Supply chain agility information systems with key factors for fashion industry competitiveness

Mustafid*

Faculty of Science and Mathematics,
Diponegoro University,
Semarang, Indonesia
Email: mustafid55@undip.ac.id
*Corresponding author

Sarrah Ade Karimariza

Study Program of Information Systems,
School of Post Graduate Studies,
Diponegoro University,
Semarang, Indonesia
Email: karimariza@gmail.com

Ferry Jie

School of Business and Law,
Edith Cowan University,
Western, Australia
Email: f.jie@ecu.edu.au

Abstract: The fashion industry has attained fast growth in the world with competitive market under conditions of uncertainty as a result of innovations in information technology and the fast changing needs of consumers. This paper develops supply chain agility information systems for fashion industry to support achievement of supply chain performance. The systems is designed theoretically and based on case study of a specific fashion industry. The finding proposes the framework of supply chain agility information systems for fashion industry within the framework of integrated information systems involving the influence of agile characteristics on each chain to improve supply chain performance. The supply chain performance comprised of three dimensions and 13 factors of the three dimensions which obtained from experts of fashion industry. The analysis using fuzzy DEMATEL ANP confirm the dimension of makes market sensitiveness and factors of customer satisfaction are key factors for fashion industry competitiveness.

Keywords: supply chain; supply chain agility; SCA; information systems; integrated information systems; supply chain performance; agile characteristics; fashion industry; market sensitiveness; materials flow; transaction flow; fashion industry competitiveness; fuzzy-DEMATEL-ANP.

Reference to this paper should be made as follows: Mustafid, Karimariza, S.A. and Jie, F. (2018) 'Supply chain agility information systems with key factors for fashion industry competitiveness', *Int. J. Agile Systems and Management*, Vol. 11, No. 1, pp.1–22.

Biographical notes: Mustafid received his Bachelor's in Mathematics from Diponegoro University, Indonesia in 1982. He received his Master and PhD in Information Engineering from Hiroshima University, Japan in 1987 and 1990, respectively. He is a Professor of Statistics and Information Systems at the Faculty of Science and Mathematics, Diponegoro University, Indonesia. He had been the Dean at the Faculty of Mathematics and Natural Science, Diponegoro University. In 2007, he founded the Master Program of Information Systems Diponegoro University, and he was the first head of program. His research focuses on subjects linked to Six Sigma, business intelligence, supply chain agility, supply chain information systems. He has published a number of specialist articles in international journals. He participated in several research projects that have been financed from national and international research programs.

Sarrah Ade Karimariza received her Bachelor's in Mathematics from Indonesia University in Electrical Engineering in 2012. She received her Master in Information Systems from the Diponegoro University, Indonesia in 2016. Her research interests include information systems, control, supply chain agility, the role of information systems in business. She had been teaching at Sains Al Quran University. Currently, she is researching an implementation of information systems and intelligent system on supply chain agility for the fashion industry.

Ferry Jie is an Associate Professor at School of Business and Law, Edith Cowan University. He has maintained a high quality of research throughout his academic career including international scholarly leadership in the areas of supply chain management and logistics, including being invited to be keynote speaker and to give public lectures at symposiums and international conferences in Indonesia, Malaysia, Vietnam, China and Australia. From 2011 to 2016, he has published 17 refereed journal articles (including six articles in *A Ranked Journal – ABDC Journal Lists*) and 15 refereed conference papers. Furthermore, he has received research grants/awards to the amount of $204,604.07 between 2010 and 2016. He has professional and community engagement activities to contribute significantly to improve the university's reputation through contribution to the wider community.

1 Introduction

The business of fashion industries today becoming increasingly complex and dynamic due to demands of fashion and business competition. Competition in this sector to be very strong, especially on the retail side. Clothing sector is a major component in the textile and fashion industry. Fashion industry as an across sectors concept that directly impact to industry relate with clothing, and can be developed to industries outside sector, such as leather goods, shoes, accessories and jewellery (Brun and Castelli, 2008). There are three important components in the business of fashion industry, namely products, brands and retail channels (Brun and Castelli, 2008). Some analysis methods are used to investigate role of supply chain agility (SCA) in managing the modern fashion industry that have high competitiveness in complex global environment (Masson et al., 2007; Kim, 2013; Lemieux et al., 2012).

The life cycle for fashion products to consumer demand increasingly shorter time, uncertainty and unpredictability (Agarwal et al., 2007). Ciarniene and Vienazindiene

(2014a) proposed that fashion industry can be characterised in terms of volatility, velocity, variety, complexity and dynamism. Hilletofth and Hilmola (2008) emphasised that the demand for textiles and fashion very quickly and can change quickly are hard to predict for the management and make it difficult for planning in the supply chain. While Christopher et al. (2004) described that markets of fashion are synonymous with rapid change and as result with success or failure is largely determined by flexibility and responsiveness. Therefore, the fashion industry must be able to anticipate that the production and distribution process not lead to a high risk in supply chain management.

Supply chain in the fashion industry is full of uncertainty and unpredictability (Lo et al., 2008). The characteristics of fashion retail are very complex with the short product life. Changes in demand or the needs of consumers can occur in any month or weekly. In order for the industry can survive in changing environment quickly with short product life, the industry must have methods to predict number of production based on consumer demand by observing the characteristics of agility. Ni and Fan (2011) proposed two-stage sales forecasting model, namely short (weekly, daily) and long (quarterly, monthly) term sales forecasting.

SCA helps industries to integrate the business by working with other stage partners to meet the growing demand from consumers. SCA can be used to cope with uncertainty and to meet consumer demand. In this era of business competition with a very tight time, the supply chain management must have the competency to meet the demands of consumers with shorter delivery time, and also can align supply in peak condition or lack of demand. The characteristics of agility for fashion supply chain have capabilities responsive to market needs that require high degree of speed and manoeuvres. SCA has the ability to quickly respond changing market and customer demands. Ciarniene and Vienazindiene (2014b) suggest that agility is a business wide capability that embraces organisational structures, information systems and logistics, and propose the SCA as business strategy that enable fashion industry to create, manufacture and deliver on the basis of real-time demand.

The impact of development of information technology or information systems very quickly, business performance improvement today has shifted to enterprise supply chain performance based on information. The role of information systems for SCA can help the management of the industry to respond more quickly. Many industries are faced with a very tight and competitive under conditions of uncertainty as a result of innovations in information technology and the changing needs of consumers. Qrunfleh and Tarafdar (2014) emphasised that information systems strategy enhances the relationship between SCA and supply chain performance. Information systems play an important role in supply chain management as tools to achieve supply chain integration and agility (Gunasekaran and Ngai, 2004). DeGroote and Marx (2013) shows that information technology can enhance role of SCA to respond to market changes by reducing costs, and improving the quality and timeliness to make the planning of production and distribution are coordinated throughout the supply chain management. Industries which have agile characteristics can monitor changes in the market and the direction of consumer desires. Supply chain performance should be also evaluated in accordance with market changes in consumer behaviour. Mavengere (2013a) developed conceptual model of supply chain strategic agility in order to define the precise role of information systems to enhance strategic agility.

Moniruzzaman et al. (2015) proposed that in the business intelligence perspective, business intelligence can help organisations to achieve supply chain performance by supporting the key areas of supply chain management, namely plan, source, make, deliver, and return. Management can apply business intelligence effectively to support supply chain management and improve SCA. The main competence for facing market changes is expressed by the characteristics of agility. The role of information systems in the SCA is to contribute for industries to identify the properties of the changes in the market and response to changes in timely and real time. Furthermore, Krotov et al. (2015) presented that mobile technology is a good candidate for enhancing SCA for achieving competitive advantage.

