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Exploring Supply Chain Absorptive Capacity in product and service focused firms

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Abstract
Innovation or market responsiveness is a key factor to firm success. Absorptive Capacity – in other words, a firm’s ability to acquire, assimilate, transform, and apply information from supply chain partners – has been posited to be an important capability for firms striving to achieve innovation. Given this, extant studies have explored Absorptive Capacity using many different methodologies and measures. While these studies provide useful insights, very few have explored differences among product and service focused firms. This is particularly important given the growing emphasis on the firm’s offering as consisting of a product and service bundle. This study informs a key curiosity in the extant literature by investigating differences in the Absorptive Capacity approaches of product and service focused firms. Data from the International Manufacturing Strategy Survey of 711 manufacturing firms in 23 countries reveals meaningful insights into different Absorptive Capacity approaches.

1. Introduction
In the age of complexity and globalization, building dynamic capabilities across the supply chain is critical for maintaining innovation required for sustainable competitive advantage (Winter, 2003; Storey, et al., 2005; Anand, et al., 2009; Wu, et al., 2010). This new environment is often characterized by complex and fast changing customer demands that require collaborations across innovative supply chain network (Cox and Alm, 1998; Piller, et. al., 2004; Pathak, et al., 2007; Agarwal and Selen, 2009). These changing demands reflect consumers’ preference of innovative products and service value features (Peppers & Rogers, 1997; Tu, et. al. 2004). This has led to shorter product life cycles and fragmentation of previously standardized products causing firms to seek increased responsiveness to their customers (Gunasekaran, et al., 2008). As a result, firms are implementing responsive supply chain strategies intended to utilize collaboration across the supply chain and better serve the product and services innovation needs (Morash, 2000; Kim and Lee, 2010; Roh, et al., 2011).

Absorptive capacity (i.e., organization’s ability to create, acquire and apply knowledge resources) is critical for organizations to sustain innovation across the supply chain. Prior
research on absorptive capacity has examined the key dimensions of absorptive capacity and its complex organizational relationships. In fact, an effective innovation hinges upon the firm’s ability (i.e., absorptive capacity) to acquire, assimilate, transform, and apply information for commercial ends from the external environment, namely from their supply chain partners (Zahra and George, 2002; Fosfuri and Tribó, 2008). In exploring the responsiveness/innovation challenge, scholars have investigated various external supply chain contexts for success (Randall, et al., 2005; Amini and Li, 2011; Flynn, et al., 2010). Others have suggested strategic fit between supply chain strategy and firm culture (Hult, et al., 2007; Roh, et al., 2008; Dowty and Wallace, 2010; Power, et al., 2010). In exploring the barriers to responsive performance, a number of articles (Storey, et al., 2005; Rauniar, et al., 2008; Zhou and Benton, 2007; Doll, et al., 2010) touch upon the importance of information acquisition, sharing and supply chain visibility.

However, little is known about the different patterns of absorptive capacity extant among firms. It is worthy to explore an integrative research model that suggests how firms acquire, assimilate, transform, and apply information both in the internal organization and supply chain contexts for the desirable innovation outcomes. This study proposes a model grounded in absorptive capacity theory (Cohen and Levinthal, 1990; Zahra and George, 2002; Tu et al., 2004; Malhorta et al., 2005; Deng et al., 2008). Our research model suggests causal links between responsive product innovation strategy, absorptive capacity, supply chain restructuring and customer value outcomes essential for the supply chain success. We then examine differences among firms in how they employ these practices for absorptive capacity.

The following section (2.0) of this manuscript discusses the theoretical grounding for the proposed model and provides a review of the absorptive capacity literature, defining the
variables and describing the relationships under study. Section 3.0 provides a description of the research methodology and data analysis, while section 4.0 provides for a discussion of the results.

2. Literature review

This section discusses absorptive capacity theory. Each relevant construct is defined and explained its essential characteristics. A research model is presented as well.

2.1. Absorptive Capacity Theory

Absorptive capacity theory is a body of literature that focuses on the organizational knowledge activities. Absorptive capacity theory addresses the following research questions (Cohen and Levinthal, 1990; Zahra and George, 2002; Malhotra et al., 2005; Tu et al., 2004):

1) What are the drivers of knowledge acquisition??

2) How are the acquired knowledge applied?

