Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 13 (1): 36-48, 2013
ISSN 1812-5654 / DOI: 10.3923/jas.2013.36.48

A Product Quality-Supply Chain Integration Framework

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Abstract: Product quality is one of the key competitive factors that will enable firms to survive and succeed in the global market place. Product quality is an important dimension of operational performance in supply chain management that has not received sufficient attention from the research community. Previous researches in this field have neglected to consider the relationship between supply chain integration and dimensions of product quality. Hence, the effect of supply chain integration on quality performance has received less attention. Therefore consideration must be given to the development of collaborative activities between manufacturer, supplier and costumer which enables firms to work together and improve product quality. Accordingly, the primary focus of this study is to investigate the relationship between dimensions of product quality and supply chain integration. The dimensions considered for product quality are design quality and conformance quality, whereas the dimensions for supply chain integration are customer integration, supplier integration and internal integration. The relationships between these dimensions are then embodied in a framework which will be validated. This research adopts both a qualitative conceptual approach and a quantitative approach in the development of the framework. The literature is consulted in identifying the dimensions of supply chain integration and product quality. These dimensions are then modeled into a questionnaire survey and are administered to identify manufacturing companies. Validity and reliability of the scales for the construct of interest were assessed through a factor analysis and Cronbach-alpha test. The results provide considerable support for our product quality-supply chain integration framework that can be used in the manufacturing sector.

Key words: Supply chain management, supply chain integration, product quality, framework, manufacturing sector

INTRODUCTION

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 (Kotcharin *et al*., 2012; Flynn *et al*., 2010; Koufteros *et al*., 2005; Lau, 2011; Kim, 2009). Hence, there are an increasing number of empirical studies and investigations devoted to the direct and indirect impacts of Supply Chain Integration (SCI) on product quality and firm performance (Kotcharin *et al*., 2012; Zhang *et al*., 2011; Zhu and You, 2011; Musheng *et al*., 2008; Tsung, 2000).

With recent advances in Information Technology (IT), the research and the practice of collaboration between firms is now having a significant impact on many aspects of supply chains (Chae *et al*., 2005; Wang *et al*., 2011; Zapp *et al*., 2012). There are some researches focusing on the interaction between the various dimensions of supply chain integration and performance (Cao and Zhang, 2011; Narasimhan and Kim, 2002; Vickery *et al*., 2003; Pagell, 2004; Hosseini *et al*., 2012). There are some researches focusing on the impact of product quality management practices (Boon-Itt, 2011; Kotcharin *et al*., 2012; Koufteros *et al*., 2005; Rosenzweig *et al*., 2003; Swink *et al*., 2007; Wong *et al*., 2011; Devaraj *et al*., 2007; Das *et al*., 2006; Cousins and Menguc, 2006; Fynes and de Burca, 2005). However, there is a lack of attention given to the relationship between supply chain integration and dimensions of product quality.

The existing researches on SCI, however, include definitions and dimensions (Van Der Vaart and Van Donk, 2008). While some researches concentrate on the individual dimensions of SCI (Cousins and Menguc, 2006; Homburg and Stock, 2004; Koufteros *et al*., 2007), especially customer and supplier integration, others use a variety of definitions to examine SCI as a single construct (Armistead and Mapes, 1993; Rosenzweig *et al*., 2003). Furthermore, many conceptualizations of SCI do

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not include the central link such as, internal integration and hence are incomplete (Flynn *et al*., 2010). External integration establishes interactive and collaborative relationships with customers and suppliers, whereas internal integration recognizes the significance of interactions between departments within a manufacturer. Both of these integrations are necessary to enhance the performance of a supply chain and improve customers' satisfaction (Flynn *et al*., 2010). Supply Chain Integration can be classified into three dimensions: (1) Customer Integration, (2) Supplier Integration and (3) Internal Integration. Customer and supplier integration are also known as external integration.

Improvements in the quality of products and services that enterprises offer may add value for customers. Clark *et al.* (1992) classified total product quality into two dimensions: firstly, conformance quality which is defined by how well the actual product conforms to the design once it has been manufactured and secondly, design quality which is defined as the extent to which quality is designed into the product (Fynes *et al*., 2005). Hence, studies which test the effect of supply chain integration on dimensions of product quality remains a research opportunity. The two main criteria for choosing Supply Chain Integration (SCI) are the degree to which a manufacturer strategically integrates with its supply chain partners and collaboratively manages intra- and inter-organizational processes. These will in turn lead to effective and efficient flows of information and hence, provide products with better qualities to the customer. However, the effect of supply chain integration on quality performance has received less attention.

The aim of the present study is (1) to review the impact of supply chain integration on performance particularly product quality, (2) to propose a product quality- supply chain integration framework and (3) to report on the validation of the framework using empirical methods.

PROPOSED FRAMEWORK

The impact of supply chain integration on performance: 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).

This study investigates some supporting literature on dimensions of supply chain integration and performance and then classifies all performance into two categories which include: strategic performance (long term critical success factors and key performance) and operational performance (short term critical success factors and key performance). Table 1 shows some related literature on the relationship between SCI and dimensions of strategic performance and Table 2 demonstrates a summary of prior literature on the relationship between each dimension of Supply Chain Integration (SCI) and operational performance which are described in the following paragraphs.

Within the context of manufacturing strategy, the importance of supply chain integration for competitive capabilities was investigated in studies of world-class manufacturers. Many researchers, including Swink *et al.* (2007), Kim (2009), Rosenzweig *et al.* (2003) and Kotcharin *et al.* (2012) investigated the effect of supply chain integration on some competitive capabilities such as; Product Quality, Delivery, Cost, Customer Service, Marketing Technology, Differentiation, reliability, Process Flexibility and New product flexibility.