In order the industries can successful in competitive business environment extremely tight, industries need to improve supply chain performance. The consistent and continuing of performance measurement at each stage in the supply chain makes a key role in the success of the industry to gain target business goals with better profitability. To meet the growing market demands very quickly, integrated supply chain information systems (SCIS) with agile characteristics can be used to manage fashion industry in improving competitive business performance. Development and implementation SCIS with the characteristics of agility are expected to be a solution to the problems and challenges aligned with the growing market demands very quickly.

This paper aims to develop SCA information systems (SCAIS) for fashion industry to support achievement of supply chain performance. Key factors of supply chain performance are determined based on the factors determined from agile characteristics which high affects to SCA. Fuzzy DEMATEL (Decision-Making Trial and Evaluation Laboratory) ANP methods are used to identify the main critical factors as key factor for fashion industry competitiveness. The contribution of this research will help management can make business plan based on needs and demands of market and customers are changing dynamically.

2 Research methodology

This research is theoretical research and case study of the specific fashion industry. The theoretical approach in this research using scientific approach involves interdisciplinary research. Design of SCAIS for fashion industry using the framework of SCA model to support achievement of supply chain performance. Model of SCA designed by agile methodology for improve the supply chain performance focuses on three dimensions comprised market sensitive, process integration and information driver obtained from experts of fashion industry. Process standards for the development of SCAIS using the systems development life cycle (SDLC) methodology with five phases, namely planning, analysis, design, implementation and maintenance.

We apply SCAIS using case study on the fashion industry. The case study chose the specific fashion industry in Indonesia that makes market sensitiveness as the main characteristics of agility in improving supply chain performance. The basic concept of agile characteristics for the SCAIS supply chain performance are determined in accordance with the development strategy of the fashion industry at each stage in the supply chain obtained from experts of modern industry fashion. The SCAIS supply chain performance comprised of three dimensions and 13 factors of the three dimensions. The 16 variables are the agile characteristics affecting the SCA. The analysis using fuzzy

DEMATEL ANP is used to identify main factors or critical factors as the key factors for agile characteristics on the fashion industry. The influence degree of agile characteristics to SCA is a basis for determination of key performance factors that have a high influence.

The data gathering for agile characteristics and strategies for industry fashion obtained using questionnaires and interviews with the Top Managers as Experts of the Fashion Industry on May 2016. Data gathering of agile characteristics are expressed in the form of influence (linguistic scale). The linguistic scale data includes five categories, namely 'no influence', 'very low influence', 'low influence', 'high influence', 'very high influence' as given in Table 1 (Sangari et al., 2015). Using the fuzzy logic methods, linguistic scale data expressed in the form of triplet x = (l, m, r), $1 \leq m \leq r$. The membership function of the fuzzy logic is in the range of 1 to 5 are normalised so that the value range of 0 to 1.

Table 1 Linguistic scales used in assessment

The influences between the factors	*Triangular fuzzy number*
No influence	(0, 0, 0.25)
Very low influence	(0, 0.25, 0.5)
Low influence	(0.25, 0.5, 0.75)
High influence	(0.5, 0.75, 1)
Very high influence	(0.75, 1, 1)

The following we apply defuzzification methods for converting fuzzy data into crisp score (Sangari et al., 2015; Tseng, 2011). From the number of evaluators *k*, fuzzy data is expressed as $\tilde{X} = (a_{1ij}^k, a_{2ij}^k, a_{3ij}^k)$ which represents the effect of the i^{th} factor on the j^{th} factor. Define normalisation by the equation:

$$\begin{aligned} xa_{1ij}^k &= \left(a_{1ij}^k - \min a_{1ij}^k\right) \Big/ \Delta_{\min}^{\max} \\ xa_{2ij}^k &= \left(a_{2ij}^k - \min a_{1ij}^k\right) \Big/ \Delta_{\min}^{\max} \\ xa_{3ij}^k &= \left(a_{3ij}^k - \min a_{1ij}^k\right) \Big/ \Delta_{\min}^{\max} \end{aligned} \tag{1}$$

where

$$\Delta_{\min}^{\max} = \max a_{3ij}^k - \min a_{1ij}^k,$$

and

$$\begin{aligned} xls_{ij}^k &= xa_{2ij}^k \Big/ \left(1 + xa_{2ij}^k - xa_{1ij}^k\right), \\ xrs_{ij}^k &= xa_{3ij}^k \Big/ \left(1 + xa_{3ij}^k - xa_{2ij}^k\right). \end{aligned} \tag{2}$$

With total value of normalised crisp:

$$z_{ij}^k = \left[xis_{ij}^k \left(1 - xls_{ij}^k\right) + xrs_{ij}^k xrs_{ij}^k \right] \Big/ \left[1 - xls_{ij}^k + xrs_{ij}^k\right], \tag{3}$$

defined crisp score by equation:

$$x_{ij}^k = \min a_{1ij}^k + z_{ij}^k \Delta_{\min}^{\max} \tag{4}$$

Fuzzy-DEMATEL method can be used to confirm the inner dependence among the factors. The role of fuzzy-DEMATEL method is can be to divide dimensions/factors into groups of factors that have indirect relations within cause and effect models (Sangari et al., 2015; Tseng, 2011). The following steps are used to obtain the solution. First, determine initial direct-influence matrix from data gathering $\boldsymbol{A}[a_{ij}]_{n\times n}$, where a_{ij} represents the influence factor i to factor j. From matrix $\boldsymbol{A}$, determine normalised direct-influence matrix:

$$\boldsymbol{D} = \left[d_{ij}\right]_{n\times n},\ 0 \le d \le 1$$

with matrix:

$$l = \min\left(\frac{1}{\max\limits_{i}\sum_{j=1}^{n} a_{ij}}, \frac{1}{\max\limits_{j}\sum_{i=1}^{n} a_{ij}}\right), \quad i, j \in \{1, 2, \ldots, n\} \tag{5}$$

Furthermore, determine total-influence matrix $\boldsymbol{T} = [t_{ij}]_{n\times n}$

$$\boldsymbol{T} = \boldsymbol{D}(\boldsymbol{I} - \boldsymbol{D})^{-1} \tag{6}$$

where $\boldsymbol{I}$ is identity matrix size of $n \times n$. From matrix $\boldsymbol{A}$, determine the sum of rows $\boldsymbol{R}$ and the sum of columns $\boldsymbol{C}$:

$$\boldsymbol{R} = \left[r_i\right]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} \tag{7}$$

$$\boldsymbol{C} = \left[c_j\right]_{n\times 1} = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} \tag{8}$$

Matrix $\boldsymbol{T}$ is total-influence matrix which can be used to investigate the inner dependence from DEMATEL results involves indirect relation within a cause and effect from overall variables agility. ($\boldsymbol{R} + \boldsymbol{C}$) shows the total influence given by factor to SCA and ($\boldsymbol{R} - \boldsymbol{C}$) shows these factors are influenced or influencing on the SCA. For index $j = i$, shows ($r_i + c_i$) the total influence is given and accepted by a factor to i^{th} while ($r_i - c_i$) shows the factors that influenced or influencing. If ($r_i - c_i$) for factor i^{th} is positive, shows the factors to i^{th} influencing other factors. Conversely, if it is negative, indicating factor to i^{th} influenced by other factors.