3) How can absorptive capacity be allocated among internal stakeholders?

4) How can absorptive capacity be shared among external stakeholders?

5) How can the different set of absorptive capacity be used to impact desirable outcomes and thus contribute for firms with different focus (e.g., products or services) for their sustainable competitive advantage?

Cohen and Levinthal (1990: p. 128) introduce absorptive capacity theory, arguing that “[…] the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities.” In their study of R&D spending, Cohen and Levinthal (1990) suggest that absorptive capacity can serve to explain resource allocation for
innovation activity. Absorptive capacity has been studied in a variety of contexts and unit of analysis levels. This is evidenced by the work of scholars who have subsequently recognized the applicability of absorptive capacity in studies of innovation, the fundamental underpinning of responsiveness. At the country level, Griffith, et al., (2003) for example, suggest that absorptive capacity can take the form of a county’s ability to acquire and digest the discoveries of other countries thus improving productivity (Deng, et al., 2009). Grunfeld, (2003) studies absorptive capacity at the inter-firm level, specifically joint ventures, describing it as the ability of a firm to learn from other partner firms. Malhotra, et al., (2005) framed absorptive capacity from an IT perspective suggesting that a supply chain integrative process mechanisms, partner interface-directed IS, and rich information exchange can enhance knowledge creation and productivity. At the firm level, Stock, et al., (2001) use R&D expenditures as a proxy for absorptive capacity suggesting improvement in product performance. Finally, Zahra and George, (2002) conduct a literature review, describing absorptive capacity in two dimensions; as the potential and realized capability of a firm. Here the authors suggest that absorptive capacity can enhance innovation and performance.

A review of the literature supports the notion that absorptive capacity enhances the innovation in diverse settings such as environmental innovation and technology alliance. It indicates that the capacity has played a significant role to acquire, assimilate, and transform the information to innovatively mobilize the knowledge and increase innovative capacity. Definition and measurement of the construct differed by studies. While some studies operationalized it as R&D intensity or organizational learning capabilities, few studies have used it in the context of new product development and knowledge transformation in the supply chain level. For example, Newey (2010) and Zhen and Anand (2010) found that increasing customer company’s absorptive
capacity correlates with the levels of supplier’s absorptive capacity. Information technology facilitates firms to bring the commercialization of new product to success (Joshi et al., 2010) but its capability to exploit knowledge decreases when it reaches optimal point (Zhou and Wu, 2010). The recent studies seemed to confirm the impact of the absorptive capacity in international settings such as in China, Taiwan, Sweden, Australia, and Korea. However, only one study explored the relationships among the four specific types of absorptive domains: acquisition, assimilation, transformation, and application of knowledge. Rare is the study that explicates the new product development capability in the international supply chain context.

Thus, the previous research in absorptive capacity suggests that it is rooted in the psychology literature, specifically cognitive theory and problem solving, absorptive capacity centers on two primary activities; (1) the acquisition of knowledge and (2) its consequent applications (Zahra and George, 2002; Storey, et al., 2005). Innovation, the root of responsiveness, requires that a firm not only have access to information, but it must also recognize its importance, possess the ability process or assimilate it, and apply it for commercially attractive and potentially innovative, responsive outcomes.

Based on the work of Cohen and Levinthal (1990) and Zahra and George (2002), we have constructed our research framework in Figure 1. This summarizes the causal chain of absorptive capacity. The critical antecedents of absorptive capacity are organizational value recognition or identification. This is quite strategic and deliberate organizational cognition and action. Essential aspect of absorptive capacity is to connect two components: potential value through knowledge acquisition and realized value through knowledge applications. Absorptive capacity in the context of supply chain is the usage of supply chain IT for knowledge acquisition in specific goal-driven context (e.g., integrative product development) and supply chain
Restructuring for transformation (e.g., operational applications). Organizations use their absorptive capacity for innovation outcomes for competitive advantage.