Some researchers have shown the relationship between supply chain integration and some dimensions of business performance such as market/product diversification, product responsiveness, time to market, market share index, customer satisfaction, financial performance, Return on Assets (ROA), sales growth, the percentage of revenues from new products, growth in sales, return on sales, growth in return on sales, growth in profit, growth in market share, Return on Investment (ROI) and growth in ROI, market performance and customer satisfaction (Flynn *et al*., 2010; Swink *et al*., 2007; Narasimhan and Kim, 2002; Droge *et al*., 2004; Kim, 2009; Fynes *et al*., 2005; Rosenzweig *et al*., 2003; Germain and Iyer, 2006).

On the other hand some researchers focus on effects of SCI on operational performance factors such as time-to-product (Droge *et al*., 2004; Das *et al*., 2006), New product introduction time, manufacturing cycle time reduction (Das *et al*., 2006), lead time, conformance to specifications, quality improvement, (Cousins and Menguc, 2006), product innovation (Koufteros *et al*., 2005, 2007), product modularity, process modularity (Droge *et al*., 2012), project team effectiveness, design performance (Petersen *et al*., 2005), profitability (Koufteros *et al*., 2005; Das *et al*., 2006), Delivery (Droge *et al*., 2012; Swink *et al*., 2007; Kotcharin *et al*., 2012; Wong *et al*., 2011; Rosenzweig *et al*., 2003; Cousins and Menguc, 2006; Das *et al*., 2006; Devaraj *et al*., 2007), Cost (Droge *et al*.,

Table 1: Summary of some prior literature on relationship between supply chain integration and strategic performance

Category	Performance	Internal integration sources	Supplier integration sources	Customer integration sources
Strategic performance	Trust	Breite and Maenpaa (2011), Fynes *et al.* (2005), Golicic and Mentzer (2006) and Huo *et al.* (2004)	Breite and Maenpaa (2011), Fynes *et al.* (2005) Golicic and Mentzer (2006) and Huo *et al.* (2004)	Breite and Maenpaa (2011), Fynes *et al.* (2005), Golicic and Mentzer (2006) and Huo *et al.* (2004)
	Marketing technology	Kim (2009) and Narasimhan and Kim (2002)	Kim (2009) and Narasimhan and Kim (2002)	Kim (2009) and Narasimhan and Kim (2002)
	Product technology	Droge *et al.* (2004), Koufteros *et al.* (2005) and Wong *et al.* (2011)	Devaraj *et al.* (2007), Droge *et al.* (2004), Koufteros *et al.*(2005), Koufteros *et al.* (2007), Petersen *et al.* (2005), Wong *et al.* (2011) and Das *et al.* (2006)	Devaraj *et al.* (2007), Droge *et al.* (2004), Koufteros *et al.* (2005) and Wong *et al.* (2011)
	Information technology	Breite and Maenpaa (2011), Kim (2009) and Vickery *et al.* (2003)	Breite and Maenpaa (2011), Kim (2009) and Vickery *et al.* (2003)	Breite and Maenpaa (2011), Kim (2009) and Vickery *et al.* (2003)
	Process technology	Cousins and Menguc (2006), Droge *et al.* (2012), Kotcharin *et al.* (2012), Rosenzweig *et al.* (2003) and Swink *et al.* (2007)	Cousins and Menguc (2006), Droge *et al.* (2012), Kotcharin *et al.* (2012), Petersen *et al.* (2005), Rosenzweig *et al.* (2003) and Swink *et al.* (2007)	Cousins and Menguc (2006), Droge *et al.* (2012), Kotcharin *et al.* (2012), Rosenzweig *et al.* (2003) and Swink *et al.* (2007)
	Commitment and Co-operation	Breite and Maenpaa (2011), Cousins and Menguc (2006), Fynes *et al.* (2005), Golicic and Mentzer (2006) and Huo *et al.* (2004)	Breite and Maenpaa (2011), Cousins and Menguc (2006), Fynes *et al.* (2005), Golicic and Mentzer (2006) and Huo *et al.* (2004)	Breite and Maenpaa (2011), Cousins and Menguc (2006), Fynes *et al.* (2005), Golicic and Mentzer (2006) and Huo *et al.* (2004)
	Adaptation	Fynes *et al.* (2005)	Fynes *et al.* (2005)	Fynes *et al.* (2005)
	Interdependence	Fynes *et al.* (2005) and Golicic and Mentzer (2006)	Fynes *et al.* (2005) and Golicic and Mentzer (2006)	Fynes *et al.* (2005) and Golicic and Mentzer (2006)
	Logistics performance	Germain and Iyer (2006) and Kim (2009)	Kim (2009)	Germain and Iyer (2006) and Kim (2009)
	Profitability	Koufteros *et al.* (2005)	Das *et al.* (2006) and Koufteros *et al.* (2005)	Koufteros *et al.* (2005)
	Quality improvement	Cousins and Menguc (2006)	Cousins and Menguc (2006) and Das *et al.* (2006)	Cousins and Menguc (2006)
	Customer service	Kim (2009) and Vickery *et al.* (2003)	Kim (2009) and Vickery *et al.* (2003)	Kim (2009) and Vickery *et al.* (2003)

Table 2: Summary of some prior literature on relationship between supply chain integration and operational performance

