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Instrument Development for Supply Chain Integration and Product Quality Relationship in Automotive Industry

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Abstract: The automotive industry is one of the most important industrial sectors in the world. Therefore, consideration must be given to the development of collaborative activities between the automotive industry and supply chain partners to survive and succeed in recent world market. Supply chain integration can collaborate between a manufacturer and its supplier and costumer which enables firms to work together and improve product quality which is an important key competitive capability. This is why, the relationship between supply chain integration and product quality in automotive industry should receive sufficient attention from the research community. Hence, the purpose of the study is to develop and validate the supply chain integration and product quality instrument in the automotive industry. The research methodology for this study was devised based on the literature in general and survey instrument in the automotive industry in particular. The instrument were examined by using a survey conducted in Malaysian Automotive and Supplier Industry for empirical analysis. The study identified indicators of each dimension of supply chain integration; particularly customer integration supplier integration and internal integration and each dimension of product quality in supply chain; specifically design quality and conformance quality and validated a supply chain integration and product quality survey instrument. This questionnaire instrument can be used effectively in any manufacturing firm.

Key words: Supply chain integration, product quality, survey instrument, automotive industry, Malaysian automotive and supplier industry

INTRODUCTION

Manufacturing sector has a critical and fundamental role to play in economic growth. The automotive industry is one of the economy cores in the manufacturing sector. The automotive industry has contributed significantly in developing nations drive towards an industrialized nation (MAI, 2012).

Industrial competitiveness is a major issue for developing and industrialized nations. In an environment of agile globalization and liberalization, industrial competitiveness for improving nations requires obtaining innovative capability and for developed nations, improving higher technological advancement. Product quality development and supply chain integration play a crucial role in industrial competitiveness.

In highly competitive environments, companies are forced to implement Supply Chain Management (SCM) in order to reach competitive advantages and enhance their supply chain performance. The SCM consists of integration, co-ordination and collaboration within organizations and all over the supply chain. That means, that the supply chain management requires internal (intraorganizational) and external (interorganizational) integration (Gimenez and Ventura, 2005) that known as supply chain integration. Supply chain integration, if applied effectively, is known to bring about a significant improvement to all companies. The target of seamless supply chain is to enhance material and information flows within a company and also connect it with other supply chain members. With the technology available today, very intimate, beneficial and profitable supply chain integrations can be structured (Yunis *et al*., 2012).

The integration of supply chain between a company and its supply chain partners can yield manufacturing competitive capabilities. Product quality is one of the key factors of competitive capability which is needed to survive and succeed in recent world market. Enhancement of product quality and services of enterprises may increase the value for customers. By evaluating the improvements of the market, managers can rank these improvements.

The objectives of the present study are: (1) To identify indicators of each dimension of supply chain

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integration; particularly customer integration, supplier integration and internal integration and each dimension of product quality in supply chain; specifically design quality and conformance quality, (2) To propose a supply chain integration and product quality survey instrument and (3) To report on validation of the survey instrument in the automotive industry.

Researchers have demonstrated that firms which collaborate and cooperate with other firms or create inter-firm relationship with others, will have better competitive advantages than those which do not. Hence, there are an increasing number of empirical studies and investigations devoted to the direct and indirect impacts of supply chain integration on product quality and company's performance (Lotfi *et al*., 2013d; Kim, 2009).

Many researches have been conducted to show the relationship between supply chain integration and some factors of supply chain performance. Some researchers believe SCI is one-dimensional (Marquez *et al*., 2004; Rosenzweig *et al*., 2003) while others have divided it into external and internal integration (Campbell and Sankaran, 2005; Petersen *et al*., 2005; Zailani and Rajagopal, 2005). There are also some researchers that have represented multiple dimensions (Droge *et al*., 2004; Gimenez and Ventura, 2005; Koufteros *et al*., 2005).

In previous study, Lotfi *et al*. (2013c) investigated and classified some supporting literature on dimensions of supply chain integration and performance and then classified all performance into two categories which include: Strategic performance and operational performance. It was concluded that very little attention has been granted to the dimensions of supply chain integration and product quality that is made of design quality and conformance quality. So, it was proposed a conceptual framework that focuses on the relationship between dimensions of supply chain integration and dimensions of product quality of the entire supply chain.