2.2 Variable definitions & exploratory hypotheses

2.2.1 Responsive Product Innovation Strategy (RPIS)

Responsive product innovation strategies (RPIS) are defined as “degree to which a firm’s business strategy reflects the importance of (1) new product frequency, (2) more innovative products, and (3) a wide product range in winning orders from customers” (Roh, et al., 2008; Randall, et al., 2003; Storey, et al., 2005; Gunasekaran, et al., 2008; Kim and Lee, 2010). Responsive Product Innovation Strategy (RPIS) is intended to enable a firm to rapidly adapt to changing customer demands by providing a variety of innovative products (Roh, et al., 2008). Firms employing the RPIS are frequently less concerned with cost as they operate in markets with low growth rates (Randall, et al., 2003). These low growth rates are suggested to impede a firm’s ability to achieve high levels of efficiency and therefore cost is abandoned as a goal, with increased focus placed on offering variety, innovation, and frequent product introductions owing
to shortened product life cycles (Storey, et al., 2005). As such, RPIS is defined in table 2 as the
degree to which a firm’s business strategy reflects the importance of (1) new product frequency,
(2) more innovative products, and (3) a wide product range in winning orders from customers. A
RPIS is implemented through innovation and the inference and responsiveness requires both
information acquisition and application (Storey, et al., 2005; Roh, et al., 2008; Gunasekaran et
al., 2008).

2.2.2 SC Information Acquisition (SCIA)

SC Information Acquisition (SCIA) is “degree to which a firm uses electronic tools (i.e., EDI) to
communicate with customers and suppliers regarding for RFx (Request For Quotes, information,
proposals) and for content and knowledge management“(Handfield and Lawson, 2007; Goodhue
et al., 1988; Bhatt & Troutt, 2005; Hong et al., 2010a, 2010c). Scholars have measured
absorptive capacity using a variety of proxies. Some scholars have used proxies such as R&D
spending (Cohen and Levinthal, 1990; Griffith, et al., 2003; Stock, et al., 2001). While few in
number, others have proposed more direct measures such as Malhotra, et al., (2005) who
measured absorptive capacity in terms of IT use for information exchange and processing. This
closely follows the conceptual dimensions presented by Cohen and Levinthal (1990), who
suggest that absorptive capacity is essentially comprised of; (1) knowledge acquisition and (2)
knowledge application. This study follows the sparse work of these previous authors suggesting
that knowledge acquisition and its subsequent application comprise the essential elements of
absorptive capacity.

The use of electronic tools such as Electronic Data Interchange (EDI), the Internet, or
other Information Technologies (IT) can facilitated knowledge acquisition by linking suppliers,
the focal firm and customers in the supply chain. This is particularly true in the context of innovation seeking firms as these organizations are increasingly utilizing IT and other electronic communication technologies to improve their responsiveness (Sambamurthy, et al., 2003). As a result, infrastructure development within the firm and its customers and suppliers has emerged as a primary purpose for IT departments (Goodhue, et al., 1988; Bhatt and Troutt, 2005). The knowledge acquisition that results from these linkages may be most critical during the early stages of innovation development (Handfield and Lawson, 2007) when the foundation of problem solving or knowledge application is created. In this way, IT can be used to acquire information related to Requests For Information (RFI) or Quotes (RFQ). As such knowledge acquisition is defined in this study as the degree to which a firm uses electronic tools (i.e., EDI) to communicate with customers and suppliers regarding for RFx (Request For Quotes, Information, Proposals) and for content and knowledge management. Table 2 shows the above mentioned each construct, definition and supporting reference base.

Bhatt and Troutt (2005) suggest that innovation responses hinge upon collaborative cross-functional decision making. In this context, cross-functional teams can recognize relevant knowledge that has been acquired, process or assimilate it, and deploy it throughout the firm thus improving the timeliness of problem solving, a fundamental activity in innovation (Hong, et al., 2005). Recognizing the potential benefits, many managers are redesigning internal relationships in hopes of improving innovation responses to produce better customer alignment, more frequent product launches, and shorter time to market (Dean and Susman, 1989; Ettlie and Stoll, 1990; Adler, 1995). These internal redesigns and enhancements have taken the form of Quality Function Deployment (QFD), Design For Manufacturing (DFM), among others (Adler, 1995). These programs provide a platform for cross-functional actors to process and integrate acquired
knowledge from customers and suppliers into the development of innovation responses, thus applying knowledge. Therefore, this study defines knowledge application as the degree to which a firm has implemented programs to (1) integrate product development and manufacturing through *QFD, DFM*, etc., and (2) improve product development/innovation performance and manufacturing through *platform design*, etc.

