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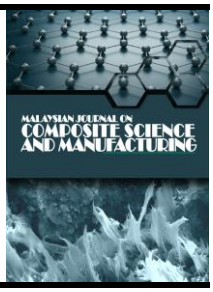

QFD Approach in Determining the Best Practices for Green Supply Chain Management in Composite Technology Manufacturing Industries

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ABSTRACT

The purpose of this paper is to determine the best practice of green supply chain management in composite technology manufacturing industries through quality function deployment or so-called as QFD approach. Since introduced, the QFD approach had been deployed in varieties of applications but lack of discussion on the know-what issues in developing the green supply chain model. Four case studies were been performed to have a consensus decision on the green supply chain practices using pre-determined parameters in QFD model. The findings show that top management commitment is the most essential element to ensure the success of green supply chain practices. Besides, workers' commitment and customer focus are significance to the establishment of 24 items or measures for green supply chain practices.

1. Introduction

An expanding number of companies rightly perceive corporate responsibility and, specifically, environmental awareness as one of the compulsory business objectives. Actually, instead of being an excessive disadvantage, ecological activities have, turn into a source of competitive equality [1]. For that reason, the significance of these green environment aspirations has influenced significance of green procurement [2]. An increasing number of companies are joining green procurement into their day-by-day operations crosswise over commercial ventures. As obvious from the Samsung sample, these projects are likewise getting to be progressively complex [3] in that they go past essential green procurement activities and concentrate on modern green supplier improvement activities that look for improving supplier capacities. Nevertheless, not all companies seek after green supplier

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advancement activities to the same degree because these activities require ability that is more advanced.

In consideration on the developing significance of green procurement and green supplier improvement, researchers have attempted to stay aware of practice by recognizing key forerunners that could drive such practices. To analyze the effects of green procurement and green supplier improvement, the (characteristic) asset based perspective is drawn. These activities speak to an arrangement of socially made and way subordinate abilities can at last results in a sustainable competitive advantage. Despite the fact that institutional demands can prompt the appropriation of green practices, it is imperative that companies create assets and abilities that can help them to react to this enforcement and eventually bring about supreme performance [4].

Accordingly, it accepted as critical to consolidate resource-based view alongside the institutional assumptions to give clarity that is more prominent on the considered relations. This research analyze the specific impact of green supplier development on the suppliers' performance. Additionally, green procurement likewise involves the company's commitment to environmental accountability. Green purchasing is regularly examined as a successful method for enhancing businesses' environmental performance. Purchasing could really be more intense change specialists than some other corporate power [5].

Sustainable improvement and environmental preservation are getting highly attention in industry. To expand the item life cycle and to seek after big business ceaselessness, a company needs to underscore environment assurance and green generation as a basic part of its social accountability. A decent green supplier choice model in an element focused and administrative environment can help decrease the ecological and lawful dangers and build the aggressiveness of a company [1, 4].

With expanding government regulation and stronger open mindfulness in environmental protection, companies today just cannot disregard ecological issues in the event that they need to make due in the worldwide business. Not with standing consenting to the natural regulations for offering items in specific nations, companies need to execute procedures to decrease the ecological effects of their items intentionally. The reconciliation of environment, monetary and social exhibitions to attain to supportable advancement is a real business challenge for the new century [6].

There are many literatures prove the implementation of GSCM give positive impact or benefits to the company. The explanation of benefits GSCM implementation can improve the confidence of company to preserve nature around [7]. It supported by Fahimnia et al. [4], which identified that the research of interest provides the motivation to implement GSCM. This is because the company that implement the GSCM will not participate if less benefit is to obtain.

In industry, there has been a pattern of "green" marketing, where companies can enhance their corporate attribute by including popular expressions, for example, sustainable, bio, green, eco and natural elements in their product. Bio composites are comparatively beset by delimitations between phases as well as not well characterized and advertised as 'bio' as produced using bio composites; may relate to completely biodegradable composites. For example, kenaf-reinforced PLA, or just semi-degradable composites, for example, hemp in an epoxy resin matrix. Regardless of the fact that the main thrust for fusing more green materials into items is just better attractiveness, it advances study in green composites.

