AN EMPIRICAL INVESTIGATION OF THE DIRECT AND INDIRECT EFFECT OF UPSTREAM AND DOWNSTREAM INTEGRATION ON PRODUCT INNOVATION

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ABSTRACT

This paper examines the relationship between customer integration and supplier integration and their impact on product innovation capability. The hypothesized relationships of this research model are tested with data drawn from the automotive industry in Thailand by using structural equation modeling. The findings illustrate that customer integration and supplier integration positively influence each other and, both together and individually, lead to improved product innovation capability. In addition, the interact effect of customer integration and supplier integration on product innovation has been found. Moreover, the additional contextual analysis was conducted.

Keywords: External Supply Chain Integration; Product Innovation; Contextual Analysis, Automotive Industry, Survey Research

INTRODUCTION

Some scholars (Rosenzweig et al., 2003) define supply chain integration as a single construct whereas others (Flynn et al., 2010) use multiple constructs to measure supply chain integration. In general, supply chain integration comprises three major elements: internal integration, customer integration and supplier integration (Flynn et al., 2010). These constructs can also be grouped into internal integration and external integration. The last two elements: customer integration and supplier integration are grouped into external integration. Knowledge about the benefits of supply chain integration on general operational performance (i.e. quality, delivery, flexibility and cost) is well-documented (Koufteros et al., 2005; Flynn et al., 2010; Wong & Boon-itt, 2011). In addition, the empirical study about the relationship between external integration and innovation capabilities exists (Koufteros et al., 2005; Peng et al., 2012); however, Peng et al. (2012) found that the relationship between supplier integration and plant innovation capability was positive and significant whereas customer integration was insignificantly related to plant innovation capability. Their study results were based on the data collected from the developed countries. Interestingly, Koufteros et al. (2005) found that supplier product integration was statistically significant related to product innovation, but it was negative. Additionally, the same authors found that supplier process integration was a nonstatistically significant related to product innovation. Consequently, the effects of these two constructs: customer integration and supplier integration on product innovation remain unclear. The link between customer
integration and supplier integration has received less attention. Thus, there is a need to reinvestigate their relationship in a particular in the emerging economies.

To date, the relationship between internal and external integration recently has been empirically tested and confirmed (Gimenez & Ventura, 2005; Koufteros et al., 2005; Koufteros et al., 2010), contributing in the knowledge that firms should work closely with their key customers and suppliers (Singh & Power, 2009). However, researchers seem still to overlook empirically investigating the relationships between the two major constructs of external integration: customer integration and supplier integration and their interaction effects to understand the relationship between customers and suppliers. Therefore, the relationship between customer integration and supplier integration and their interaction effects remain for potential research opportunities.

In addition, the analysis of contextual factors such as firm size and sales and in particular the use of multiple group analysis to compare what the difference is between the groups is still lacking, particular in the emerging economies. This study assumes that the different characteristics of contextual factors may relate to the implementation level of customer integration, supplier integration and accordingly, product innovation capability.

The purpose of this research is to analyze the interaction effect; direct, indirect and total effects of customer integration and suppliers on product innovation. The results of the study provide an understanding about the relationship between customer integration and supplier integration resulting in product innovation in Thailand’s automotive industry. Frohlich and Westbrook (2001) point out the fact that the linkage between upstream and downstream is little known. The same authors also address the fact that firms may decide to integrate with their upstream or downstream firms differently. Thus, this study would provide route options for managers who wish to improve a firm’s product innovation capability and have to make a decision on external integration as to which route they should emphasize.

The empirical findings also highlight the theoretical and practical benefits of implementing upstream and downstream integration or external integration: customer integration and supplier integration simultaneously. The additional context analysis by using multiple group analysis provides useful insights for both scholars and practitioners to see how different firm sizes and sales have different levels of integration and how these impact on product innovation. The results of the study also help managers to decide whether to engage into supply chain integration and further support the relational view of the firm (RV) (Dyer & Singh, 1998) in the sense that a close relationship built between customers and suppliers can contribute to improving a firm’s product innovation capability. This is because the external resources from the suppliers and the customers are crucial sources for product innovation (Lau et al., 2010).

To sum up, this study contributes to existing knowledge four ways. First, it tests the relationship between customer integration and supplier integration, the relationship between customer integration and product innovation and the relationship between supplier integration and product innovation. Second, the interactive effect of customer integration and supplier integration on
product innovation is empirically tested and confirmed. Third, the direct and indirect effects are examined. Fourth, the contextual issues such as size and sales of firms are analyzed.

The rest of the paper is structured as following. The study is described below; beginning with the theoretical background and the development of the research hypotheses. The research methodology is described next, prior to the presentation of the findings and analyses. These are discussed and managerial implications identified. The paper concludes with a review of the limitations of the study and recommendations for further research are provided.

