TOWARDS AN IMPLEMENTATION OF SUSTAINABLE SUPPLY CHAIN MANAGEMENT (SSCM) ASSESSMENT FRAMEWORK AND FUTURE RESEARCH DIRECTION

[1]Salinee SANTITEERAKUL, [2]Aicha SEKHARI, [1]Apichat SOPADANG, [2]Yacine OUZROUT, [1]Sermkiat JOMJUNYONG

[1]Department of Industrial Engineering, Faculty of Engineering, Chiang Mai University

[2]DISP-lab (Decision & Information Systems for Production systems), University Lumiere Lyon2

Introduction

Sustainable development is of growing importance to the industrial sector because the current exploitation and lacking affection of resources use, together with the pollution generated cannot continue at present rates. Moreover, the negative social impacts are increasing because of the industrial operations. The development of sustainability performance measurement demonstrates a significant contribution to enhance and implement sustainable development and exhibits a way to manage sustainability in supply chain.

An effective of method for sustainable performance assessment with emphasis on sSCM subjects has been developed in the previous work (Santiteerakul et al., 2015). Managers related industries can use the purpose model to construct the sustainability measurement model. Based on the implementation of a sustainable supplier evaluation, companies identify and prioritize opportunities for improvement which may lead to the reduction of impacts of environmental and social impacts that are associated with their activities. Furthermore, the results from proposed approach can be used for benchmarking, to improve sustainability performance and to develop better sustainable processes. In order to implement the proposed conceptual framework and the model construction method in a practical situation. This work implements the sSCM assessment framework to develop the sustainability performance measurement model into 3 case studies, i.e. one case in the electronics industry and two cases in the agriculture industry.

Literature Review on sSCM Performance Measurement Model

While the social and the environmental are clearly associated in the sustainable development context, there is very little research addressing the social dimension. A comprehensive literature review on SSCM identified that out of 191 papers, 140 addressed the environmental dimension while only 20 addressed the social dimension (Seuring, 2008). Hence, the literatures which consider at least two sustainability dimensions will be reviewed in this section.

Similarly, with the classification criteria from traditional supply chain, two aspects which are component of measures and component in supply chain are adopted for analyzing sustainability metrics. In traditional SCM, the component of measures focus only economic dimension. Meanwhile component of measures in sSCM has extended to environmental and social dimension. Most of literatures use the TBL developed by Elkington, (1999) to classified sustainability criteria, as shown in , (Hassini et al., 2012; Veleva and Ellenbecker, 2001; Veleva et al., 2001; Zhu and Sarkis, 2004; Zhu et al., 2012)(Veleva et al. (2001), Veleva and Ellenbecker (2001), Szekely and Knirsch (2005), Hassini et al (2012), Zhu and Sarkis (2004, 2012)). Except Figge et al., (2002) adopted the balanced scorecard (BSC) to classified performance measures in sustainability context by adding environmental and social aspects to business strategy. In addition, they proposed a new perspective called non-market perspective in order to integrate strategically relevant but not market-integrated environmental and social aspects. Indicators in non-market aspect can impact company's performance in all four perspectives of the conventional BSC. For example, indicators relevant to legality or human rights can effect to expenditure of company, employee satisfaction, or customer satisfaction.

Veleva et al. (2001) argued that sustainable production indicators should also include economic and social measures. They also proposed a framework that consists of five levels for categorizing existing indicators relative to the basic principles of sustainability. Their study provided a method of

evaluating a set of indicators that focus on environmental, health and safety aspects of production, and work is underway to expand their method to include social and economic aspects to inform decision-makers and measure progress towards more sustainable production. Furthermore, Veleva and Ellenbecker (2001) presented a set of indicators of sustainable production for promoting business sustainability. They first introduce the concept of sustainable production which includes six dimensions and desirable qualities. Based on that framework, they suggested five stages of core and supplemental indicators for raising the awareness of firms and measuring their progress toward sustainable production systems. The six dimensions are, namely, (1) energy and material use, (2) the natural environment, (3) economic performance, (4) community development and social justice, (5) workers, and (6) products.