**Table 2. Variable definitions.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>References</th>
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<tbody>
<tr>
<td>SC Information Acquisition (SCIA)</td>
<td>Degree to which a firm uses electronic tools (i.e., <em>EDI</em>) to communicate with customers and suppliers regarding for RFx (Request For Quotes, information, proposals) and for content and knowledge management.</td>
<td>Handfield &amp; Lawson (2007); Goodhue et al., (1988); Bhatt &amp; Troutt (2005); Hong et al., 2010a, 2010c.</td>
</tr>
<tr>
<td>NPD Assimilation (NPDA)</td>
<td>Degree to which a firm has implemented programs to (1) integrate product development and manufacturing through <em>QFD, DFM</em>, etc., and (2) improve product development/innovation performance and manufacturing through <em>platform design</em>, etc.</td>
<td>Dean &amp; Susman, (1989); Ettlie &amp; Stoll, (1990); Adler, (1995); Hong et al., 2005; Huang and Rice, 2009; Doll et al., 2010.</td>
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<tr>
<td>Supply Chain Transformation (SCT)</td>
<td>Degree to which a firm engages in a series of actions intended to bring significant changes in the supply chain, including changes in the supplier’s or customer’s portfolios, the supplier/customer development, and the coordination of flow of goods.</td>
<td>van Hoek et al., 1999; Voordijk, 1999; Croom, 2001; Grant, 2005; Lao et al., 2010.</td>
</tr>
<tr>
<td>Operations Applications (OA)</td>
<td>Degree to which operational performance demonstrates high levels of improved performance in (1) <em>time to market</em> and (2) <em>mix flexibility</em>.</td>
<td>Randall, et al., (2003); Roh, et al., (2008); Woodruff (1997); We et al., 2010.</td>
</tr>
<tr>
<td>Firm Innovation Performance (FIP)</td>
<td>Degree of improvement of business performance in terms of <em>market share</em> and <em>sales</em> compared to three years ago.</td>
<td>Calantone et al. (1995); Jeong &amp; Hong (2007); Hong et al., 2009.</td>
</tr>
</tbody>
</table>
2.2.3 Absorptive Capacity NPD Assimilation (NPDA)

Absorptive Capacity NPD Assimilation (NPDA) is Degree to which a firm has implemented programs to (1) integrate product development and manufacturing through QFD, DFM, etc., and (2) improve product development/innovation performance and manufacturing through platform design, etc.”( Dean and Susman, 1989; Ettlie & Stoll, 1990; Adler, 1995; Hong et al., 2005; Huang and Rice, 2009; Doll et al., 2010). According to Skinner, (1974) a RPIS is one that can adapt to changing customer/market demands quickly by achieving short production lead times and batch flexibility (Randall, et al., 2003). In addition to shorter production lead times (Randall, et al., 2003), responsiveness is often manifested through the ability to offer a wide variety of products which results from product innovations and/or improvement efforts (Roh, et al., 2008). Such manifestations of responsiveness can emerge as important context specific innovation outcome goals of the firm (Osservatorio Economico Montebellunese, 2002; Ciappei and Simon, 2005). This is not surprising as speed in terms of lead times and time-to-market can enable a firm to provide customers with new products more frequently, enhancing the mix and creating competitive advantage (Stalk, 1990). In environments where outcomes such as time-to-market and mix flexibility are desired by customers, these outcomes can create customer value (Woodruff, 1997). Given this the present study defines a dependent variable of customer valued RSC outcomes as the degree to which operational performance demonstrates high levels of improved performance in (1) time to market and (2) mix flexibility.

2.2.4 Supply Chain Transformation (SCT)

Supply chain transformation involves a series of action plans that intend to implement substantial changes in supply chain infrastructure (Kopczak, 1997; Croom, 2001; Grant, 2005; van Hoek et al., 1999; Roh et al., 2011). From a absorptive capacity theory perspective, Zahra and George
(2002) identified inter-organizational network restructuring. Firms use different initiatives for supply chain restructuring. Examples of supply chain restructuring include restructuring supply strategy, implementing supplier development, increasing the level of coordination of planning decision and flow of goods with suppliers, rethinking distribution strategy and increasing the level of coordination of planning decisions and flow of goods with customers (Amini and Li, 2011).