Category	Indicators	Internal integration sources	Supplier integration sources	Customer integration sources
Operational performance	Customer satisfaction	Fynes *et al.* (2005), Kim (2009), Rosenzweig *et al.* (2003) and Swink *et al.* (2007)	Fynes *et al.* (2005), Kim (2009), Rosenzweig *et al.* (2003) and Swink *et al.* (2007)	Fynes *et al.* (2005), Kim (2009), Rosenzweig *et al.* (2003) and Swink *et al.* (2007)
	Cost	Cousins and Menguc (2006), Kim (2009), Kotcharin *et al.* (2012), Rosenzweig *et al.* (2003), Swink *et al.* (2007) and Wong *et al.* (2011)	Cousins and Menguc (2006), Kim (2009), Kotcharin *et al.* (2012), Rosenzweig *et al.* (2003), Swink *et al.* (2007), Wong *et al.* (2011), Devaraj *et al.* (2007) and Das *et al.* (2006)	Cousins and Menguc (2006), Kim (2009), Kotcharin *et al.* (2012), Rosenzweig *et al.* (2003), Swink *et al.* (2007), Wong *et al.* (2011) and Devaraj *et al.* (2007)
	Delivery	Cousins and Menguc (2006), Kotcharin *et al.* (2012), Rosenzweig *et al.* (2003), Swink *et al.* (2007) and Wong *et al.* (2011)	Cousins and Menguc (2006), Kotcharin *et al.* (2012), Rosenzweig *et al.* (2003), Swink *et al.* (2007), Wong *et al.* (2011), Das *et al.* (2006), Devaraj *et al.* (2007) and Droge *et al.* (2012)	Cousins and Menguc (2006), Kotcharin *et al.* (2012), Rosenzweig *et al.* (2003), Swink *et al.* (2007), Wong *et al.* (2011), Devaraj *et al.* (2007) and Droge *et al.* (2012)
	Financial performance	Droge *et al.* (2004), Germain and Iyer (2006), Kim (2009) and Rosenzweig *et al.* (2003)	Droge *et al.* (2004), Kim (2009), Petersen *et al.* (2005) and Rosenzweig *et al.* (2003)	Droge *et al.* (2004), Germain and Iyer (2006), Kim (2009) and Rosenzweig *et al.* (2003)
	Market performance	Cousins and Menguc (2006), Droge *et al.* (2004), Kim (2009) and Swink *et al.* (2007)	Cousins and Menguc (2006) Droge *et al.* (2004) Kim (2009) and Swink *et al.* (2007)	Cousins and Menguc (2006), Droge *et al.* (2004), Kim (2009) and Swink *et al.* (2007)
	Firm performance	Cao and Zhang (2011), Narasimhan and Kim (2002) and Vickery *et al.* (2003)	Cao and Zhang (2011), Narasimhan and Kim (2002), Vickery *et al.* (2003) and Pagell, 2004)	Cao and Zhang (2011), Narasimhan and Kim (2002) and Vickery *et al.* (2003)
	Time performance	Cousins and Menguc (2006)	Cousins and Menguc (2006) and Das *et al.* (2006)	Cousins and Menguc (2006)
	Product performance	Droge *et al.* (2004), Droge *et al.* (2012) and Swink *et al.* (2007)	Das *et al.* (2006), Droge *et al.* (2004), Droge *et al.* (2012,) and Swink *et al.* (2007)	Droge *et al.* (2004), Droge *et al.* (2012) and Swink *et al.* (2007)
	Conformance to specifications	Cousins and Menguc (2006)	Cousins and Menguc (2006)	Cousins and Menguc (2006)
	Product quality	Boon-itt (2011), Kotcharin *et al.* (2012), Koufteros *et al.* (2005), Rosenzweig *et al.* (2003) Swink *et al.* (2007) and Wong *et al.* (2011)	Boon-itt (2011), Kotcharin *et al.* (2012), Koufteros *et al.* (2005), Rosenzweig *et al.* (2003) Swink *et al.* (2007) and Wong *et al.* (2011)	Boon-itt (2011), Kotcharin *et al.* (2012), Koufteros *et al.* (2005), Rosenzweig *et al.* (2003) Swink *et al.* (2007) and Wong *et al.* (2011)

2012; Swink *et al*., 2007; Kotcharin *et al*., 2012; Wong *et al*., 2011; Rosenzweig *et al*., 2003; Cousins and Menguc, 2006; Devaraj *et al*., 2007), process flexibility and Process improvement (Kotcharin *et al*., 2012; Swink *et al*., 2007; Rosenzweig *et al*., 2003; Cousins and Menguc, 2006), production flexibility (Devaraj *et al*., 2007; Wong *et al*., 2011) and new product flexibility (Swink *et al*., 2007).

Germain and Iyer (2006) investigate internal integration and customer integration on logistics performance and Cao and Zhang (2011), Vickery *et al*. (2003) and Narasimhan and Kim (2002) focus on firm performance and also Pagell (2004) indicates the relationship between firm performances with only supplier integration. Some dimensions of Supply Chain Practical Capability such as technological factor , logistical factor and structural factor have been researched by Kim (2009) and Vickery *et al*. (2003). Narasimhan and Kim (2002) show the positive effects of internal integration on both external integration: supplier and customer integration and vice versa.

We categorize performance into two categories which are strategic performance and operational performance as shown in Table 1 and 2. There are some indicators for strategic performance in some prior literature on relationship between supply chain integration and strategic performance such as: trust, marketing technology, product technology, information technology, process technology, commitment and co-operation, adaptation, interdependence, logistics performance, profitability, quality improvement and customer service.

