The effect of supply chain information integration and logistics integration on firm performance

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ABSTRACT
Supply chain integration involves both material and information integration. While the aspects of information technology and information sharing have been included in many studies, the logistics integration of the material flow between supply chain partners has been largely absent in empirical research. In this paper, we investigate the integration of both information and materials between supply chain partners. Using data set from 232 Australian firms, we found that logistics integration has a significant effect on operations performance. Information technology capabilities and information sharing both have significant effects on logistics integration. Furthermore, strategic supplier relationships have both direct and indirect effects on the operational performance of the firm; with the indirect effect via information integration and logistics integration.

Keywords: supply chain management, logistics integration, information integration, organisational performance

INTRODUCTION
Most definitions of supply chain management explicitly recognize the existence of two flows through the chain; there is a flow of goods and an equally important flow of information (Fisher, 1997; Pagell, 2004). Supply chain integration must thus comprise both information and material, and cannot restrict itself to only one. Higher levels of integration are characterized by increased logistics-related communication, greater coordination of the firm’s logistics activities with those of its suppliers and customers, and more blurred organizational distinctions between the logistics activities of the firm and those of its suppliers and customers (Stock et al., 2000).

Logistics integration refers to specific logistics practices and operational activities that coordinate the flow of materials from suppliers to customers throughout the value stream (Stock et al. 2000). Logistics provides industrial firms with time and space utilities, by providing the necessary quantity of goods is in the right place at the right time (La Londe 1983, Caputo and Mininno 1998). Grounded on earlier research, the theoretical construct of logistic integration is derived to include the seamless integration of the logistics function of the various supply chain partners (Stock et al., 1998, 2000).

Information integration refers to the sharing of key information along the supply chain network which is enabled by information technology (IT). One of the main purposes of information integration is to achieve real-time transmission and processing of information required for supply chain decision making. Lee et al (2000) show that information sharing can lead to lower cost through reductions in
inventories and shortages. However, in order to realize this value, changes in the logistics system are required, such as Vendor-Managed Inventory (VMI) programs, lead time reductions, order quantity reductions and more frequent deliveries.

In the light of supply chain integration concept, logistics and information integration reflect two interrelated forms of integration which flow in opposite directions (i.e. forward and backward respectively). Forward integration is concerned with the physical flows of materials from suppliers to manufacturers which we refer to logistics integration. On the other hand, backward integration is concerned with the coordination of information technologies and the flows of information from manufacturers to suppliers.

While IT and information sharing have been included in many empirical studies, the logistics integration of the material flow between supply chain partners has received less attention. Noticeable exceptions are Frohlich and Westbrook (2001), Sheu et al (2006), Zhou and Benton (2007), and Li et al. (2009). Frohlich and Westbrook (2001) modeled supply chain integration in terms of both information and material using eight items concerning IT, information sharing as well as logistics integration. They found that wider scope of integration had a positive association with performance improvement. However, since the items were combined into a single construct, they were unable to identify any relationship between information integration and logistics integration. Based on a study of five pairs of suppliers and retailers in Taiwan, Sheu et al (2006) developed and proposed a relationship model, including long-term relationship, supply chain architecture (including e.g. information sharing and IT capabilities), supplier-retailer collaboration, and performance. They concluded that better IT capabilities as well as better communication contribute to a better platform for both parties to engage in supply chain coordination, participation and problem-solving activities. Zhou and Benton (2007), studied the effect of information sharing on supply chain practice; the latter captured as a construct including elements of planning, production, and delivery practice. They found that information sharing significantly impacts supply chain practice, and a significant effect of delivery practices on delivery performance. The study by Li et al. (2009) included IT implementation (both technology capabilities and information sharing), supply chain integration (of logistics systems) and performance. They found that IT implementation had a significant effect on supply chain
integration, and indirectly on performance. However, no direct effect on performance by IT implementation was noted.

In this paper we investigate the relationships among information integration, logistics integration, strategic supplier relationships, and the effects on operational performance. We use constructs developed and verified by Chen and Paulraj (2004). We review the relationships and present the hypotheses. Then, the survey methodology and results are presented. Finally, the implications for managers and researchers are discussed.

