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Confirmatory Factor Analysis Of Flexibility Supply Chain For Malaysian Automotive Suppliers

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Abstract

In this globalized era, flexibility supply chain and organizational performance are increasing in the automotive industry. The objectives of this paper are to explore and perform structural analysis of Flexibility Supply Chain (FSC) construct. Data were obtained from 243 top management posts among Malaysian automotive suppliers. This paper presents the results of the Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), and reliability analysis, which are empirically verified and validated. A set of assessment measurement of FSC is expected to be suitable to improve the competitiveness and selected characteristics. The results show that two FSC constructs are acceptable for further analysis. The paper also proposes the future direction at the end of this research.

Keywords: Flexibility supply chain; lean operation; structural equation modeling; confirmatory factor analysis; automotive suppliers

Abstrak

Dalam era globalisasi ini, Rantaian Bekalan Fleksibiliti (FSC) dan prestasi organisasi semakin meningkat dalam industri automotif. Objektif kertas ini adalah untuk meneroka dan melaksanakan analisis struktur pembolehubah FSC. Kajian ini melibatkan 243 pengurusan tertinggi dalam kalangan pembekal automotif di Malaysia. Kertas kerja ini membentangkan keputusan Analisis Faktor Eksploratori (EFA), Analisis Faktor Pengesahan (CFA) dan analisis kebolehpercayaan yang disahkan secara empirik dan kesahan. Satu set pengukuran penilaian FSC dijangka sesuai untuk meningkatkan daya saing dan ciri-ciri yang dipilih. Keputusan menunjukkan bahawa dua pembolehubah FSC boleh diterima untuk analisis selanjutnya. Kertas ini juga mencadangkan hala tuju masa depan di akhir kajian ini.

Kata Kunci: Rantaian bekalan fleksibiliti; operasi lean; model persamaan berstruktur; analisis faktor pengesahan; pembekal automotif

■1.0 INTRODUCTION

The automotive industry is one of the most important industries in the Malaysian manufacturing sector. Based in the ASEAN region with a population of more than 500 million people, Malaysia provides many opportunities for the global automotive industry to establish manufacturing and operations in the country. Malaysia has built a real image of the national car manufacturer within the global automotive industry over the last two decades (Talib et al., 2012; Zadry, 2005). The automotive industry is designated to increase the industrialization process and enable the country to achieve the developed nation status by 2020. Based on the National Automotive Policy (NAP) in 2006 and 2009, the Malaysian government announced the policy for the development of the national automotive industry of OEMs, suppliers and related industries in the early 1980s (Wad & Govindaraju, 2011; Malaysian-German Chamber of Commerce and Industry (MGCC), 2012).

In Malaysia, a strategy for gaining and keeping a competitive advantage in a dynamic environment is by creating a flexible organization. Flexibility is the organizatio's ability to meet an increasing variety of customer expectations without excessive costs, time, organizational disruptions, or performance losses (Grigore, 2011). In achieving company objectives, flexibility should be viewed from a value chain perspective (satisfying customer needs) rather than from an equipment or process perspective (Yu & Jing, 2004). Therefore, flexibility supply chain management is broadly defined as including product development, manufacturing, logistics, and spanning flexibilities.

With these issues in mind, this paper aims to assess the implementation of FSCM in increasing innovation performance. Additionally, this paper looks at the methods of implementation of FSCM in automotive suppliers.

2.0 LITERATURE REVIEW

Overview Malaysian Automotive Industry

Before the 1960's, cars imported into Malaysia were in the form of Completely Build up Unit (CBU). In May 1964, the Malaysian government formulated a policy to promote an integrated automobile industry to strengthen Malaysia's industrial base (Hazel, 2006). The objectives of the policy were to reduce imports, save foreign exchange, create jobs, develop strong relationships in the future and in the past with other economy, industrial and technology transfer. Following this, the government launched Heavy Industries Corporation of Malaysia Berhad (HICOM) in 1980.

The launch of National Car Project (NCP), Perusahaan Otomobil Nasional (PROTON), in May 1983, has transformed Malaysia from a car assembling country to a car manufacturing country (Hashim, 2008). The purpose of the joint venture with Mitsubishi Motors Corporation of Japan was to understand and learn from the Japanese technology in gearing up for future challenges. Meanwhile, in 1996, Modenas, the national motorcycle project was launched and this was followed by the Malaysian Truck and Bus project.