2.2.5 Operational Applications (OA)

Operational applications (OA) is “degree to which operational performance demonstrates high levels of improved performance in (1) time to market and (2) mix flexibility.” (Dean and Susman, 1989; Ettlie & Stoll, 1990; Adler, 1995; Hong et al., 2005; Huang and Rice, 2009; Doll et al., 2010). Although “there is a growing importance of services in today’s developed economies” (Gunasekaran, 2005: p. 1), knowledge and research related to service operations management (SOM) is limited when compared to manufacturing operations (Machuca et al., 2007). Within the limited SOM literature, some researchers view service and manufacturing as two discrete classifications (service versus non-service or manufacturing versus non-manufacturing), (Dilworth, 1993; Castells and Aoyama, 1994) whereas others considered service and manufacturing classifications as a continuum in which firms may be more service-focused or more product-focused and vice versa (Hill et al., 2002; Mont, 2002; Gunasekaran, 2005).

The first major difference is customer involvement in the production process (Bitner et al., 1997; Foster et al., 2000). While customer involvement is less apparent in product-focused firms, it is essential in service-focused firms (Foster et al., 2000). Involvement can range from low participation to high participation (product co-creation). As their level of involvement increases,
customers become more important in co-creating the service experience. Under such circumstances, customers often assume production roles (as co-producers of value) and have influence over the productivity, quality, and value of the outputs (Bitner et al., 1997). Consider Adidas, where service (customer) focus has enabled the firm to outperform more product-focused competitors. Their service-focus is manifested in highly integrative supply chain practices connecting customers and suppliers (Berger and Piller, 2003). Adidas employs a process they refer to as ‘elicitation’ whereby “the supplier has to interact with the customer to obtain specific information to define and translate the customers needs and desires into a concrete product specification. However, instead of just listening to the customer, in many cases customers are performing this design activity by themselves…” supported by the manufacturer (Berger and Piller, 2003: p. 43). The focus for Adidas is thus more on the creation of the environment or connectivity shared by its customers and suppliers, and less upon the product itself. In this environment, the customer is a co-producer of value in that they enter their own order information and as such greatly influence the nature of their transaction in coordination with other supply chain actors, creating a unique experience (or product). Table 2 is a summary of constructs, definition and the list of literature base for building an absorptive capacity.

2.3 Exploratory hypothesis

A key purpose of this study is to uncover varying patterns in the way firms employ the variables conceptualized in sections 2.2.1 through 2.2.5. As described earlier, these variables were conceptualized from Zahra and George (2002). At this point, we seek to extend the work of Malhotra et al. (2005) who put forth an exploratory study of supply chain partnership configurations for absorptive capacity. Specifically, Malhotra et al. (2005) used cluster analysis
to identify five configurations. These were collectors, connectors, crunchers, coercers, and collaborators. Similarly, in this exploratory study, we posit.

**H1: Different and distinct clusters of Supply Chain Information Acquisition, NPD Assimilation, Supply Chain Transformation, and Operations Application will emerge among firms.**

### 3.0 Research Methods

The relationships under study are tested using data collected from 711 plant managers or manufacturing executives during the 2005 International Manufacturing Strategy Survey (IMSS). The key respondents represent firms from twenty-three countries and all employed more than 100 employees at the time of the survey. The firms are located throughout Europe, Asia Pacific, North and South America and can be classified in of the following International SIC codes; (1) fabricated metal products, (2) machinery and equipment, (3) office, accounting, and computing equipment, (4) electrical machinery, (5) radio, television, and communication equipment, (6) medical, precision, and optical instruments, (7) motor vehicles, trailers, and semi-trailers, (8) other transportation equipment, and (9) other miscellaneous manufactured products.

The survey instrument was developed in English and translated into the local language for distribution in non-English speaking countries. These translators served as research coordinators, who were university professors in the area of Operations and Supply Chain Management in most cases. This was done in an effort to ensure reliable translation by a research coordinator familiar with business and operations concepts. Firms were contacted in advance of the initial wave of mailings to assess participation interest. This was done in an attempt to ensure an acceptable response rate, which was realized as the lowest response rate was 25% in any individual country. This is generally considered to be adequate for empirical survey based
research. Series of IMSS data have been used for major operations and supply chain journals (Voss and Blackmon, 1998; Frolich and Westbrook, 2001; Cagliano et al., 2006; Hong et al., 2009; Yang et al., 2011).

