

Investigation of the Impact of Supply Chain Integration on Product Innovation and Quality

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Abstract. *This paper addresses integration issues in supply chains, and tries to investigate how different aspects of integration are linked with some product features. Integration, in this study, is interpreted as “internal”, “upstream” (supply) and “downstream” (demand). Two product features considered in this study are “product innovation” and “product quality”. To examine the relationships between supply chain integrations - as mentioned above, and product features, this research follows a survey method used in the automotive industry. The results imply that supply chain upstream integration has a higher impact on product quality, compared to internal and supply chain downstream integrations. It is also found that the influence of supply chain downstream integration on product innovation is greater than other variables. In brief, this study mainly tackles the importance of specific levels of supply chain integration and its effects on two product features.*

Keywords: *Supply chain upstream integration; Supply chain downstream integration; Internal integration; Product features.*

INTRODUCTION

These days, the competitive global marketplace has a great influence on business activities, whether they are local or international. Apparently, supply chains, as a key part of global business, should be considered in particular. In supply chain management, it is necessary for industries to develop and organise networks of activities involved in procurement, production and delivery of products globally. Considering the characteristics of the abovementioned global market, a prerequisite for successful Supply Chain Management (SCM) is the integration of flows of material and information [1]. Effective and efficient supply chain management requires integrated business processes that go beyond purchasing and logistics activities.

Supply chain integration is crucial for SCM, however, there are doubts about the applicability of supply chain integration practices in particular. Frohlich and Westbrook [2] point out that the supply chain integration practices vary, depending on the type of firm strategy. They also state that different aspects

of supply chain integration might be important under different circumstances. Hence, there is still a need for more research to investigate the relationships between each supply chain integration practice and different types of firm competitive capability.

In this paper, the concept of supply chain integration is identified into different dimensions: internal, upstream or supply side, and downstream or demand side integration. This paper investigates the role of specific supply chain integration practices in predicting product quality and innovation performance. The main objective of the research is to discover whether product quality and innovation performance require different types of supply chain integration strategy. This research partly fills the gap by helping practitioners to select which supply chain integration strategies are most appropriate for their particular situations.

The method applied by this study to test its hypotheses is the survey method. The survey method has been recognised as a research approach designed to collect, systematically, the descriptions of existing phenomena in order to describe or explain what is going on; data are obtained through the direct questioning of a sample of respondents [3,4]. Surveys can be useful when a researcher wants to collect data on phenomena that usually cannot be directly observed [5].

In the context of supply chain management and

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operations management, there are numerous studies which have applied the survey method. Ahlstrom and Westbrook [6] use the survey method to test suppliers' collaboration theories. Sahay [7] also has used the survey method in the field of mass customisation. Please see [8-10] for other examples and recent applications of the survey method in the supply chain context.

LITERATURE REVIEW

A review of the literature in this section is organised in three subsections, based on the different types of integration across the supply chain.

Supply Chain Integration

There is realization that the basic concept of supply chain management is to integrate production and information flow across the supply chain processes [1]. In the supply chain context, integration is defined as the extent to which all activities within an organization, and the activities of its suppliers, customers, and other supply chain members, are integrated together [11]. An integrated supply chain is linked organizationally and coordinated with information flow, from raw materials to the on-time delivery of finished products to customers. The entire supply chain is linked by information about anticipated and actual demand.

Frohlich and Westbrook [2] identify two interrelated forms of integration that manufacturers regularly employ. The first type of integration involves integrating the forward physical flow of delivery between suppliers, manufacturers and customers. The second type of integration involves the backward integration of information technologies and the flow of data from customers to suppliers. Stevens [12] classifies supply chain integration into three levels, from functional integration to internal integration and to external integration. However, this study focuses only on internal and external integration, because functional integration is claimed as a basic requirement for all firms to implement and achieve.

Internal Integration

To support customer requirements at the lowest total system cost, internal integration represents the integration of all internal functions, from material management to production, sale and distribution. At this stage, the firm focuses on the internal flow of goods into the organization and also on the way out to the customer. Moreover, internal integration is characterized by full system visibility from distribution to purchasing, and required integration across functions under the control of the firm to achieve customer satisfaction. In practice, it means that special attention

must be given to the interface between functional areas such as procurement, production, logistics, marketing, sales and distribution [12].

