



SUPPLY CHAIN SUSTAINABILITY: METHODOLOGY OF DEVELOPING THE SCORE METRICS

Mohd Faiz Mokhtar, Badrul Omar, Nik Hisyamudin Muhd Nor and Wan Azlinda Wan Mohamed
Faculty of Mechanical and Manufacturing, University of Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, Johor, Malaysia
E-Mail: hd120141@siswa.uthm.edu.my

ABSTRACT

In this paper, a framework was developed which will support the development of score metric for supply chain sustainability in design phase. The framework will be used to consolidate the information of sustainability issues involving environmental, social and economic by integrating the design stage and supply chain activities. A list of the current sustainability issues in supply chain, from 2014, will be extracted from five companies namely Apple, Panasonic, Sime Darby, IKEA and Sony. Hence, the current sustainable issue was identified and the proposed framework developed will guide the development of a score metric for sustainable supply chain in the design phase.

Keywords: supply chain, design phase, sustainability, score metric.

INTRODUCTION

The product development process moves very rapidly nowadays and hence new tools and techniques are needed to enhance this process. The tools and techniques were developed in order to meet customer and technical requirements. Through this, the product time to market can be further reduced by not sacrificing the quality of the product.

Currently, sustainability becomes the issue that may affect the cost and time needed in product development especially in the operational stage. Sustainability calls for three pillars which are profit, planet and people, which is also known as the triple bottom line (TBL). The environmental, social and economics are the TBL issues.

Supply chain is one of the process in the development of new product. It involves partners such as supplier, manufacturer, distributor, retailer and customer. In order to develop a new product, the design stage play an important role to make sure it can be considered in any other stages in product lifecycle. As supply chain generate the systematic flow of product lifecycle, it needs some effort in the design stage by introducing a new type of assessment so that it can be use to satisfy the whole process of supply chain to manage to optimise the cost and time needed.

Environmental issues are obviously important for human life especially for the future generation. Because of that, engineering activities totally need to work simultaneously with prevention/reduction of negative effect on ecosystem. This effort is the responsibility of everyone involved in product development starting from pre-manufacturing, manufacturing, product in-use and product recovery stages. In this case, the effect on the environment from these activities must be considered and kept in mind.

Through the process of supply chain the information flow can be managed in the best way in order to connect the various stages involved in product development. This paper will discuss further about specific factors of sustainability effect on supply chain.

Next, the methodology framework of developing the score metric for sustainability supply chain will be proposed.

PRODUCT DESIGN AND SUPPLY CHAIN SUSTAINABILITY

Product Lifecycle Management (PLM) is the process involving the various types of stages. In this context, the process provides the product flow from stage to stage. Through various stages, the information management is most important part to connect the strategy and operation in order to produce product which satisfy the customer needs. Product design, manufacturing process and supply chain activities must be link in similar direction so that the capabilities and the competencies can be flexible, advance process technologies and collaborative supplier practices (Marsillac AND Roh 2014).

In order to achieve that, the alignment product design with supply chain performance must be improved so that it can be responsive (Khan *et al.* 2012). In design stage, there are many design tools which are not only capable to do the design work but can also be used to define the further stages of product lifecycle including manufacturing, logistic, product in-use and product recovery. Because of that, there are a lot of interest in developing new tools which can help the designer in order to consider/identify some aspect of product chain. The tools developed can be used to reduce the cost of production with the time-to-market can be minimize and the product quality can be remain.

Day by day, the request for product in the market increase inline with the increase of users/consumers. This make the industry players compete rigorously with different types of techniques and systems. Industry must adapt in these situation so that the demand by users/consumers can be met.

Design stage

Design stage can provide a lot of data about the product development. This is because the process in this stage will consider a lot of information which will give an



important review about the real product. Supply chain is an important role in product lifecycle because it gives a lot of impact especially to the issue of sustainable.

Design for product lifecycle is the technique used to reduce environmental loads, resource consumption and waste generation while increasing living standards and corporate profits (Fukushige *et al.* 2012). The design of product lifecycle includes the steps of modeling the lifecycle itself, evaluating it from various viewpoints and pinpointing solutions to optimize the lifecycle as a whole (Alting and Jørgensen 1993).

There are some researchers involved in this current field which focuses on the lifecycle strategy planning. The techniques of analysis such as QFD, LCA, Evaluating EOL recovery profit and so on which aims to get the best information of product, process and supply chain for product lifecycle in the design stage. Most of the method use in certain parameters involving application in specific product or material but there are still lacking in the use the idea of basic framework.

Many model of knowledge managements have been introduced. Some of the models already applied successfully in the industries and gives a lot of benefit in term of profit, process, management, time and information flow. But there is still a lack of models used to analyze the sustainable issue involving all 3 pillars that may be effect the cost, time and quality of product during the design stage. This is significant in order to develop metrics which can use to identify the best design with consideration on the issue of sustainability.