Combination fuzzy DEMATEL with analytic hierarchy process (ANP) is used to determine the ranking of the influence of all the factors (Sangari et al., 2015; Tseng, 2011). To determine the ranking of all the factors, first determine total-influence matrix $\boldsymbol{T} = [t_{ij}]_{n\times n}$ as in equation (6). Then determine matrix $\boldsymbol{T}_d^a$ using normalisation matrix $\boldsymbol{T}$, determine unweighted super matrix $\boldsymbol{W} = [w_{ij}]_{n\times n}$ with transposing $\boldsymbol{T}_d^a$. Furthermore, from weighted super matrix $\boldsymbol{W}^a = \boldsymbol{T}_d^a\boldsymbol{W}$, determine global weight:

$$w_i = \lim_{g\to\infty}(\boldsymbol{W}^a)^g \tag{9}$$

Total priority index (TPI) for the ranking of the influence of factor to SCA represented by the equation:

$$TPI_i = \frac{w_i \left(\max_i s_i - s_i \right)}{\max_i s_i - \min_i s_i} \tag{10}$$

where s_i is a current crisp score.

3 The characteristics of SCIS

In this section, presents the strategic role and characteristics of integration of supply chain in the information systems which called the SCIS based on literature reviews. SCIS designed in this paper have strategic role to improve the supply chain performance which is determined by agile characteristics. SCIS as a toll is used to help management of industry in managing and optimising enterprise resources in accordance with the resource of the industry to respond consumer and market demands. The SCIS is used to manage the overall information input from all of each stage within integrated database (Aarabi and Shariatmadari, 2012). The SCIS have a role to analyse information from the consumers needed to improve supply chain performance as a basic for managing all resources in accordance with all stage on the supply chain from supplier to consumer. The integration of information and material flows among supply chain partners have effect on supply chain performance. The characteristic of supply chain performance comprises four key competitive dimensions in processes, namely quality, delivery, flexibility, and cost (Prajogo and Olhager, 2012).

The implementation of SCIS for improving supply chain performance must meet the requirements in order to improve the consistency of quality of products and reduce cost of product in order to improve the efficiency and productivity. SCIS for the fashion industry can be defined as information systems that automate the flow of information between industry and its each chain on the supply chain to optimise the planning, sourcing, manufacturing and delivery of products. The SCIS with agile characteristics has a role to make the right product and at the right time to customers and make to survive in the rapidly changing market.

Mavengere (2013b) presents that industries can use the advances in information technology/information systems to enhance the three-dimensional strategic agility, namely strategic sensitivity, response and collective capabilities. Tseng et al. (2011) shows that the applications of advanced information technology/information systems in supply chain management is the cause criteria leading to marketing performance and customer satisfaction as the high supply chain performance. Schaltegger and Burritt (2014) present a practical approach to sustainability supply chain performance measurement and management. Mandal and Bagchi (2016) emphasised that knowledge management and information technology has important influence to supply chain performance.

An enhancement of highly supply chains performance in the fashion industry not only applies new technologies but also emphasise sustainable improvement strategies (Li et al., 2014). Supply chain sustainability has an important role for supply chain performance in the fashion industry in order to increase consumer awareness for the environment. Shen (2014) emphasise that many fashion industries realise the importance of sustainability in business practices in supply chains. Khurana and Ricchetti (2016) have identified fashion brand perspective on sustainable supply chain management.

Maruster et al. (2008) proposed the concept of sustainability knowledge, which refers to the processes that govern knowledge, used to define sustainable information systems.

There are three strategies that can be applied to enhance the role of SCIS sustainability, namely implementation of efficiency, consistency and sufficiency (Schaltegger and Burritt, 2014). Efficiency in the context of a sustainable approach guided by the principle of creating economic value to the community and environmental impacts. Consistency approach is to replace materials for sustainable aspects. Sufficiency approach is based on the fact that any product that does not have to be produced will not cause negative impacts for the industry and the environment. Supply chain management is guided by the principles of sufficiency focused on elimination. In the implementation SCIS sustainability, three strategies can be combined with each other.

SCIS sustainability can be used to manage and measure supply chain performance sustainability. The role of sustainable supply chain performance becomes an important factor as a tool to evaluate, monitor and control the performance of the supply chain process in order to improve supply chain strategy to align with strategic business processes. The supply chain performance index can use to measure supply chain performance of any time, thus enabling the industry to get feedback continuously from internal and external, and management can take the necessary corrective action to better results in the any time. Implementation of SCIS sustainability for the industry should not be seen only from the aspect of cost of activities business, should also be considered in terms of increased productivity, reduce costs, and improve profitability.

The role of SCIS to improve the high supply chain performance of the fashion industry is also performed with flexibility philosophy. Swafford et al. (2008) indicate that the implementation of supply chain flexibility with the integrated information systems can enhance the role of the SCA with more competitive business performance. Jie et al. (2015) has developed a theoretical concept of the flexible supply chain performance to improve supply chain performance. Tuo et al. (2014) showed that the information systems flexibility and supply chain performance leads to competitive advantage. Chan et al. (2016) emphasised that two organisational flexibility factors, namely strategic flexibility and manufacturing flexibility are the critical antecedents to SCA. Whereas in the perspective of electronic fashion (e-fashion), Lo et al. (2008) presented the role of an e-fashion supply chain management systems by adopting the techniques of the semantic web and multiple agents can be to improve the supply chain performance.

4 The framework of supply chain performance

The following presents the basic framework of supply chain performance to achieve a competitive advantage in the fashion industry. Supply chain performance is comprised in four dimensions of agile characteristics covering the market sensitiveness, information driver, process integration and flexibility (Christopher, 2000). In this paper, we proposed the basic framework market sensitive (D1), process integration (D2) and information driver (D3) as supply chain performance for fashion industry. Since three dimensions of supply chain performance has systemic characteristics, so it can be integrated in one model to improve role of SCA. Every dimension in supply chain performance has factors affecting the SCA of fashion industry. Three dimensions of agile characteristics and 13 factors classified into each dimension given in Table 2.

Table 2 Agile characteristics

No.	*Dimensions*	*Factors*
1	Market sensitiveness (D1)	Delivery speed (F1)
		New product introduction (F2)
		Customer satisfaction (F3)
		Lead time reduction (F4)
2	Process integration (D2)	Centralised and collaborative planning (F5)
		Service level improvement (F6)
		Trust development (F7)
		Cost minimisation (F8)
		Quality improvement (F9)
		Minimising resistance to change (F10)
3	Information driver (D3)	Data accuracy (F11)
		Use of information technology tools (F12)
		Minimising uncertainty (F13)

Three dimensions and 13 factors used as a basis for determining key factors for the implementation of SCA to increase supply chain performance so that fashion industry more competitiveness. The fashion industry which selected as a case study confirmed that market sensitiveness is the main agile characteristics by strategy which the consumer expectations related to the dimension of market sensitiveness and is considered to be fulfilled if existing conformity between sustainability, quality and the best price.