Upstream and Downstream Integration

Upstream and downstream integration involve full supply chain integration, which extends the scope of integration outside the company to embrace suppliers and customers [12]. More specifically, this stage of integration represents more than a change of focus from product-oriented to customer-oriented in relation to mutual support and cooperation. A review of external supply chain integration literature reveals two major areas of emphasis. They are: (i) Customer integration and (ii) Supply integration.

For supply integration, integration back down to the suppliers represents a change in attitude away from conflict to cooperation, starting from product development, the supply of high quality products, process and specification change information, technology exchange and design support. Some researchers have investigated supply-side integration in different dimensions. Handfield [13] defines supply integration as obtaining frequent deliveries in small lots, using single or dual sources of supply, evaluating alternative sources on the basis of quality and delivery instead of price, and establishing long-term contracts with suppliers. In terms of logistics communication, this concept could view supply integration as effective alignment, information sharing and supplier participation between suppliers and manufacturers.

In terms of customer integration, the firm will penetrate deep into the customer organization to understand the product, culture, market and organization, so that it can respond rapidly to the customer's needs and requirements. The important concept of demand integration is based on the improvement of demand planning and visibility in supply chains. Without information sharing from one end of the supply chain to the other, tremendous inefficiencies can occur in customer service.

RESEARCH QUESTIONS

Recent studies have indicated that supply chain integration will directly lead to considerable improvement in the firm's performance. Stevens [12] believes that to achieve a competitive advantage, supply chain integration is crucial. The study of [14] in consumer products manufacturing demonstrates a significant relationship between supply chain integration intensity and such measures as cost, process flexibility, product quality and delivery. However, much of the previous research has failed to separate supply chain integration into different stages. Therefore, this study will specifically

aim to present and test hypotheses linking the stage of supply chain integration and product quality and innovation.

Supply Chain Integration and Product Quality Performance

According to Total Quality Management (TQM), the key issue, regarding extension of a total quality approach across the organizational interface is, essentially, related to integration [15]. Dyer [16] states that effective collaboration between functions and between customers and suppliers can increase product quality. To support this statement, Wisner and Staley [17] surveyed 500 purchasing professionals and found that their high level of service quality, leading to customer satisfaction, was related to the level of collaboration with internal suppliers and internal customers. Moreover, inter-functional integration within a firm can improve performance, in terms of better customer service [18].

Extended to external integration, previous studies have shown that supply integration leads to improved product quality. Erickson and Kanagal [19] and Wong [20] report that integrating with suppliers, in terms of supplier participation and information sharing, can help companies achieve higher product quality performance. In addition, strategic supplier partnership through technology sharing has been reported to yield specific benefits, in terms of product quality [21,22]. Besides supply integration, demand integration is also significantly related to product quality, in terms of customer satisfaction and product customization, because firms that closely interact with selected customers will better understand the detailed wants and needs of their customers [6,23]. Basnet et al. [24] also find significant correlation between information sharing with customers through an understanding of customer need and product quality.

Therefore, the following hypothesis was established.

Hypotheses 1a-1c

The higher the supply chain integration ((a) internal, (b) supply and (c) customer integration) is, the higher the product quality performance will be.

Supply Chain Integration and Product Innovation Performance

The ability to develop new products rapidly is an important source of competitive advantage in many industries [25,26]. More specifically, as suggested by Clark and Fujimoto [27], automakers that can develop new products more quickly than competitors have an advantage, because their current models are

more advanced and include the latest in technology. Moreover, Gomes et al. [28] found a significant relationship between performance in product innovation and functional integration through a survey of 40 British and Dutch companies from various sectors. To support this finding, Kahn and Mentzer [18] and Song et al. [29] indicate that the level of cross-functional integration is significantly related to new product development performance. It is also expected that supply integration will lead to improved product innovation performance. Ragatz et al. [22] developed an integrating supplier framework, suggesting that effective integration of suppliers into product innovation can yield such benefits through reduced product development time and improved access to an application of technology. Within this perspective, other studies (e.g. [30]) also state the effects of supplier involvement in the performance of a process of production innovativeness. Consequently, close linkages between design and manufacturing, both internally and with suppliers, are often important for the success of product innovation [27]. In further discussion on customer involvement, Stank et al. [23] suggest that demand integration relies on an assessment of a firm's strengths and weaknesses relative to the service requirements of its customers. In this concept, Waller et al. [31] pointed out that making a decision, based on the consuming organization through a vendor-managed inventory, can shorten product development time. A survey of 160 Indian firms reveals that the level of customer involvement is high in the product development process [7]. Therefore, the following hypotheses are established.