Perusahaan Otomobil Kedua (PERODUA) was established in 1993 with technical cooperation from Daihatsu, a subsidiary of Toyota Corporation (Rosli, 2006). Both PROTON and PERODUA dominated the local automotive industry to bring Malaysia into the current rapid growth in the 1990s. The national car project contributed to the development of the local automotive industry with the presence of 350 component manufacturers, and suppliers comprising of 234 Proton vendors and 135 Perodua vendors (Amrina & Yusof, 2009).

The ASEAN Free Trade Area (AFTA) was established in January 1992. It was initially made up of six countries, and has increased to ten by 1999 (Habidin, 2012). The aim of AFTA was to increase ASEAN's competitive edge and provide a complete production center for the global market. However, with the full implementation of AFTA, competition became increasingly fierce amongst the national carmaker. The main instrument or mechanism in the realization of AFTA was the Common Effective Preferential agreements Tariffs (CEPT) (Urata, 2002). Starting from January 1993, under the CEPT, Malaysia has to fully comply with minimum tariffs, 0-5 percent over 10 years of period. With this, the Malaysian automotive industry will no longer be protected once the barrier is lifted (Ching, 2008).

Tariffs are the main tools used to regulate imports of goods. It is one of the government policies to protect the local automotive industry. It has also reduced the balance of payment deficit because high tariffs reduce domestic demand for imported vehicles (Habidin, 2012). As a result, foreign exchange expenditure can be reduced. In addition, tariff rates have increased government revenue from the tariff payments. Malaysia has long depended on high tariffs, import quotas and licensing system of motor vehicle parts imports to protect the car manufacturing industry to continuously defend the automotive protection policies (Habidin, 2012). The automotive industry has thus been so far able to meet government requirements in the efforts of industrialization to improve the economy.

Flexibility Supply Chain (FSC)

FSC is used to represent the abilities in a firm’s internal supply chain functions such as those in development, purchasing, manufacturing, and distribution (Swafford et al., 2008). The key for flexibility is the understanding that the marketing resources are amenable to change and can accommodate multiple configurations. They also determined that FSC represents operational abilities within the supply chain functions and suggest that increasing the flexibility is possible by building an effective coordination platform with suppliers. A key element of flexibility is the understanding that marketing resources are amenable to change and can accommodate multiple configurations.

With reference to previous studies related to FSC definition, it is concluded that there are two key factors to define FSC, which are flexibility supply chain and lean supply chain. In other words, the integration between FSC c
reates effective quality initiative implementation by focusing on the business process improvement which assists to contribute to the improvement of business process performance, financial benefit, customer satisfaction and working culture towards continuous enhancement as the key for excellence improvement for business and organization.

In an increasingly competitive automotive industry, the related parties must adopt the best measures for the company to stay competitive in the face of increasing competition, changing market demands and growing needs of customers. The delivery system and the quality of goods will be affected (Ambe & Badenhorst-Weiss, 2010). Thus, the automotive manufacturers should take a flexible and responsive measure to overcome all the needs of customers.

FSC was defined as an ability of the purchasing function to respond in a timely and cost-effective manner to change the requirements of purchased components in terms of volume, mix, and delivery date (Pujara and Kant, 2013). The authors have been exploring three dimensions of flexibility namely as: delivery policy, supplier responsiveness, and adaptability. In the research, they only focus on the flexibility of the linkages that are aligned in response to customer needs. This research also focuses on two types of flexibility; offering flexibility and partnering flexibility. Furthermore, the FSC is an essential element in the success of the supply chain in an uncertain environment. It can measure the degrees of the supply chain which will react to the random fluctuations in supply and demand changes (Agus, 2011; Smith, 2012; Balasubramaniam, 2014).

In addition, flexibility may be defined as the ability to change or react with little change in time, effort, cost or performance. There are three dimensions of flexibility, namely product flexibility, volume flexibility, and launch/new product flexibility. The four types of flexibility as main factors for this research are new product flexibility, sourcing flexibility, product flexibility, delivery flexibility and information systems flexibility (Fantazy et al., 2012). The types of flexibility are listed here as they provide direct impact on the competitive position of a firm in the market.

Lean Supply Chain (LSC)

The Lean concept is a comprehensive approach for continuous manufacturing improvement based on the notion of eliminating waste in the manufacturing process (Habidin & Yusof, 2013). In the automotive industry, the lean concept is an initiative to optimize automotive manufacturing (Womack et al., 1990). Furthermore, the implementation of the lean concept aims to gain long term strategic profit as shown by the success of Toyota with the evidence of a rapid increase in automotive industry (Smart et al., 2003). The success of Toyota has attracted the attention of automotive companies to apply the lean system as practised by the Company. Taiichi Ohno developed the lean strategy in 1950s at the Toyota Motor Company (Ohno, 1998).

