



Selecting Multiple Criteria Decision Aid for Measuring Sustainability Supply Chain Performance

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Selecting Multiple Criteria Decision Aid for Measuring Sustainability Supply Chain Performance

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Abstract

Sustainability performance in supply chain has been recognized as competitive indicator for business. There are various existing approaches that organizations apply to evaluate their performance on sustainable supply chain management (sSCM). From our previous works, we found that none of existing approaches can solve the criticism of sustainable supply chain performance systems because the complexity of supply chain, complicated analysis methods, and several of involving stakeholders. Hence performance measurement model for evaluating sustainable supply chain should be developed in order to solve the criticism of existing approaches. Because of sustainability assessment needs a set of multidimensional indicators and there are both quantitative and qualitative indices. So multiple criteria decision aid (MCDA) is considered to be a tool for evaluating sustainability for supply chain. This paper aims to analyse and compare characteristics of frequently used MCDA, which proper to measure sustainability performance. The characteristics of sSCM performance measurement model are clarified and preliminary methods are proposed. Moreover, the directions of future research to develop sSCM performance measurement have been enhanced in this paper.

Key words: Multiple criteria decision aid, sustainability supply chain, performance measurement, sustainability criteria

1 Introduction

Measuring sustainability among supply chain has been gaining in popularity for the last two decades. However, criticisms of sustainable supply chain performance measurement systems were made on existing performance measurement approaches such as complicated analysis, implement difficulties, unbalanced between financial and non-financial performance, unrelated with customers or organization's objectives. Existing approaches to evaluate sustainability performance in organization or supply chain are grouped into four groups in our previous work [14] which are:

- 1) Using management system (MS) e.g. ISO MS standards or guidelines, SA8000, Electronic Industry Citizenship Coalition (EICC);
- 2) Using performance measurement system (PMS), which divided into two categories, the first category is *adding sustainability aspect into existing PMS model*, e.g. sustainability balanced scorecard (SBSC), which is proposed by Figge et al (2002) (cited by [14], GreenSCOR by Supply Chain Council (SCC, 2008). The second category is *developing new sustainability metrics*, e.g. sustainability metrics from Lowell Center for Sustainable Productin (LCSP);
- 3) Using reporting system e.g. Global Reporting Initiative (GRI);
- 4) Using others approaches such as decision-making tool, e.g. fuzzy multi-criteria model sustainability model by Erol et al. (2011) (cited by [14]).

By using PMS consideration design from Neely et al. (1995) (cited by [14]) to compare existing approaches, we found that none of existing approaches can solve all of these criticisms. Consequently, four issues to develop future sustainable supply chain performance measurement system are proposed as following ;

- Considering relationship between sustainability performance with organization strategies and objectives ;

- Defining leading and lagging indicators for enhancing key success indicators to achieve a long-term sustainable supply chain ;
- Including decision-making or mathematical model to integrate and aggregate qualitative indicators (especially in social dimension) leads to more precise for evaluating sustainability performance ;
- Focusing on how performance measurement model can evaluate sustainability across organizations in their supply chain.

The goal of our research work is to evaluate sustainability performance in the context of supply chain management. The expected results will show sustainability performance level of organizations and the consequence will lead to an improving direction for organizations and supply chain who need to increase their competitiveness. The framework to develop sustainability supply chain management (sSCM) performance measurement (PM) model is shown in Fig1. This paper focuses on an analysis for selecting decision-making method in order to construct an appropriate preference model to measure sustainability performance in supply chain context.

According to Fig1, an exploration of sustainability indicators in the context of supply chain and a comparative study of existing evaluation approaches have been done in our previous work [14]. The objective of this paper is to selecting the methods to construct sSCM performance measurement model based on multi-criteria decision theory. The characteristics of MCDA and a set of preliminary MCDA methods for measuring sustainability in supply chain are proposed. Consequently, the detailed structure of sSCM performance measurement model will be proposed in our future work.