The following describes each dimension and its factors in each dimension as given in Table 2. Market sensitiveness (D1) as the first dimensions for supply chain performance is supply chain ability to read and respond to market demand. There are three ways to read the market demand. First, by analysing sales information from retail sides who deal directly with consumers. Second, use a fashion consultant services that do field survey. Third, follow the designers at leading fashion industries in large cities (fashion centre). After the process of reading the market demand, parts manufacturing began to respond to the request. This response process performed by the manufacturer with two main activities, namely design and production. Design provides planning process regarding these types of items, the physical design of the product, the amount, the type of raw materials needed, and others. While the production of physical products includes appropriate activities to realise the design stage of the start of raw materials, pattern making, fabric cutting, assembly, until the labelling.

The production process of SCA for the fashion industry divided into two productions, covering the production of sample and production based on the response of the sample. First, the sample production is intended to introduce new products to consumers through retail side. Factors of delivery speed (F1) are an appropriate speed product delivery (product sample or products based on orders). The new product introduction factor (F2) is required to respond to the consumer's desire for the information of new product. Such information is the basis for the decision of the manager in the purchase of products to be sold in the shop. Purchasing/ordering this product captured the manufacturers to conduct production (upon request) and shipping. Once the products reach the consumers, a factor of the customer satisfaction (F3) is obtained. Time lapses between the request and

delivery called lead time. Factors of lead time reduction (F4) are an effort to reduce lead time (F4). Therefore, the requests can be responded to as soon as the competitive advantage of industries.

Table 3 Description of agile characteristics

No.	*Agile characteristics*	*Description*
1	Market sensitiveness (D1)	D1 is considered to be fulfilled if existing conformity between sustainability, quality and the best price. In addition, D1 can be achieved with new designs or follow the latest trends.
2	Process integration (D2)	D2 is overcome by choosing a business partner terms compared with term suppliers and retail. Business partners are classified into three classes (based key performance indicators), namely the platinum class with business guarantee within five years, gold class with three-year business guarantee, and third, the silver class with a one year business guarantee.
3	Information driver (D3)	D3 are currently being developed with online transaction activities. Consumers purchase certain products, followed by updating the database automatically. This data is also used for consumer viewing habits based on transactions per month or per style.
4	Delivery speed (F1)	F1 is entirely dependent forwarder services.
5	New product introduction (F2)	F2 are performed with many utilising the website to display the latest products or will come. Collaboration conducted by a famous designer or artist.
6	Customer satisfaction (F3)	F3 are more related to the quality of production and the return of the product if it does not match expectations.
7	Lead time reduction (F4)	F4 is achieved by a strategy of local-to-local and efficiency of all state.
8	Centralised and collaborative planning (F5)	F5 is achieved by providing business opportunities according to their classification (key performance indicators).
10	Trust development (F7)	F7 constructed with information disclosure, awards to business partners according to their classification, and a two-way discussion.
11	Cost minimisation (F8)	F8 conducted with the global strategy for the raw materials consolidation.
12	Quality improvement (F9)	F9 is filled with raw materials and ensure the safety from the product, existing Strengthen quality system
13	Minimising resistance to change (F10)	F10 conducted with a commitment by a business partner from the beginning, flexibility, product allocation certainly (T-shirts, denim) and the product is uncertain. The allocation of products based on the season (summer/winter).
14	Data accuracy (F11)	F11 is secured by the independent auditor (one year) and internal auditors (per month). Data is also renewable in real time (online).
15	Use of information technology tools (F12)	F12 is enhanced by providing information technology staff centrally for ensure the data, marketing, and security.
16	Minimising uncertainty (F13)	F13 enhanced by prediction from a specific month (style) and market intelligence (current trends).

Process integration (D2) as the second dimension for supply chain performance in fashion industry means that there is cooperation between all parties (buyer and seller) in the overall supply chain process. Related parties include the suppliers of raw materials, manufacturing, and retail. One of the factors of dimension of process integration (D2) is centralised and collaborative planning (F5) means to reduce lead time, reduce excess inventory of products, increase sales, and improve service to consumers. Service level improvement F6 is required to improve service to consumers and improve competitiveness (among trading partners). Trust development (F7) is required to develop trust in raw material suppliers, manufacturing, manufacturing and retail. Cost minimisation (F8) means to find collective solutions to reduce production costs. Quality improvement (F9) to maintain or increase the value of a product in the eyes of consumers. Quality improvement (F9) also required to improve the quality of raw materials, quality of design and production, and to reach the consumers in good condition (through retail). Minimising resistance to change (F10) is required in order to face an unstable fashion.

Information driver (D3) as the third dimension for supply chain performance in fashion industry means that information flows from the entire supply chain colleagues. Information driver includes the factor of use of information technology tools (F12) to share information. Data accuracy (F11) represent the quality of the information flowing. Data accuracy (F11) must be maintained throughout the supply chain. If the data accuracy does not fit on the retail side, the error continues to the manufacturers up to suppliers of raw materials. Uses of information technology tools (F12) realise the information flow from and to all related parties. Minimising uncertainty (F13) is required to minimise uncertainty from suppliers and demand (quantity and quality aspects). Therefore, the minimising uncertainty aims to reduce inefficiencies.

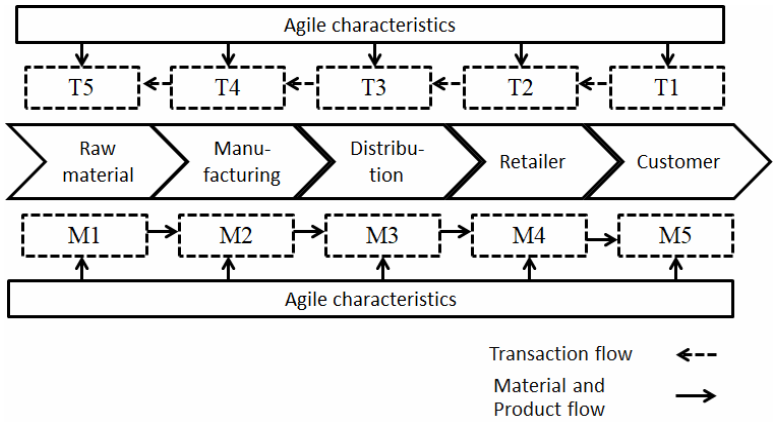
5 Model of SCA for fashion industry

The following presents theoretically model of SCA for industry fashion based on the literatures and case study of the specific fashion industry in Indonesia. The proposition of this research states that the influence of agile characteristics will have an impact to the SCA, which in turn will improve the supply chain performance. The supply chain of fashion industry involving five main stage, namely raw material, manufacturing, distribution, retail, and consumer (Ciarniene and Vienazindiene, 2014a). Model of SCA is constructed base on integration of the relationship among agile characteristics (dimensions and factors) in accordance with each stage of material/product flow and transaction flow (Figure 1). Figure 1 presents model of SCA for fashion industry.

Agile characteristics approach in SCA is required as an approach to face the rapidly changing and uncertainty business challenges. Fashion industries are faced with challenges such as rapid managerial and technological changes, market uncertainty, dynamic market, decrease product life cycle and market segmentation in the global business environment (Gligor et al., 2015). Therefore, the ability of managerial to adapt changing market conditions is essential for the survival of business industries. The role of agile characteristics in the supply chain is essential and strategic for respond to market changes quickly and effectively. Agile characteristics for fashion industry are not only to

respond to changes in general, but also to be able to respond specific and dramatic changes.