Phillis and Davis (2009) proposed a multi-stage fuzzy model to assess a corporation's sustainability. This model consists of two fundamental components: human and ecological. The human component has four inputs: economic, political, knowledge, and welfare. The ecological component has also four inputs: air, water, land and biodiversity. However, this model is used to assess only lagging indicators of corporation's sustainability. It is suitable to monitor historical evolution and compare the company with competitors. But it is not suitable for managing risk or giving improvement actions.

Another aspect is using component in supply chain as a criterion to identify performance metrics. Components in supply chain can be considered by processes, sustainable practices, or partners in SCM. Zhu and Sarkis (2004) developed GSCM practices metrics to measure an extent of adopting GSCM practices in their companies. They collect the data, using survey approach, in 186 respondents of Chinese manufacturing. The respondents were requested to indicate, using a five-point Linkert-type scale, the perceived extent of adopting each of the GSCM practices. They classified the practices into four group based on SC processes which are (1) internal environmental management (2) external GSCM practices (3) investment recovery and (4) eco-design. Then Zhu et al. (2007) has separated the second group (external GSCM practices) into two groups. Hence the new evaluation of GSCM practices are classified into five groups, which are (1) internal environmental management (IEM) (2) green purchasing (GP) (3) customer cooperative (CC), (4) investment recovery (IR) and (5) eco-design (ECO). They studied the adoption of GSCM practices in different industry (Zhu et al., 208), examined the relationship between GSCM practice and GSCM performance (Zhu and Sarkis (2004), Zhu et al. (2007, 2012)). Again a five-point Likert scale was used to determine if associated with their implementation of GSCM practices. The GSCM performance is classified into three groups which are (1) environmental performance (EP), (2) positive economic performance, and (3) operational performance (OP).

Process and partner in supply chain cab be used for classifying performance metrics in sustainable supply chain. Hassini et al (2009) proposed a framework for sSC metrics using TBL principle and supply chain partner (supplier, manufacturer, distributor, retailor, and customer). Moreover, they addressed to use decision level (strategic, tactical, and operational) at the stage of choosing appropriate measures.

In addition to consider performance metric from research works, the metrics from existing tool and guideline are analyzed in this section, which are GreenSCOR and GRI. The GreenSCOR is separated from conventional SCOR in version9.0. This model focuses only environmental dimension and measures environmental impacts in term of carbon emission, air pollutant emission, liquid waste generated, solid waste generated, and percent recycled waste. GRI is a guideline to report company sustainability performance. Performance metrics are classified into six categories: economic, environmental, labor practices and decent work, human rights, society, and product responsibility

The proposed sSCM measurement model

Conceptual Framework

The previous work (Santiteerakul et al., 2015) has developed the framework to measure sustainability performance for sSCM. This framework allows decision makers identifying the sustainability measures based on their interesting area in sustainability criteria. There are eight categories of sustainability criteria in this framework which are financial, non-financial, raw material, natural resources, energy, human health and safety, human resources development, and ethical issues (see Figure 1). The sustainability criteria in this framework have developed based on the concept of

human needs and the TBL concept and have justified by analyze with standards, guide lines, and regulation involving sustainable development perspective.