Hypotheses 2a-2c

The higher the integration of the supply chain ((a) internal, (b) supply, and (c) customer integration) is, the higher the product innovation performance will be.

Hypotheses group 1 and 2 are summarized in Figure 1.

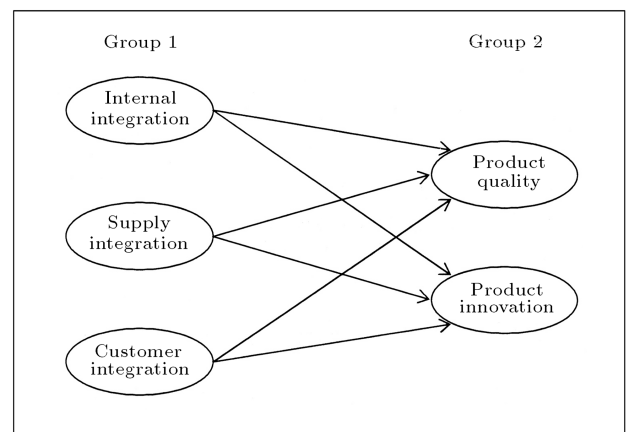


Figure 1. Reserach Hypotheses.

METHODOLOGY

The research method used to test the hypotheses is the survey method. This study uses a five-point scale for three constructs of independent variables (internal integration, supply integration and customer integration) and two dependent variables (product quality and product innovation performance) to draft a questionnaire. This draft questionnaire was then pre-tested with academics and practitioners to check its content validity and modified accordingly. The modified questionnaire was pilot tested to examine its suitability for the target population before large-scale mailing (the questionnaire can be found in the appendix).

Empirical data was obtained through a questionnaire survey from production or purchasing managers, who had knowledge of supply chain management practices. These respondents were asked to rate their firms, relative to their understanding of supply chain integration and firm performance in his/her plant. The unit of analysis in this study was limited to the plant level. Within this perspective, Flynn et al. [32] point out that most empirical research in operations management occurs at the corporation or individual level of analysis. Moreover, the independent variables of supply chain management practices usually reflect corporate level practices. Similarly, the dependent variable of firm competitive capability also reflects the corporate level results.

The survey specifically concentrates on the automotive industry. This study selects this industry because of the following reasons. First, the automotive industry is seen as an indicator to measure the wealth of the economy [33]. Second, the literature in the automotive supply chain has been well documented in previous research and there is a clear structure of the automotive supply chain [34]. Finally, the automotive sector has been a leader in implementing supply chain management strategies in Iranian industries. Some

questionnaires have been submitted by post with a cover letter indicating the purpose of this study to qualified automotive suppliers. Some questionnaires have also been handed in directly, and some have been filled through structured interviews. The total number of distributed questionnaires was 403.

Initially, 91 completed responses were received and succeeding follow-ups collected more than 20 responded questionnaires. The total 111 responses were returned at a response rate of 27.5 %, which is a good response rate.

The non-response bias was evaluated using the method suggested by Armstrong and Overton [35]. This method tests for a significant difference between early and late respondents, with late respondents being considered non-respondent. By using this method, although it did not investigate non-responses directly, a comparison was made between those subjects who responded in the first wave and those of the second wave [36]. A one-way analysis of variance (ANOVA) was used to make the comparisons in demographic variables, namely, the number of employees, the respondent's position and the number of years in business. Along with the demographic variables, randomly selected variables were also included in this analysis. The results indicated no significant difference in any criteria, the significant level of which was far from 0.1. Based on the ANOVA test, the non-response bias may not be a problem in this study, and the two waves were pooled for subsequent analysis.

DATA ANALYSIS

Table 1 presents the correlations between variables, which can serve as a predictor of predictive validity. In fact, predictive validity represents how the scores on one scale relate to the scores on others. In the current study, the results indicate that the three independent variables (internal, supply and customer integration) are strongly correlated with firm performance (product

Table 1. Correlations among constructs.