Figure 1 Model of SCA for fashion industry



SCA for fashion industry is defined as the ability of the supply chain of fashion industry to respond quickly to market changes and consumer needs. Implementation of SCA means use of market knowledge and the concept of virtual enterprise to seize the profitable market appropriately. SCA is also the ability of industries resources to adapt quickly to the heterogeneous consumer needs. Implementations of SCA within the industry are required to face the competitive pressure in the current condition and future and to gain a competitive advantage. Accordingly, SCA should be able to respond to the needs of consumers and markets that changing very rapidly. Responsive means fast and have a high degree of manoeuvrability.

The following presents the description of SCA for fashion industry as given Figure 1. The flow of transactions starting from the data of product demand from consumers (T1), purchase products at retail (T2) include the type, number and size of the product, as well as orders from consumers, sales data from retail (T2) and booking of retail corresponding with code products (T3), sales data, orders for products and production time (T4), and the booking data from the manufacturing cover the amount and type of fabric (T5). While the material flow starting from the availability of raw materials (M1) such as cloth, the fabric is processed into finished products (M2), schedule and delivery time of products to retail and customer (M3), a product from manufacture for distribution(M4), and products from retail (M5).

The material flow starting from the supply of raw materials such as cloth, heading to the production process, resulting in a yield of apparel products. These products are distributed to retail and consumer. The performance of each stage is interrelated and can not be separated one from the other. While, the flow of information for production starting from sales heading to the production and production processes up until the raw material of fabric.

6 SCAIS for fashion industry

The SCAIS for fashion industry is constructed based on the SCA model as given in Section 5 to support achievement of supply chain performance as described in Section 4. SCAIS is designed theoretically and case study of the specific fashion industry. Process standards for the development of SCAIS using the SDLC methodology. The implementation of SCAIS for fashion industry can be operationalised using software of integrated information systems. Information of the material/product flow and transaction flow on the integrated information system serves to provide information services of industry data through the electronic web. Design of SCAIS using programming language PHP methods and MySQL database serve as an integrated database in accordance with the needs of SCA.

The case study chose specific fashion industry in Indonesia that makes market sensitiveness as the main agile characteristics in improving supply chain performance. The agile characteristics more detail which influence the SCA adapted to the strategy of fashion industry development. The basic agile characteristics of supply chain performance comprised of three dimensions and 13 factors of the three dimensions which obtained from Experts as given in Table 2.

Figure 2 The integrated information systems for fashion industry

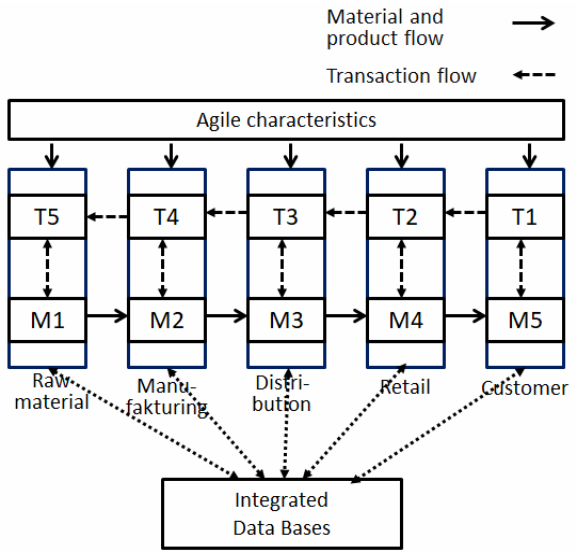
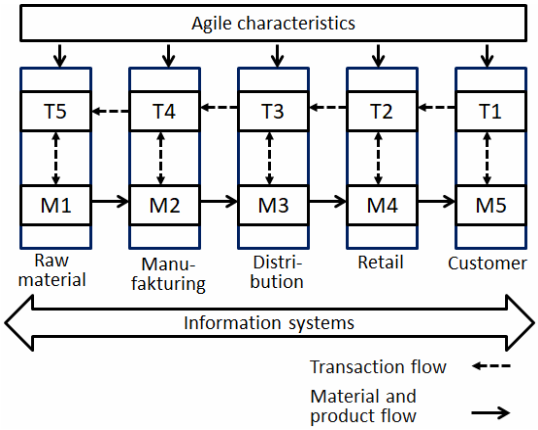


Figure 2 presents the conceptually of designing an integrated information system using the framework of integrated databases. The model of SCAIS for fashion industry is given in Figure 3. The SCAIS is designed within the framework of integrated information systems based on the material/product flow and transaction flow which influenced by agile characteristics. As the input for SCAIS are flow of materials/products and flow of

transactions from the supply chain as described in Section 5. Based on integrated raw material, manufacturing, distribution, retailer and customer, the resulting output of SCAIS is the right products which distributed at the right amount, to the right consumer and at the right time in accordance with characteristics of costumer satisfaction. The SCAIS for the fashion industry focus on the mainly stage includes of five stages, namely raw material, manufacture, distribution, retail and customer. At each stage is determined by the flow of material/product and flow of transaction. The description of flow on the SCA is given in Section 5. The successful of the SCAIS strongly influenced by the integrated database system which is supporting elements of the systems. For displaying data or information as required, necessary data that complete, accurate, and easily as needed. Therefore, it is important to have integrated database system that intelligent and agile capable of fulfilling the needs of data or information for management. The role of SCAIS can determine the critical factors as the key factors in accordance with the agile characteristics.

Figure 3 Model of SCAIS for fashion industry



An integrated information system used to integrate suppliers and customers requirement on the operations of SCA. The role of integrated information systems is to improve the relationship between supplier (industry) with the consumer or market in real time. This system will automatically update the data stored in integrated database based on the flow of material/product and transactions. To construct SCAIS more efficient require transfer of quickly and accurately data and information throughout SCA with vendor managed inventory. Vendor managed inventory is designed to facilitate the transfer of data and providing saving benefits of time and cost for suppliers and customers.

SCAIS is as tool to assist management for improving supply chain performance in order to achieve a competitive advantage of the fashion industry, and have important role in the coordination of supply chain and respond to changing environment and enable the industry to respond to market changes rapidly. SCAIS which given in Figure 3 is used to manage the entire materials and information from five different stage in an integrated database.

The determination of key factors from agile characteristics to improve supply chain performance determined by quantity and quality of materials flow and transaction flow which influenced by agile characteristics. The agile characteristics on SCAIS include 16

variables (dimensions and factors) that involved in the framework of supply chain performance. The role of agile characteristics to increase supply chain performance is determined by the degree of influence and ranking of the agile characteristics to SCA, and interrelationships among dimensions and factors on SCA. The characteristic of agility has a strong relationship with cost efficiency and consumer effectiveness in any environmental situation based on the flow of materials/ products and the flow of transactions. The characteristics of agility for SCA in SCAIS are the basic of the industry to make the right product and at the right time to customers.

Implementation of SCAIS for improving business process performance requires knowledge of various fields, such as business process management involves continuous improvement, quality control and the basis of innovation in business processes to improve the efficiency and effectiveness of the industry. Business process management utilising information technology/information systems to design socio-technical systems work, including designs based on issues related to business intelligence and human resources. Business process management constructed as a comprehensive management approach helps industries to operate and achieve the business objectives of the industry, dealing with logistics, manufacturing, financial services, healthcare, and other costs associated with the industry. SCAIS sustainability give way continuous search innovating on each stage of the supply chain to gain competitive advantage and reduce the problem, which is not conformity along the chain on the SCAIS.