Sharing information, material and financial information within the organizational units can act as supply chain management (Stadtler and Kilger, 2008) so, that it will meet the needs of the customer and lead to an enhancing of the entire supply chain involved (Lotfi *et al*., 2013a).

Supply Chain Integration (SCI) can be defined with the amount of collaboration between a manufacturer and its supply chain partners as well as the extent to which a producer conducts internal and external organizational processes (Flynn *et al*., 2010). The integrated supply chain can cause in the effective gains and flows of services, money, information, products and decisions with the goal of offering highest value to firm's customers (Frohlich and Westbrook, 2001). Companies need to recognize where they stand in their supply chains, where they lack integration and how to improve that Which in turn would make them more efficient, effective and competitive in the World market (Lotfi *et al*., 2013b).

Supply chain integration includes of internal and external integration. The external integration is also divided into customer and supplier integration. In this study, the internal integration, customer integration and supplier integration upon some researches was considered (Wong *et al*., 2011; Koufteros *et al*., 2005; Stank *et al*., 2001; Narasimhan and Kim, 2002).

Customer integration refers to acquiring technological, marketing, production and inventory information from the customers (Mentzer, 2004; Lau *et al*., 2010). Manufacturers can use these acquired information and customer requirements to produce products that meet users' preferences (Chen and Paulraj, 2004; Flynn *et al*., 2010; Zhao *et al*., 2011). Customer integration direct to establish a relationship with customers and hence gaining a better and clearer understanding of customers' preferences and also includes methods and ways to enhance coordination among the manufacturer and the customer (Swink *et al*., 2007; Frohlich and Westbrook, 2001).

Supplier integration involves a relationship between the firm and the upstream suppliers (Vijayasarathy, 2010). With supplier integration, suppliers provide information and participation in making decisions (Petersen *et al*., 2005) with sharing production plans, demand forecasts and levels of inventory to enhance the product and production requirements and better utilizing the supplier's and factory's capabilities and structure of cost. Such effective relationships and communications possess a major significance in advanced firms since suppliers know the components supplied better than the firms (Jammernegg and Reiner, 2007; Luo, 2007; Zhao *et al*., 2011; Swink *et al*., 2007).

Internal integration demonstrates the extent to which a firm can build all its functions and practices into a collaborative and organized manner to meet customers' needs (Zhao *et al*., 2011; Kotcharin *et al*., 2012). It involves integration across departments and functions under the control of the manufacture from incoming material to distribution in order to fulfill customers' requirements. Therefore, the functions and departments within a manufacturer operate as one integrated and coordinated system working together to meet customers' requirements and improve performance. There are some very important elements that lead to better performance such as, shared information, joint planning, functional coordination teams and collaborating together (Flynn *et al*., 2010; Boon-Itt, 2011).

According to Feigenbaum (Reeves and Bednar, 1994) product quality defines as "The composite of product characteristics of engineering and manufacture that determine the degree to which the product in use will meet the expectations of the customer". Fujimoto (1999) divided quality into two categories: Design quality and conformance quality that design quality include, customer needs, product concept and product plan (basic design) and also conformance quality consists product design, process design, process, product structure and product function.

Design quality can be noted as the inherent value of a product in the marketplace or how to measure the characteristics of a product designed to meet the requirements of a given group of customers. It measures how well the customer expectations are represented in the product concepts and then into detailed product designs. According to Fynes and De Burca (2005) design quality can distinguished in engineering design quality and industrial design quality. Engineering design is the development of a product from its technical view via detail design and the design of the relevant manufacturing process and tools. Engineering design quality is measured by frequency of engineering change notices, technical performance, material, design, cost and ease of production or assembly (Fleischer and Liker, 1992). On the other hand, industrial design is primarily concerned with matters of style and aesthetics. Industrial design quality is measured with perceptions of aesthetics, ease-of-use and appearance (Yamamoto and Lambert, 1994).