One of the main principles in implementing the lean initiative is to eliminate any waste that adds to the cost of the product and service (Ohno, 1998). Waste has been classified into seven categories which are also known as the seven deadly wastes. These include overproduction, waiting, transportation, over processing, inventory, motion and defects (Womack & Jones, 1996; Habidin et al., 2014). Apart from that, the objective of the lean practice is to ensure smooth manufacturing flow by upgrading productivity to the level of quality products, utilization of production labor, reduced delivery time and effective manufacturing cost through continuous improvement process. Consequently it helps organizations in improving the targeted performance and gaining benefit from the environment (Forrester et al., 2010; Kuei et al., 2001).

The lean concept is also based on the principles of the Toyota Production System (TPS). Among the principles are to specify value, identify the value stream, make the value-creating step flow, promote a pull culture, and pursue perfection (Womack & Jones, 1996; Ngai et al., 2004). Most importantly, the readiness towards change for continuous improvement should be maintained and strengthened. The reason is that transformation to the lean system requires a radical change which involves the overall system formation and organizational culture (Nordin et al., 2010).

Several previous researchers have strongly argued that if an organization neglects lean initiatives, in the future it will face difficulties in its capability to compete globally with an emphasis on quality products, high level of service, and fast delivery with low cost (Srinivasaraghavan & Allada, 2006). In recent years, research on the lean concept has focused on the relationship between the lean implementation with multiple performance measurement. In addition, the implementation of the lean system positively results in greater excellent organizational performance compared to other initiative systems such as flexible manufacturing system and computer-integrated manufacturing system (Anand & Kodali, 2009)

In 1980, the lean concept attracted considerable interest in the business environment while later, in 1990, lean agile manufacturing emerged as a new strategy for the company (Rahiminia et al., 2009). The term ‘lean’ means developing a value of stream to eliminate all waste including time and to enable a level schedule (Ambe, 2010). This is because the elimination of waste and ensuring value are core objectives of the lean concept (Habidin & Yusof, 2012; Singh & Acharya, 2014; Yusof et al., 2014).

The development of a set of FSCM practices includes strategic supplier partnership, customer relationship, information sharing, information quality, internal lean practices, and postponement (Yusof et al., 2014). The researchers propose that through the elimination of waste, the continued implementation of lean has the advantage of speeding up production processes, improve product quality, and customer satisfaction. They also defined FSCM as a one set of activities which has been undertaken by an organization to promote the effective management of the OP. This has been viewed from the supplier side and the customer side. Lean practices are to ensure smooth manufacturing flow by upgrading productivity to the level of quality products, the utilization of production labor, reduced delivery time, and at the same time, its impact to the effective manufacturing cost through continuous improvement process (Li et al., 2005; Jaya et al., 2012; Habidin et al., 2012).

LSC is a strategy based on cost and time reduction to improve the efficiency (Habidin et al., 2014; Duarte et al., 2011). It is focused on optimizing the supply chain in all process, looking for simplification, reducing waste and reducing the activities that do not add value. Adopters of lean strategy will implement practices such as mass production, just-in-time, and long-term supplier relationships to eliminate waste and automatically achieve a lower cost.

Lean manufacturing as a program is aimed mainly at increasing the efficiency of operations (Qi et al., 2011). Qi et al’s study focused on the two initiatives (lean and agile manufacturing) which were used by manufacturing plant managers to improve the operational capabilities. The purposes of their research were to investigate the internal and external factors which drove the choice of lean and agile operations capabilities and their respective impact on operational performance. They had proved that the implementation of lean manufacturing had an impact towards raising the cost performance.

■3.0 METHODOLOGY

In this study, one of the objectives is to investigate the instrument of FSC. The survey methodology which will be explained later consists of aspects of data collection, reliability, and validity.

Data Collection

In this study, the mail survey method was utilized to collect data because it is a relatively simple way to collect quantitative data. The questionnaires were mailed to 243 top management posts. The large (9’’ x 12’’) mailing envelopes included a cover letter and instrument survey stapled together, as well as a stamped return envelope.