THEORETICAL BACKGROUND AND HYPOTHESES

In this section, we first explain the notion of logistics integration and its impact on firm performance. We then discuss the role of supply chain information integration – both IT and information sharing – in supporting the material flow integration. Thirdly, the strategic relationship with suppliers is discussed as an antecedent of supply chain information management and its potential direct impact on firm performance. Subsequently, we develop our research hypotheses linking strategic relationship with suppliers, information integration, logistics integration, and operational performance.

Logistics integration

The increasing competition has driven firms to not only improve their internal operations (such as process control and inventory management), but also focus on integrating their suppliers into the overall value chain processes. The contribution of suppliers in delivering values to customers, hence, building competitive capabilities (quality, delivery, flexibility, and cost) has been well recognized. The concept of integrated logistics has changed the view of competition; from between individual firms to between supply chain networks which reflects a broader view of operations from intra-firm level to inter-firm level. The essence of logistics integration is well-coordinated flow of materials from suppliers which allow firms to have a smooth (seamless) production process (Frohlich and Westbrook, 2001). Such coordination produces a seamless connection between firms and suppliers in such a way that the boundary of activities between the two parties is getting blurred (Stock et al., 1998, 2000). It has been well argued that having solid logistics integration will reduce various
problems which have been permeating in the firm’s interface area, most notably is the bullwhip effect due to demand uncertainty. Integrated logistics also allow firms to adopt lean production systems which are characterized by reliable order cycles and inventory reduction. By and large, logistics integration allows companies and their supply chain partners to act as a single entity which would result in improved performance throughout the chain (Tan, Kannan, and Handfield, 1998). In other words, through logistics integration, firms can have the potential benefits of vertical integration (quality, dependability, planning and control, and lower costs) without having it in the physical sense (La Londe and Masters, 1994).

The majority of surveys report a positive relationship between supply chain integration and performance (Van der Vaart and van Donk, 2008). DeToni and Nassimbeni (1999) found that better performing plants exhibit a higher level of logistic interactions, Frohlich and Westbrook (2001) that the widest arcs of integration had the strongest association with performance improvement, Sheu et al. (2006) that higher levels of collaboration result in operational efficiency in the supply chain system, and finally Li et al. (2009) that supply chain integration is significantly related to supply chain performance. Thus, we can formulate our first hypotheses:

H1: Logistics integration has a positive relationship with firm’s operational performance.

Supply chain information integration

Our review of the literature concerning the topics related to supply chain information integration suggest two major aspects: the technical aspects (information technology connection), and the social aspects (information sharing and trust). It is the notion of this paper that both aspects of information integration are important. Over reliance on technology without willingness and trust to share the critical information pertaining to supply chain will not make the firms meaningfully connected; thus, failing to produce logistics integration. Only firms that are capable of building both the technical and social aspects of information integration will see the maximum benefits of logistics integration (Chae, Yen, and Sheu, 2005; Fawcett, Osterhaus, Magnan, Brau, and McCarter, 2007). Each of the two aspects of information integration is discussed below.
Information technology

Information (and communication) technology plays a central role in supply chain management in the following aspects. First, IT allows firms to increase the volume and complexity of information which needs to be communicated with their trading partners. Second, IT allows firms to provide real-time supply chain information, including inventory level, delivery status, and production planning and scheduling which enables firms to manage and control its supply chain activities. Third, IT also facilitates the alignment of forecasting and scheduling of operations between firms and suppliers, allowing better inter-firms coordination. As such, the problems in coordinating supply chain activities which often are hindered by time and spatial distance can be reduced (Paulraj and Chen, 2007).

The use of IT in supply chain has received considerable attention with various technologies have been introduced for Business-To-Business (B2B) communication, including web internet, B2B private (Ethernet), and EPOS (Electronic Point of Sale). Studies have shown that effective IT connection improves the integration between supply chain partners in terms of material flows (Soliman and Youssef, 2001). In this regard, IT supports key processes in supply chain, including sourcing, procurement, order fulfilment (Kehoe and Boughton, 2001; Swaminathan and Tayur, 2003). This improved logistics integration between supply chain partners yields a number of operational benefits, including reduction in costs (Nooteboom, 1992), lead time (Liu, Zhang, and Hu, 2005), and risks (Clemons, Reddi, and Row, 1993) as well as improvement in sales, distribution, and customer services, and service levels (Seidmann and Sundararajan, 1997).