The main consumer for natural fiber composite materials is automotive industry. It is now one of the biggest clients of composite materials, so extending to green composites is a natural expansion of their manufacturing interest. The bigger components of automotive parts need reinforcement and shape maintenance. Utilizing a fiber-reinforced material expands the elasticity of the part and increase tensile strength of the component. Natural fibers are important to the automotive industry because of their low density, low cost, and non-abrasive qualities. On the other hand, they stay less

solid than their manufactured partners and vulnerable to water logging and harm. Consequently, green composites are presently utilized for indoor structural component.

Besides that, the recent development of materials in automotive industry is towards substituting metal parts increasingly by polymer composites that can improve the fuel efficiency and weight reduction of the vehicles. The mechanical properties of composite failure in compression are the opposite of metals. Generally, most composites are classified by a brittle instead of ductile response to load. In the meantime, the high performance materials have become conceal in high technology industry for instance nuclear engineering, sport and renewable energy, automotive and aerospace. The significant of composite materials that can contribute to the chance of parts weight reduction and increase mechanical properties, and provide the ability to form complex shape. These can result in fuel efficiency and high functionality.

The use of carbon fibers and composites as advanced materials give better corrosion resistance, high fatigue, low thermal expansion in the forenamed industries [8]. Recently, the main industries that utilize composite parts produced and manufactured in United Kingdom are; Aerospace (36%), Wind Energy (33%), Automotive (8%) and Marine (8%) industries. This increase in composites utilization has been observed around the world, as reflected by raising carbon fiber request.

The objective of this paper is the to explore the combination of WHAT versus HOW in determining the best practice of green supply chain management in composite technology manufacturing industries through quality function deployment or so-called as QFD approach. The followings sub topic will explain the review of literature on QFD, followed by research method, result and discussion. The conclusion will summary the findings of this study.

2. Quality Function Deployment

Companies are currently confronting more noteworthy difficulties than any time in recent memory in addressing the needs of their undeniably requesting clients and representatives in an evolving financial and innovative environment. The fundamental business instabilities and dangers have added to make driving and overseeing especially intricate and troublesome QFD is a helpful device that can help the companies move towards more proactive item advancement. Right from the centerpiece of twentieth century, the world started to involve in the strengthening of worldwide rivalry [9].

In request to face this escalated rivalry, makers and administration suppliers were obliged to make an interpretation of client inclinations into technical parameters and values. To complete this interpretation precisely, QFD method developed in Japan through 1970s. The designers of QFD named the ‘client inclinations’ as ‘voice of clients’ [10]. The core part of QFD is the development of a matrix called House of Quality (HOQ), which is the configuration of four matrices. In a HOQ matrix, client voice is sustained as the info and specialized parameters with qualities are inferred as the yield. While creating a HOQ matrix, other than considering client voice, contenders’ position and interrelationships among the specialized parameters are viewed as reported in [11].

QFD is a procedure utilized for interpreting the ‘voice’ of clients into specialized necessities such that internal procedures can express what the clients need and meet their requirement and demand [13]. QFD is a client driven methodology and a helpful method for company to plan their products and service, which can help to offer to customer. It also can be considered as the company administration approach for proficiently making an interpretation of client needs into requirement of design and parts arrangement, and manufacturing planning and controls in order to attain customer satisfaction.

QFD purposely enhanced the quality of parts and components to interpret client demands, as far as particular prerequisites or requirement, into planning and activities. Through these activities, an association that effectively actualizes QFD can enhance engineering information, productivity and quality, reduce costs, product development time and design changes [13]. The concept of QFD is established to consider the quality at beginning stage of the design process. QFD is for plainly understanding and applying both management and engineering. The use of QFD technique led effectively in both improving quality of existing products and developing new product. QFD is an intense way to achieve customer satisfaction by responding to the customer needs and doing benchmark to improve the process, to enhance the output in order to minimize the utilization of resources [14]. This methodology also is an orderly idea to set up and make an interpretation of the client needs into product improvement including product design and development.

In addition, other concept of QFD is to interpret the stakeholders requirements into product design or engineering specification, and thus into flow of the process and finally into product requirement [15]. It is a technique, which structures the interpretation of stakeholders necessities into technical specification that are mostly comprehend by engineers. Each interpretation includes a framework. Through a progression of intuitive frameworks, QFD utilized to address any business circumstance including a large number of criteria, necessities or requests.