Conformance quality refers to how well products delivered to customers conform to the product design or specifications, including reliability, defects in the field, fit and finish and durability (Clark and Fujimoto, 1991). According to Fynes and De Burca (2005), conformance quality can be categorized in two terms of internal conformance quality and external conformance quality. Internal conformance quality is the ability to achieve objectives of quality in the manufacturing unit and implemented as a construct to use measures of defect rates, new product yield and scrap and rework (Fynes and De Burca, 2005). On the other hand external conformance quality is the ability to meet objectives for quality from users' sight and marketplace which measures with, delivered quality and value, customer complaints frequency, the systems for tracking customer frequency and the priority given to solving product problem frequency (Choi and Eboch, 1998).

As the chain of quality indicates, a high design quality and a high conformance quality are required in order to achieve a high level of total product quality (Clark and Fujimoto, 1991; Fujimoto, 1999).

MATERIALS AND METHODS

To develop the instrument for supply chain integration and product quality relationship that applicable in the automotive industry, three dimensions of supply chain integration and two important dimensions of product quality in supply chains were considered.

In this study, a draft survey instrument, applicable in the automotive industry was constructed and validated by academician and practitioner experts in the field of supply chain management in the automotive industry. Afterwards, the modified instrument was implemented and the gathered data was analysed for validity and reliability of the survey.

This study was conducted to provide a deep understanding and a set of theoretical and empirical findings. Quantitative method was applied to the data gathered from Malaysian Automotive and Supplier Industry in the year 2013. In this method, all the relevant secondary data on general information and demographic, customer integration, supplier integration, internal integration, design quality and conformance quality were used for analysis.

Survey strategy was selected for this specific research with the questionnaire instrument because it is a common research strategy in business and management research, to collect information by asking questions which would allow the researchers to gather abundant data from a large population in a low cost way (Saunders *et al*., 2012). Keller *et al*. (2002) described how the quality measures of the research could be affected by the procedure of scale growth in rating the questions. Based on some related researches in SCM, this study is assessed 5-point Likert scale in this study (Wong *et al*., 2011; Wu *et al*., 2011; Cao and Zhang, 2011; Fynes *et al*., 2005; Koufteros *et al*., 2007; Cousins and Menguc, 2006; Das *et al*., 2006; Koufteros *et al*., 2005; Frohlich and Westbrook, 2001; Omar *et al*., 2010).

The population which was studied in this study, was the Malaysian Automotive and Supplier Industry in manufacturing sector and the sampling method which was applied in it, was the simple random sampling method in probability sampling technique because the chance to select each case is equal and known.

The questionnaire was distributed randomly to the Malaysian Automotive and Supplier Industries in manufacturing sector as target sample via three methods: Email, visiting the companies and participating in the "Vendors Briefing" meetings of large car manufacturers of Malaysia.

Total 250 questionnaires distributed to the Malaysian automotive and supplier industry. This was done with the objective to obtain at least 15-20% response rate. Based on some researchers 15-20% is "normal" (Bagchi and Skjott-Larsen, 2004). Out of the 250 questionnaires distributed, 50 usable responses were analysed representing 20% of those surveyed.

Statistical analysis: This study used SPSS (version 21) to carry out descriptive statistics analysis, variable reliability and validity analysis.

RESULTS AND DISCUSSION

Instrument development: After overviewing the literature on supply chain integration and product quality, this study investigated some supporting literature on indicators of supply chain integration and product quality and then classified the indicators into two categories which include: Information integration and organizational integration as a scope of integration among supply chains based on Skjott-Larsen and Bagchi (2002) study.