Information sharing

While the technological aspect of information integration is important, it is the frequency, the quantity and the quality of information that is shared that really matters. As Fawcett et al. (2007) held, large investments in IT could fail to produce expected benefits if it is not supported by willingness to share needed information. This is because information sharing requires firms to exchange strategic information of supply chain. The strategic supply chain information provides leverages to the supply chain partner for making strategic decision in their operations. For example, point of sale history helps suppliers to successfully forecast demand which subsequently improves service level and efficiency to
their customers. Similarly, real-time inventory position helps suppliers to plan their replenishment and delivery schedules; thus, improving service levels and reducing inventory costs (Seidmann and Sundararajan, 1997). Such level of information sharing requires frequent and intense communication between firms and suppliers in order to build trust between the two parties. Indeed, trust is one of the key ingredients for all cooperative behaviours, including information sharing. High levels of trust in supply chain relationships constitutes high levels of cooperative behaviour between supply chain partners which leads to high degree and symmetry of strategic-information flows between them (Klein, Rai, and Straub, 2007). In the absence of trust, the IT investment will be used at a minimal level as only transactional data is exchanged, such as materials or product orders. A number of studies have demonstrated various benefits of having information sharing with supply chain partners, including inventory reductions (Lee, So, and Tang, 2000; Yu, Yan, and Cheng, 2001), lower costs (Cachon and Fisher, 2000), and shorter lead times of order processing (Dejonckheere, Disney, Lambrecht, and Towill, 2004).

Supply chain information integration and logistics integration

As Frohlich and Westbrook (2001) suggested, the material flow from upstream to the downstream supply chain entities must be supported by the information flow from downstream to upstream. Based on five case studies of dyads (supplier-retailer), Sheu et al. (2006) found that better IT capabilities as well as better communication contribute to a better platform for both parties to engage in coordination, participation and problem-solving activities. Thus, both information technology and information sharing can be viewed as antecedents to material flow integration.

H2: The intensity of information technology connection between firms and their suppliers has a positive relationship with logistics integration.

H3: The intensity of information sharing between firms and their suppliers has a positive relationship with logistics integration.
Strategic supplier relationships

The ways firms relate with suppliers have changed considerably. Given that manufacturing firms are getting more and more focused on their core competence, their reliance on strategic suppliers increases (Prahalad and Hamel, 1990). Among the changes, three key aspects of supplier relationships are highlighted here. First, the trend now is to build a long-term relationship with suppliers rather than short-term contracts (Helper, 1991; Ogden, 2006). Second, in conjunction with the first point, firms now use fewer suppliers over a longer period of time rather than keeping a large base of suppliers which allow them to change suppliers for almost every contract. The benefits of having low price resulted from creating competition among suppliers are now changed into low (price) total cost of ownership due to long-term and large volume of purchases (Helper, 1991). Third, the relationship with suppliers has been enhanced into strategic level where suppliers are now considered as the integral part of the firm’s operations (Chen and Paulraj, 2004; Choi and Hartley, 1996; Kotabe, Martin and Domoto, 2003). This change has driven into various avenues of collaboration, including joint improvement program, early supplier integration in product design, and profit and risk sharing. One aspect of strategic supplier relationship is extended longevity. This long-term relationship has several implications, and one of them is that firms may be ready for putting large investment in building the relationship, including IT and information sharing (De Toni and Nassimbeni, 1999). Klein et al. (2007) found that the greater the mutual trust, the greater the IT customization and the greater the strategic information flows. Sheu et al (2006) found that long-term orientation affects supply chain architecture, which includes IT capabilities and information sharing. Paulraj et al (2008) found a significant relationship between strategic relationship with suppliers and information sharing.

We can thus formulate the following two related hypotheses:

\textbf{H4:} The strategic relationship between firms and their suppliers has a positive relationship with information technology connection between firms and their suppliers.