THEORETICAL PERSPECTIVES AND HYPOTHESES

The resource based view (RBV)

The resource based view (RBV) of the firm considers a firm as a unique bundle of resources, including both the tangible and intangible, that enable it to achieve relative advantages resulting in superior performance (Barney, 1991). Traditionally, RBV focuses on the firm’s internal resources but in supply chain management research, researchers have begun to address the external resources available to the firm through its supply network. Therefore, customer integration and supplier integration may be considered as resources. Since the resources needed may be located outside the firm’s boundary; therefore, forming a close relationship allows firms to be able to access strategic resources. For instance, in this research, information such as market information is needed for suppliers to plan for their capacity and production. Therefore, in order to access this strategic resource, supplier firms should collaborate with the customers. In turn, customer firms want to know about the supplier inventory level in order to fulfill its customer requirements. Both firms should work together, communicate and share information. Later this close relationship would block the others (competitors) from their network. This implies that resources became valuable, rare and hard to imitate and imperfectly mobile (Barney, 1991). The RBV also includes capability (Barney, 1991) since resources are sources of capability (Grant, 1996). In this research, a logic of resource-capability relationship that has been used in a previous study (Rosenzweig et al., 2003) is adopted to frame the relationship between customer and supplier integration resulting in developing product innovation capability.

The relational view of strategic management (RV)

The RV theory is suggested by (Dyer & Singh, 1998) to be complementary to the RBV used to frame the relationship between customer integration and supplier integration in this research. Besides employing the RBV to frame the relationships of the constructs, the relationships between customer integration and supplier integration and their impact on product innovation are framed by borrowing some perspectives of the RV. One perspective of the RV suggests that relational rents would occur through the inter-firm knowledge sharing routine. Integrating with customers and suppliers may be considered as inter-firm resources and knowledge sharing. This routine sharing could help to expedite products and process development and also improve them. Thus, sharing information between customers and suppliers would help firms to develop
products quickly or help firms to introduce new product quickly. Under RV, collaborative
advantage is accumulated when there is collaboration for mutual benefit. In short, competitive
advantage will result when an exchange relationship is built.

**Defining the constructs**

*Customer Integration*

In our study, customer integration is “the degree to which a firm can partner with its key
customers to structure their inter-organizational strategies, practices, procedures and behaviors
into collaborative, synchronized and manageable processes in order to fulfill customer
requirements” (Chen & Paulraj, 2004; Flynn et al., 2010; Zhao et al., 2011).

*Supplier Integration*

For this study, supplier integration was defined as “the degree to which a firm can partner with
its key supply chain members (suppliers) to structure their inter-organizational strategies,
practices, procedures and behaviors into collaborative, synchronized and manageable processes
in order to fulfill customer requirements” (Yeung et al., 2009; Flynn et al., 2010).

*Product Innovation*

Koufteros et al. (2005) describe product innovation capability as the extent to which the
manufacturing enterprise is capable of introducing new products and features in the market.
Similarly, the innovation capability includes a firm’s ability to innovate new products (Lau et al.,
2010) and as well as improve existing products/processes (Peng et al., 2008).

**The relationship between customer integration and supplier integration**

Singh and Power (2009) point out that some firms may not wish to engage with suppliers and
customers because these arrangements may be costly, difficult to manage and allow
opportunistic behaviour to occur. Meanwhile other studies (Rosenzweig et al., 2003; Flynn et al.,
2010; Koufteros et al., 2010) disclose that supply chain integration creates several benefits to
operational performance and also firms’ performance. The positive results might be based on the
condition that firms have developed appropriate relationships with customers and suppliers
(Singh & Power, 2009).

Integrating suppliers and customers into the supply chain in order to develop new products and
processes is crucial (Frohlich & Westbrook, 2001). The same authors propose two types of
integration: forward physical flow (delivery integration) and backward flow of information
(information integration). The external integration comprising of customer and supplier
integration are fundamental components of the arcs of integration concept (Frohlich &
Westbrook, 2001). Customer integration is involved with building a close collaboration and
sharing information with key customers to provide the firm with strategic insights to satisfy the
customer (Schoenherr & Swink, 2012). While supplier integration is involved with coordinating
and sharing information activities with key suppliers to provide the firm with strategic insight into a supplier’s processes and capabilities (Schoenherr & Swink, 2012).

In this research, the direction of integration is a two-way relationship based on the adopted work of Holweg and Pil (2008) which suggests that the direction of the flow of information can be bi-directional. Based on this knowledge, the relationships between customer integration and supplier integration are positioned as two-way relationships. Similar work of Gimenez and Ventura (2005) found that internal integration has influenced external collaboration and vice versa. In short, internal integration is correlated with external integration. Stank et al, 2001 (2001) state that the key to facilitating behavioural change shifted from traditional arms-length to a partnership is the relationship between external and internal collaboration. For example, information on order patterns, planned product promotions and valuable service feedback should be informed or shared with the supply chain partners (Stank et al., 2001). The researchers (Stank et al., 2001; Gimenez & Ventura, 2005) emphasise that internal integration is essential to facilitate collaboration with the external firms. Therefore, in this research, the relationship between customers and suppliers may be similar to the relationship between external and internal integration. In addition, the concept of the value chain (Porter, 1985) suggests that firms should exploit the linkages within a firm’s value chain and between the value chains of its suppliers and customers. This means that not only is internal integration required, but it is necessary to integrate with those outside in order to receive superior performance (Frohlich & Westbrook, 2001). In order to enhance its competitive position, the firm should optimize and coordinate linkages to integrate value activities. Furthermore, literature also suggests that firms are more likely to reply to the external linkages in which the network comprises resources, knowledge and information (Teece, 1992). Therefore, based on this logic, customers and suppliers should be linked together. As a result of forming integrative relationships, a customer’s resources and capability and supplier’s resources and capability are exchanged and shared. Moreover, based on fact that the supply chain perspective viewed the supply chain as a single entity (Singh & Power, 2009); therefore, firms along the supply chain including the customers and suppliers are required to collaborate and coordinate across individual firm function and across the supply chain (Sanders, 2007). Literature also points out that when firms have strong customer relationships, these firms are likely to have strong supplier involvement (Singh & Power, 2009). This allows the following hypothesis to be proposed:

H1: customer integration and supplier integration are positively related to each other.