Indicators of supply chain integration: Based on some previous researches, were considered three dimensions of supply chain integration in this study, including: Internal integration, customer integration and supplier integration (Wong *et al*., 2011; Koufteros *et al*., 2005; Stank *et al*., 2001; Narasimhan and Kim, 2002). Furthermore, we take information integration and organizational integration into consideration for each dimension as a classification of integration among supply chains based on Skjott-Larsen and Bagchi (2002) study. Table 1

Table 1: Indicators of each dimensions of supply chain integration

Indicator	Dimensions of SCI	Statement	Source
Information integration			
Traditional communication	II, SI and CI	To the extent of communication with our departments and our major customers/suppliers through information technologies (e.g., e-mail/fax/phone/Internet/Extranet)	Wong *et al*. (2011), Flynn *et al*. (2010), Narasimhan and Kim (2002) and Frohlich and Westbrook (2001)
Advanced communication	II, SI and CI	To the extent of communication with our departments and our major customers/suppliers by using computer to computer links, EDI (the electronic data interchange) or ERP (the enterprise resource planning)	Wong *et al*. (2011), Flynn *et al*. (2010), Narasimhan and Kim (2002) and Frohlich and Westbrook (2001)
Feedback	SI and CI	Follow-up with our major customers/suppliers for feedback	Joshi Sarang *et al*. (2012), Zhao *et al*. (2011), Flynn *et al*. (2010), Narasimhan and Kim (2002) and Frohlich and Westbrook (2001)
Inventory	II, SI and CI	Real-time searching of the level of inventory internally and share knowledge of inventory to and from our major customers/suppliers	Wong *et al*. (2011), Flynn *et al*. (2010), Narasimhan and Kim (2002) and Frohlich and Westbrook (2001)
Track and- trace	II, SI and CI	Using of track and trace systems across departments and with our major customers/suppliers (e.g., Barcoding, RFID)	Zhang *et al*. (2011) and Boehme (2009)
Quick ordering	SI and CI	Establishment of quick ordering systems with our major customers/suppliers	Wong *et al*. (2011), Flynn *et al*. (2010), Narasimhan and Kim (2002) and Frohlich and Westbrook (2001)
Organizational integration			
Responsibility our plant to	II	Have a high level of responsibility within meet other department's needs	Wong *et al*. (2011), Flynn *et al*. (2010) and Narasimhan and Kim (2002)
Periodic meetings	II .	Utilization of periodic interdepartmental meetings among internal functions	Flynn *et al*. (2010)
Strategic	SI and CI	Have a high degree of strategic partnership with our major customers/suppliers	Barnes and Liao (2012), Wong *et al*. (2011), Flynn *et al*. (2010) and Narasimhan and Kim (2002)
Joint planning	SI and CI	Have a high degree of joint planning and forecasting with major customers to anticipate demand visibility and also with to obtain a rapid response ordering process	Wong *et al*. (2011), Flynn *et al*. (2010), Narasimhan and Kim (2002) and Frohlich and Westbrook (2001)
Decision making flows with/among	SI and CI	Relative degree of major customers'/suppliers' involvement (decision making) with our departments and physical flows among firm departments: R and D (research and development)/Engineering	Ebrahim (2012), Wong *et al*. (2011), Flynn *et al*. (2010), Bagchi and Skjott-Larsen (2004) and Narasimhan and Kim (2002)
	II, SI and CI	Inventory management	Wong *et al*. (2011), Flynn *et al*. (2010), Bagchi and Skjott-Larsen (2004) and Narasimhan and Kim (2002), Frohlich and Westbrook (2001)
	II and SI	Procurement	Wong *et al*. (2011), Flynn *et al*. (2010), Bagchi and Skjott-Larsen (2004), Narasimhan and Kim (2002) and Frohlich and Westbrook (2001)
	II and CI	Marketing and Sales	Wong *et al*. (2011), Flynn *et al*. (2010), Narasimhan and Kim (2002) and Frohlich and Westbrook (2001)
	II, SI and CI	Production and Packing	Wong *et al*. (2011), Flynn *et al*. (2010), Bagchi and Skjott-Larsen (2004), Narasimhan and Kim (2002) and Frohlich and Westbrook (2001)
	II, SI and CI	Quality control	Machikita and Ueki (2012)
	II, SI and CI	Distribution	Wong *et al*. (2011), Flynn *et al*. (2010), Bagchi and Skjott-Larsen (2004), Narasimhan and Kim (2002)
	II	Finance and Human resource departments	Singh *et al*. (2013)
	II, SI and CI	Supply chain software implementation	Bagchi and Skjott-Larsen (2004)

summarizes the indicators of Internal Integration (II), Customer Integration (CI) and Supplier Integration (SI).