Elements	Internal Integration	Supply Integration	Customer Integration	Product Quality	Product Innovation
Internal Integration	1				
Supply Integration	0.505	1			
Customer Integration	0.504	0.520	1		
Product Quality	0.425	0.452	0.410	1	
Product Innovation	0.269	0.355	0.400	0.476	1

quality and innovation), indicating that firms commonly implement all supply chain integration practices (internal integration, supply integration and customer integration) in order to achieve high performance in product quality and innovation. However, it is important to note that the strength of the correlations is higher for product quality than for product innovation. In addition, within product innovation performance, customer integration seems to have the strongest correlation compared to the rest of the internal and supply integration.

Table 2 shows the two multiple regressions of the three supply chain integration activities regressed on the two firm performance measures. Overall, both relationship models resulted in the R-square of 0.25 and 0.21, indicating the acceptable explanatory power of the variance of the dependent variable. In addition, these R-square values were accompanied by an F-statistic for the regression, which was highly significant, indicating a relatively strong relationship. In regard to regression analysis with product quality, the result indicates that the strongest predictor was supply integration, followed by customer and internal integration, based on beta values. In regard to product innovation, the analysis for each individual predictor also indicates that customer integration shows the strongest significant predictor, followed by supply integration. However, internal integration is the only variable that is not significantly related to product innovation.

The overall result suggests that supply chain integration practices, which are proven to effectively influence product quality, do not necessarily indicate a similar effect in product innovation. For example, internal integration is highly significant when associated with only product quality, but not with product innovation. In addition, it is interesting to find that the impact of predictor variables (beta values) is different, depending on specific firm performance. For instance, customer integration shows a relatively stronger relationship with product innovation than with product quality.

DISCUSSION AND CONCLUSION

The results illustrated in Table 2 provide some support for the model in this study. The positive effects of supply and customer integration on both product quality and innovation are supported. Therefore, this result provides a confirmation of previous studies; that firms operating in highly collaborative practices with suppliers and customers are likely to have an excellent performance in product quality and innovation, due to the improvement of information visibility in the supply chain. However, more specifically, the results in multiple regressions show the different impacts of each integrative practice in explaining specific performance (product quality and product innovation). In consistency with this observation, some research, such as [2], also suggests that different business goals might require different aspects of supply chain integration practices. The findings of the current study support this view. Firms targeting high product quality performance have a greater need for supply integration than customer integration. On the other hand, firms that focus on product innovation need more focus on customer integration than supply integration. This result could be explained in two ways.

Firstly, most suppliers in the automotive industry will expect to participate in Supplier Relationship Management (SRM) provided by automakers, in order to control and ensure the high quality of their incoming parts. Therefore, as a part of SRM, supply integration should be expected to play a significant role in purchasing and production systems, leading to high product quality performance. Secondly, for firms focusing on product innovation, the role of the customer should be emphasized, moving to further involvement in the new product development process. Being more integrated with customers also enables firms to more quickly respond to their product changing needs in the product innovation process.

Internal integration, on the other hand, indicates not only the weakest relationship with product quality

Table 2. Regression analyses of supply chain integration practices on firm performances.

	Product Quality		Product Innovation	
	Std. Beta	Sig.	Std. Beta	Sig.
Internal Integration	0.18	0.05	0.04	0.67
Supply Integration	0.24**	0.01	0.20*	0.04
Customer Integration	0.20*	0.03	0.28**	0.00
* p < 0.05	R2=0.25		R2=0.21	
** p < 0.01	F statistics = 15.99**		F statistics = 11.15**	

but is also an insignificant predictor of product innovation. This seems surprising given that this particular integration practice plays the weakest role. However, some researchers postulate that internal integration has an indirect effect and not necessarily a direct influence [37]. Internal integration seems to be a prerequisite for the influence of supply chain integration practices on high product quality and innovation performance. Managers must ensure that all functional teams within the firm are integrated, in order to achieve supply and customer integration.

In terms of research contributions, this study highlights the importance of a specific level of supply chain integration in considering strategies for boosting the competitive capability of the firm. However, these results should not be interpreted to mean that other weaker predictor variables in specific performance should be ignored. In fact, these variables may be interacted with or moderated, so that the magnitude of its effect is changed. Future research should consider explaining such interaction and moderation in different supply chain integration practices. In regard to implications for managers, firms need to choose a specific supply chain integration strategy on developing product quality and product innovation. The results provide managerial insights about specific integration practices that are effective in specific product quality and innovation performance. Managers can, therefore, ask about operational objectives in their firms so that they can focus on the right supply chain integration strategy. In addition, the findings provide additional support, building on previous literature mostly conducted in Western countries, for the value of supply chain integration. The results of this study offer confirmation within a different context, as an empirical study of supply chain integration in the automotive industry.