7 The key factors to achieve fashion industry competitiveness

The following presents the case study in the specific Fashion Industry in Indonesia using fuzzy DEMATEL ANP aims to determine critical factors as key factors affecting to the SCA according to agile characteristics in the framework of supply chain performance. Key factors are obtained from interrelationships influence of variable of agile characteristics to the SCA. Key factors are determined based on the ranking by top priority of critical factors affecting to the SCA for enhance agile capabilities to achieving supply chain performance within the overall supply chain. The ranking of critical factors and the degree of interrelationships influence of those agile characteristics have a strategic role in enhance the fashion industry competitiveness.

The information and data gathering related to the supply chain performance improvement strategy and the influence of agility characteristics (dimensions and factors) to SCA obtained by interviews with Experts of modern fashion industry. The fashion industry states that the consumer expectations related to the dimension of market sensitiveness and is considered to be fulfilled if existing conformity between sustainability, quality and the best price. In addition, to get the influence of the characteristics of agility by considering their inter-correlations among dimensions or factors within the framework of the supply chain performance. The description of agile characteristics strategy given in Table 3. Data gathering from questionnaire are converted into the form of crisp score is given in Table 4, Table 5 and Table 6.

Data gathering of empirical case study are design in the form of the influence of each variable as dimensions and factors to SCA, and direct relation among the variables (dimensions and factors) on SCA. The influence of variables are categorised in statement five categories, namely no influence, very low influence, low influence, high influence,

and very high influence (Table 1). The data gathering for three variables of dimensions and 13 variables of factors are designed in the form of linguistic data and interpreted in a fuzzy linguistic scale.

Table 4 The relation of agile characteristics to SCA

No.	*Dimensions/factors*	*Defuzzification result*
1	Market sensitiveness (D1)	0.750
2	Process integration (D2)	0.958
3	Information driver (D3)	0.750
4	Delivery speed (F1)	0.963
5	New product introduction (F2)	0.738
6	Customer satisfaction (F3)	0.513
7	Lead time reduction (F4)	0.963
8	Centralised and collaborative planning (F5)	0.513
9	Service level improvement (F6)	0.738
10	Trust development (F7)	0.738
11	Cost minimisation (F8)	0.963
12	Quality improvement (F9)	0.738
13	Minimising resistance to change (F10)	0.738
14	Data accuracy (F11)	0.963
15	Use of IT tools (F12)	0.738
16	Minimising uncertainty (F13)	0.513

Table 5 The direct relation matrix among dimensions

	D1	*D2*	*D3*
D1		0.733	0.733
D2	0.967		0.733
D3	0.967	0.967	

Table 6 The interrelationships between factors on SCA

	F1	*F2*	*F3*	*F4*	*F5*	*F6*	*F7*	*F8*	*F9*	*F10*	*F11*	*F12*	*F13*
F1		0.967	0.733	0.967	0.500	0.733	0.500	0.500	0.033	0.500	0.033	0.267	0.267
F2	0.033		0.733	0.033	0.033	0.033	0.500	0.033	0.500	0.033	0.033	0.267	0.267
F3	0.500	0.267		0.500	0.033	0.733	0.733	0.267	0.967	0.500	0.500	0.500	0.733
F4	0.967	0.733	0.733		0.733	0.733	0.733	0.733	0.033	0.733	0.267	0.733	0.967
F5	0.733	0.733	0.267	0.967		0.267	0.267	0.733	0.500	0.500	0.733	0.967	0.733
F6	0.733	0.733	0.967	0.500	0.500		0.733	0.000	0.033	0.267	0.267	0.267	0.267
F7	0.267	0.733	0.733	0.500	0.500	0.500		0.267	0.733	0.267	0.267	0.267	0.033
F8	0.500	0.033	0.033	0.967	0.500	0.267	0.267		0.967	0.033	0.967	0.733	0.267
F9	0.967	0.267	0.967	0.733	0.500	0.967	0.733	0.733		0.267	0.267	0.267	0.733
F10	0.733	0.500	0.500	0.733	0.267	0.733	0.267	0.733	0.500		0.500	0.500	0.500
F11	0.500	0.500	0.500	0.733	0.267	0.267	0.267	0.967	0.733	0.733		0.733	0.733
F12	0.733	0.267	0.267	0.500	0.733	0.733	0.500	0.733	0.733	0.500	0.967		0.500
F13	0.967	0.500	0.733	0.967	0.733	0.267	0.267	0.967	0.733	0.267	0.733	0.500	

By defuzzification using equations (1) to (4), the data in the linguistic scale is converted into fuzzy numbers to obtain crisp values. Table 4 presents the relation of agile characteristics (dimensions and factors) to SCA which is expressed by crisp score with

range from 0 to 1. Table 4 shows that the variable which has very high influence involve the process integration (D2) for dimensions, and delivery speed (F1), Lead time reduction (F4), cost minimisation (F8), and data accuracy (F11) for the factors. By the same method obtained Table 5 and Table 6 which is presents the defuzzification result with crisp score for direct relation case among dimensions and factors on SCA. The degree of these relations can be used to develop a work program or strategy for achieving supply chain performance. Table 5 and Table 6 shows that the degree of influence for direct relation between dimensions or factors enable different. For example, the interrelationship between D1 and D2 shows that the influence of D1 to D2 is 0.733, while the reverse influence of D2 to D1 is 0.967.

The influence given and received by each dimensions and factors of characteristics agility obtained from total-influence matrix $\boldsymbol{T}$ using equation (6). The total-influence matrix $\boldsymbol{T}$ is obtained from normalised direct-influence matrix $\boldsymbol{D}$ using equation (5). The sum of rows $\boldsymbol{R}$, the sum of columns $\boldsymbol{C}$, ($\boldsymbol{R} + \boldsymbol{C}$) and ($\boldsymbol{R} - \boldsymbol{C}$) in Table 7 and Table 8 are obtained from total-influence matrix $\boldsymbol{T}$ using equations (6), (7) and (8). In Table 7 and Table 8, ($\boldsymbol{R} + \boldsymbol{C}$) presents the total influence given by factors (agile characteristics) to SCA, and ($\boldsymbol{R} - \boldsymbol{C}$) shows factors are influenced or influencing on the SCA. If ($\boldsymbol{R} - \boldsymbol{C}$) is positive, it means that dimensions/factors i^{th} influencing other dimensions/ factors. Conversely, if ($\boldsymbol{R} - \boldsymbol{C}$) is negative, it means that dimensions/factor i^{th} is influenced by other dimensions/factors.

Table 7 The influence given and received by each dimensions

Dimensions	*R*	*C*	*R + C*	*R – C*
Market sensitiveness (D1)	6.199	7.514	13.713	–1.315
Process integration (D2)	6.829	6.829	13.658	0.000
Information driver (D3)	7.514	6.199	13.713	1.315

Table 8 The influence given and received by each dimensions on SCA

Factors	*R*	*C*	*R + C*	*R – C*
Delivery speed (F1)	3.148	4.178	7.325	–1.030
New product introduction (F2)	1.418	3.471	4.890	–2.053
Customer satisfaction (F3)	3.481	3.976	7.457	–0.495
Lead time reduction (F4)	4.333	4.389	8.722	–0.057
Centralised and collaborative planning (F5)	4.128	2.983	7.110	1.145
Service level improvement (F6)	2.784	3.498	6.282	–0.715
Trust development (F7)	2.737	3.288	6.025	–0.552
Cost minimisation (F8)	3.317	3.609	6.925	–0.292
Quality improvement (F9)	4.043	3.483	7.526	0.560
Minimising resistance to change (F10)	3.557	2.605	6.162	0.952
Data accuracy (F11)	3.896	3.000	6.896	0.896
Use of IT tools (F12)	4.008	3.295	7.303	0.713
Minimising uncertainty (F13)	4.272	3.345	7.617	0.927

Based on the data gathering, three dimensions of market sensitiveness (D1), process integration (D2) and information driver (D3) in Table 7 presents the same total influence that is 13.7. However, from the value ($\boldsymbol{R} - \boldsymbol{C}$) for the D3 is 1.315 (positive) and for the D1 is –1.315 (negative), which means that the dimension D3 influencing to dimension

D1. For dimension of process integration (D2) with $\boldsymbol{R} - \boldsymbol{C}$ is 0.000 means that the dimension D2 not influencing to other dimensions and also is not influenced by other dimensions.