There are also some indicators for operational performance that indicate in some prior literature on relationship between supply chain integration and operational performance such as: Customer satisfaction, Cost, Delivery, Financial Performance, Market performance, Firm Performance, Time Performance, Product Performance, Conformance to specifications and Product Quality. Table 2 shows these performance indicators and related sources of previous researches.

From Table 2, we can conclude that lack of attention has been granted to dimensions of supply chain integration and product quality which contains design quality and conformance quality.

Supply chain integration and product quality: There are other researches that look at quality in supply chain management (Devaraj *et al*., 2007; Swink *et al*., 2007; Das *et al*., 2006; Koufteros *et al*., 2005). Cousins and Menguc (2006) work on quality improvement and supply chain integration. Kotcharin *et al*. (2012), Wong *et al*. (2011), Boon-Itt (2011) and Rosenzweig *et al*. (2003) investigate the significant effect of SCI on overall product quality but only Fynes *et al*. (2005) present the relationship of supply chain relationship quality on two important dimensions of product quality that are design quality and conformance quality.

Kotcharin *et al*. (2012) investigated the interaction of internal and external integration and noted the corresponding impact on competitive capabilities (Product Quality, Delivery, Low Cost and Process Flexibility). They used the Structural Equation Modeling (SEM) to analyze the empirical data collected from the survey conducted with the cooperation of 130 automotive suppliers in Thailand. Their findings include a positive relationship between internal integration and external integration; and also a high level of product quality attained through internal and external integration leading to an enhanced delivery capability.

Wong *et al*. (2011) investigated the contingency effects of Environmental Uncertainty (EU) on the relationships between three dimensions of supply chain integration specifically internal integration, supplier integration and customer integration and four dimensions of operational performance, namely, delivery, production cost, product quality and production flexibility. They gathered data from 151 automotive manufacturing companies in Thailand and found that under a high EU, the relationship between supplier/customer integration and delivery and flexibility performance and those between internal integration and product quality and production cost, will be enhanced.

Boon-Itt (2011) examined the effect of communication and collaboration as types of information technology on the relationship between supply chain integration and product quality performance among 111 Thai suppliers and automakers in the automotive industry. They found that under framework linking supply chain integration strategies and product quality performance, different information technology types can be set up to enhance product quality.

Devaraj *et al*. (2007) investigated the relationships between eBusiness capabilities (customers, purchasing and collaboration), production information integration (supplier integration and customer integration) and operational performance (cost, quality, flexibility and delivery). Data from 120 automotive and computers/ electronics industries were collected and analyzed. Their findings include the positive effect of supplier integration on all dimensions of operational performance and demonstrate its greatest impact on delivery time, costs and quality.

Swink *et al*. (2007) researched about four different types of strategic integration at the manufacturing plant level. They investigated the roles that manufacturing-based competitive capabilities (cost efficiency, quality, delivery, process flexibility and new product flexibility) play in adjusting the relationships between strategic integration (corporate strategy integration, product-process technology integration and strategic supplier integration) and business performance (market performance and customer satisfaction). A survey was conducted among 224 manufacturing firms in North America and the results illustrated that customer and supplier integration activities provide benefits for business performance and also that strategic supplier integration has a significant relationship with market performance, but not with customer satisfaction.

Koufteros *et al*. (2005) examined the effect of uncertainty, equivocality and platform development strategy on the relationships among internal integration, external integration and competitive capabilities (product innovation, quality, profitability). They gathered the data from 244 manufacturing companies of several industries. They found that both internal and external integration have a positive effect on product innovation and quality and eventually profitability. Their findings also include internal integration as an important factor of external integration leading to higher levels of competitive capabilities.

Rosenzweig *et al*. (2003) examined the ways that manufacturing-based competitive capabilities (product quality, delivery reliability, process flexibility and cost leadership) mediate the association between supply chain integration and business performance (Return on Assets (ROA), customer satisfaction, sales growth and the percentage of revenues from new products). They gathered and analyzed data obtained from 238 manufacturers in the top quartile of sales revenues in 35 countries and found that supply chain integration intensity leads directly to an enhanced business performance, hence, approving the conventional wisdom concerning the growing importance of supply chain integration in the consumer products sector. They also concluded that the benefits of integration should first be transformed into operational capabilities credited by customers, such as product quality, process flexibility, delivery reliability, or cost leadership.

Fynes *et al*. (2005) focused on the interaction between different dimensions of Supply Chain (SC) relationships (such as trust, commitment, adaptation, communication and collaboration) and quality performance. They examined two dimensions of product quality including design quality and conformance quality but they did not search on the direct effect of supply chain integration. They propose that some dimensions of supply chain relationship quality such as communication, trust, adaptation, commitment, interdependence and co-operation are strong indicators of a higher order construct. They also found the relationship between these indicators and two dimensions of product quality (design quality and conformance quality) in one hand and on the other; they showed the positive effect of product quality dimensions on customer satisfaction. They developed a framework, incorporating dimensions of SC relationships and quality performance. The model was validated using data collected from 200 suppliers in the electronics sector in the Republic of Ireland by using AMOS 4. Their findings asserted that by focusing on the management of SC relationships organizations, product quality can be enhanced.

From the literature review, we can conclude that very little attention has been granted to the dimensions of supply chain integration and product quality which is composed of design quality and conformance quality. Even though Fynes *et al*. (2005) investigated on these two dimensions of product quality, but they did not research into their direct effect on supply chain integration. Therefore, the relationship between supply chain integration with the complete dimensions of product quality has not received sufficient attention from the research community.