\textbf{H5:} The strategic relationship between firms and their suppliers has a positive relationship with information sharing between firms and their suppliers.
Chen and Paulraj (2004) modeled a long-term relationship as a potential antecedent of buyer performance. Vickery et al. (2003) suggest that long-term relationships can result in improved firm performance, and De Toni and Nassimbeni (1999) found that better performing plants exhibit a better use of long-term supply agreements with sources. With this, we arrive at our final hypothesis:

H6: The strategic relationship between firms and their suppliers has a positive relationship with firm’s operational performance.

The research model is shown in Figure 1. The six hypotheses build up the model, linking strategic supplier relationships, information integration, logistics integration, and performance.

**Figure 1 Research Framework**

**METHODS**

**Sample and procedures**

The empirical data for this study was drawn from managers of the Australian manufacturing firms whose primary responsibilities are related to the daily operations of the firms. The list of the respondents was purchased from a mailing list company. In total, 1,800 surveys were mailed out, and 232 usable responses were received; hence, the response rate is 13.1%. The data were checked for bias using correlations of responses between early respondents and late respondents based on industry sectors and organisational size. The chi-square tests on both categories did not indicate any significant difference between the two groups of respondents.

In terms of industry sectors, 16% of the respondents came from electronic/electrical, 25% from machinery, 8% from automotive, 11% from chemical, 4% from food processing, 7% from construction, and 12% from other manufacturing sectors. The remainder sectors identified as “others” included medical equipment, wood, printing and paper, defence. In terms of organizational size (based on the number of employees), 46% of the respondents came from firms with less than 100 employees, 35% of the firms have between 100 and 500 employees, and the remainder 19% of the respondents came from large manufacturing with over 500 employees. More than half of the respondents (55%) held a position as operations managers, 27% supply chain / logistics managers, 18% procurement / purchasing, and 3% customer services managers.
Measures

All items used to build the scales in this study were adapted from the study by Chen and Paulraj (2004). A 5-point Likert scale was used to provide responses. For strategic supplier relationship, information technology, information sharing, and logistics integration, the scales ranged from 1 (strongly disagree) to 5 (strongly agree). For operational performance, the respondents were asked to assess their firm’s performance relative to the best competitor in the market with the scale ranging from 1 (weakest in the industry) to 5 (strongest in the industry). The items used in this study can be found in Table 1.

Table 1 Scale validity and reliability

DATA ANALYSIS

Scale validity and reliability

We used confirmatory factor analysis to simultaneously validate the measures of all variables used in this study. The items loaded significantly on their respective constructs. The item loadings and the overall model fit results ($\chi^2 = 425.74$; d.f. = 283; RMSEA = 0.047; NFI = 0.938; CFI = 0.976) suggest acceptable unidimensionality and convergent validity for the measures (Bagozzi, Yi, and Philips, 1991; Bollen, 1989; Carmines and McIver, 1981; Hoskisson, Hitt, Johnson, and Moesel, 1993). Cronbach’s alpha suggest satisfactory reliability of the five constructs (Nunnally, 1978). The results of the confirmatory factor analysis and the Cronbach’s alpha are presented in Table 1.

The slightly lower than standard acceptable value of $\alpha$ for performance (< 0.7) is interpreted such that performance is indeed composed of multiple dimensions or elements. Such disparate measures as quality, delivery, flexibility, and cost performance contributed to this construct, and this could suggest that some firms (often) specialize or focus to excel in only a subset of these performance dimensions.

We used Harmann’s single-factor test to check for common method variance (Podsakoff et al. (1986)). This test was conducted using principal component analysis and loading all 26 items on one factor. The test checks if one single factor would emerge from factor analysis, which would point towards the presence of common method bias. The factor analysis indicated that less than 25%
variance was extracted and that half of the items suffered from poor factor loadings, well below 0.5. These results suggest that common method variance was not a significant problem in the data set.