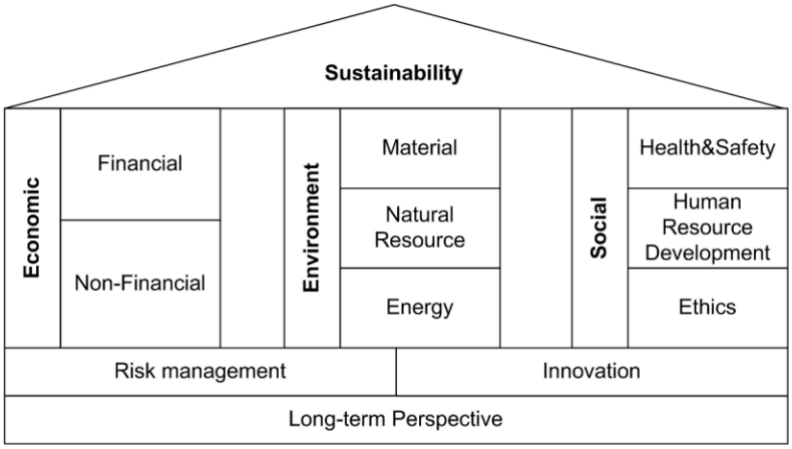

Figure 1 Sustainability Criteria Categorization

In order to measure sustainability performance for supply chain management, it is needed to link the concepts of supply chain and sustainability. The term "supply chain" consists of multiple firms, both upstream and downstream, and the ultimate consumer. Supply chain involves with flows of products, materials, information, and finances from a source to a customer (Mentzer et al., 2001; Santiteerakul et al., 2012). Activities in supply chain concept have to be identified by an engagement level in both upstream and downstream. The engagement divided into three levels, which are company level, supply chain level, and stakeholder level. The engagement level is shown in Figure 2.

- Company level considers activities of owned company which does not engage with any external groups or companies.
- Supply chain level considers activities under taken to create opportunities for negotiation, consultation or simply exchange of information between or among company and its supply chain (suppliers, outsourced companies, customers, users or others). However, the supply chain level consists of three sub-levels which are direct supply chain, extended supply chain, and ultimate supply chain following degrees of supply chain complexity from Mentzer et al., (2001).
- Stakeholder level considers activities under taken to create opportunities for negotiation, consultation or simply exchange of information between or among company and stakeholders. In this work, stakeholder is defined as individual or group that has an interest in any decision or activity of a company including second-tier suppliers, customer's customers, users, and so on. The local communities or the government can be considered as the stakeholders of supply chain.

Moreover, this proposed framework enhances an engagement level of elements in supply chain as an important perspective to identifying the sustainability measures. According to the literature review, the existing process categorization in sSCM focus on primary activities regarding to material flow process but the human resource management and business ethics are supporting (or secondary) activities. Therefore, the processes or activities, which relating to social dimension, are missing in consideration in sSCM. This work enhances the valuable of adopting the value chain model (Porter, 2008) which covers both primary and secondary activities for constructing the sustainability performance measurement model. Hence the value chain model and the process based approach (Chan and Qi, 2003) are adopted for constructing the sustainability measures model. This leads to an implementation of the proposed framework allowing decision makers to measure sustainability performance in any process or activity in the company and its supply chain. In order to implementing the proposed conceptual framework and the model construction method in practical situation, this work has implemented the proposed sSCM model