Proposed product quality-supply chain integration framework: The review of the literature illustrates that a supply chain consists of multiple firms, both upstream (supply), downstream (distribution) and the ultimate customer (Christopher, 2011). We argued about product quality based on Clark *et al*. (1992). Here total product quality is composed of two dimensions. Firstly, conformance quality which is defined by how well the actual product conforms to the design once it has been manufactured and secondly, design quality which is defined as the extent to which quality is designed into the product (Fynes *et al*., 2005). Based on this classification for product quality and Flynn *et al*. (2010) research for integrated relationship between manufacturers and their supply chain partners, our proposed framework is shown in Fig. 1.

This framework is derived from the literature review as given in this paper. The proposed framework is divided in two main categories: Supply Chain Integration and Product Quality. We consider three types of supply chain integration: customer integration, internal integration and supplier integration as independent variables and two types of product quality: conformance quality and design

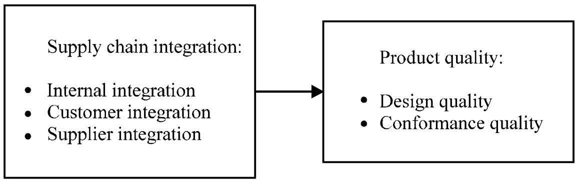

Fig. 1: Research proposed framework

quality as dependent variables. Our analysis focuses on the relationship between dimensions of supply chain integration and dimensions of product quality of the entire supply chain.

MATERIALS AND METHODS

To illustrate the relationship of supply chain integration and product quality in the manufacturing sector, we consider two important dimensions of product quality in supply chains specifically design quality and conformance quality.

The proposed methodology for conducting this study is as follows:

- Construct a literature review on the relationship between dimensions of product quality and supply chain integration
- Construct a framework between dimensions of supply chain integration and dimensions of product quality based on literature review
- Construct a draft questionnaire to validate the proposed framework
- Modify the questionnaire
- Design and implement the survey
- Analyze the 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 manufacturing sector in the year 2012. 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.

The data required for the quantitative analysis was collected with the aid of a questionnaire that was devised to address the proposed framework. According to Creswell (2009), investigators use a questionnaire to a sample or to an entire population of people to describe the attitudes, opinions, behaviors, or characteristics of a population as it is a common and accepted method to provide data for social science research.

The sampling method which was applied in this study was the simple random sampling method. A simple random sample is a sampling method in which every member of the population has an equal and independent chance of being chosen. Data collection procedure in this study was a cross-sectional survey design. Cross-sectional studies involve observations of the whole population, or a representative subset, at a specific period of time. The target respondent was the manufacturing sector.

There are many ideas for an adequate sample size in Structural Estimating Modeling (SEM). Hatcher (1994) mentions in his book that the minimum size of the sample should be five times the number of variables. Therefore, since there are five variables in this study, 25 respondents or more should be adequate. From 100 surveys just 32 surveys were returned, 2 of them were ignored because they showed the same grading for all the questions. The method to submit the survey was sent via email from the 32 returned surveys. The response rate was 30% for 30 usable surveys. The empirical analysis used data from a total of 30 manufacturing companies. Validity and reliability of the scales for the constructs of interest were assessed through a factor analysis and Cronbach-alpha test. For the purpose of this research, respondents were chosen randomly in the period of two months in the manufacturing sector.

INSTRUMENT DEVELOPMENT

The data in this study was mainly drawn from the survey questionnaire. The questionnaire had six sections, namely (1) general information, (2) customer integration, (3) supplier integration (4) internal integration (5) design quality and (6) conformance quality.

Table 3 demonstrates the details of the questionnaire which had 42 questions; 19 on general information, 5 on customer integration, 5 on supplier integration, 5 on internal integration, 4 on design quality and 4 questions on the conformance quality.

The questionnaire was distributed randomly to the target sample via email. The questionnaire items are included in Appendix. This study used SPSS v.20 to perform descriptive statistics analysis, variable reliability and validity analysis. These analyses are described in the following sub-sections.

Reliability: In this research, a primary sampling with the size of 30 samples in the manufacturing sector had been done by using the internal consistency method. In fact, the measurement tool was considered by using statistical methods. In other words, variable's reliability of this research has been determined based on the Cronbach alpha to be between 0 and 1. If the calculated coefficient is near to zero, it indicates a lack of reliability of question and if this value is close to one, it indicates a high reliability. Some fields accept alpha levels higher than 0.45. In social sciences, the alpha level of 0.70 is considered good and its reliability is accepted.

According to the Table 4 the values of the alpha coefficient for all independent and dependent variables are more than 0.70 and the total Cronbach alpha is 0.855 (Table 5). This means that the items have relatively high internal consistency.

Table 3: Summary of research variables

Variable	No. of questions	Role	Scale
General information	19	Demographics and general	Nominal and ordinal
Customer integration	5	Independent	Ordinal
Supplier integration	5	Independent	Ordinal
Internal integration	5	Independent	Ordinal
Design quality	4	Dependent	Ordinal
Conformance quality	4	Dependent	Ordinal

Table 4: Cronbach's alpha for research variables

Variable	Items	Alpha
Customer integration	5	0.81
Supplier integration	5	0.83
Internal integration	5	0.80
Design quality	4	0.78
Conformance quality	4	0.77

Validity: The questionnaire was tested for two main types of validity: content validity and construct validity. Content validity is a judgement, by experts, of the extent to which a question truly measures the concept it was supposed to measure. The instrument developed in this study demonstrates the content validity as the selection of measurement items was based on both, an exhaustive review of the literature and detailed evaluations by ten academicians and five manufacturers during pre-testing. The questionnaire was finalized after some small modifications. The feedback obtained during a pilot study helped to ensure that the items were representative of the construct. Therefore, it is argued that the measures satisfy the conditions for content validity.