As an additional check, we conducted discriminant validity analysis to examine if the explanatory (functionalist and institutionalist drivers) and dependent (performance) constructs significantly overlap each other. As suggested by Venkatraman (1989), discriminant validity was established by conducting Confirmatory Factor Analysis (CFA) on each pair of the constructs in this study. For each pair, CFA was conducted twice. The first CFA allowed the correlation between the two constructs to be freely estimated. The chi-square value of this model was estimated. In the second CFA the correlation between the two constructs was fixed to 1.0, and the chi-square value of this model was estimated. If the difference between the chi-squares obtained from the first and second CFA (i.e. $\Delta \chi^2$) is greater than the chi-square value at the degree of freedom of 1 and significance level of $p<0.01$ (i.e. 6.64), this provides a reasonable evidence of discriminant validity of the constructs (Ahire, Golhar, and Waller, 1996). With five constructs incorporated in this study, we conducted ten chi-square tests. The values of $\Delta \chi^2$ for all tests confirm the discriminant validity of the constructs and lend further evidence towards the lack of common method variance.

**Structural model**

We present the results of the structural equation model (SEM) in Figure 2. The ratio of $\chi^2$ (434.40) to degrees of freedom (287) is less than the recommended value of 3.0 for satisfactory fit of a model to data (Bollen, 1989; Carmines and McIver, 1981; Hair, Anderson, Tatham, and Black, 1998). In line with the prescriptions (Mulaik et al., 1989), the fit indices (NFI = 0.936; NNFI = 0.971; CFI = 0.975) and the Root Mean Square Error of Approximation (RMSEA = 0.048) are deemed acceptable. The results of the six hypotheses are outlined below.

**Figure 2 Results of path analysis**

Logistics integration shows a positive relationship with performance, supporting H1. Both IT and information sharing show a positive relationship with logistics integration, supporting H2 and H3. Strategic supplier relationship shows positive relationships with both IT and information sharing, hence, supporting H4 and H5. We tested the direct association of strategic supplier relationship with
operational performance and found it to be positive and significant, supporting H6. Overall, this suggests that supplier relationship affects performance through other avenues in addition to what is explained by information integration and logistics integration. We found that organizational size had no significant effect on operational performance.

**DISCUSSION OF THE FINDINGS AND THEIR IMPLICATIONS**

This study contributes to the research stream on logistics integration by investigating the relationships between strategic buyer–supplier relationships, information integration, logistics integration and competitive performance. In general, the results of this research provide empirical evidence that effective external logistics integration is engendered by strategic buyer–supplier relationships and information integration. Specifically, this study contributes to supply chain studies with the following respects. First, it demonstrates that the integration of material flow needs to be underpinned by information integration. In this way, the supply chain (material flows from suppliers) will be neatly guided by demand chain (information flow from customers). Second, this study also shows the importance of both technical (hard) and social (soft) aspects of information integration. This highlights the need for balancing the two aspects which have been addressed separately in previous studies on supply chain. Indeed, the findings show correlation between IT and information sharing, suggesting that the improvement in one aspect will likely to be followed by the other. Third, this study demonstrates that strategic buyer–supplier relationships help foster collaborative behaviours which are translated into various forms, including information integration. As mentioned earlier, information integration cannot be achieved unless the relationship between two supply chain partners does not go beyond trading (transactional) relationship. The risk of putting huge investment in IT and sharing sensitive information is a serious hindrance which can only be taken when firms have a strategic and long term relationship. At the same time, the effective use of information integration is also determined by how well firms understand the exchanged information, and this can only be achieved through learning process over a long period of time. Fourth, the study demonstrates the direct effect of strategic supplier relationship on operational performance which is not mediated by information integration and logistics integration. Such practice as joint quality improvement program is one of the
examples which contribute to firm’s performance. This finding reinforces the importance of network capability in addition to internal capability of firms. Finally, this study provides support for the validity of the constructs developed by Chen and Paulraj (2004). The replicated use of established constructs is important in maintaining the consistency of the content validity and allows researchers to pursue deeper understanding involving similar measures.

CONCLUSION AND LIMITATIONS

This study shows that both information and material integration are important for supply chain integration. Supply chain integration is important as it has positive effects on firm performance. At the same time, supply chain integration is a difficult task as it involves many management aspects on the dyadic relationship between supplier and buyer in terms of both “hardware” (the IT capability for technical connectivity) and “software” (the willingness to share information) in support of the logistics integration activities concerning the physical material flow between the two parties. Such complex issues can only be managed where there is a strong and strategic relationship between firms and their suppliers. This study, therefore, reinforces the importance of building strategic relationships with suppliers which have been promoted since the emergence of the quality management era. All in all, operational performance is positively affected by all constructs included in this study; either directly or indirectly. This suggests that the integration of supply chain partners is multi-faceted, and that many competencies act complementary to achieve higher level of performance.