This stems from QFD innately utilizing and arranging a considerable lot of the Total Quality Management (TQM) tools and procedures in a thorough and strategic style. At the point when utilized as a part of the assessment period of a project, QFD can guarantee that every significant issue emphasized and can give another premise to company's projects. The HOQ is the most important fundamental for the QFD idea.

The HOQ comprises of seven essential steps: (1) identify the client's needs or requirement, (2) identify specialized elements (partner qualities) of the necessities, (3) relate the client's necessities to the specialized components, (4) conduct and evaluate competing products, (5) relate the specialized elements distinguished in step 2 to show any connection, (6) assess specialized elements and create targets and (7) figure out which specialized component to convey in the rest of the creation process.

More centers diverted to green item outline and development. The exploration using QFD in creating transport and delivery arrangements remains unexplored; would be a promising range to seek after [16]. QFD likewise connected in different industries such as manufacturing, transportation, hardware, development, instruction and services. QFD can convey enormous proficiency to company in light of the fact that error (of item targets, advertising systems, and vital creation control focuses) and requirement for changes are minimized. The advantages of QFD incorporate product design, the potential for breakthrough improvement, shorter process cycles with less design changes, lower project and product costs, and, most critically, customer satisfaction. The details record of QFD's advantages are gathered into four zones: customer introduction, reduction of execution time, advancement of cooperation, and procurement of documentation.

3. Research Method

Four companies were intensely investigated and addressed as 'Company A', 'Company B', 'Company C' and 'Company D' to disclosure the private information for privacy and confidential. Company A, located in Kedah, Malaysia. This company was formed in 1998 is a Joint Venture (JV) company between the Boeing Company and Hexcel Corporation for composites fabrication and minor parts assembly.

Second, Company B was established in 1997. This company, which located in Batu Berendam Airport, Malacca, Malaysia is a JV company between Germany and Malaysia. Manufacture of dome, racing yachts and powerboats also experienced in the aircraft and automotive industry, environmental industry, and the use of composites in architecture and building construction.

Third, Company C is a JV Company between RPC Company located in Australia. This company was establishing in 2013 and stated in Krubong Industrial Park Malacca, Malaysia. There is expertise in manufacturing structural composite product, ballistic protection products and fire protection products. This company undertakes the function of product design, pattern making, material procurement, process engineering, quality control, logistics, and manufacturing. Fourth, Company D was incorporated on 20 November 1990 and located in Composites Technology City in Batu Berendam, Melaka, Malaysia. This company runs the manufacturing of composites aero structures also providing other services such as engineering design, composites assemblies and R&D, automotive composites structures and for military defense related equipment.

The objective of the research method to be developed in the present work is to adapt the approach of QFD in the definition and specification of a class of advanced manufacturing system. The QFD approach has been developed as an advance quality system made up of an integrated set of quality tools and techniques to provide customer-driven product and service. The two principal aspects in QFD were focusing on:

i. WHAT is required to satisfy the customer (the customer requirements), and
ii. HOW important are things to the customer (the relative importance)

4. Result and Discussions

QFD applies its tools and techniques to improving the product, and to the process of product development and services. The procedures inherent in the approach allow trade-offs to be made on parameters that affect the objective of meeting the customer requirements. In this analysis, there are five steps to develop the HOQ for GSCM improvement as follows in Figure 1:

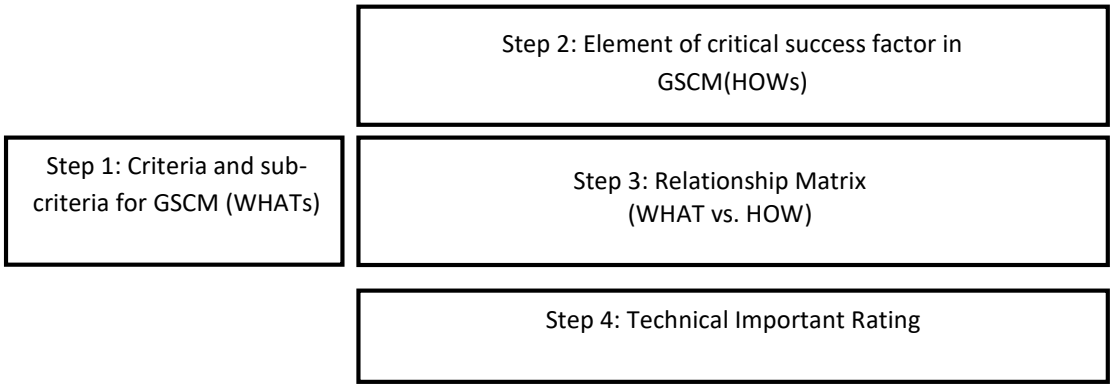

Fig. 1. Four room in development of HOQ

The step one or first room in HOQ are contain a criteria and sub-criteria of GSCM which is concern about the voice of customers that a structured list of requirement due to product and attributes as the customer describe them. The list is often referred as the WHATs that a customer needs or expect in a particular product or improvement (criteria of green supplier). This list of primary (main criteria) is usually vague and very general in nature. The secondary (sub-criteria) is explaining the greater detail than those on the list of primary customer requirements.

4.1 STEP 1: Criteria and sub-criteria for GSCM (WHATs

There are three groups of main criteria and 24 sub-criteria in GSCM. The main criteria consist of GC, EMS and GP. Table 1 shows the list of customer requirement for GSCM (WHATs room)

Table 1
The list of customer requirement for GSCM (WHATs room)

Primary (main criteria)	Secondary (sub-criteria)	Abbreviations
Green Competencies (GC)	Environment-friendly raw materials	SC1
	Green considerations in design	SC2
	Taking environmental criteria into consideration	SC3
	Use of cleaner technology processes to make savings (energy, water, wastes)	SC4
	Recycling of materials internal to the company	SC5
	Environmental-friendly packaging	SC6
	Taking back and reuse packaging from customer	SC7
	Environmental-friendly transportation	SC8
	Recovery of the company's end-of-life products	SC9
Environmental Management System (EMS)	Implementation of ISO 14001	SC10
	Government regulatory compliance	SC11
	Eco-labeling	SC12
	Provide employees training on environmental issues	SC13
	Provide customer/supplier training on environmental program	SC14
	Providing customer/supplier with information on environmental friendly products and/ or production methods.	SC15
	Commitment to periodical environmental auditing to 2nd tier supplier	SC16
Green Performance (GP)	Restrict and prohibit use of hazardous substances	SC17
	Optimization of energy efficiency/consumption	SC18
	Use of alternative sources of energy	SC19
	Optimization of processes to reduce solid wastes	SC20
	Optimization of processes to reduce water waste disposal	SC21
	Optimization of processes to reduce water use	SC22
	Optimization of processes to reduce air emissions	SC23
	Remanufacturing/rebuild/reuse of product	SC24

4.2 STEP 2: Element of critical success factor in GSCM (HOWs)

The second room in HOQ represent the company requirement (technical requirement or also called as measurable requirements); which mean HOWs company take part in order to achieve the implementation of GSCM (critical success factor). The element of success factor has been summarizing base on semi-structured interview and observation in four composite manufacturing industries. Table 2 shows the list of element of critical success factor.

Based on structured interview between four composite companies the data has been summarized. It shows the relevance between purchasing activities with success factor in order to achieve the GSCM. There are four elements of success factor that strongly related with each of purchasing activities; which is ensure training needs are identified and records of who has been

trained in which topics (SF5); ensure workers commitment (SF9); Employee training / employee involvement (SF10); and Top management commitment (SF12).