3.1 Data analysis

Item measures were theorized from the literature discussed earlier and selected based on their appropriateness for measuring the domain of each variable as well as for testing of the relationships between the variables under study (Cagliano et al., 2006). Following Hair, et al., (2006), exploratory and confirmatory techniques were used to ensure appropriate scientific measurement and testing rigor. The items are displayed in table 3.

The items were analyzed in an aggregate fashion using SPSS 15.0. An Exploratory factor analysis (EFA) exercise produced a simple factor structure using Principal Components Analysis (PCA) extraction method with an oblique (Oblimin) rotation. The number of factors was intentionally unspecified in search of Eigenvalues > 1. This resulted in the six factors displayed in table 2 with all cross loadings suppressed at < 0.4, indicative of discriminate validity. The structure matrix provides factor loadings for all of the items > 0.8 suggesting convergent validity. Three exceptions exist (R3 at 0.77, S13 at 0.69, and ST3 at .77). While the authors find these results slightly disappointing, the values are sufficient for research of this nature as values of 0.5 and 0.6 are viewed as satisfactory (see Cagliano, et al., 2006; and Bagozzi and Yi, 1988). With evidence of convergent and discriminant, attention turns to reliability. Cronbach’s Alphas (α) all generated values > 0.7 indicating adequate reliability (Hair, et al., 2006; and Cronbach, 1951). Content validity was confirmed via literature review (see table 2.)
Table 3. Factor analysis *(from the structure matrix, Oblimin rotation. PCA extraction).*

<table>
<thead>
<tr>
<th><strong>Responsive Product Innovation Strategy (RPIS)</strong></th>
<th>Cronbach's alpha: .762</th>
<th><strong>Loadings</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 - Consider the current importance of offering new products more frequently to win orders from your major customers.</td>
<td>0.873</td>
<td></td>
</tr>
<tr>
<td>R2 - Consider the current importance of offering more innovative products to win orders from your major customers.</td>
<td>0.821</td>
<td></td>
</tr>
<tr>
<td>R3 - Consider the current importance of offering a wider product range to win orders from your major customers.</td>
<td>0.771</td>
<td></td>
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<table>
<thead>
<tr>
<th><strong>SC Information Acquisition (SCIA)</strong></th>
<th>Cronbach's alpha: .725</th>
<th><strong>Loadings</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>SI1 - Indicate to what extent do your key/strategic customers use electronic tools (Internet or EDI based) with you for content and knowledge management?</td>
<td>0.862</td>
<td></td>
</tr>
<tr>
<td>SI2 - Indicate to what extent do your key/strategic customers use electronic tools (Internet or EDI based) with you for RFx (request for quotation, proposal information)?</td>
<td>0.848</td>
<td></td>
</tr>
<tr>
<td>SI3 - Indicate to what extent do you use electronic tools (Internet or EDI based) with your key/strategic suppliers for content and knowledge management?</td>
<td>0.694</td>
<td></td>
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<table>
<thead>
<tr>
<th><strong>NPD Assimilation (NPDA)</strong></th>
<th>Cronbach's alpha: .719</th>
<th><strong>Loadings</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>NA1 - Increasing the organizational integration between product development and manufacturing through QFD, DFM, Design for assembly, teamwork, job rotation and co-location, etc.</td>
<td>0.884</td>
<td></td>
</tr>
<tr>
<td>NA2 - Increase performance of product development and manufacturing through platform design, standardization, and modularization</td>
<td>0.882</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th><strong>Supply Chain Transformation (SCT)</strong></th>
<th>Cronbach's alpha: .738</th>
<th><strong>Loadings</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>ST1 - Rethinking and restructuring supply strategy and the organization and management of suppliers portfolio</td>
<td>0.834</td>
<td></td>
</tr>
<tr>
<td>ST2 - Implementing supplier development and vendor rating programs</td>
<td>0.821</td>
<td></td>
</tr>
<tr>
<td>ST3 - Increasing the level of coordination of planning decisions and flow of goods with suppliers including dedicated investments</td>
<td>0.770</td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th><strong>Operational Applications (OA)</strong></th>
<th>Cronbach's alpha: .702</th>
<th><strong>Loadings</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>OA1 - Time to market</td>
<td>0.877</td>
<td></td>
</tr>
<tr>
<td>OA2 - Mix flexibility</td>
<td>0.875</td>
<td></td>
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</tbody>
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<tr>
<th><strong>Firm Innovation Performance (FIP)</strong></th>
<th>Cronbach's alpha: .776</th>
<th><strong>Loadings</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>IP1 - What is the current business unit performance in terms of market share compared to three years ago?</td>
<td>0.897</td>
<td></td>
</tr>
<tr>
<td>IP2 - What is the current business unit performance in terms of sales compared to three years ago?</td>
<td>0.894</td>
<td></td>
</tr>
</tbody>
</table>
The measurement and structural models were tested using confirmatory methods in Analysis of Moment Structures (AMOS) 19.0. The measurement model is available from the first author. The adequacy of the models was assessed using model fit statistics, item loadings (lamdhas), and the statistical significance of the structural path coefficients. This analysis is consistent with the two step approach suggested by Anderson and Gerbing, (1988) for structural equation model (SEM) testing of the measurement model followed by the structural model. The measurement model produced acceptable results for the three tests suggested by Hair, et al., (2006); (1) an absolute fit index, (2) an incremental fit index, and (3) the chi-squared test.