A limitation of this study is the sample population, which is restricted to Australian manufacturing firms. Even though we expect these results to hold for supply chains in general, we cannot claim that this is the case. Therefore, future research may extend this study to a broader population of firms, including other countries, and other business environments (including services) to get a wider population for generalizability of the results. Also, in this study we rely on the perception of the buyer firm on the relationship with the supplier. It would be beneficial to investigate both parties of dyadic relationships to hear “both sides of the story” concerning issues of reciprocity and mutual effects.
REFERENCES


Figure 1 Research Framework

Figure 2 Results of path analysis

** The path is significant at the 0.01 level.
Table 1 Scale validity and reliability

<table>
<thead>
<tr>
<th>Scales</th>
<th>Items</th>
<th>Loading Paths</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic supplier relationship</td>
<td>We expect our relationship with key suppliers to last a long time</td>
<td>0.71</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>We collaborate with key suppliers to improve their quality in the long run</td>
<td>0.79</td>
<td></td>
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<tr>
<td></td>
<td>The suppliers see our relationship as a long-term alliance</td>
<td>0.81</td>
<td></td>
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<tr>
<td></td>
<td>We view our suppliers as an extension of our company</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>Information technology</td>
<td>There are direct computer-to-computer links with key suppliers</td>
<td>0.76</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>Inter-organizational coordination is achieved using electronic links</td>
<td>0.91</td>
<td></td>
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<tr>
<td></td>
<td>We use information technology-enabled transaction processing</td>
<td>0.86</td>
<td></td>
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<tr>
<td></td>
<td>We have electronic mailing capabilities with our key suppliers</td>
<td>0.50</td>
<td></td>
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<tr>
<td></td>
<td>We use electronic transfer of purchase orders, invoices and/or funds</td>
<td>0.55</td>
<td></td>
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<tr>
<td></td>
<td>We use advanced information systems to track and/or expedite shipments</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>Information sharing</td>
<td>We share sensitive information (financial, production, design, research, and/or competition)</td>
<td>0.64</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Suppliers are provided with any information that might help them</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exchange of information takes place frequently, informally and/or timely</td>
<td>0.83</td>
<td></td>
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<td></td>
<td>We keep each other informed about events or changes that may affect the other party</td>
<td>0.77</td>
<td></td>
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<tr>
<td></td>
<td>We have frequent face-to-face planning/communication with our suppliers</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td>Logistics integration</td>
<td>Inter-organizational logistic activities are closely coordinated.</td>
<td>0.75</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>Our logistics activities are well integrated with suppliers’ logistics activities</td>
<td>0.88</td>
<td></td>
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<tr>
<td></td>
<td>We have a seamless integration of logistics activities with our key suppliers</td>
<td>0.89</td>
<td></td>
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<tr>
<td></td>
<td>Our logistics integration is characterized by excellent distribution, transportation and/or warehousing facilities</td>
<td>0.85</td>
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<tr>
<td></td>
<td>The inbound and outbound distribution of goods with our suppliers is well integrated</td>
<td>0.78</td>
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<tr>
<td></td>
<td>Information and materials flow smoothly between our suppliers and us</td>
<td>0.67</td>
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<tr>
<td>Operational performance</td>
<td>Performance of our final products</td>
<td>0.48</td>
<td>0.64</td>
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<td></td>
<td>Speed of deliveries</td>
<td>0.52</td>
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<td></td>
<td>Volume or capacity flexibility</td>
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<td></td>
<td>Degree of product variety</td>
<td>0.54</td>
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<tr>
<td></td>
<td>Production costs</td>
<td>0.47</td>
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\[ \chi^2 = 425.74 \quad df = 283 \quad RMSEA = 0.047 \quad NFI = 0.938 \quad NNFI = 0.972 \quad CFI = 0.976 \]

Note: All scales except for Operational Performance are taken from Chen and Paulraj (2004)