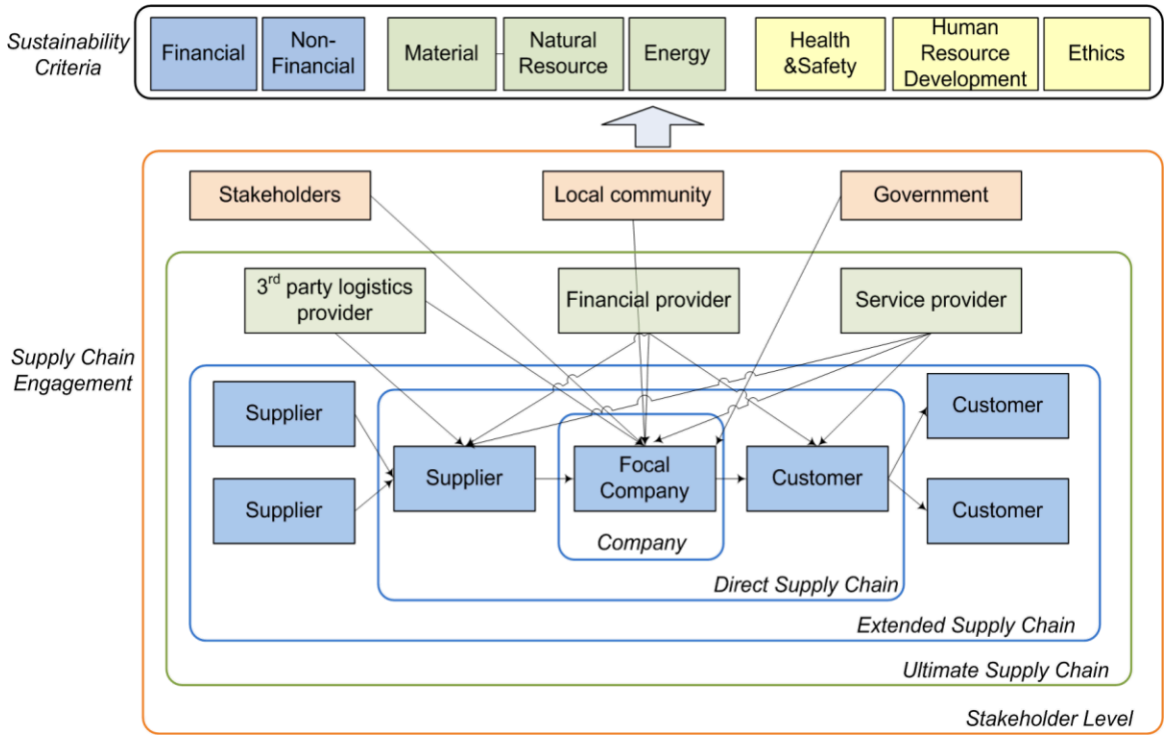

Figure 2 The sSCM assessment framework

Case 1: Supplier evaluation in electronics industry

The hard disk drive (HDD) manufacturer in Thailand aims to motivate suppliers for participating in EICC (Electronics Industry Citizenship Coalition) program. The company needs to measure supplier's sustainability performance integrate their suppliers with their existing supplier performance assessment system for supporting company's decision-making. Until now, the company works with 247 suppliers who produce parts and components for manufacturing HDD. 127 suppliers are located in Thailand, 36 suppliers are located in China, 21 suppliers in Malaysia and 21 suppliers in Singapore respectively.

The procurement manager has developed the supplier' s performance measurement system based on the proposed sSCM assessment framework (Figure 2). The indicators and measures are selected by a brainstorming meeting among the middle management team of the company. The sustainability measurement system consists of three dimensions, 10 indicators, and 25 measures, which are shown in Figure 3.

The performance measurement model development consists of two parts. (1) Determining the priority weight of indicators and measures. The fuzzy AHP (FAHP) is selected to determine the priority weight. In this case, the procurement manager is a decision-maker who identify the weight of indicators. The global priority weight of 25 measures, 10 indicators, and 3 dimensions are shown in Figure 3. (2) Develop the supplier's performance assessment method. After weighting the FAHP model for determining priority weight for alternatives, the decision maker evaluates suppliers in each sustainability measure (level 3) by using the measurement rating scale. All quantitative and qualitative measures are converted to five-level performance rating, which are very poor (VP), poor (P), average (AVG), good (G), and very good (VG).