The relationship between customer integration and product innovation and the relationship between supplier integration and product innovation

The benefits for collaboration with other firms help firms to improve performance and gain a source of competitive advantage (Day, 1994). Based on the RV (Day, 1994), when the inter firm relationship is built, it would gain mutual benefits and these generated benefits would be greater than the individual does separately. Similar to the knowledge view of the firm, supplier and customer integration that are involved with knowledge dissemination and sharing activities help to improve firm capabilities (Grant, 1996). According to Dyer and Singh (1998), forming a long
term relationship with business partners allows the firms to be able to combine resources in a unique way resulting in realizing a competitive advantage and gaining relational rents. The RV perspective is used to be a complementary support to the RBV to frame the relationship between customer integration and supplier integration resulting in generating product innovation capability. This implies that the relative rents or benefits that come from sharing information with their supply chain partners can help to increase a firm’s capabilities.

In addition, forming a close relationship between customers and suppliers may allow them to be able to acquire resources, knowledge and information through their network. It also creates synergistic effects of complementary resource and knowledge which can facilitate firms to accelerate new product development processes (Knudsen, 2007). The same author also points out that the involvement of the suppliers can assist firms to identify technical problems and ensure production innovation that is portable in the production process. Working together Japanese suppliers and their customers can shape the design of the components, tailored for the customer’s product and in some cases it is possible to develop an entire system to meet the customer requirements (Liker et al., 1996) is one example of establishing a close relationship between automakers and suppliers. Additionally, one aspect of the supplier involvement is that during the product development cycle, there is frequent communication including intense and regular sharing of technical information to improve performance (Liker et al., 1996). This may reinforce the necessity for the level of information sharing or the higher level of integration with customers and suppliers, resulting in greater performance (Frohlich & Westbrook, 2001). In short, knowledge about the relationship between supply chain integration and competitive capabilities including product innovation are well documented (Frohlich & Westbrook, 2001; Rosenzweig et al., 2003; Koufteros et al., 2005; Flynn et al., 2010; Peng et al., 2012). Therefore, product innovation capability may be influenced by the direct involvement of customers and suppliers. Hence, the higher level of integration with customers and suppliers would provide greater potential benefits. This allows the following hypothesis to be proposed:

H2: the higher the level of customer integration, the better innovation product capability
H3: the higher the level of supplier integration, the better innovation product capability

The hypotheses can be summarized in diagrammatic form, as shown in Figure 1.

**Figure 1:** The research model
RESEARCH METHODOLOGY

Measures and questionnaire design

The use of dyadic relationship with a major customer and supplier is commonly practice in supply chain integration research (Zhao et al., 2011). Moreover, the use of a single informant is a common practice in survey research when key informants are likely to provide accurate information on customer integration because of their familiarity with major customers (Zhao et al., 2011). The unit of analysis is at the firm level and strategic positions such as president, vice president of purchasing, managing director, supply chain director and procurement manager are prospective respondents. The adapted items of customer integration, supplier integration and product innovation capability were taken from previous studies such as Flynn et al (2010), Koufteros et al (2002) and Menor et al (2007). A 7-point Likert scale was used with “1” for “strongly disagree” and “7” for “strongly agree”. This study employed the Q-sorting technique which comprised three separate stages: (1) item creation; (2) structured interview and Q-sort; and (3) large scale testing (Moore & Benbasat, 1991). Three Q-sort rounds were completed prior to distributing the final questionnaires to prospective respondents for a large-scale survey. Detailed Q-sort results are available from the authors.

Sample and data collection

The sample frame was the list of members of Thailand Automotive Industry 2011, consisting of 1,858 companies. The research targeted both tier 1 and tier 2 automotive suppliers having least 100 employees. After screening for unrelated business operators, firms unwilling to participate in the survey and invalid addresses, 698 firms remained as potential participants in the study. The response rate was 37.10%. Table 1 provides a profile of the respondents to the survey. Table 2 provides a profile of the companies by number of employees, annual sales, type of firm ownership and position in supply chain.

