complexity in the external environment refers to complexity created by the environment, whereas internal complexity refers to complexity, even though unintended, but arises due to actions taken by the organisation to address their changing priorities. External complexity puts a pressure on organisations to becoming adaptable while internal complexity makes it difficult for companies to be adaptable to the changing environment. Change, uncertainty, and complexity are not only due to industry structure and relationships but can be unique and internal to each organization. One of our interviewees termed this as "*self-induced*". At a time when customers are demanding flexibility and academics are investigating the concept of agility, the internal processes, which are geared toward delivering lean and efficient supplies, are rapidly changing and becoming ever more complex. According to one of the Supply Chain Manager we interviewed, "*Does our planning process change a lot because of external factors like market change? Not significantly. Is our supply chain changing because of internally driven factors? Yes it is, because we're constantly remodeling our manufacturing and warehousing environments and looking at new suppliers and ways of rationalizing our supplier base. When you're changing those 3 things internally, within your own walls, you're creating change that is complex to manage".*

5.0 Conclusions

Recently, Sidorova et al (2008) noted an increasing interest among researchers to study information systems and technologies relate to market-level issues as compared with individual, project, organizational or group. Market-level issues, according to the authors, include studies of E-Marketplaces, auctions, on-line consumers, and EDI, which are all directly or indirectly related to supply chain management. Within the supply chain management literature, on the other hand, the role of this information systems and technologies in increasing supply chain agility is one of the key priorities to organizations (Swafford et al, 2008).

The literature informs how agility is required in competing in the changing, dynamic environment. However, our field study indicated that, even though the external is changing as it has been and as it will continue to change, and even though these changes would certainly affect the way companies compete with each other, they are not the only source of change and complexity. Another source of changes which require companies to be more flexible and adaptable comes from within each company's walls. These include changing strategies, structures, processes, infrastructure, etc. Such changes add to complexity in the way organizations respond to their suppliers and customers and the complexity can be unique from one organization to another. The main challenge is to translate this into something understandable to the IT vendors, and for IT vendors to be able to take into account different models and complexities faced by each adopting organization.

Agility is the capability required to operating and competing in changing and dynamic business environment. Systems developers, particularly third party vendors, need to be able to understand the internal processes, change, uncertainty, and complexity in each different types and echelon of supply chain to ensure that the supply chain strategy and operation always co-evolve with supply chain systems and technologies. Organisations can assess their supply chain agile capability by evaluating how rapidly they can respond to different sort of changes: internal and external; upstream and downstream. For a company that is closer to the end-consumers, demand information may be visible but the volatility of the supply market hinders the company from being responsive enough to meet demand. Whereas, for a company that is closer to the end-

supplier, even with a high level of efficiency and productivity, lack of visibility about the demand market may impede production planning. Future research may focus on developing frameworks of how relationship and trust among trading partners could be improved so that information systems and technology could be more effective in providing transparency and visibility of information and hence the supply chain agility.

Lack of generalization has been one of the major criticisms faced by the field study method. However, according to Yin (1994), generalization in the case study research is achieved through analytical generalization rather than statistical generalization. While maintaining the level of rigor necessary in conducting this research, another important aim was to ensure that the outcome of this research is relevant to practice. Relevance implies "demonstrating a meaningfulness regarding its application to the significant problems and opportunities being faced by today's organizations and their members" (Zmud, 1996, p.xxxvii). Relevance was enhanced in this research by the use of interviews, which gave the interviewees opportunities to describe their views and experiences openly and not restricted by structured questionnaires.

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