The Root Mean Residual Error (RMR) test for absolute fit in this case produces an acceptable result of 0.03, below the generally accepted cutoff value of 0.05. An additional absolute fit index, Goodness-of-Fit (GFI) and Adjusted Goodness-of-Fit (AGFI) also produced acceptable values > 0.9. In this case, the values for GFI and AGFI are 0.98 and 0.97 respectively. The Comparative Fit Index (CFI) provides for a measure of incremental fit. The measurement model under study here produces a value of 0.98, which is greater than the generally accepted cutoff value of 0.9. Finally, the chi-squared ($X^2$) test is evaluated. $X^2/d.f.$ is a generally accepted test of the data fit between the observed and estimated covariance matrices. This test indicates adequate fit as $X^2/d.f.$ generates a value of 1.61 which is below the generally acceptable cutoff value of 2. As such, the analysis of the measurement model produces satisfactory results.

The variable measures were also examined for reliability, convergent validity, and discriminant validity using confirmatory methods. Reliability can be measured using Cronbach’s ($\alpha$), as discussed earlier in this data analysis, or Composite Reliability. Both tests produce acceptable results in the case of this study as all values exceed the cutoff point of 0.7 as displayed in table 3. Average Variance Extracted (AVE) was calculated as it serves as a
confirmatory method for assessing convergent validity by assessing the amount of variance that is explained by each variable due to trait and measurement error. AVE scores for the variables under study all produced adequate evidence of convergent validity by generating values > 0.5, with the exception of the SCT variable which produced an AVE value of .49. The SCT variable was retained in the model as this relatively minor statistical concern was considered to be outweighed by the variable’s theoretical significance in examining absorptive capacity.

Discriminant validity is also tested using AVE by examining if the AVE value of each construct is greater than the square of the correlations (Braunscheidel and Suresh, 2009). Conversely, the square root of a construct’s AVE should be greater than the correlations between constructs (Chin, 1998b; Fornell and Larcker, 1981; Koufteros, 1999; Koufteros et al., 2001). Table 3 displays the correlations between all latent variables. The AVE for each variable is displayed on the diagonal and immediately followed by the square root of each respective AVE. Each is greater than the value of the correlations in its corresponding row and column. This provides support of discriminant validity as none of the constructs share more variance with any other constructs, than with its own manifest items.

3.1.1 Cluster Analysis

Since multicollinearity is a noted concern when conducting cluster analysis (Hair et al. 2005), we examined the variance inflation factor (VIF) first. A VIF greater than 10 indicates the presence of multicollinearity among the variables (Hair et al. 2005; O’Brien 2007). For service-focused firms, VIFs ranged from 2.04 to 1.22 and for product-focused firms VIFs from 1.69 to 1.15. The results suggested that multicollinearity was not a serious threat. To indentify different pattern of absorptive capacity, a two-step clustering procedure was used (Ketchen & Shook 1996; Hair et
al. 2005). In the first stage, we used a hierarchical method with Ward’s partitioning and Euclidean distance in order to maximize within-cluster homogeneity and between-cluster heterogeneity (Aldenderfer & Blashfield 1984). Standardization of the variables was not used because the scales of the data are consistent with 5 point liker scales. The dendogram and then the incremental changes in the agglomeration coefficient were carefully examined, which suggested a sizable leap in the agglomeration coefficient in the three-cluster model for product-focused firms and four-cluster model for service-focused firms. A test of mean rank differences on the ten measurement items for absorptive capacity showed that they are significantly different at .0001 level. In the second stage, we used K-means algorithm to classify the samples into the identified numbers of clusters.