Table 1: The sample profile

<table>
<thead>
<tr>
<th>Job Title</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>President/CEO</td>
<td>22</td>
<td>8.49</td>
</tr>
<tr>
<td>Vice president/Director</td>
<td>21</td>
<td>8.10</td>
</tr>
<tr>
<td>General manager</td>
<td>35</td>
<td>13.51</td>
</tr>
<tr>
<td>Manager (plant manager, supply chain, logistics, purchasing/procurement and operations)</td>
<td>116</td>
<td>44.80</td>
</tr>
<tr>
<td>Others (engineering, manufacturing/production, project, sales and marketing)</td>
<td>65</td>
<td>25.10</td>
</tr>
<tr>
<td>Total</td>
<td>259</td>
<td>100%</td>
</tr>
</tbody>
</table>
Table 2: Company profile

<table>
<thead>
<tr>
<th>Characteristics of firms</th>
<th>Frequency</th>
<th>%</th>
<th>Characteristics of firms</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of employees</td>
<td></td>
<td></td>
<td>Ownership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 200</td>
<td>62</td>
<td>23.75</td>
<td>100% Thai owned</td>
<td>78</td>
<td>29.89</td>
</tr>
<tr>
<td>200-499</td>
<td>70</td>
<td>26.82</td>
<td>Joint-venture</td>
<td>90</td>
<td>34.48</td>
</tr>
<tr>
<td>500-999</td>
<td>66</td>
<td>25.29</td>
<td>Wholly foreign owned</td>
<td>93</td>
<td>35.63</td>
</tr>
<tr>
<td>More than 1,000</td>
<td>261</td>
<td>100.00</td>
<td></td>
<td>261</td>
<td>100.00</td>
</tr>
<tr>
<td>Total</td>
<td>261</td>
<td>100.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual sales (in millions Baht)</td>
<td></td>
<td></td>
<td>Company position</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 200</td>
<td>49</td>
<td>18.77</td>
<td>Supplier tier 1</td>
<td>196</td>
<td>75.10</td>
</tr>
<tr>
<td>201-499</td>
<td>40</td>
<td>15.33</td>
<td>Supplier tier 2</td>
<td>65</td>
<td>24.90</td>
</tr>
<tr>
<td>500-999</td>
<td>35</td>
<td>13.41</td>
<td></td>
<td>261</td>
<td>100.00</td>
</tr>
<tr>
<td>1,000-2,999</td>
<td>74</td>
<td>28.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above 3,000</td>
<td>63</td>
<td>24.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>261</td>
<td>100.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DATA ANALYSIS AND RESULTS

Structural equation modeling (SEM) was used to analyze the data and its relationships (Hair et al., 1998) and then a two step approach was carried out to test the hypotheses: (1) test measurement model to check the validity and reliability of the item scales and (2) test structural model (Anderson & Gerbing, 1988).

Measurement model, validity and reliability

The assumptions of linearity, additivity model specification, multi colinearity and homoscedasticity were checked through the correlation analysis (Berry & Feldman, 1985). Table 3 shows details of the summary statistics for each construct with mean, standard deviation and correlation matrix of measures variables. The overall fit that is recommended to check the goodness of fit index (GFI); comparative fit index (CFI); normed fit index (NFI); root mean square error of approximation (RMSEA); standardized root mean square residual (SRMR) goodness of fit index were used in evaluating the measurement model fit (Hu & Bentler, 1999; Shah & Goldstein, 2006).

Data Analysis and Results
The fit indices that are commonly recommended to check, include the goodness of fit index (GFI); adjusted goodness-of-fit index (AGFI), comparative fit index (CFI); normed fit index (NFI); root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR) (Hu & Bentler, 1999; Shah & Goldstein, 2006). The overall model fit is good with $\chi^2 = 126.087$, df = 64, CMIN /df= 1.97, p= 0.000, GFI =.935, AGFI = 0.893, NFI=.939, CFI = 0.969, RMSEA =.051 and SRMR .061.

The scale reliability of each construct was assessed by using Cronbach’s Alpha. The Alpha value of every factor was greater than 0.70, indicating that it was a very good statistical result (Hair et al., 1998). The instruments for the constructs were validated by factory analysis using principal axis factoring with oblique factor rotation and their result confirmed the structure of the constructs. The convergent validity was checked for construct validation by using a confirmatory factor analysis and standardized factor loading which was greater than 0.5, indicating good convergent validity among the instruments of each construct (Byrne, 2001). In addition, average variance extracted (AVE) of each construct was assessed and AVE should be at least 0.5 to be considered as adequately convergent and a construct reliability (CR) value between 0.6 and 0.7 is acceptable (Hair et al., 1998). The results are presented in Table 3. The non-response bias was conducted and found that the data did not have an indicator for early versus late responses (Armstrong & Overton, 1977). One –way ANOVA was implemented to check a significant difference of different groups. The results show that a significant difference was not found. Table 4 shows details of the summary statistics for each construct with mean, standard deviation, correlation matrix of measures variables and square root of average variance extracted.

Table 3: Assessment of reliability and construct validity

<table>
<thead>
<tr>
<th>Items</th>
<th>Factor loading</th>
<th>$t$-value</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CI: Customer integration (CR=0.86 , AVE =0.55 )</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We establish more frequent contact with our major customers</td>
<td>0.657</td>
<td>1.00</td>
<td>0.854</td>
</tr>
<tr>
<td>Our major customers are linked with information network</td>
<td>0.705</td>
<td>9.575</td>
<td></td>
</tr>
<tr>
<td>Our major customer share market information with us.</td>
<td>0.805</td>
<td>9.972</td>
<td></td>
</tr>
<tr>
<td>Our major customer shares demand forecast with us.</td>
<td>0.771</td>
<td>9.952</td>
<td></td>
</tr>
<tr>
<td>We share our available inventory with our major customer.</td>
<td>0.754</td>
<td>9.984</td>
<td></td>
</tr>
<tr>
<td><strong>SI: Supplier Integration (CR=0.90 , AVE =0.64 )</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We share our inventory levels with our major supplier.</td>
<td>0.841</td>
<td>1.00</td>
<td>0.875</td>
</tr>
<tr>
<td>We share our production plans with our major supplier.</td>
<td>0.751</td>
<td>13.221</td>
<td></td>
</tr>
<tr>
<td>We share our demand forecasts with our major supplier</td>
<td>0.765</td>
<td>10.835</td>
<td></td>
</tr>
<tr>
<td>Our major supplier shares their production capacity with us.</td>
<td>0.812</td>
<td>12.067</td>
<td></td>
</tr>
<tr>
<td>Our major supplier shares available inventory with us.</td>
<td>0.820</td>
<td>14.286</td>
<td></td>
</tr>
</tbody>
</table>
Table 4: Mean, standard deviations and correlations of the construct