Table 2
The list of element of critical success factor

Element of Critical Success Factor	Abbreviations
Identification of customer needs/customer focus	SF1
Defining production / operations procedures to ensure greater efficiency	SF2
Ensuring that staff are issued correct versions of documentation needed to perform task	SF3
Ensure identity of preferred suppliers and a system that been used	SF4
Ensure training needs are identified and records of who has been trained in which topics	SF5
Ensure customer complaints are properly addressed	SF6
Ensure minimization and commitment to remove non-conformities	SF7
Identification of courses for non-conformity	SF8
Ensure workers commitment	SF9
Employee training / employee involvement	SF10
Benchmarking	SF11
Top management commitment	SF12

These four elements play an important role in order to ensure the purchasing activities give an effective implementation to the company. Commitment from both management and employees is required in ensuring all task given is carried out smoothly and efficiently. This sentence has been supported by [17] study that stated; top management commitment and workers' commitment give a greater impact in each of purchasing activities. Factor that implementation of workers training and a training record give an advantages to the companies in order to create a dedicated and knowledgeable employee, hence it ensure give a positive impact to each of purchasing activities. Therefore, the workers training will give a value added to the companies.

Based on four purchasing activities; purchasing process has a strong relevancy to the element of success factor. Where 11 out of 12 element of success factor influence the effectiveness of purchasing process to ensure the process run smoothly and successfully give a value added to company. Purchasing process always related to the other activities in purchasing such as supplier selection, supplier performance and approval supplier list to ensure the effectiveness of purchasing activities and give the better impact to the company's performance.

The relevancy between purchasing activities and critical success factor give and impact in implementation of GSCM, as stated by the Mahmood [18] the analysis of GSCM implementation in manufacturers industry is covering the category such as element of success factor and criteria of green supplier. The research done by [19-21] found that the research that included these categories can provide a general overview of the implementation of GSCM. Hence to implement the GSCM, the author was identified the relationship between element of success factor with criteria of green supplier using QFD method to analyze the data and determine the level of relationship between these two categories of GSCM implementation.

4.3 STEP 3: Relationship Matrix between WHATs and HOWs

For this third room; develop the nature of relationship between WHATs and HOWs in the planning matrix (relationship matrix). In the relationship matrix this is the intersection of the WHATs row and the HOWs column. Depending on the degree of contribution for the element of success

factor towards achieving the criteria of GSCM; the relationship between WHATs and a HOWs is be categorized as “strong”, “medium”, “weak or no” relationship value to each specific WHATs and HOWs pairing. For this an appropriate scale is three (9-3-1); which mean 9 represent strong relationship, 3 represent medium relationship and 1 represent weak relationship is applied. In the relationship matrix; the illustrated using symbols ○(9), □(3), and △ (1).

This stage is one of the key elements of the QFD method because it is the one which permits the transition to be made between what the criteria of GSCM and element of success factor in GSCM. In determining the strength of the relationships between HOWs and WHATs, the judgment is to be based on the extent to which the element of success factor can impact the criteria of GSCM. Table 3 until Table 5 show the relationship between WHATs and HOWs, based on three categories of main criteria.

Table 3
Relationship matrix between Green Competencies and element of success factor

	SFs (HOWs)		SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8	SF9	SF10	SF11	SF12
	SCs (WHATs)													
Green Competencies (GC) (0.333)	SC1	0.069	○		□	○		□	□	□		□	○	○
	SC2	0.089	○	□		△	□				□	○	○	○
	SC3	0.016	○		□	○	△	△	△	△	△		□	□
	SC4	0.029	□	○		○	○				△	□		
	SC5	0.066	□	□							○	□		□
	SC6	0.035	○	○	△	□	□				□	○	○	○
	SC7	0.014	△	□	○						□	□		○
	SC8	0.007	△		□	○							○	○
	SC9	0.007	△		○			○	○	○			○	□

From Table 3, the analysis shows the strong relationships between SF12 (top management commitment) with sub-criteria of GC such as SC1, SC2, SC5, SC6, SC7, and SC8. The hypothesis can be made:

i. In order to achieve the successful of GC criteria in GSCM; the top management must give full commitment.
ii. GC sub-criteria are focusing more on operational activities of GSCM that related to the top management in the company, such as green consideration in design and environmental-friendly packaging

The second strong relationship is between SF1 (identified customers focus) and sub-criteria of GC such as SC1, SC2, SC3 and SC6. Based on current environmental situation, customer becomes more awareness in choosing the environmental friendly product. Therefore, identified the customers focus or need have higher relationship in sub-criteria of GC such as environment-friendly raw materials (SC1), green consideration in design (SC2), taking environmental criteria into all consideration (SC3), and environmental-friendly packaging (SC6).