To examine the reliability and stability of the proposed four-cluster solution, we conducted discriminant analysis, with the ten items given as independent variables and group membership as the dependent variable. The analysis confirmed that 93.9% of the respondents from the service focused sample were categorized properly and 85.3% from the product focused firms, an evidence of good differentiation among the clusters (Refer to Table 8). Table 9 and Figure 6 show the taxonomy of ERPS integrations from the K-means cluster analysis. Three different patterns arose from the product focused firms sample and four patterns from the service focused firms.
Figure 6: Configuration of Absorptive Capacity.

A. Product Focused Firms  
B. Service Focused Firms

4. Discussion of results

We tagged each clusters after comparing them to the absorptive capacity configurations that Malhorta et al. (2005) used.

Configuration 1: Collector. Firms in this cluster seem to focus their resources on new product development assimilation and attempt to increase the levels of operational application effectively. Compared to other clusters, the collectors exhibit the lowest levels of supply chain information acquisition and supply chain transformation. Thus, these firms endeavors to collect knowledge from customers and suppliers and then apply them to bring forth integrated product design. Firms involved in this configuration, however, are not able to effectively absorb the strategic knowledge to transform the supply chains and further it seems that they suffer from the
lack of acquiring the broad base of customers and suppliers to make the strategic decision. Probably, they concentrate on maximizing operational application within the organizational boundary and absorptive capacity has room for expansion to create network knowledge to understand the market and collaborate with suppliers.

**Configuration 2: Cruncher.** We identify the firms in this cluster as cruncher. Malhotra et al. (2005) characterized the firm as having a moderate level of absorptive capability to create the market knowledge and assimilate it to transform the supply chain. The capability levels of the knowledge acquisition, assimilation, transformation, and application in the cluster were higher than the collectors but the degree was modest. All the capabilities are moderately developed, suggesting that all four aspects of absorptive capacity are taking place to a moderate degree. These firms are relatively well informed of the market situation and opportunities and risks behind the supply chain. However, the sharing of information change is narrow on account of less integrated information processing mechanisms. Furthermore, the firms face the risk not to exploit the knowledge to fully cultivate and restructure the supply chain and realize it to apply to operations.

**Configuration 3: Collaborator.** The collaborators are the companies that possess the most progressive level of absorptive capacity. They seem to involve their customers and suppliers actively to understand the market and catch the critical preference changes in customers. They convert the knowledge to create attractive and innovative products and transform the supply chain to reflect the needs emerged in this process. The level of coordination and supplier development, as a result, frequently brings other opportunities to revamp the supply chain and increase the efficiency. Such knowledge acquisition, assimilation and transformation ability enable the firms to operate more flexibly in a shorter time span. While for the product
focused firms (33.7%), the largest number of firms fell into this category, the smallest number of firms (19.4%) were classified as collaborators.

**Configuration 4: Coercer.** Coercer emerged only from the service focused sample. The cluster was distinctive in two ways. First, the supply chain information acquisition capability for RFx (request for quotation, proposal information) was much higher than any other clusters. RFx serves to target specific market segment and narrow the new product development strategy down on the identified customers. Because it offers a substantive means to understand the market, the acquisition capability is desired for both product- and service-focused firms. However, it requires much effort to develop such capability because of the challenging nature to build up and support the infrastructure and train the competent workforce. In service industry, understanding the key customers is crucial, and some firms are making their efforts to fully develop this RFx capability. Second, the firms in this configuration achieved the highest degree of operational application than the other firms. It is interesting that although their NPD assimilation and SC transformation capability are lower than the collaborators, they apply the knowledge to attain a better degree of operational application. One explanation is that some service firms might not pay much attention to integrating the organization for NPD and to transforming the supply chain. Their primary interest goes to understand the customers and meet their expectation with speed and flexibility. About 20% of the service firms are identified as coercers.

**References**
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