In terms of information integration, communication is one of the important key indicators of integration within the firm and with major customers/suppliers which requires all the departments to communicate through IT tools (Wong *et al*., 2011; Flynn *et al*., 2010; Narasimhan and Kim, 2002; Frohlich and Westbrook, 2001). Communication methods can be classified into two groups: Traditional communication methods and advanced communication methods. The use of telephone, fax, e-mail, written letters and face-to-face contact are cassified as traditional communication methods (Wong *et al*., 2011; Narasimhan and Kim, 2002; Flynn *et al*., 2010; Sriram and Stump, 2004; Leek *et al*., 2003). On the other hand, computer-to-computer links, Electronic Data Interchange (EDI) and Enterprise Resource Planning (ERP) are known as advanced communication methods (Wong *et al*., 2011; Narasimhan and Kim, 2002; Flynn *et al*., 2010; Sriram and Stump, 2004; Lee and Whang, 2000; Sahin and Robinson, 2005). Real-time searching of the level of inventory information being the other indicator, can lead to an internal integration and share knowledge of inventory with company's major customers/suppliers to conduct a customer/supplier integration (Wong *et al*., 2011; Flynn *et al*., 2010; Narasimhan and Kim, 2002; Frohlich and Westbrook, 2001). The usage of track and trace systems across the departments or with company's major customers/suppliers is more common in integrated firms (Zhang *et al*., 2011; Boehme, 2009). Also, follow-up feedback (Joshi Sarang *et al*., 2012; Zhao *et al*., 2011; Flynn *et al*., 2010; Narasimhan and Kim, 2002; Frohlich and Westbrook, 2001) and the establishment of quick ordering systems with company's major customers/suppliers (Wong *et al*., 2011; Flynn *et al*., 2010; Narasimhan and Kim, 2002; Frohlich and Westbrook, 2001) are significantly important.

On the other hand, in terms of organizational integration, there are some indicators like the sense of responsibility within the departments in a firm (Wong *et al*., 2011; Flynn *et al*., 2010; Narasimhan and Kim, 2002), periodic interdepartmental meetings (Flynn *et al*., 2010) and physical flows among firm departments. There are also some strategic partnership (Barnes and Liao, 2012; Wong *et al*., 2011; Flynn *et al*., 2010; Narasimhan and Kim, 2002), joint planning and forecasting (Wong *et al*., 2011; Flynn *et al*., 2010; Narasimhan and Kim, 2002; Frohlich and Westbrook, 2001) and the involvement of major customers/suppliers in the decision making process in departments. These departments include R and D (research and development)/Engineering (Ebrahim, 2012; Wong *et al*., 2011; Flynn *et al*., 2010; Bagchi and Skjott-Larsen, 2004; Narasimhan and Kim, 2002), Inventory management (Wong *et al*., 2011; Flynn *et al*., 2010; Bagchi and Skjott-Larsen, 2004; Narasimhan and Kim, 2002; Frohlich and Westbrook, 2001), Marketing and sales (Wong *et al*., 2011; Narasimhan and Kim, 2002; Flynn *et al*., 2010; Frohlich and Westbrook, 2001), Procurement (Wong *et al*., 2011; Flynn *et al*., 2010; Bagchi and Skjott-Larsen, 2004; Narasimhan and Kim, 2002; Frohlich and Westbrook, 2001), Production and packing (Wong *et al*., 2011; Flynn *et al*., 2010; Bagchi and Skjott-Larsen, 2004; Narasimhan and Kim, 2002; Frohlich and Westbrook, 2001), Quality control (Machikita and Ueki, 2012), Distribution (Wong *et al*., 2011; Flynn *et al*., 2010; Bagchi and Skjott-Larsen, 2004; Narasimhan and Kim, 2002) and Supply chain software implementation (Bagchi and Skjott-Larsen, 2004) with company's major customers/suppliers.