To measure the validity of the instruments, construct validity with the aid of factor analysis was conducted. The construct validity of a test is calculated over a period of time on the basis of an accumulation of evidence.

To make the decision about which variables are involved in each factor, according to a rule of thumb, for a sample with capacity of 30, variables with modulus coefficient greater than 0.4 and eigenvalue greater than 1 are considered. (Hair *et al*., 1998) The eigenvalues are then revealed in a scree plot diagram. Measure of Sampling Adequacy (MSA) is a criterion used to determine the validity of factor analysis. According to (Hair *et al*., 1998), if MSA is greater than 0.50, the result

Table 5: Summary items analysis from SPSS

Scale statistics	No. of items		Mean		Variance		Std. deviation
	23		93.267		111.926		10.580
Summary item statistics	**Mean**	**Min**	**Max**	**Range**	**Max./Min.**	**Variance**	**No. of item**
Item means	4.055	3.367	4.667	1.300	1.386	0.077	23
Item variances	0.725	0.368	1.109	0.741	3.016	0.052	23
Inter-item correlations	0.270	-0.238	1.000	1.238	-4.199	0.052	23
Reliability statistics	**Cronbach's alpha**		**Cronbach's alpha based on standardized items**				**No. of items**
	0.855		0.859				23

Item-total statistic	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Cronbach's alpha if item deleted
CI1	89.233	100.254	0.775	0.879
CI2	89.633	97.275	0.666	0.880
CI3	89.167	103.868	0.453	0.886
CI4	89.900	103.266	0.394	0.888
CI5	89.600	102.800	0.422	0.887
SI1	89.300	97.803	0.692	0.879
SI2	89.200	107.338	0.287	0.890
SI3	89.267	105.306	0.328	0.889
SI4	89.267	105.237	0.314	0.890
SI5	89.233	101.289	0.653	0.881
II1	89.033	106.447	0.306	0.890
II2	89.033	104.861	0.438	0.886
II3	88.600	104.662	0.556	0.884
II4	89.067	105.030	0.436	0.886
II5	89.067	103.857	0.619	0.883
DQ1	89.433	104.323	0.302	0.891
DQ2	89.300	99.183	0.615	0.881
DQ3	88.967	103.757	0.466	0.886
DQ4	89.033	105.413	0.294	0.891
CQ1	89.233	101.289	0.653	0.881
CQ2	89.300	97.803	0.692	0.879
CQ3	88.733	104.202	0.482	0.885
CQ4	89.267	101.857	0.440	0.887

for factor analysis is valid. There are 3 independent and 2 dependent variables in this research. According to the factor analysis results, the items have high validity in constructing the variables. The details of factor analysis for each variable are presented as follows.

Customer integration: The first factor analysis is related to customer integration. The statistic value of KMO for this analysis is 0.735 that is presented in Table 7 and shows that the result of factor analysis is valid. According to factor analysis, all items are provided for customer integration factor. As it is mentioned before, only questions that have variables with modulus coefficient greater than 0.4 and eigenvalue greater than 1 will be selected as the question which forms the analysis. Results from Table 6 show the eigenvalue for the first factor to be larger than the eigenvalue for the next factor (2.921 vs. 0.813). Additionally, the first factor accounts for 58.427% of the total variance. This suggests that the scale items are uni-dimensional and Fig. 2 shows the scree plot for customer integration.

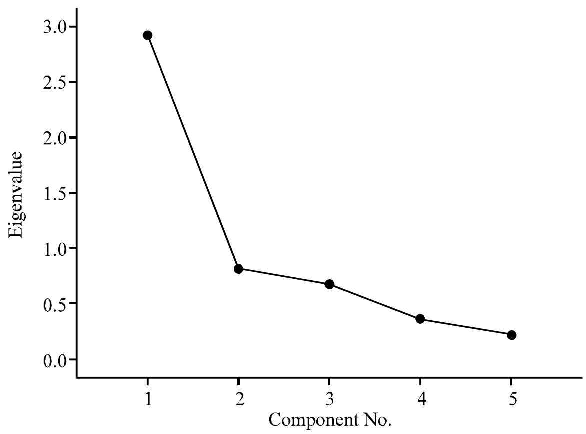

Fig. 2: Scree plot for customer integration

Table 6: Total variance explained

Variable	Components of each variable	Initial eigenvalues	Total variance (%)
Customer integration	1	2.921	58.427
	2	0.813	16.261
	3	0.677	13.547
	4	0.366	7.319
	5	0.222	4.446
Supplier integration	1	3.038	60.751
	2	0.816	16.312
	3	0.734	14.677
	4	0.331	6.619
	5	0.082	1.641
Internal integration	1	2.840	56.793
	2	0.787	15.736
	3	0.671	13.425
	4	0.412	8.248
	5	0.290	5.797
Design quality	1	2.407	60.177
	2	0.907	22.664
	3	0.434	10.848
	4	0.252	6.311
Conformance quality	1	2.378	59.446
	2	0.734	18.345
	3	0.582	14.547
	4	0.307	7.663

Extraction method: Principal component analysis

Supplier integration: The second factor analysis is about supplier integration. The statistic value of KMO for this analysis is 0.682 as presented in Table 7 proving that the result of factor analysis is valid. According to factor analysis, all items are provided for the supplier integration factor. Results from Table 6 illustrate that the eigenvalue for the first factor is larger than the eigenvalue for the next factor (3.038 vs. 0.816). Additionally, the first factor accounts for 60.751% of the total variance. This suggests that the scale items are uni-dimensional and Fig. 3 shows the scree plot for supplier integration.