Table 8 shows that the factors centralised and collaborative planning (F5), minimising resistance to change (F10), minimising uncertainty (F13), data accuracy (F11), use of IT tools (F12) and quality improvement (F9) were identified as the most influencing factors in achieving supply chain performance. While lead time reduction (F4), cost minimisation (F8), customer satisfaction (F3), trust development (F7), service level improvement (F6), delivery speed (F1) and new product introduction (F2) were identified as the most influenced factors.

The results given in Table 8 also presents that the factor lead time reduction (F4) has total value ($\boldsymbol{R} + \boldsymbol{C}$) of greatest influence (8.722). This is consistent with the opinion of Top Manager of the fashion industry as the case study at the time of interview. The manager stated that the most critical terms in the fashion supply chain is the lead time (F4). Lowest total effect ($\boldsymbol{R} - \boldsymbol{C}$) in Table 8 is the factor new product introduction (F2) which is has total value of influence 4.890.

Table 9 Ranking dimension influence on SCA

Dimensions	*Wi*	*Si*	*TPI*	*Ranking*
Market sensitiveness (D1)	0.363	0.750	0.363	1
Information driver (D3)	0.305	0.750	0.305	2
Process integration (D2)	0.332	0.958	0.000	3

Table 10 Ranking factors influence on SCA

Factors	*Wi*	*Si*	*TPI*	*Ranking*
Customer satisfaction (F3)	0.091	0.513	0.091	1
Minimising uncertainty (F13)	0.074	0.513	0.074	2
Centralised and collaborative planning (F5)	0.066	0.513	0.066	3
Quality improvement (F9)	0.078	0.738	0.039	4
Service level improvement (F6)	0.077	0.738	0.039	5
New product introduction (F2)	0.076	0.738	0.038	6
Trust development (F7)	0.076	0.738	0.038	7
Use of IT tools (F12)	0.073	0.738	0.036	8
Minimising resistance to change (F10)	0.057	0.738	0.029	9
Delivery speed (F1)	0.091	0.963	0.000	10
Lead time reduction (F4)	0.096	0.963	0.000	11
Cost minimisation (F8)	0.078	0.963	0.000	12
Data accuracy (F11)	0.066	0.963	0.000	13

Using DEMATEL fuzzy-ANP method to determine ranking of dimensions/factors based on direct influence of agility characteristics to SCA and influence of interrelationships among the variables for dimensions and factors on the SCA. The ranking of variables from dimensions and factors useful to choose the main priorities from overall the variable agility by considering inner dependence of each characteristics of agility. The dimensions and factors are ranked on the basis of their TPI denoted by TPI_i. TPI TPI_i are derived by

equation (10), which is calculated based on the total weight of the i^{th} factor w_i and the corresponding crisp score s_i. The weight of the i^{th} factor w_i calculated by equation (9), and the corresponding crisp score w_i are given in Table 4.

The agile characteristics (dimensions or factors) with the highest TPI values identify the key factors or critical factors for achieving supply chain performance through SCA. Table 9 shows the results of computing TPI for ranking of dimensions of agile characteristics. Table 9 shows that the main priority is the variable of dimensions of market sensitiveness (D1), followed by the information driver (D3) and process integration (D2). While for the results of TPI from factors of agility characteristics i^{th} is given in Table 10. Table 10 shows the biggest to the smallest of the degree of priority. Five biggest ranking starting from customer satisfaction (F3), minimising uncertainty (F13), centralised and collaborative planning (F5), quality improvement (F9) and), service level improvement (F6). These results indicate that the top priority is customer satisfaction. The factors with a higher priority has strategic role as the key factors to achieve supply chain performance most excellent.

8 Conclusions

SCAIS as integrated information systems which designed based on the material/product flow and transaction flow which influenced by agile characteristics in supply chain performance framework. SCAIS as a tool used to support management of fashion industry that makes strategy of market sensitiveness and customer satisfaction as the main agile characteristics aims to improve supply chain performance in order to achieve fashion industry competitiveness. Successful implementation of SCAIS is closely related to the competence of the fashion industry for managing and optimising industry resources in accordance with the resource of the industry owned to respond and capture market and consumer demands. Based on the flow of material/ product and flow of transaction, SCAIS can support to determine the critical factors as the key factors in accordance with the agile characteristics.

The decision to define measure of supply chain performance determined by materials/ products flow and transaction flow which influenced by agile characteristics within the framework of SCA. The influence of agile characteristics on fashion industry covers the influence of agile characteristics to SCA. The fuzzy DEMATEL ANP method is used to identify main factors or critical factors as the key factors that have a high influence. The results of the research with case study for the specific fashion industry shows that the factor lead time reduction is identified has greatest influence and as the most influenced factor. This is consistent with the opinion from top manager of the fashion industry. TPI as the ranking of agile characteristics (dimensions and factors) are useful to choose the main priorities from overall the characteristics of agility. The results of the research also indicate that based on the ranking factors influence on SCA as the top priority is customer satisfaction. The dimensions and factors with higher priority has a strategic role to achieve supply chain performance most excellent.

The case study of this research chose the specific fashion industry that makes market sensitiveness as the main characteristics of agility in improving supply chain performance using strategy that the consumer expectations related to the dimension of market sensitiveness. The strategy is considered to be fulfilled if existing conformity between

sustainability, quality and the best price. In fact, there are some fashion industries with market sensitiveness as the same main characteristics agility, but with different strategy. For example, the other fashion industry makes market sensitiveness as the main characteristic of agility by strategy that market sensitiveness conducted by establish good relationships with loyal customers. Accordingly, the fashion industries use different strategies allow the description agile characteristics are also different, and consequently provide a degree of influence and top priority of agile characteristic as the key factors to achieve supply chain performance most excellent are also different.

The basic concept of SCAIS is designed as an enabling tool to assist management of supply chain performance to achieve the fashion industry competitiveness. Implementation of SCAIS for fashion industry with high competitiveness using the concept of agility which require knowledge of various fields, such as management of total quality control, vendor managed inventory, continuous improvement and basic innovation for improving efficiency and effectiveness business process for achievement of key performance indicators of supply chain performance.

Acknowledgements

This paper is result of research by research grants from School of Postgraduate Studies Diponegoro University in 2016 with Number: 1045.P/UN7.4/KU/2016. The author would like to thank the Dean of School of Postgraduate Studies and Chairman of the Master Program of Information System of Diponegoro University. The authors would like to thank also presented to experts in the SCA and modern fashion industry who have helped in data gathering process.