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>CI</th>
<th>SI</th>
<th>PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI</td>
<td>5.64</td>
<td>0.94</td>
<td>0.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SI</td>
<td>4.92</td>
<td>0.94</td>
<td>0.500**</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>PI</td>
<td>5.33</td>
<td>0.93</td>
<td>0.371**</td>
<td>0.270**</td>
<td>0.81</td>
</tr>
</tbody>
</table>

**Correlation is significant at the 0.01 level (2-tailed). Note: CI = customer integration; SI = supplier integration, PI = product innovation. The square root of average variance extracted is given along the diagonal.

Structural model

AMOS 20 with the maximum likelihood estimation method to estimate the relationship among constructs and to test hypotheses was used. The overall fit indices of the structural model indicated that the theoretical model fitted the data (Bollen, 1989) ($\chi^2 = 97.971.84$ with degrees of freedom = 61, $p = 0.002$, (CMIN/df = 1.60); GFI = 0.950, AGFI = 0.914; CFI = 0.981; NFI = 0.952; RMSEA = 0.048 and SRMR = 0.056). These indices indicated that all measures of fit exceeded the recommended values (Hu & Bentler, 1999). The results of structural model are presented in Figure 2. The results of testing three hypotheses are listed below.

H1: Customer integration and supplier integration have a positive each other. This hypothesis is supported, as the parameter estimate (0.517) is significant ($t = 5.400$, $p = 0.000$).

H2: Customer integration has a positive relationship on product innovation. This hypothesis is supported, as the parameter estimate (0.293) is significant ($t = 3.663$, $p = 0.000$).

H3: Supplier integration has a positive relationship product innovation. This hypothesis is supported, as the parameter estimate (0.197) is significant ($t = 2.457$, $p = 0.014$).

The interaction effect

The interaction effects of customer integration and supplier integration (CI*SI) on product innovation is significant at $t = 2.457$, $p = 0.014$ and a standardized estimate of 0.129.
Figure 2: Structural model

![Structural model diagram]

**Correlation is significant at the 0.05 level (two-tailed).**
***Correlation is significant at the 0.001 level (two-tailed)

Direct, indirect and total effects

With respect to customer integration this has a direct effect (0.293) on product innovation. It has an indirect effect (0.101) on process flexibility via supplier integration, with the total effect being 0.394. With respect to supplier integration this has a direct effect (0.197) on product innovation. It has an indirect effect (0.151) on product innovation via customer integration, with the total effect being 0.348. Table 5 shows the results of the direct, indirect and total effects.

Table 5: Estimates of standardized direct, indirect and total effects of the exogenous constructs on the endogenous constructs

<table>
<thead>
<tr>
<th>Exogenous construct</th>
<th>Endogenous construct: product innovation</th>
<th>Direct effect</th>
<th>In direct effect</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Integration</td>
<td></td>
<td>0.293</td>
<td>0.101</td>
<td>0.394</td>
</tr>
<tr>
<td>Supplier Integration</td>
<td></td>
<td>0.197</td>
<td>0.151</td>
<td>0.348</td>
</tr>
</tbody>
</table>
Additional contextual analysis

*Direct, indirect and total effects of sizes: large versus small*

For the large firms, with respect to customer integration this has a direct effect (0.262) on product innovation. It has an indirect effect (0.140) on product innovation, with the total effect being 0.402. With respect to supplier integration this has a direct effect (0.246) and indirect effect on product (0.149), with the total effect being 0.395. For the small firms, with respect to customer integration this has a direct effect (0.272) on product innovation. It has an indirect effect (0.109) on product innovation, with the total effect being 0.381. With respect to supplier integration this has a direct effect (0.221) and an indirect effect on product innovation (0.135), with the total effect being 0.356. Please see Table 6, 7 and 8.

**Table 6: Contextual analysis: Firm size (n=261)**

<table>
<thead>
<tr>
<th>Path</th>
<th>Hypotheses</th>
<th>Aggregated sample (n=261)</th>
<th>&lt; 500 (n=132)</th>
<th>&gt; 500 (n=129)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI ↔ SI</td>
<td>H1</td>
<td>0.517***</td>
<td>0.495***</td>
<td>0.569***</td>
</tr>
<tr>
<td>CI → PI</td>
<td>H2</td>
<td>0.293***</td>
<td>0.272**</td>
<td>0.262**</td>
</tr>
<tr>
<td>SI → PI</td>
<td>H3</td>
<td>0.197**</td>
<td>0.221*</td>
<td>0.246**</td>
</tr>
</tbody>
</table>

* p < 0.1 level (two-tailed) ** p < 0.05 level (two-tailed) *** p < 0.001 level (two-tailed).