Indicators of product quality: In this study, two dimensions of product quality as design quality and conformance quality were considered. According to Fynes and De Burca (2005), design quality can distinguished in engineering design quality and industrial design quality. Engineering design quality is measured by engineering change notices frequency, technical performance, material, design, cost and ease of production or assembly (Fleischer and Liker, 1992). On the other hand, industrial design quality is measured with perceptions of aesthetics, ease-of-use and appearance (Yamamoto and Lambert, 1994). In term of design quality, the indicators for engineering design quality and indicators for industrial design quality were demonstrated. Then each indicator was with a statement.

This study categorized conformance quality in two terms: Internal conformance quality and external conformance quality (Fynes and De Burca, 2005). Internal conformance quality is measured by defect rates, new product yield, scrapandrework (Fynes and De Burca, 2005; Zeng *et al*., 2013). On the other hand external conformance quality is measured by, customer complaints frequency, the systems for tracking customer frequency and the priority given to solving product problem frequency (Choi and Eboch, 1998). The indicators of conformance quality in two categories of internal conformance quality and external conformance quality, with a statement for each one, are indicated in Table 2. Table 2 shows indicators of each dimensions of product quality with related statements.

Table 2: Indicators of each dimensions of product quality

	Indicator	Statement	Source
Design quality			
Engineering design quality	Engineering change	Minimum/no engineering change take place in the first year after product introduction due to production problems	Fynes and De Burca (2005), Fleischer and Liker (1992) and Fynes *et al.* (2005)
	Technical performance	Meet expected technical performance	Fynes and De Burca (2005), Fleischer and Liker (1992) and Fynes *et al.* (2005)
	Material, design and cost	Meet the customers' criteria for material, design and cost	Fynes and De Burca (2005) and Fleischer and Liker (1992)
	Ease of production or assembly	Meet the criteria for ease of production or assembly	Fynes and De Burca (2005) Voss and Blackmon (1994), Fleischer and Liker (1992) and Fynes *et al.* (2005)
Industrial design quality	Ease of use	Meet the criteria for ease of use	Yamamoto and Lambert (1994), Fynes and De Burca (2005)
	Perceptions of aesthetics and appearance	Meet expected perceptions of aesthetics and appearance	Yamamoto and Lambert (1994) and Fynes and De Burca (2005)
Conformance quality			
Internal conformance quality	Scrap and rework cost	No internal scrap and rework costs as a percentage of product cost	Fynes and De Burca (2005), Voss and Blackmon (1994) and Fynes *et al.* (2005)
	Internal yield introduction	No internal yield on new product	Fynes and De Burca (2005) Voss and Blackmon (1994) and Fynes *et al.* (2005)
	Defect rate	No defect rate for this product at final inspection	Fynes and De Burca (2005) and Voss and Blackmon (1994) and Fynes *et al.* (2005)
External conformance quality	Value and quality	Meet customer's expectations in terms of value and quality (the capability to offer consistent quality product)	Oghazi (2009)
	Return product and complaint	No return product and customer complaint during the warranty period	Voss and Blackmon (1994), Fynes *et al.* (2005) and Maani *et al.* (1994)
	Tracking system	Use the customer tracking system	Voss and Blackmon (1994) and Fynes *et al.* (2005)
	Solve a product problem	Attention given to solve a product complaint	Wu *et al.* (2006)

Table 3: Cronbach's alpha for research variables

Variable	No. of items	Role	Cronbach's alpha
Customer integration	6	Independent	0.824
Supplier integration	6	Independent	0.848
Internal integration	6	Independent	0.900
Design quality	4	Dependent	0.912
Conformance quality	5	Dependent	0.766

Validation of instrument: After investigating the indicators of each dimensions of supply chain integration and product quality, were arranged in a draft questionnaire. Then interviewed with experts in the field of supply chain management to test for content validity to know each question truly measures the concept (Shariat Panahy *et al*., 2013). The instrument developed in this study illustrates the content validity as the choice of measuring items was based on both, an exhaustive literature review and detailed evaluations by ten academicians and five manufacturers. The questionnaire was finalized after some small modifications. This modified questionnaire was implemented in the study to validate the instrument of measurement by using SPSS (version 21) to carry out descriptive statistics analysis, variable reliabilityandvalidity analysis.