Through this work, the information will be synchronized to get the best/optimum design which provide the quality of the product with minimal cost and time needed by considering the the effect of sustainability issues in the supply chain.

Total design

Stewart Pugh () introduced one of prescriptive design model namely the total design. Total design is the model that involves the five main stages starting from market research and ends with the customer. As with most other systematic design process, these models involve the multi-disciplinary effort, which will link to the various stages.

Total Design is the integrator between the academia and industry in complex design model because it goes far beyond those supported by the more traditional monolithic model, whether in industry or academia (Finke *et al.* 1992). This design model get the information from the market to sales, is an iterative one and recourse can be made in any of earlier stages, as new ideas and information emerge (Evbuomwan *et al.* 1996).

With current methods and tools in product development process, this design model has the capability to improve in design decision making for the further stages of product chain. In order to reach to these aims, the direction of product development must be interconnected which the design activity considers the product lifecycle including the pre-manufacturing, manufacturing, in-use and product end-of-life.

Product specification is one of the stage in total design design model. Using this model, the real phases of design start after identifying the product design specification (PDS). PDS use to provide the characteristic of the specific elements of the product. Through this stage, the properties of the product will be list so that it can be use to describe the early design model either in technical or customer need perspectives.

Current sustainability issues in supply chain

International companies were concerned about sustainability issues that can be effect the people and planet. Because of that, the interest of understanding about sustainability increases and it is related to the aim for reducing the cost, time and improve the product quality. Supply chain is involved in a lot in are in product operation and the sustainability issue is often a big part in meeting these aims. With that, most companies organize annual meeting to discuss sustainability issues. Figure 1 shows the current sustainable issue on supply chain base on the annual report release by five major companies namely Apple, Panasonic, Sime Darby, IKEA and Sony.

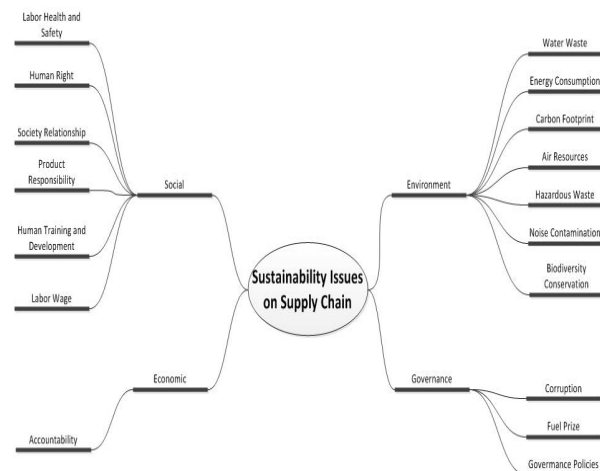


Figure-1. Current sustainable issue on supply chain.

Panasonic concentrate on ISO26000 Social Responsibility and put the issues of human rights, labor practices, environment, fair operating practices, consumer issues and community. SONY in their Corporate Social Responsibility (CSR) report stated agendas on corporate governance, compliance, human resources, responsible sourcing, quality and services, community and Environment. Based on this two reports, they have similar issues on the environment, which focus on effort to reduce CO² output, energy saving, global warming prevention, recovery resources, water resource conservation, biodiversity conservation and chemical substances management.

Apple in their Supplier Responsibility 2014 Progress Report highlight some issues involving educating and empowering workers, labor and human rights, health and safety, accountability and environment. IKEA Group Sustainability Report talks about engaging people



involving customers and co-workers, resource and energy independence, supporting human rights and the governance and ethics including the public policy. Sime Darby Plantations reported in their 2014 sustainability report mostly on palm oil sustainability. Here they try to consider the sustainability in the best way related on the values, ethics and governance, caring for our people, caring for our environment, caring for our future and assuring our practices.

Besides there are some current issues contributing on the issue of sustainability especially in governance aspect. With the fuel global prices seems unstable, the cause and effect need to be handled by all countries around the world. Some of the countries face this situation by introduced policy which can give positive or negative effect on company operation. Corruption is not a new problem in the world. This issue is common happened in most country but the difference is how serious and what method to control/curb it.

Company implementation to encounter the current issue of sustainability

Large company tackle sustainability issue by making their product friendly and the same time creating solution involving the environment, social and economic aspects. The idea is to make all the sustainability issues as public entities so that all these issues to be a responsibility to these companies.

As all these issues are from the huge company, their main aim are similar which to increase their profit every year. To maintain the trend, these companies need to identify the aspect that can contribute by optimizing the issue effected on environment, social and economic.

Environmental issues must need to be a priority of responsibility since this is the main contributing factor in sustainability from policies of governance or world organisation. All companies which directly involve in the industry including manufacturer, supplier, retailer or logistic must be aware with all current policies.

All companies involved by selling their product also need to distribute the information about sustainability which can also contribute for increasing profit. This can be done by organizing the training or workshop as to ensure all these involved are aware about issue of sustainable supply chain.