**Table 7: Estimates of standardized direct, indirect and total effects of the exogenous constructs on the endogenous constructs: Large firm**

<table>
<thead>
<tr>
<th>Exogenous construct</th>
<th>Endogenous construct: product innovation</th>
<th>Direct effect effect</th>
<th>In direct effect</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Integration</td>
<td></td>
<td>0.262</td>
<td>0.140</td>
<td>0.402</td>
</tr>
<tr>
<td>Supplier Integration</td>
<td></td>
<td>0.246</td>
<td>0.149</td>
<td>0.395</td>
</tr>
</tbody>
</table>
Table 8: Estimates of standardized direct, indirect and total effects of the exogenous constructs on the endogenous constructs: Small firm

<table>
<thead>
<tr>
<th>Exogenous construct</th>
<th>Endogenous construct: product innovation</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Direct effect effect</td>
<td>In direct effect</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Customer Integration</td>
<td>0.272</td>
<td>0.109</td>
<td>0.381</td>
<td></td>
</tr>
<tr>
<td>Supplier Integration</td>
<td>0.221</td>
<td>0.135</td>
<td>0.356</td>
<td></td>
</tr>
</tbody>
</table>

Direct, indirect and total effects of sales

For the firm with sales less than 1,000 million baht (please see table 10), with respect to customer integration this has a direct effect (0.240) on product innovation. It has an indirect effect (0.141) on product innovation, with the total effect being 0.381. With respect to supplier integration this has a direct effect on product innovation (0.303) and an indirect effect (0.112), with the total effect being 0.415. For the firm with sales between 1,001-2,999 million baht (please see table 11), with respect to customer integration this has a direct effect (0.322) on product innovation. It has an indirect effect (0.033) on product innovation, with the total effect being 0.355. With respect to supplier integration this has a direct effect (0.065) and an indirect effect on product innovation (0.163), with the total effect being 0.228. For the firm with sales of more than 3,000 million baht (please see table 12), with respect to customer integration this has a direct effect (0.392) on product innovation. It has an indirect effect (0.162) on product innovation, with the total effect being 0.554. With respect to supplier integration this has a direct effect on product innovation (0.263) and an indirect effect (0.241), with the total effect being 0.304. Please see Table 9, 10, 11 and 12.

Table 9: Contextual analysis: Sales (n=261)

<table>
<thead>
<tr>
<th>Path</th>
<th>Hypotheses</th>
<th>Aggregated sample (n=261)</th>
<th>Low n = 121</th>
<th>Medium n = 77</th>
<th>High n =63</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI ← SI H1</td>
<td>0.517***</td>
<td>0.466***</td>
<td>0.506*</td>
<td>0.616*</td>
<td></td>
</tr>
<tr>
<td>CI → PI H2</td>
<td>0.293***</td>
<td>0.240**</td>
<td>0.322**</td>
<td>0.392**</td>
<td></td>
</tr>
<tr>
<td>SI → PI H3</td>
<td>0.197**</td>
<td>0.303*</td>
<td>0.065****</td>
<td>0.263****</td>
<td></td>
</tr>
</tbody>
</table>
Note: Low = < 1,000 million Baht, medium = 1,001-2,999 million Baht, high = > 3,000 million Baht. 1 USD = 29.00 Baht (approximately).

* $p < 0.1$ level (two-tailed) ** $p < 0.05$ level (two-tailed) *** $p < 0.001$ level (two-tailed).

**** SI → PI of both medium and high sales are not statistically significant at $p < 0.05$ level (two-tailed).

**Table 10:** Estimates of standardized direct, indirect and total effects of the exogenous constructs on the endogenous constructs: Sales < 1,000 million baht

<table>
<thead>
<tr>
<th>Exogenous construct</th>
<th>Endogenous construct: product innovation</th>
<th>Direct effect effect</th>
<th>In direct effect</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Integration</td>
<td>0.240</td>
<td>0.141</td>
<td>0.381</td>
<td></td>
</tr>
<tr>
<td>Supplier Integration</td>
<td>0.303</td>
<td>0.112</td>
<td>0.415</td>
<td></td>
</tr>
</tbody>
</table>

**Table 11:** Estimates of standardized direct, indirect and total effects of the exogenous constructs on the endogenous constructs: Sales 1,001-2,999 million baht

<table>
<thead>
<tr>
<th>Exogenous construct</th>
<th>Endogenous construct: product innovation</th>
<th>Direct effect effect</th>
<th>In direct effect</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Integration</td>
<td>0.322</td>
<td>0.033</td>
<td>0.355</td>
<td></td>
</tr>
<tr>
<td>Supplier Integration</td>
<td>0.065</td>
<td>0.163</td>
<td>0.228</td>
<td></td>
</tr>
</tbody>
</table>

**Table 12:** Estimates of standardized direct, indirect and total effects of the exogenous constructs on the endogenous constructs: Sales > 3,000 million baht