Reliability

Reliability is the extent to which a measurement of a single variable or sets of variable are consistent with what they are intended to measure (Hair et al., 1998). Reliability is undertaken to ensure the quality of instrument. Therefore, the test on reliability of measurement is very important as a prerequisite to build validity (Schwab, 1980) to determine the stability and consistency (Sekaran, 2003), and allow a high degree of correlation among items which comprise the measure.

Reliability test is the most frequently used in empirical studies for assessing the internal consistency and it is verified by using Cronbach’s Alpa Coefficient (Cronbach, 1951). In this study, Cronbach’s Alpha was used to assess the reliability for each construct to measure the internal consistency and indicate how different items can reliably measure the construct. This alpha value range from 0 to 1 indicates higher levels of internal consistency.

Validity

Another aspect of ascertaining the soundness of the instrument is validity testing. Not only the measuring instrument should be reliable, it must also be valid. Validity refers to the extent to which the level of instrument should be measured (Sekaran, 2003).

To meet the requirement of specifying the measurement model and identifying the indicator measuring each construct, factor analysis was conducted. First, the exploratory factor analysis (EFA) was used to identify tentative items, as well as to suggest items for deletion and places where the item should be added. Conducting EFA on a single summated scale will indicate whether all items within the summated scale load on the same construct or whether the summated scale actually measures more than one construct. At this stage, convergent validity was tested in which for each construct, an item loading higher than 0.4 would be accepted (Hatcher, 1994; Shepherd & Helms, 1995).

Secondly, factor analysis was utilised in the confirmation on developed factors or constructs. In this study, the confirmatory factor analysis (CFA) was conducted based on multiple factor first order confirmatory. CFA is the most comprehensive method to test and examine the extent to which the data set fits the measurement structure. The next stage in the analysis was to test the measurement model, in which the FSC constructs and LSC constructs were tested based on multiple factor (first order confirmatory).

Statistical Analysis

In this study, the survey instrument was analyzed using two statistical software packages. The Statistical Package for Social Sciences (SPSS) for Windows Version 17.0 was used to perform the required statistical analysis of the data from surveys. The Structural Equation Modeling (SEM) AMOS Version 20.0 was also used in the analysis.

AMOS Version 20.0 had been selected to perform the SEM analysis. AMOS uses the basic overall goodness-of-fit measure to assess the compatibility of the proposed model with the observable data. The general model of goodness-of-fit is assessed using the following six criteria: Chi-square over degrees of freedom (X2/df), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Comparative Fit Indexes (CFI), Tucker Lewis Index (TLI), and Root Mean Square Error Approximation (RMSEA).

SEM is derived from multivariate techniques, with the objectives of expanding the researcher's explanatory ability and statistical efficiency. The next step in the analysis involved factors analysis. Exploratory Factor Analysis (EFA) with varimax rotation was performed on FSCM constructs. This section explains the results of Explanatory Factor Analysis (EFA). The EFA applied as the primary component analysis was used for the extraction method (Tinsley & Tinsley, 1987).

At a minimum, a 0.4 loading of each item on its respective factor was considered adequate for that factor. The first factor consisted of four items from FSC construct which are FSC1, FSC2, FSC3, and FSC4. No item was recommended to be omitted. The second factor can be classified as LSC and consisted of five items (LSC1, LSC2, LSC4, LSC5). One item was recommended to be excluded from the analysis is LSC3. Finally, the EFA of 9 items of FSC construct yielded two factors which explained 80.11% of the total variance, as shown in Table 1. This indicated that the influence of two latent FSCM variables were associated.

A basic model measurement test was utilised as a base for the full structural model fit (Handley & Benton, 2009). If the measurement model is acceptable, then one can proceed for structural model testing. Authentication measurement model was conducted to evaluate the value of construct validity by using the maximum probability method. Confirmation factor analysis techniques (CFA) were based on comparison of variance-covariance matrix obtained from samples which were derived from the model.

The Cronbach's alpha measurement of reliability of the FSC construct was between 0.892 and 0.944. As the Cronbach's alpha value for each factor was above 0.70 (Nunally, 1978), all factors were accepted as being reliable for the study. Table 1 shows the result of EFA and reliability analysis for FSC measures.

Table 1 EFA and reliability analysis for FSC constructs

Factors	Number of items	First Eigen value	Percentage of variance explained	Alpha (α) values
		1.269	80.105	
FSC	4			0.892
LSC	5			0.944

4.0 RESULTS AND DISCUSSION

Confirmatory Factor Analysis (CFA)

The next analysis involved testing the measurement model, where FSCM constructs on multiple factor.