The analysis shows the relationship matrix between Environmental Management System (EMS) and success factor in Table 4. Based on the analysis the author defined that the strongest relationship between SF1 and EMS sub-criteria. The two summarizes can be made in this relationship matrix analysis:

i. Six out of seven sub-criteria have strong relationship with identification of customer needs/customer focus; this is because the customer trends now are more aware of the environment in buying the product. Therefore, a customer need was affect the attributes of the product including the value and cost can give a positive result of investments in the GSCM.
ii. The EMS criteria give a better environmental performance to the companies; therefore, the EMS criteria must in line with the customer need to achieve the strong performance of GSCM.

Table 4
Relationship matrix between Environmental Management System and element of success factor

	SFs (HOWs)		SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8	SF9	SF10	SF11	SF12
	SCs (WHATs)													
Environmental Management System (EMS)(0.333)	SC10	0.112	●	●	●	●	●	●	●	●	■	■		●
	SC11	0.085	●	■	■	●	■	▲	▲	▲	■			●
	SC12	0.012	●		■	●							●	▲
	SC13	0.046		●	●	■	●				●	●		●
	SC14	0.029	●	▲		■	■							
	SC15	0.019	●	●	■	■					▲			■
	SC16	0.029	●	●	●	●	●	●	●	●			▲	■

The second strongest in relationship matrix between EMS is SF4 (ensure identity of preferred suppliers and a system that been used). The identity of supplier and system that been used is the important thing in ensure the successful of implementation of GSCM. Identity of supplier can be defined as the overall information about the supplier and the system used, such as certification of environment ISO14001 (SC10), government regulatory compliance (SC11), eco-labelling system (SC12), and commitment to periodical environmental auditing to 2nd tier supplier (SC16).

The third analysis of relationship matrix is between Green Performance (GP) and element of success factor. As referred to Table 5, there are two element of success factor that have strong relationships with the GP criteria; which is SF12 (top management commitment) and SF2 (defining production / operations procedures to ensure greater efficiency). This two-success factor gives the critical impact on GP criteria of GSCM such as:

i. The efficient of Top Management system is able to bring a massive change to green performance in company.
ii. The company need to be sensitive with the changes of current situation (more focusing on environmental problem) and maximizing production operations with the application of green performance as the agent in the continuous improvement activities.

	SFs (HOWs)											
			SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8	SF9	SF10	SF11	SF12
	SCs (WHATs)													
Green Performance (GP) (0.333)	SC17	0.041	●								■		●	●
	SC18	0.028	●	●		●					●			●
	SC19	0.007	■	▲		●					▲		●	●
	SC20	0.058	▲	●		■	●				■	■		●
	SC21	0.087	▲	●		■	●				■	■		●
	SC22	0.017	▲	●		■	●				■	■		●
	SC23	0.037	▲	●		■	●				■	■		●
	SC24	0.063	●	▲		●					▲			●

Table 5
Relationship between Green Performance and element of success factor

4.4 STEP 4: Technical important rating

The technical important rating room is used to evaluate the HOWs ratings. These are the combination of the degree of priority for the company requirement (HOWs room) and the strength of the relationship between the criteria of GSCM and element of success factor. The technical important ratings are expressed in two ways in the planning matrix; which is Actual value (Eq. 1) and Relative value (Eq. 2).

$$Actual\ value\ of\ importance\ rating =$$

$$= \sum [(Weightage\ of\ WHAT's) \times (Strength\ of\ WHAT'\ vs.\ HOW's)] \quad (1)$$

$$Relative\ value\ of\ importance\ rating =$$

$$\frac{= Actual\ value\ of\ importance\ rating}{Total\ value\ of\ importance\ rating} \times 100 \quad (2)$$

The actual value is the numerical value calculated using the formula and it does not have any significant as far as indicating the degree or importance of the HOWs. Thus the relative values will be used in determining to what degree of importance each of the HOWs has. Table 6 summarizes the technical importance rating between WHATs and HOWs. The HOWs element will be ranked after getting the value of relative importance of HOWs.