<table>
<thead>
<tr>
<th>Exogenous construct</th>
<th>Endogenous construct: product innovation</th>
<th>Direct effect effect</th>
<th>In direct effect</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Integration</td>
<td>0.392</td>
<td>0.162</td>
<td>0.554</td>
<td></td>
</tr>
<tr>
<td>Supplier Integration</td>
<td>0.263</td>
<td>0.241</td>
<td>0.304</td>
<td></td>
</tr>
</tbody>
</table>
DISCUSSION

The purpose of this study is to examine the relationship between customer integration and supplier integration and also examine how this form of integration can achieve better product innovation. By contrast with prior study (Peng et al., 2012), the finding indicates that customer integration has a positive relationship with product innovation. Meanwhile, previous study (Koufteros et al., 2005) could not find a statistically significant link between supplier process integration and product innovation; however, this study empirically indicated that supplier integration has a positive relationship with product innovation. The results of the study suggest that the relationship between customer integration and suppliers is correlated. In addition, the results of the study show that the total effect of customer integration (0.394) on product innovation is slightly greater than that of supplier integration (0.348). A possible explanation for this is that items used to measure customer integration such as frequent contact, information network and market information, may be directly related to the measurable items in the product innovation construct. Additionally, the results of the study may reinforce the fact that customers are a source of new ideas or market information that is important for manufacturers to respond to the market. This does not mean that suppliers are less important because the results also show that supplier integration can help firms to increase product innovation capability. Another explanation is that two constructs: customer integration and supplier integration are not defined symmetrically. Singh and Power (2009) point out that researchers should not assume that these effects have similar size and strength. However, at a practical level, the results indicate that customer integration has a stronger relationship with product innovation than that of supplier integration. Interestingly, the total effect of supplier integration on product innovation has a slightly greater than that of customer integration in the firms grouped as low sales. By contrast with medium sales and high sales, a low sales group has the indirect effect of supplier integration via customer integration a slightly lower than that of customer integration via supplier integration.

Implication for theory

As for the results of the study, it provides several implications and contributions for research and practice. First, this is a large scale empirical research that supports H1, H2 and H3 that customer integration and supplier integration are related to each other and these high correlated relationships enhance product innovation capability. Individually and both together customer integration and supplier integration have a positive relationship with product innovation. This study also empirically tested the logic of the resource-capability relationship (Rosenzweig et al., 2003) and support theories: the RBV (Barney, 1991) and the RV (Dyer & Singh, 1998) as well as empirically supporting the suggestion of value chain linkages (Porter, 1985) to exploit the benefits of the external linkages. This study suggests that two forms of integration: customer integration and supplier integration are related to each other. This implies that the relationship between customer integration and supplier integration are two-way relationships. Although this study did not analyze in the same way as Frohlich and Westbrook’s (Frohlich & Westbrook, 2001), similar concepts about supplier-facing, customer-facing and outward-facing may be applied. Based on the result, the relationships between customer integration and supplier integration are correlated (0.517) considered as high, this may imply that those patterns such as

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outward-facing of integration may emerge in this study. The degree of integration of suppliers
and customer integration is high. However, further studies should conduct the patterns of
integration based on the suggestion of Frohlich and Westbrook. This high correlation can be
explained such that in order to satisfy customer’s customer or make the firms different from the
competitors, the customer firms need to work with their suppliers in the early stages of product
development. This may be common practice in the automotive industry where information on
future products or features should be shared with upstream firms or suppliers. Therefore, there is
a need for customers to share and work together with the suppliers. In turn, the suppliers seek to
improve capabilities such as product innovation through acquiring strategic resources from the
customers. The information and knowledge from suppliers are crucial for manufacturers who
have to respond to their customers. Thus, it may imply that information sharing with customers
may make suppliers important sources of innovation. Two firms form a close collaboration;
therefore, the directions of integration are towards each other. Thus, this finding of results can
advance knowledge in supply chain integration whereby previous studies (Koufteros et al., 2005;
Flynn et al., 2010; Koufteros et al., 2010; Zhao et al., 2011) emphasize only a single direction of
supply chain integration rather than testing whether customer integration and supplier integration
relationships are developed simultaneously.

The research model is supported by a holistic view of supply chain integration as a single entity
that supply chain partners should work closely with each other. Based on the RBV and the RV,
the forms of integration between customer integration and supplier integration reinforce the way
that both firms utilize their critical resources to generate or improve a firm’s capability. Since
one may lack the necessary information, the other may have this resource. Thus, they need to
share resources and information leading to forming close relationships, contributing to mutual
benefits in this case to enhance product innovation. Moreover, the study results disclose that the
higher level of correlation between customer integration and supplier integration generates better
total effects. Although the small firms have higher path coefficients from customer integration to
product innovation than that of the large firms, the total effects from customer integration to
product innovation are smaller than that of the large firms. This may reinforce the importance of
the high level of integration such that a higher level of integration leads to better performance
(Frohlich & Westbrook, 2001; Flynn et al., 2010). In this study, the relationship between
customer integration and supplier integration of the larger firms is highly correlated to each
other, more so than that of the relationship of customer integration and supplier integration of the
small firms.

In addition, this study provides the results of the effect of interaction on customer integration and
supplier integration. The interaction effect of customer integration and supplier integration on
product innovation has been found. This also helps to reinforce the fact that the pursuit of
collaboration between two firms is needed. Additionally, this implies that the engagement with
suppliers and customer generates benefits in terms of enhancing product innovation. This can be
motivation for firms to enter into collaborative relationships.