CFA for FSCM constructs- multiple factors

In this stage, the FSC Model with two factors manifested an adequate fit outcome as shown in Table 2 and Figure 1.

Table 2 CFA: multiple factor for FSC

Fct	χ2/df	p-v	GFI	AGFI	CFI	TLI	RMSEA
FSCM	2.49	. 001	0.94	0.90	0.98	0.97	0.078

Note: Fct=Factor, Pv=P-value

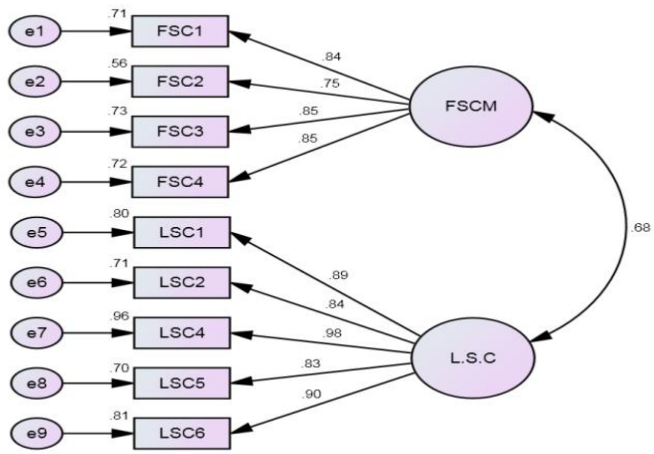

Figure 1 The output path diagram for FSC model

The χ2 statistics were 64.741 (degree of freedom = 26, $p < 0.001$), with the ratio of χ2/df value being 2.490 less than 3.0. The Goodness Fit Index (GFI) was 0.946 and Adjusted Goodness of Fit (AGFI) was 0.906 which was moderate fit. The comparative fit index (CFI) was 0.980, Tucker Lewis coefficient (TLI) was 0.973. Values higher than 0.8 indicate a marginal fit (Hu & Bentler, 1999) whereas values higher than 0.9 represent a good fit (James et al., 1982; Lin et al., 2005). The value of (RMSEA) was 0.078, which is less than 0.08, thus indicating a good fit. Values lower than 0.8 indicate a good fit, and values higher than 0.8 represent reasonable errors of approximation in the population (Hu & Bentler, 1998). Hence, the test outcome suggests that these two constructs can be used for the FSC implementation. All canonical correlation (rc) values were less than 1.0 at 0.68, signalling that the discriminant validity was tested and acceptable.

Based on the results of EFA, reliability, and CFA, the findings were acceptable which is EFA have 9 items of FSC construct yielded two factors which explained 80.11% of the total variance and the Cronbach's alpha measurement of reliability of the FSC construct was between 0.892 and 0.944. For CFA, all the goodness of fit indices were acceptable. Therefore, these two constructs as applicable for measuring the FSC implementation for Malaysian automotive suppliers.

■5.0 CONCLUSION

A significant conclusion could be derived from the findings in the previous section: FSC implementation brings major changes to the organization either in terms management, administration, and operation. It has become an important practice in the aspect of maintenance to enhance the organization capability and ability in operation and management. Data for the study were collected from a sample of 243 Malaysian automotive suppliers and the research model was tested using Structural Equation Model (SEM). Based on EFA, CFA, and reliability, the result of the two factors showed that the measurement model for FSCM constructs had a good fit and the model could be considered valid and reliable for Malaysian automotive suppliers. In future, the authors are interested to study the structural relationship between FSC and information sharing and organizational performance among Malaysian automotive suppliers.

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Appendix

Flexibility Supply Chain

FSC1 Extent to which your company is able to change production volume capacity.
FSC2 Extent to which your company is able to reduce manufacturing throughput times to satisfy customer delivery.
FSC3 Extent to which your company is able to assess the ability to rapidly phase out old products and introduce new ones.
FSC4 Extent to which your company is able to assess the ability to rapidly respond to change in demanded product volumes.

Lean Supply Chain

LSC1 Extent to which our supply chain supplies predictable products
LSC2 Extent to which our supply chain reduces any kind of waste as much as possible.
LSC3 Extent to which we give our suppliers feedback on quality and delivery performance.
LSC4 Extent to which we take active steps to reduce the number of suppliers in each category.
LSC5 Extent to which we include our key suppliers in our planning and goal-setting activities.
LSC6 Extent to which we have continuous improvement programs that include our key suppliers.

Note
1. Drop Item (exploratory factor analysis)