Literature of sustainable supply chain

The growing numbers of sustainability issues bring the integration between stages in product chain. Early design stages of product development process are targeted by most researchers to improve decision making. This situation provides a real challenge to improve the design activity in order to generate new idea/tools to predict further stages. As it needs to be competitive, the objectives are to reduce cost and time-to-markets, improve the quality and to be innovative (Gehin *et al.* 2008).

In recent years, there are increasing issues involve in sustainability supply chain. Anggapa Gunasekaran with his team publish various paper in this issue including: ((Ageron *et al.* 2012), (Gunasekaran and

Spalanzani 2012), (Ji *et al.* 2014), (Gunasekaran *et al.* 2015)). Robert D. Klassen also is the person directly involve in social and environment sustainability by publish some paper including (Klassen AND Vereecke 2012), (Gavronski *et al.* 2012), (Lee *et al.* 2014).

In the other hand, Suhaiza Zailani (Zailani *et al.* 2012) provides proof of the effect of sustainable supply chain performance using 400 survey on manufacturing firm in Malaysia based on environmental purchasing and sustainable packaging. Because of that, it is important to determine the intersection of sustainability, environmental management and supply chain while contributing on the environmental operations and policy, strategy, finance, product design, supplier relation and post-consumer product management (Linton *et al.* 2007).

Proposed framework for developing the score metric

Designs usually produce a lot of solution in product development process. When the design idea /solution converge, the design process becoming more complex to ensure the quality of product. Figure 2 shows the project flow of developing the score metrics based on sustainability supply chain in design phase. With the objective to integrate the design process and sustainable supply chain, this work concentrates on any area related to the two fields.

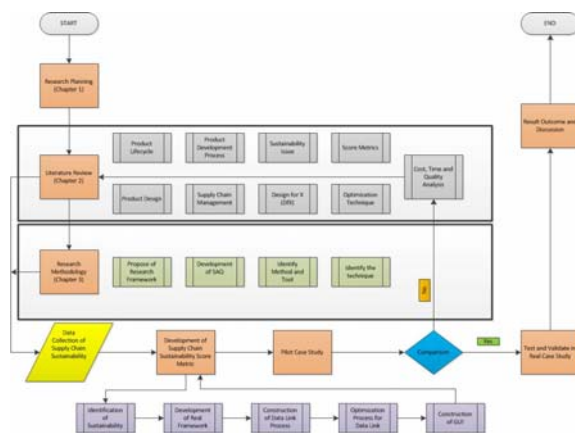


Figure-2. Project flow of developing the score metrics based on sustainability supply chain in design phase.

Research methodology will suggest the strategy of this work based on previous literatures. In this stage, the self-assessment questionnaire (SAQ) develops as a tool to collect the data about sustainable supply chain from industries. The method that can be used in this project is lifecycle assessment (LCA) which will be used from the early product development until product recovery. Quality function deployment (QFD) will be used in design stages to identify the requirement of product technical, customer and sustainability. To integrate sustainable supply chain, QFD approach will be used as it is the common tool for environmentally conscious design process (Büyüközkan & Berkol 2011).



Bullwhip effect is the inherent increase in demand fluctuation up the supply chain and produces excess inventory and poor customer service (Buchmeister *et al.* 2014). This effect will be look specifically and will involve the stages of manufacturing to customer. Design for Manufacturing (DfM), design for Environment (DfE), Design for Lifecycle (DfLf), Design for Customer (DfC), Design for Logistics (DfLc) will be consider in design stages. All this tools will help the design process to identify and manage the sustainable issue in supply chain activity.

All data collection then will be used to develop the score metrics by managing design criteria and sustainable supply chain into formula algorithm using Microsoft Excel. The system develop will be tested on the real product development process as case studies. Next, this system will be adding optimization technique (Artificial Neural Network and Artificial Bee Colony) before it will be tested again to real product development process. The results finally will be compare based on quality, cost and time taken.

CONCLUSIONS

In order to realise the effort of sustainable supply chain in early design stage, the complete methodology must be planned to drive this project. With the proliferation of large industries around the world, the competition of producing new product into the market also increases. The various method introduced in recent time so that it can help to reduce the time and cost of developing product also to improve the quality.

In this paper, the current sustainable issues of supply chain listed were identified from 2014 Corporate Sustainability Report from five companies. This proposed framework next hopefully will be the guidance for moving to further stages which to develop new thinking of the product development especially in the early design stage by evaluating the impact of the sustainability for the supply chain.

It is expected the approach will provide the new insight towards the correlation between the design process to the score metrics of sustainability which would be useful for future designer and researcher. It will also provide an optimum technique to the designer in order to predict sustainable supply chain at the early stages of product development.

ACKNOWLEDGEMENT

This work is supported by Research Grant Scheme VOT E024 under Ministry of Education, Malaysia.

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