Reliability: In this study, a primary sampling with the size of 50 samples in automotive industry had been done and by using, the internal consistency method that shows the reliability based on the Cronbach alpha. In this study, the Cronbach alpha level of 0.70 is considered good and the reliability is accepted. Table 3 indicates the level of Cronbach alpha for all variables are more than 0.70 that shows high internal consistency. The results of reliability analysis from SPSS are shown in Table 4.

Validity: The instrument was examined for two major types of validity: Content validity and construct validity. Content validity was based on both, an exhaustive literature review and detailed evaluations by SCM experts before implementing the survey. Construct validity was conducted by using the factor analysis method (Hair *et al*., 2010).

Table 5 and 6 shown the summaries of validity of all independent and dependent constructs. The statistic value of KMO for each variable shows that the result of factor analysis is valid. The eigenvalue for the first factor of each variable with percentage of the total variance suggest that the scale items are unidimensional.

This study demonstrates supply chain integration and product quality indicators which were identified, based on the literature review. It also constructs an instrument to investigate the relationship between dimensions of supply chain integration and dimensions

Table 4: Summary items analysis from SPSS

	Scale statistic			
	Mean	Variance	Std. deviation	N of items
	97.8600	134.572	11.60051	27

Summary item statistics	Mean	Min	Max	Range	Max/Min	Variance	N of Item
Item means	3.624	2.860	4.140	1.280	1.448	0.161	27
Item variances	0.787	0.353	1.241	0.889	3.520	0.060	27
Inter-Item covariances	0.161	-0.312	0.740	1.053	-2.371	0.032	27
Inter-Item correlations	0.212	-0.303	0.869	1.172	-2.865	0.050	27

	Reliability statistics		
	Cronbach's alpha	Cronbach's alpha based on standardized items	N of items
	0.875	0.879	27

Item-total statistic	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Cronbach's alpha if item deleted
CI1	94.220	125.481	0.470	0.869
CI2	94.800	123.673	0.390	0.872
CI7	94.300	127.031	0.444	0.870
CI8	94.440	121.313	0.525	0.867
CI11	94.280	125.675	0.510	0.869
CI14	94.240	125.207	0.452	0.870
SI1	94.360	122.643	0.551	0.867
SI2	94.420	117.473	0.660	0.863
SI7	94.460	120.539	0.615	0.865
SI8	94.540	121.641	0.569	0.866
SI9	94.360	123.215	0.428	0.870
SI11	94.380	123.914	0.448	0.870
II1	93.720	125.349	0.616	0.867
II2	93.900	122.949	0.498	0.868
II3	93.840	124.913	0.432	0.870
II9	93.880	126.230	0.448	0.870
II10	93.780	128.134	0.421	0.871
II11	93.740	127.788	0.479	0.870
EDQ1	93.800	126.449	0.420	0.870
EDQ2	93.940	128.180	0.304	0.873
EDQ3	93.840	127.607	0.339	0.872
EDQ4	93.880	124.393	0.538	0.868
ICQ1	94.760	130.227	0.158	0.878
ICQ2	94.800	130.735	0.150	0.877
ICQ3	94.940	128.466	0.268	0.874
ICQ4	93.740	127.298	0.301	0.874
ECQ5	95.000	129.020	0.203	0.877