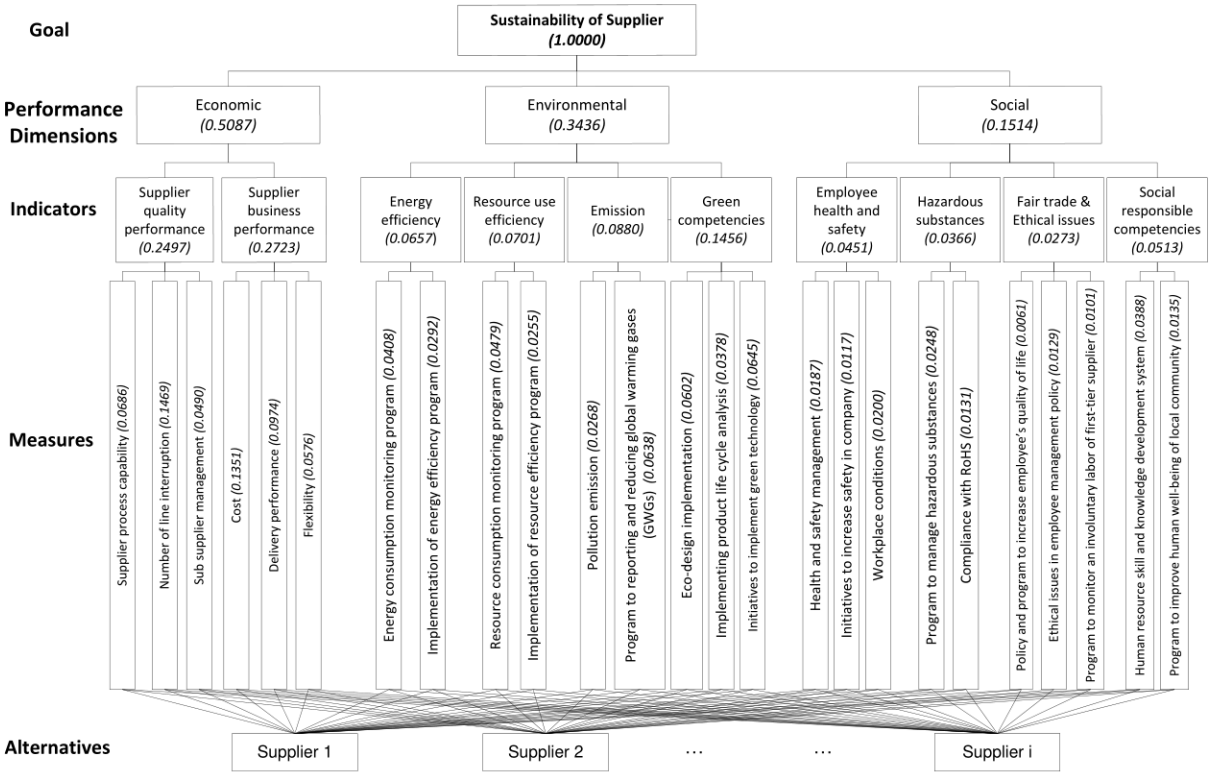

Figure 3 The sustainability indicators and measures of supplier evaluation

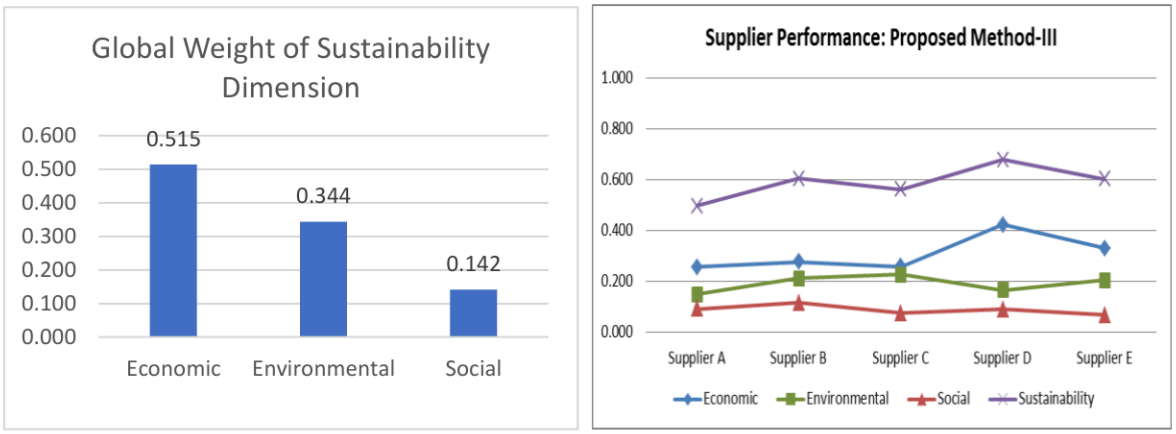

Figure 4 Global weight of sustainability dimension and supplier performance: Electronics

Based on the global priority weight of sustainability measures and the supplier performance rating, the final priority weight of each supplier can be evaluated. The results of overall sustainability performance in each supplier are shown in Figure 4. It can be noted that among five given suppliers, supplier D has the highest sustainability performance followed by supplier B, E, C, and A respectively. Therefore, the sustainability performance ranking among five suppliers is D>B>E>C>A. An analysis of supplier's performance in economic, environmental, and social dimension found that for economic performance, supplier D is the best performance followed by E, C, B, and A respectively. For environmental performance, the best supplier is C, followed by B, E, D, and A respectively. For social performance, the best supplier is B, followed by A, D, C, and E respectively.

Case 2: Sustainable Supply Chain of Organic vegetable

The researchers aim to evaluate the sustainability performance in an organic vegetable supply chain. The developed measurement model measures the sustainability performance of firms in a direct supply chain level, which are the organic farmers, 1st tier supplier, and 1st tier customer (seller or retailer).