The rank scale is based on 5-4-3-2-1 is been used, where 5 represent the most importance option and 1 the least important. The need to introduce the rank at this stage is necessary as not all of the HOWs are deployed, whereas the value for the Actual values and the relative important are calculated for all the option. Rank value is used as it gives more meaningful degree of relative importance of the HOWs, as compared to percentage of the relative importance. The formula to determine the Rank is given in Eq. 3:

$$Rank = (Value\ of\ relative\ importance \times 5) / maximum\ value\ of\ relative\ importance \quad (3)$$

The sample of calculation SF6 for Actual importance, relative importance and rank:

$$\begin{aligned} Actual\ importance &= \sum[(0.069 * 3) + (0.007 * 9) + (0.112 * 9) + (0.085 * 1) + \\ (0.029 * 9)] &= 1.624 \\ Relative\ importance &= (1.624 / 54.906)\ x100 \\ &= 0.03\ x100 \\ &= 3 \\ Rank &= (3 * 5)/16 \\ &= 1\ \# \end{aligned}$$

The result for all calculation of actual importance, relative importance and rank shown in Table 6. Based on the Table 6, it shows that the five elements of success factors have the highest relative importance; which are SF12 (top management commitment), SF9 (ensure workers commitment), SF1 (Identification of customer needs/customer focus), and SF4 (ensure identity of preferred suppliers and a system that been used). It can be concluded that the four elements provide have a big impact on the criteria for development of GSCM. This strong relationship between criteria of green supplier and element of success factor can ensure the successful of implementation of GSCM into industrial sector in Malaysia.

Table 6
Summary of actual importance, relative importance and rank

	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8	SF9	SF10	SF11	SF12
Actual importance	6.176	5.334	3.496	6.097	5.449	1.624	1.624	1.624	7.985	2.997	3.451	9.049
Relative importance	11	10	6	11	10	3	3	3	15	5	6	16
Rank	3	3	2	3	3	1	1	1	5	2	2	5

5. Conclusions

This paper discusses the analysis on criteria of GSCM to identify the weightage of each criteria listed using QFD tools. The analysis of QFD is to solve complex problem based on decision-making. Based on the higher weightage of each criteria; a rank have been determined to see the high requirement in order to select the green supplier for GSCM. The criteria of implementation of ISO 14001 have higher rankings compare to other criteria. It shows that ISO 14001 as a main requirement for choosing the green supplier. These findings also have identified that the successful implementation of GSCM has a relevancy between purchasing activities and element of success factor. There are 12 elements of success factor based on literature review has been chosen as structured interview question that resulting the commitment of workers and top management as a highly needed in ensure the successful implementation of GSCM in company. The QFD tools used to analyse the relationship between these two main factors; Criteria of GSCM and element of success factor that contributes to the successful of GSCM implementation. Based on the result the authors summarized that these two main factors have strong relationship. The authors then developed one checklist of GSCM based on this research as a guide and referencing for other companies in Malaysia for selecting and implementing the GSCM concept.

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References

[1] Stefan Schrettle, Andreas Hinz, Maike Scherrer -Rathje and Thomas Friedli, "Turning Sustainability into Action: Explaining Firms' Sustainability Efforts and Their Impact on Firm Performance," *International Journal of Production Economics* 147, no. PA (2014): 73–84.

[2] Constantin Blome, Daniel Hollos and Antony Paulraj, "Green Procurement and Green Supplier Development: Antecedents and Effects on Supplier Performance," *International Journal of Production Research* 52, no.1 (2014): 32-49.

[3] Annonymous. "Applying Samsung's Innovative Spirit to Eco-Friendly Product Design," *Samsung Newsroom,* June 2017, https://news.samsung.com/global/applying-samsungs-innovative-spirit-to-eco-friendly-product-design

[4] Behnam Fahimnia, Joseph Sarkis and Hoda Davarzani, "Green Supply Chain Management: A Review and Bibliometric Analysis," *International Journal of Production Economics* 162, no. C (2015): 101-114.

[5] Meow Yee Foo, Kanagi Kanapathy, Suhaiza Zailani and Mohd Rizaimy Shaharudin, "Green Purchasing Capabilities, Practices and Institutional Pressure," *Management of Environmental Quality* 30, no. 5(2019): 1171-1189.