Internal integration: The third factor analysis is related to internal integration. The statistic value of KMO for this analysis is 0.770 as shown in Table 7 proving that the result of factor analysis is valid. Hence, all items are provided for the internal integration factor. Results from Table 6 demonstrate that the eigenvalue for the first factor is larger than the eigenvalue for the next factor (2.840 vs. 0.787). In addition, the first factor accounts for 56.793% of the total variance. This suggests that the scale items are uni-dimensional and Fig. 4 shows the Scree plot for internal integration.

Design quality: The fourth factor analysis is related to design quality. The statistic value of KMO for this analysis is 0.655 as presented in Table 7 which shows that the result of factor analysis is valid. Therefore all items are provided for design quality factor. Results from Table 6 show the eigenvalue for the first factor is larger than the eigenvalue for the next factor (2.407 vs. 0.907). Moreover,

Table 7: KMO and Bartlett's test of the variables

Kaiser-Meyer-Olkin measure	Bartlett's test of sphericity	Determinant approx.	χ^2	df	Sig.
Customer integration	0.735	53.888	10	0.000	0.131
Supplier integration	0.682	79.723	10	0.000	0.049
Internal integration	0.770	45.548	10	0.000	0.179
Design quality	0.655	38.404	6	0.000	0.239
Conformance quality	0.715	31.324	6	0.000	0.311

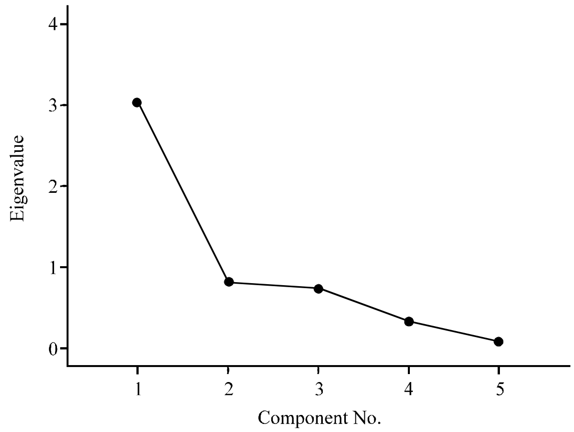

Fig. 3: Scree plot for supplier integration

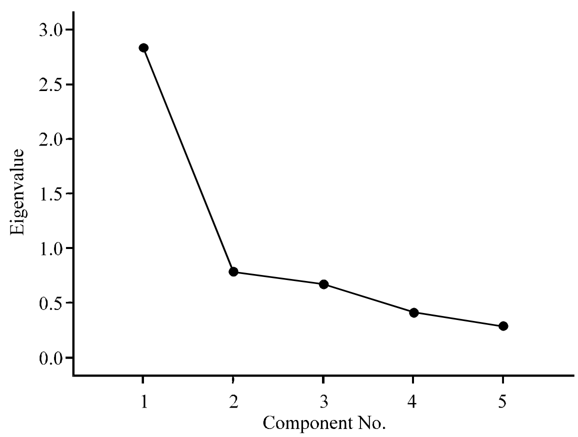

Fig. 4: Scree plot for internal integration

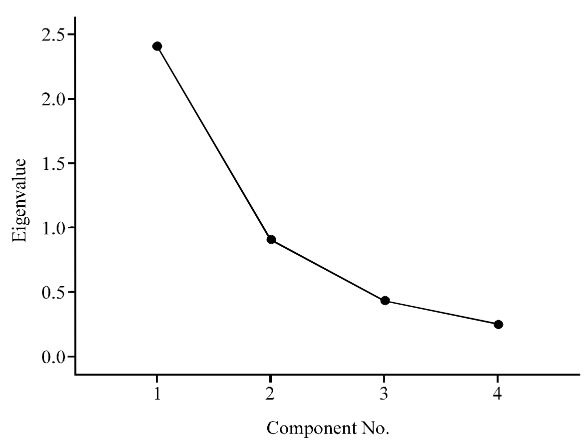

Fig. 5: Scree plot for design quality

the first factor accounts for 60.177% of the total variance. This suggests that the scale items are uni-dimensional and Fig. 5 shows the scree plot for this variable.

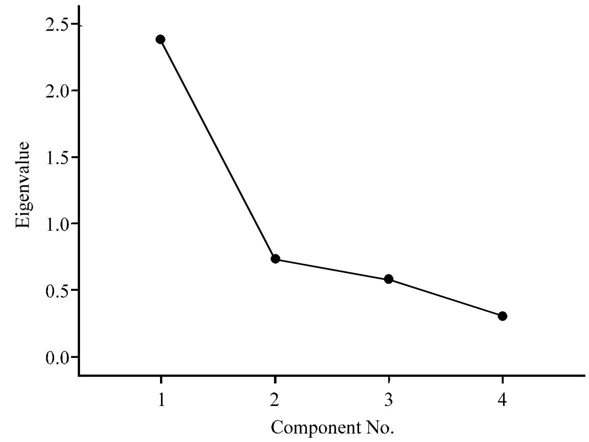

Fig. 6: Scree plot for conformance quality

Table 8: Component matrix

Component	Questions	Factor loading
Customer integration	CI2	0.829
	CI1	0.802
	CI5	0.796
	CI3	0.726
	CI4	0.657
Supplier integration	SI3	0.889
	SI4	0.886
	SI2	0.746
	SI5	0.674
	SI1	0.671
Internal integration	II3	0.863
	II5	0.824
	II4	0.716
	II2	0.694
	II1	0.650
Design quality	DQ4	0.837
	DQ1	0.809
	DQ2	0.774
	DQ3	0.673
Conformance quality	CQ2	0.886
	CQ4	0.794
	CQ3	0.712
	CQ1	0.674

Extraction method: Principal component analysis

Conformance quality: The last factor analysis is related to conformance quality. The statistic value of KMO for this analysis is 0.682 that is presented in Table 7 and shows that the result of factor analysis is valid. Hence, all items are provided for design quality factor. Results from Table 6 show the eigenvalue for the first factor to be larger than the eigenvalue for the next factor (2.378 vs. 0.734). Additionally, the first factor accounts for 59.446% of the total variance. This suggests that the scale items are uni-dimensional and Fig. 6 shows the scree plot for conformance quality.