There are 3 sets of sustainability indicators and measures to assess the sustainability of supplier, farmer, and seller respectively. All of indicators and measures are identified based on the eight criteria of sSCM framework in Figure 2. There are 15 experts from academic, government, local communities, and enterprise sectors who select and evaluate a suitability of indicators and measures.

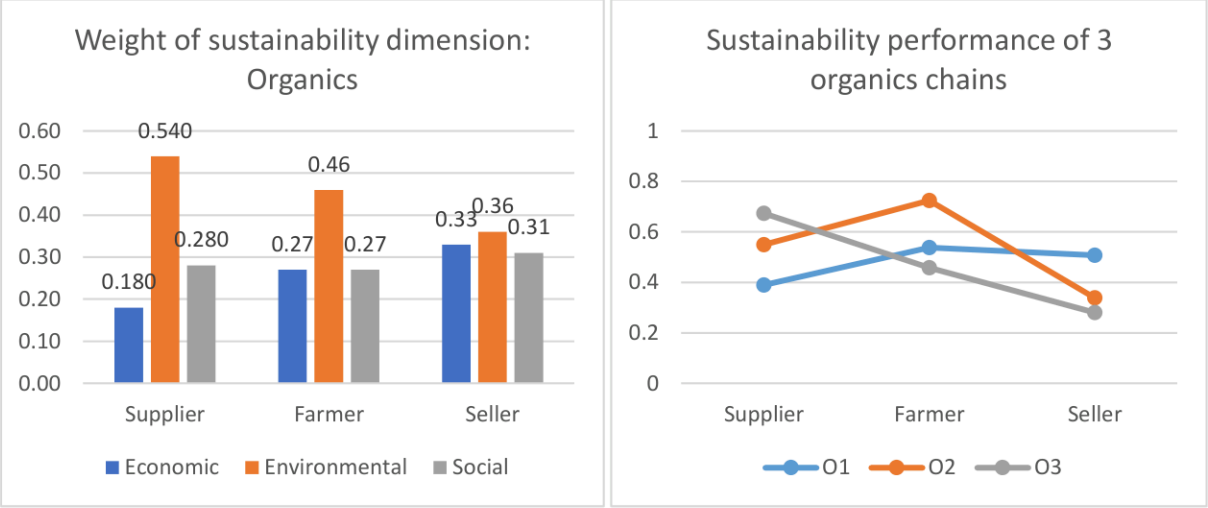

Figure 5 Global weight of sustainability dimension and supply chain performance: Organics

This work obtains 19 measures and 8 indicators for evaluating sustainability of supplier, 20 measures and 8 indicators for evaluating sustainability of organic farmer, and 15 measures and 8 indicators for evaluating sustainability of seller/retailer. The AHP approach is selected to determine the priority weight of indicators and measures by 10 decision makers from academic, government and enterprise sectors. The global priority weight of sustainability dimensions in each element of supply chain are shown in Figure 5. For organic vegetable supply chain, an environmental dimension obtains the most important priority in all elements of supply chain (supplier, farmer, and seller). An economic and social dimension obtain similar important priority in farmer and seller element. An economic dimension obtains the least priority in supplier element.

This model evaluates the sustainability performance of three organic supply chains. This means that 3 organic farms, 3 suppliers, and 3 sellers are evaluated by the proposed model by using TOPSIS. The results of sustainability evaluation are shown in Figure 5.

Case 3 Sustainable Supply Chain of Hydroponic vegetable

The researchers aim to evaluate the sustainability performance in a hydroponics vegetable supply chain. The developed measurement model measures the sustainability performance of firms in a direct supply chain level, which are the organic farmers, 1st tier supplier, and 1st tier customer (seller or retailer). There are 3 sets of sustainability indicators and measures to assess the sustainability of supplier, farmer, and seller respectively. All of indicators and measures are identified based on the eight criteria of sSCM framework in Figure 2. There are 15 experts from academic, government, local communities, and enterprise sectors who select and evaluate a suitability of indicators and measures.