[6] Mohammad Shamsuddoha, "Integrated Supply Chain Model for Sustainable Manufacturing: A System Dynamics Approach", in *Sustaining Competitive Advantage Via Business Intelligence, Knowledge Management, and System Dynamics* (Advances in Business Marketing and Purchasing, Vol. 22B), ed. Mohammed Quaddus and Arch G. Woodside (Bingley, UK: Emerald Publishing Limited, 2015), 155-399.

[7] Rakesh Kumar Malviya and Ravi Kant, "Green Supply Chain Management (GSCM): A Structured Literature Review and Research Implications", *Benchmarking: An International Journal* 22, no. 7 (2015): 1360-1394.

[8] Christelle Morin, Anne Loppinet-Serani, François Cansell and Cyril Aymonier,"Near-And Supercritical Solvolysis of Carbon Fibre Reinforced Polymers (CFRPs) for Recycling Carbon Fibers as a Valuable Resource: State of the Art," *Journal of Supercritical Fluids* 66, no.1 (2012): 232–240.

[9] Abdul Munaf Shaik, VVS Kesava Rao and Ch Srinivasa Rao, "Development of Modular Manufacturing Systems—A Review." *The International Journal of Advanced Manufacturing Technology* 76, no.5-8 (2014): 789–802.

[10] Sekar Vinodh and Suresh Kumar Chintha, "Application of Fuzzy QFD for Enabling Agility in a Manufacturing Organization: A Case Study," *The TQM Journal* 23, no.3 (2011): 343–357.

[11] Ming Li, Lei Jina and Jun Wang, "A New MCDM Method Combining QFD with TOPSIS for Knowledge Management System Selection from the User's Perspective In Intuitionistic Fuzzy Environment." *Applied Soft Computing Journal* 21, no. 1 (2014): 28–37.

[12] Gülçin Büyüközkan and Çigdem Berkol, "Designing a Sustainable Supply Chain Using an Integrated Analytic Network Process and Goal Programming Approach in Quality Function Deployment," *Expert Systems with Applications* 38, no. 11 (2011): 13731–13748.

[13] Hendry Raharjo, Aarnout Brombacher and Min Xie, "Dealing with Subjectivity in Early Product Design Phase: A Systematic Approach to Exploit Quality Function Deployment Potentials," *Computers and Industrial Engineering* 55, no. 1 (2008): 253–278.

[14] Ashok Kumar, Jiju Antony and Tej S. Dhakar, "Integrating Quality Function Deployment and Benchmarking to Achieve Greater Profitability," *Benchmarking: An International Journal* 13, no. 3 (2006): 290–310.

[15] Yoji Akao and Glenn H. Mazur, "The Leading Edge in QFD: Past, Present and Future," *International Journal of Quality and Reliability Management* 20, no.1 (2003): 20–35.

[16] Ilke Bereketli and Mujde Erol Genevois, "An Integrated QFDE Approach for Identifying Improvement Strategies in Sustainable Product Development," *Journal of Cleaner Production* 54, no. 1 (2013): 188–198.

[17] Ram Narasimhan, Srinivas Talluri and David Mendez, "Supplier Evaluation and Rationalization via Data Envelopment Analysis : An Empirical Examination," *The Journal of Supply Chain Management* 37, no. 2 (2001): 28–37.

[18] Wan Hasrulnizzam Wan Mahmood, Mohd Nizam Ab Rahman and Baba Md Deros, "A Comparative Analysis of Supplier Performance Measures for Malaysian Aero Composite Manufacturing Companies: Case Study," In *Green and Energy Management,* (2011): 1–7.

[19] Purba Rao, "Greening the Supply Chain: A New Initiative in South East Asia," *International Journal of Operations and Production Management* 22, no. 6 (2002): 632–655.

[20] Qinghua Zhu and Joseph Sarkis, "Relationships between Operational Practices and Performance Among Early Adopters of Green Supply Chain Management Practices in Chinese Manufacturing Enterprises," *Journal of Operations Management* 22, no. 3 (2004): 265–289.

[21] Qinghua Zhu and Joseph Sarkis, "An Inter-Sectoral Comparison of Green Supply Chain Management in China: Drivers and Practices," *Journal of Cleaner Production* 14, no.5 (2006): 472–486.