Table 8 shows factor loading for all components ranging between 0.650 and 0.889. We found that most of the factor loading for each component is above 0.7 and all factor loading were over 0.650 and highly significant which supported the proposed framework and confirmed the structure of the constructs.

CONCLUSION

This research will supply empirical support for the argument that an understanding of quality product performance requires considering factors beyond quality practices. Focusing on the management of supply chain integration can also lead to an enhanced product quality in organizations. This study indicates product quality-supply chain integration framework in supply chains to be reliable and valid for the evaluation of the relationship between dimensions of product quality and dimensions of supply chain integration. The dimensions considered for product quality are design quality and conformance quality, whereas the dimensions for supply chain integration are customer integration, supplier integration and internal integration.

The objective of this research was to develop a valid and reliable instrument for the relationship between dimensions of product quality and dimensions of supply chain integration which were identified based on the literature review. The validity of the proposed framework was evaluated by the analysis conducted on the data gathered from the questionnaire. The analysis included, content validity, construct validity and reliability which were applied to 23 items from 5 constructs. Based on the obtained results, all 5 constructs namely, design quality, conformance quality, customer integration, supplier integration and internal integration are shown to be valid. The values of the Cronbach's alpha, correlation coefficients and composite reliability prove the reliability of product quality-supply chain integration instrument. Factor loading demonstrated that all 5 constructs are uni-dimensional. Therefore, the overall results in this pilot study indicate that the proposed framework can be confidently adopted for use in future study.

Our study has two main limitations relating to its scope and method. Firstly, we only focused on effects of supply chain integration on product quality but there are several other important dimensions of competitive capabilities which may also lead to improvements of firm performance. Secondly, our model is constructed particularly for the manufacturing sector. Further studies should include relationships between more constructs and also involve firms in other sectors besides manufacturing.

This framework can be used effectively in any manufacturing firm. In the future work, research will be extended by applying the analysis on the population via., Structural Estimation Modeling (SEM) which is a statistical technique for testing and estimating the relationship of data by factor analysis, path analysis and regression which may result in refining and expanding the framework. SEM tests the framework for its usefulness and applicability. Future work should consider more competitive dimensions also expand the framework to include other industrial sectors besides manufacturing.

APPENDIX

Questionnaire items: For three variables includes: Customer Integration, Supplier Integration and Internal Integration scales were 5-point Likert with anchors ''not at all" and "extensive". For two variables includes: Design Quality and Conformance Quality scales were 5-point Likert with anchors ''not important" and "absolutely critical".

Customer integration (CI): As studied by Wong *et al.* (2011), Narasimhan and Kim (2002) and Flynn *et al.* (2010):

CI1: Share information to major customers through information technologies
CI2: Have a high degree of joint planning and forecasting with major customers to anticipate demand visibility
CI3: Have a high level of information sharing with major customers about market information
CI4: Our customers provide information to us in the procurement and production processes
CI5: Our customers are involved in our product development processes

Supplier integration (SI): As studied by Wong *et al.* (2011), Narasimhan and Kim (2002) and Flynn *et al.* (2010) for SI1-3 and Flynn *et al.* (2010) for SI4, 5:

SI1: Share information to our major suppliers through information technologies
SI2: Have a high degree of strategic partnership with suppliers
SI3: Have a high degree of joint planning to obtain rapid response ordering process (inbound) with suppliers
SI4: Our major supplier shares available inventory with us
SI5: We share our demand forecasts with our major supplier

Internal integration (II): As studied by Wong *et al.* (2011), Narasimhan and Kim (2002) and Flynn *et al.* (2010) for SI1-4 and Flynn *et al.* (2010) for SI5:

II1: Have an integrated system across functional areas under plant control
II2: Have a high level of responsiveness within our plant to meet other department's needs
II3: Within our plant, we emphasize on information flows among purchasing, inventory management, sales and distribution departments
II4: Within our plant, we emphasize on physical flows among production, packing, warehousing and transportation departments
II5: The utilization of periodic interdepartmental meetings among internal functions

Design quality (DQ): As studied by Fleischer and Liker (1992), Fynes *et al.* (2005) and Fynes and de Burca (2005):

DQ1: Average number of engineering change orders in first year after product introduction due to production problems
DQ2: Technical performance
DQ3: Meets the criteria for ease of production or assembly
DQ4: Matches the requirements of the customer's production process

Conformance quality (CQ): As studied by Voss and Blackmon (1994), Fynes and de Burca (2005) and Fynes *et al.* (2005) for CQ1-3 and Maani *et al.* (1994) for (CQ4):

CQ1: Internal scrap and rework costs as a percent of product cost
CQ2: Internal yield on new product introduction
CQ3: Defect rate for this product at final inspection
CQ4: Return product and customer complaint during the warranty period

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