This work obtains 18 measures and 8 indicators for evaluating sustainability of supplier, 20 measures and 8 indicators for evaluating sustainability of organic farmer, and 15 measures and 8 indicators for evaluating sustainability of seller/retailer. The AHP approach is selected to determine the priority weight of indicators and measures by 10 decision makers from academic, government and enterprise sectors. The global priority weight of sustainability dimensions in each element of supply chain are shown in Figure 6. For hydroponics supply chain, all the elements in supply chain (supplier, farmer, and seller) give the most priority to the performance in economic dimension. The raw material supplier gives the priority of environmental dimension more than social dimension. The farmer gives the same priority of environmental dimension as social dimension. The seller gives the priority of social dimension more than environmental dimension.

This model evaluates the sustainability performance of three hydroponic supply chains. This means that 3 organic farms, 3 suppliers, and 3 sellers are evaluated by the proposed model by using TOPSIS. The results of sustainability evaluation are shown in Figure 6.

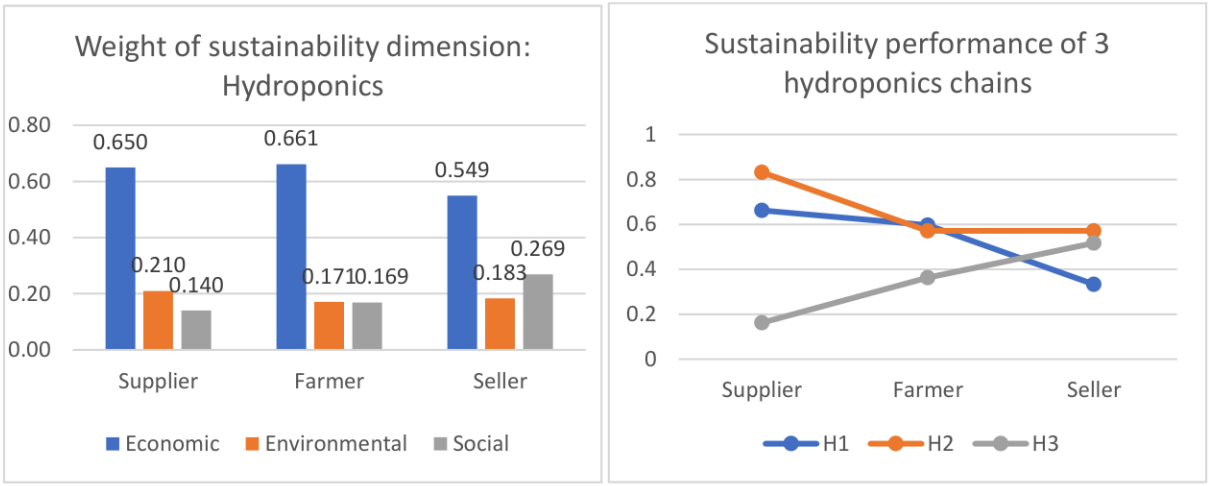

Figure 6 Global weight of sustainability dimension and supply chain performance: Hydroponics

Results of comparative study

The proposed sSCM assessment framework is a generic framework that helping the decision makers construct the sustainability measures model. This approach leads to an implementation of the proposed framework allowing decision makers to measure sustainability performance in any process or activity in the company and its supply chain. In order to implement the proposed conceptual framework and the model construction method in a practical situation. This work implements the sSCM assessment framework to develop the sustainability performance measurement model into 3 case studies, i.e. one case in the electronics industry and two cases in the agriculture industry. The results of comparative issues are shown in Table1. The results show that the proposed framework can implement to construct the sustainability model in a direct supply chain level either the business activities of a company or the firm strategy in a supply chain.

Table 1 Comparative of sSCM assessment implementation of 3 case studies

Comparative issue	Electronics	Organics	Hydroponics
Supply chain engagement level	Direct supply chain	Direct supply chain	Direct supply chain
Business activity	Procurement	Firm's strategy	Firm's strategy
Number of set of indicators and measures	1	3	3
Number of sustainability dimension	3	(3, 3, 3)	(3, 3, 3)
Number of indicators	10	(8, 8, 8)	(8, 8, 8)
Number of measures	25	(19, 20, 15)	(18, 20, 15)
Method to determine priority weight	FAHP	AHP	AHP
Method to evaluate alternative's performance	Criteria rating	TOPSIS	TOPSIS

Note: (x, y, z) represents the number of (supplier, farmer, seller)

Conclusions

There are two aspects for managing sustainability in business i.e. sustainability of product and sustainability of process. This research focuses on the second aspect. Hence, the sustainability

performance measurement model is developed based on process point of view. Moreover, our research work focuses more on strategic and tactical level more that operational level in order to dealing with an implementation of sustainability practices in company and direct supply chain level. An approach to construct sustainability indicators and metrics is based on sustainability in process point of view. In other words, this performance measurement system measures corporate sustainability competitiveness. The proposed approach is not suitable to construct sustainability indicators and metrics for product life cycle assessment or product life cycle management.