References

Aarabi, M. and Shariatmadari, S. (2012) 'Information systems of supply chain management in SMEs: sustainable approach', *International Journal of Research in Management and Technology (IJRMT)*, Vol. 2, No. 5, pp.519–524.

Agarwal, A., Shankar, R. and Tiwari, M.K. (2007) 'Modeling agility of supply chain', *Industrial Marketing Management*, Vol. 36, No. 4, pp.443–457.

Brun, A. and Castelli, C. (2008) 'Supply chain strategy in the fashion industry: developing a portfolio model depending on product, retail channel and brand', *Int. J. Production Economics*, Vol. 116, No. 2, pp.169–181.

Chan, A.T.L., Ngai, E.W.T. and Moon, K.K.L. (2016) 'The effects of strategic and manufacturing flexibilities and supply chain agility on firm performance in the fashion industry', *European Journal of Operational Research*, Vol. 259, No. 2, pp.486–499.

Christopher, M. (2000) 'The agile supply chain: competing in volatile markets', *Industrial Marketing Management*, Vol. 29, No. 1, pp.37–44.

Christopher, M., Lowson, R. and Peck, H. (2004) 'Creating agile supply chains in the fashion industry', *International Journal of Retail and Distribution Management*, Vol. 32, No. 8, pp.367–376.

Ciarniene, R. and Vienazindiene, M. (2014a) 'Agility and responsiveness managing fashion supply chain', *Procedia – Social and Behavioural Sciences*, 15 September, Vol. 150, pp.1012–1019.

Ciarniene, R. and Vienazindiene, M. (2014b) 'Management of contemporary fashion industry: characteristics and challenges', *Procedia – Sosial and Behavioural Sciences*, 26 November, Vol. 156, pp.63–38.

DeGroote, S.E. and Marx, T.G. (2013) 'The impact of IT on supply chain agility and firm performance: an empirical investigation', *International Journal of Information Management*, Vol. 33, No. 6, pp.909–916.

Gligor, D.M., Esmark, C.L. and Holcomb, M.C. (2015) 'Performance outcomes of supply chain agility: when should you be agile?', *Journal of Operations Management*, Vol. 33, No. 1, pp.71–82.

Gunasekaran, A. and Ngai, E.W.T. (2004) 'Information systems in supply chain integration and management', *European Journal of Operational Research*, Vol. 159, No. 2, pp.269–295.

Hilletofth, P. and Hilmola, O.P. (2008) 'Supply chain management in fashion and textile industry', *International Journal of Services Sciences*, Vol. 1, No. 2, pp.127–147.

Jie, F., Kevin, K.A. and Mustafid (2015) 'Supply chain performance flexibility in the Australian beef industry', *International Journal of Logistics Research and Application*, Vol. 19, No. 4, pp.300–317.

Khurana, K. and Ricchetti, M. (2016) Management in the fashion business, an appraisal', *Journal of Fashion Marketing and Management*, Vol. 20, No. 1, pp.89–104.

Kim, B. (2013) 'Competitive priorities and supply chain strategy in the fashion industry', *Qualitative Market Research: An International Journal*, Vol. 16, No. 2, pp.214–242.

Krotov, V., Junglas, I. and Steel, D. (2015) 'The mobile agility framework: an exploratory study of mobile technology enhancing organizational', *Agility Journal of Theoretical and Applied Electronic Commerce Research*, Vol. 10, No. 3, pp.1–7.

Lemieux, A.A., Pellerin, R., Lamouri, S. and Carbone, V. (2012) 'A new analysis framework for agility in the fashion industry', *International Journal of Agile Systems and Management*, Vol. 5, No. 2, pp.175–197.

Li, Y., Zhao, X., Shi, D. and Li, X. (2014) 'Governance of sustainable supply chains in the fast fashion industry', *European Management Journal*, Vol. 32, No. 5, pp.823–836.

Lo, W.S., Hong, T.P. and Jeng, R. (2008) 'A framework of E-SCM multi-agent systems in the fashion industry', *International Journal Production Economics*, Vol. 114, No. 2, pp.594–614.

Mandal, P. and Bagchi, K. (2016) 'Strategic role of information, knowledge and technology in manufacturing industry performance', *Industrial Management and Data Systems*, Vol. 116, No. 6, pp.1259–1278.

Maruster, L., Faber, N.R. and Peters, K. (2008) 'Sustainable information systems: a knowledge perspective', *Journal of Systems and Information Technology*, Vol. 10, No. 3, pp.218–223.

Masson, R., Iosif, L., MacKerron, G. and Fernie, J. (2007) 'Managing complexity in agile global fashion industry supply chains', *The International Journal of Logistics Management*, Vol. 18, No. 2, pp.238–254.

Mavengere, N.B. (2013a) 'Information technology role in supply chain's strategic agility', *International Journal Agile Systems and Management*, Vol. 6, No. 1, pp.7–24.

Mavengere, N.B. (2013b) 'The role of information systems in promoting strategic agility in supply chains', *Journal of Information Technology Case and Application Research*, Vol. 15, No. 4, pp.13–33.

Moniruzzaman, M., Kurnia, S., Parkes, A. and Maynard, S.B. (2015) 'Business intelligence and supply chain agility', *Proceedings of the 26th Australasian Conference on Information Systems*.

Ni, Y. and Fan, F. (2011) 'A two-stage dynamic sales forecasting model for the fashion retail', *Expert Systems with Applications*, Vol. 38, No. 3, pp.1529–1536.

Prajogo, D. and Olhager, J. (2012) 'Supply chain integration and performance: the effects of long-term relationships, information technology and sharing, and logistics integration', *International Journal of Production Economics*, Vol. 135, No. 1, pp.514–522.

Qrunfleh, S. and Tarafdar, M. (2014) 'Supply chain information systems strategy: impacts on supply chain performance and firm performance', *International Journal of Production Economics*, Vol. 147, Part B, pp.340–350.

Sangari, M.S., Razmi, J. and Zolfaghri, S. (2015) 'Developing a practical evaluation framework for identifying critical factors to achieve supply chain agility', *Measurement*, February, Vol. 62, pp.205–214.

Schaltegger, S. and Burritt, R. (2014) 'Measuring and managing sustainability performance of supply chains: review and sustainability supply chain management framework', *Supply Chain Management: An International Journal*, Vol. 19, No. 3, pp.232–241.

Shen, B. (2014) 'Sustainable fashion supply chain: lessons from H&M', *Sustainability*, Vol. 6, No. 9, pp.6236–6249.

Swafford, P.M., Ghosh, S. and Murthy, N. (2008) 'Achieving supply chain agility through IT integration and flexibility', *International Journal of Production Economics*, Vol. 116, No. 2, pp.288–297.

Tseng, M.L. (2011). 'Using a hybrid MCDM model to evaluate firm environmental knowledge management in uncertainty', *Applied Soft Computing*, Vol. 11, No. 3, pp.1340–1352.

Tseng, M.L., Wu, K.J. and Nguyen, T.T. (2011) 'Information technology in supply chain management: a case study', *Procedia – Social and Behavioural Sciences*, 25 November, Vol. 25, pp.257–272.

Tuo, G., Okyere, S. and Otchere, F.A. (2014) 'Supply chain information system flexibility and performance in the print industry in some selected printing press in Kumasi', *International Journal of Humanities and Social Science*, Vol. 4, No. 3, pp.292–301.