Based on multiple-group analysis, the results suggest that the larger firms seem to have higher
path coefficients from customer integration to product innovation and supplier integration to
product innovation. This implies that the size of firms may impact on product innovation
capability. The results disclose that the small firms have a better alignment between customer integration and production innovation. This may imply that the smaller firms are more innovative in particular with products than the large firms. However, the smaller firms seem to have not well integrated with suppliers. This leads to lower direct impact of product innovation. The findings of the study also reveal that the large firms have a better link between supplier integration and product innovation resulting in better product innovation that that of the small firms. This implies that sizes of firms relate to resource availability and may relate to levels of integration effort. The large firms are in a better position to acquire more resources. However, the results show that the path coefficient from customer integration to product innovation of the small firms is higher than that of the large firms. Interestingly, this may reinforce that customers are important sources of information and knowledge that can have an influence on product innovation in particular that of the small firms. Overall, both large and small firms seem to have better customer integration than supplier integration. There may be further studies about power and dependence in the supply chain and the same research model should be further re-tested in different countries or industries.

Also based on the multiple group analysis on the amount of sales, the firms with sales greater than 3,000 million baht have the strongest effect of customer integration on product innovation and also total effects on product innovation. This may be common for the firms that have high revenue to obtain more resources contributing to enhancing their product innovation capability. In contrast, the firms with sales of less than 1,000 million baht have the strongest linkage between supplier integration and product innovation whereas the linkages from supplier integration to product innovation of the firms with sales of between 1,001 -2,999 million baht and the firms with sales greater than 3,000 million baht have no statistical significance. This interesting finding may imply that for the firms with sales less than 1,000 million baht, suppliers are crucial sources to increase their product innovation capability.

**Implications for practice**

First, the results of this study suggests to practitioners that firms should work with customers and suppliers simultaneously rather than integrating with either key customers or key suppliers. The managers should treat supply chain integration as a holistic view. Besides each individual form of integration leads to improved product innovation capability, implementing customer integration and supplier integration together can lead to improved product innovation. Therefore, firms should form integrative relationships with customers and suppliers simultaneously to receive mutual benefits. The closer relationship implies a better position of firms to access the strategic resources from their network. The high level of integration between customers and suppliers leads to the higher level of product innovation capability.

In addition, each form of integration leads to different levels of product innovation capability improvement. For example, customer integration has a stronger link to product innovation. Thus, managers who wish to use product innovation to compete in the market or win orders should realize that business processes and activities related to customer integration should be shared and fed back to their suppliers. These customer integration activities can be a useful guideline if they wish to implement the external supply chain integration. Without well integrating with suppliers, firms may not enhance their product innovation capability much. Based on this study, managers
should pay more attention to supplier integration because integrating with suppliers seems to be something they are inexperienced in. In other words, they should balance the supply side-supplier integration.

However, if the company has limited resources, the findings of the study also can be a guideline for managers who have to make a decision as to which form of integration they may want to choose to emphasize. Interestingly, an indirect effect of supplier integration on product innovation via customer integration is slightly higher than that of customer integration via supplier integration. This is because the link from customer integration to product innovation is stronger than that of supplier integration. In other words, firms still may not have good supplier integration. However, it does not mean that an indirect effect of customer integration on product innovation via the supplier is less important. For a large firm, an indirect effect of customer integration on product innovation via supplier integration accounts for more than half of the direct effect. When combining both effects together, the total effect is even larger. This provides useful insights for managers that more effective collaboration between customers and suppliers is required and this would lead firms to improve their product innovation.

CONCLUSION

Our study has provided an empirically supported model to assist academics and practitioners in understanding the relationship between customer integration and supplier integration and its impacts on product innovation in the emerging economies. The relationships between customer integration and supplier integration have been found to be developed simultaneously. The direct, indirect and total effect of the relationships of customer integration and supplier integration on product innovation has provided useful insights into the pattern of supply chain integration and its effect on a firm’s product innovation capability. Each individual customer and supplier integration provides different effects on product innovation. If firms have limited resources, managers may consider a route from customer integration to product innovation. This link provides the stronger result of product innovation improvement. However, the interaction effect has been found so that it is suggested that firms should integrate their business process with both customers and suppliers simultaneously. A larger firm seems to have the advantage of size; however, surprisingly, a small firm has stronger links from customer integration to product innovation. However, this advantage may be the only factor for enhancing product innovation capability, but a level of integration between customers and suppliers may be another factor influencing the success of product innovation improvement. Also firms with sales less than 1,000 million baht have the strongest links between supplier integration and product innovation. Meanwhile the firms with medium and higher sales seem to be inexperienced in supplier integration, but the link between customer integration and the product innovation capability of these firms are stronger than that of the firms with sales of less than 1,000 million baht.

This study has contributed to the operations and supply chain management literature by providing a further study on the alignment of the external supply chain integration and product innovation capability in Thailand by using empirical data from automotive suppliers. The results enhance practitioners’ understanding about implementing external integration in Thailand.
context. However, the use of data from Thailand’s automotive industry may limit the ability to generalize the results. Therefore, similar studies should be carried out in other industry sectors and in developed and developing economies.
REFERENCES


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