The selected sustainability indicators and metrics are specific to implement only in case study company and specific supply chain (organics and hydroponics cases). It means that if other companies/supply chains need to measure sustainability performance of firm or specific activity. They should construct their own performance indicators and metrics. However, the proposed sSCM assessment framework provides a generic approach to construct sustainability indicators and metrics.

Because of the research work on measuring social performance in supply chain is still in the beginning stage. Researchers can adopt the proposed sustainability criteria to enhance key social practices for sSCM in industrial sector.

According to our limitation that this work focuses the sustainability only in process point of view. However, there are various research works that try to measure sustainability of product. This work has proposed well-defined sustainability criteria in industrial sector and it can be adopted as criteria for sustainability of product. The research challenges are how we can adopt these sustainability criteria into the product aspect and how we can integrate these two aspects for considering the sustainability in supply chain at same time.

References

- Chan, F.T.S., Qi, H.J., 2003. An innovative performance measurement method for supply chain management. Supply Chain Manag. Int. J. 8, 209–223. doi:10.1108/13598540310484618
- Elkington, J., 1999. Cannibals with forks: the triple bottom line of 21st century business. Capstone, Oxford.
- Figge, F., Hahn, T., Schaltegger, S., Wagner, M., 2002. The Sustainability Balanced Scorecard – linking sustainability management to business strategy. Bus. Strategy Environ. 11, 269–284. doi:10.1002/bse.339
- Hassini, E., Sutri, C., Searcy, C., 2012. A literature review and a case study of sustainable supply chains with a focus on metrics. Int. J. Prod. Econ. 140, 69–82.
- Mentzer, J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D., Zacharia, Z.G., 2001. Defining Supply Chain Management. J. Bus. Logist. 22, 1–25. doi:10.1002/j.2158-1592.2001.tb00001.x
- Phillis, Y.A., Davis, B.J., 2009. Assessment of Corporate Sustainability via Fuzzy Logic. J. Intell. Robot. Syst. 55, 3–20. doi:10.1007/s10846-008-9289-3
- Santiteerakul, S., Sekhari, A., Bouras, Abdelaziz, Sopadang, A., 2012. Sustainability Indicators for Evaluating Sustainable Supply Chain. Presented at the International Conference on Green and Sustainable Innovation (ICGSI) 2012, Chiang Mai, Thailand, p. 15 p.
- Porter, M.E., 2008. Competitive Advantage: Creating and Sustaining Superior Performance. Simon and Schuster.
- Santiteerakul, S., Sekhari, A., Bouras, A., Sopadang, A, " Sustainability Performance Measurement Framework for Supply Chain Management ", Int. J. Product Development, Vol. 20, No. 3, 2015
- Seuring, S., Müller, M., 2008. From a literature review to a conceptual framework for sustainable supply chain management. J. Clean. Prod. 16, 1699–1710. doi:10.1016/j.jclepro.2008.04.020
- Veleva, V., Ellenbecker, M., 2001. Indicators of sustainable production: framework and methodology. J. Clean. Prod. 9, 519–549. doi:10.1016/S0959-6526(01)00010-5
- Veleva, V., Hart, M., Greiner, T., Crumbley, C., 2001. Indicators of Sustainable Production. J. Clean. Prod. 9, 447–452.

- Zhu, Q., Sarkis, J., 2004. Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. J. Oper. Manag. 22, 265–289. doi:10.1016/j.jom.2004.01.005
- Zhu, Q., Sarkis, J., Lai, K., 2012. Green supply chain management innovation diffusion and its relationship to organizational improvement: An ecological modernization perspective. J. Eng. Technol. Manag. 29, 168–185. doi:10.1016/j.jengtecman.2011.09.012