Table 5: Factor analysis of independent variables

Variable	Eigen values	Variance (%)	KMO	Item code	Item description	Factor loading
Customer integration	3.517	58.619	0.712	CI1	To the extent of communication with our major customers through information technologies (e.g., e-mail/fax/phone/Internet/Extranet)	0.743
				CI2	To the extent of communication with our major customers by using computer to computer links, EDI (the electronic data interchange) or ERP (the enterprise resource planning)	0.699
				CI7	Have a high degree of strategic partnership with our major customers	0.873
				CI8	Have a high degree of joint planning and forecasting with major customers to anticipate demand visibility	0.743
				CI11	Relative degree of major customers' involvement (decision making) with our marketing and sales department	0.785
				CI14	Relative degree of major customers' involvement (decision making) with our distribution department	0.740
Supplier integration	3.642	60.696	0.737	SI1	To the extent of communication with our major suppliers through information technologies (e.g., E-mail/fax/phone/internet/extranet)	0.729
				SI2	To the extent of communication with our major suppliers by using computer to computer links, EDI (the electronic data interchange) or ERP (the enterprise resource planning)	0.865
				SI7	Have a high degree of strategic partnership with suppliers	0.880
				SI8	Have a high degree of joint planning to obtain a rapid response ordering process (inbound) with suppliers	0.700
				SI9	Relative degree of major suppliers' involvement (decision making) with our R and D (research and development)/engineering department	0.683
				SI11	Relative degree of major suppliers' involvement (decision making) with our procurement department	0.794

Table 5: Countinue

Variable	Eigen values	Variance (%)	KMO	Item code	Item description	Factor loading
Internal integration	3.918	65.295	0.811	II1	To the extent of communication with our departments through information technologies (e.g., E-mail/fax/phone/internet/extranet)	0.924
				II2	To the extent of communication with our departments by using computer to computer links, EDI (the electronic data interchange) or ERP (the enterprise resource planning)	0.749
				II3	Real-time searching of the level of inventory	0.760
				II9	Within our plant, we emphasize on physical flows among Procurement/marketing and sales department	0.685
				II10	Within our plant, we emphasize on physical flows among Production and packing department	0.813
				II11	Within our plant, we emphasize on physical flows among quality control department	0.892

Table 6: Factor analysis of dependent variables

Variable	Eigen values	Variance (%)	KMO	Item code	Item description	Factor loading
Design quality	3.176	79.409	0.827	EDQ1	Minimum/no engineering change take place in the first year after product introduction due to production problems	0.887
				EDQ2	Meet expected technical performance	0.835
				EDQ3	Meet the customers' criteria for material, design and cost	0.909
				EDQ4	Meet the criteria for ease of production or assembly	0.931
Conformance quality	2.682	53.644	0.578	ICQ1	No internal scrap and rework costs as a percentage of product cost.	0.832
				ICQ2	No internal yield on new product introduction	0.877
				ICQ3	No defect rate for this product at final inspection	0.776
				ICQ4	Meet customer's expectations in terms of value and quality (the capability to offer consistent quality product)	0.447
				ECQ5	No return product and customer complaint during the warranty period	0.648

of product quality in the automotive industry, rooted from the indicators of each of these dimensions. This model can be implemented in the automotive industry by researchers in the future studies. Although, in the previous research, the researchers (Lotfi *et al*., 2013c) investigated the relationship between dimensions of supply chain integration and dimensions of product quality of the entire supply chain in the manufacturing sector, they did not specifically focus on the automotive industry. This study in automotive industry produced results which corroborate the findings of the previous work in the manufacturing sector (Lotfi *et al*., 2013c).

CONCLUSION AND FUTURE IMPLICATION

In this study, based on the literature review, the indicators of each dimension of supply chain integration and product quality were identified. Moreover, an instrument to investigate the relationship between dimensions of supply chain integration and dimensions of product quality in the automotive industry was constructed. This instrument was validated and evaluated by academicians and practitioners experts in the field of SCM via interviewing with them and also by using SPSS to carry out descriptive statistics analysis, variable reliability and validity analysis. Based on the obtained results, all 5 constructs namely, customer integration, supplier integration, internal integration, design quality and conformance quality, are shown to be valid. The values of the Cronbach's alpha, correlation coefficients and composite reliability prove the reliability of supply chain integration-product quality instrument. Factor loading demonstrated that all 5 constructs are unidimensional. The questionnaire instrument has 27 items from 5 constructs.

This questionnaire instrument can be used effectively in any automotive industry. Future work should consider more competitive dimensions which may also lead to improvements of firm performance, also expand the framework to include other industrial sectors besides automotive industry.

The validated instrument may use in any study to find the relationship between supply chain integration and product quality in manufacturing sector.

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