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APPENDIX

QUESTIONNAIRE ON SUPPLY CHAIN MANAGEMENT

Name of Company:
Name of the Employees:

General Information

This part of the questionnaire just tries to gather some general information about your purchasing, supply, distribution and sales, activities.

- 1.1. What is your company's product(s)?
- 1.2. How many raw material/component suppliers do you have?
- 1.3. On average, how many direct suppliers do you have for each component?
- 1.4. How many people work in your purchasing and supply management department?
- 1.5. How many customer/buyer companies do you have?
- 1.6. On average, how many direct customer/buyer companies do you have for each of your products?
- 1.7. How many people work in your marketing and sales management department?

Information on Supply Chain Management/Supplier Integration

This part of the questionnaire relates to information on your suppliers, and relationships you have with them. If your company has already worked out a supply chain

management policy or is working on it currently, it would be great if you could attach these documents to the completed questionnaire.

- 2.1 You have effective communications with your suppliers on research activities and new product development (R&D).
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 2.2 You and your supplier have transparent information about each others inventory status.
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 2.3 You and your suppliers provide each other with each others production plan.
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 2.4 You collaborate with your suppliers development programme(s).
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 2.5 You and your suppliers are aware of each other medium-term and long-terms policies and strategies?
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 2.6 You and your suppliers share technical information with each other if required.
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 2.7 You have long-term relationships with your suppliers.
Strongly Agree Agree Neutral
Disagree Strongly Disagree

Information on Demand Chain Management/Customer Integration

This part of the questionnaire relates to information on your customers, and relationships you have with them. If your company has already worked out a customer relationship management policy or is working on it currently, it would be great if you could attach these documents to the completed questionnaire.

- 3.1 You have effective communication with your customers on research activities and new product development (R&D).
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 3.2 You and your customers have transparent information about each others inventory status.
Strongly Agree Agree Neutral
Disagree Strongly Disagree

- 3.3 You and your customers provide each other with each others production plan.
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 3.4 You collaborate with your customers development programme(s).
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 3.5 You and your customers are aware of each others medium-term and long-terms policy and strategies.
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 3.6 You and your customers share technical information with each other if required.
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 3.7 You have long-term relationships with your customers.
Strongly Agree Agree Neutral
Disagree Strongly Disagree

Information on Internal Integration

This part of the questionnaire relates to information on your company, and relationships between the different sections within your organisation.

- 4.1 You have effective communications between different departments regarding a new product or process development project.
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 4.2 Different but related production sections have transparent information about the inventory status of each other.
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 4.3 Different departments in your company provide each other with their plan(s).
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 4.4 Different departments in your company collaborate with the company development programme(s).
Strongly Agree Agree Neutral
Disagree Strongly Disagree
- 4.5 Different departments in your company share technical information with each other quickly if required.
Strongly Agree Agree Neutral
Disagree Strongly Disagree

Information on Product Quality and Product Innovation

This part of the questionnaire relates to information on your company, and associated Product Quality and Product Innovation information.

- 5.1 Your products are differentiated from competitors' because of their quality.
 Strongly Agree Agree Neutral
 Disagree Strongly Disagree
- 5.2 Your customer(s) is satisfied with the quality of your products (evidences of customer feedback are required).
 Strongly Agree Agree Neutral
 Disagree Strongly Disagree
- 5.3 Your customer(s) enjoys continual improvement of your product quality (evidences of customer feedback are required).

Strongly Agree Agree Neutral
 Disagree Strongly Disagree

- 5.4 Your products are differentiated from competitors' because of their innovative design.
 Strongly Agree Agree Neutral
 Disagree Strongly Disagree
- 5.5 Your customer(s) is satisfied with the innovative design of your products (evidences of customer feedback are required).
 Strongly Agree Agree Neutral
 Disagree Strongly Disagree
- 5.6 You introduce new products to your customers ahead of your competitors.
 Strongly Agree Agree Neutral
 Disagree Strongly Disagree

Thank you very much for your time and cooperation.