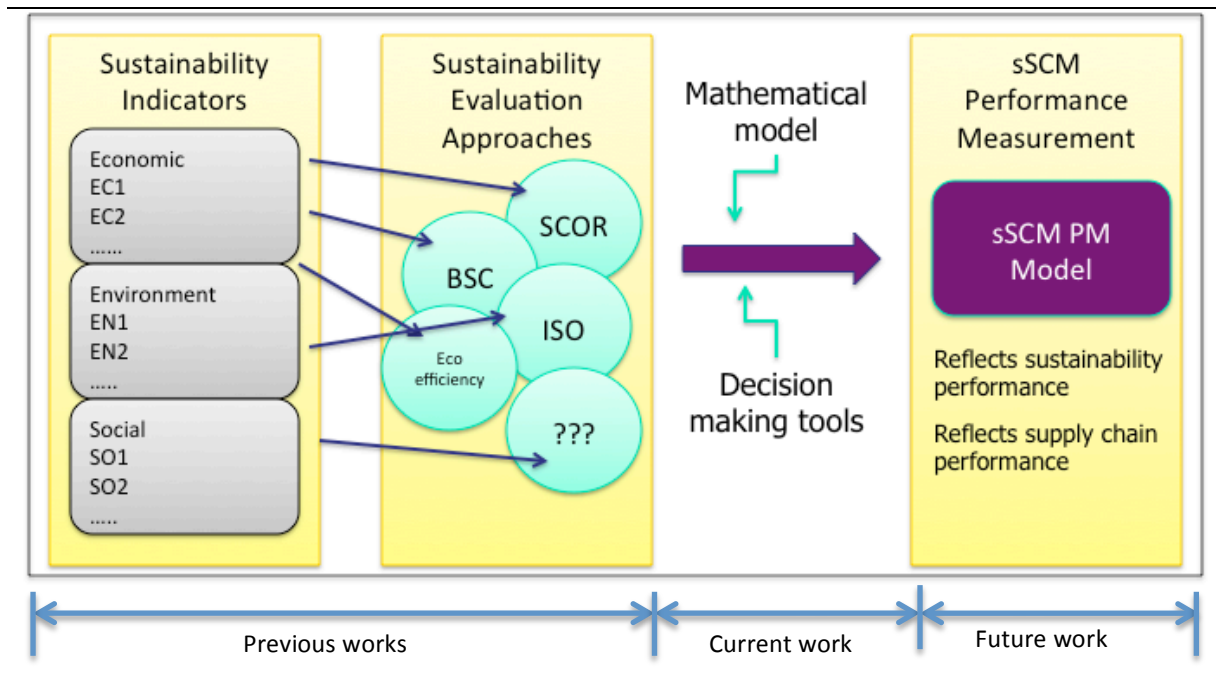


Figure1: Overall research framework: Developing sSCM performance measurement model

This paper is structured into five main sections. First, the research framework and the summarized of our previous work are introduced. Second, the literature on concept of MCDA is presented and the difference perspectives between MCDA and multiple criteria decision-making (MCDM), the MCDA category, and the criteria to select MCDA method are discussed. After that, the determination of sSCM performance measurement is analysed. Consequently, The comparison and selection of MCDA methods are analysed. Finally, the findings from this selection are presented and the future directions to construct sSCM performance measurement model are discussed.

2 Research framework of sSCM performance measurement

The research framework and summarized of previous research works ([14],[15],[16]) are explained in this section. The objectives of research is to develop performance measurement tool for evaluating sustainability performance in the context of supply chain management. The expected results from our research work should answer two main questions ; (1) how to measure sustainability performance in the context of supply chain ? And (2) If we can measure sustainability performance, how companies improve their performance into a higher level ?

Because of there are no evaluation model which can be used in all situations. Thus, we are focusing on an evaluation model which can be applied to measure sustainability in Thai electronics industry. Because of this industry has been a major driver of export growth for the country and Thailand is the 13th rank of global exporter in electrical and electronics industry (Global Trade Atlas, 2009). Meanwhile electronics industry has been forced from several international regulations and standards to take into account of environmental and social impacts. Moreover, The Thai government has supported to increase sustainability in this industry by provided both short-term and long-term projects in sustainability issues.

Although a sustainability measurement through the supply chain is still one of criticism of sSCM performance measurement. But our sSCM evaluation model has not developed to solve this obstacle yet. The boarder of supply chain perspective in our research framework has been defined as *supply chain orientation* (SCO) perspective, which recognizes on a company who addressed supply chain issues involved relationship management across company into their systemic and strategic implications.

In the context of sustainability indicators, we have developed the sustainability aspects based on both sustainable development and supply chain contexts by using SCOR model to define supply chain's activities and selecting sustainability indicators from relevant regulations, standards, guidelines, and academic researches. We categorized sustainability indicators in each process and constructed a sSCM framework to measure sustainability performance as Fig3. In each process, we grouped the indicators into sustainability aspect. We put the aspects related with social issues (labor and human rights, ethic, and society involvement) in PLAN process because it is difficult to measure a social performance in each process. Moreover, we want to focus a social dimension in term of policy level. After categorized sustainability aspects, we found that material use, and energy and resource use are basic issues which located in all processes.

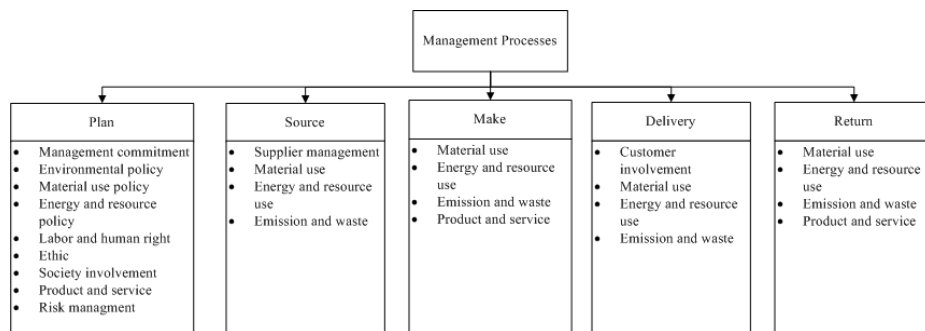


Figure3 Sustainability aspects in term of SCOR model framework

The existing approaches to investigate and measure sustainability suppl chain performance are analyzed [14]. We found that using decision-making approach or mathametical model will provide a meaningful information to measure sustainability performance regarding to our research problem. The next section will introduce the relevant literatures in decision-making context and the criteria for selecting appropriate methods to measure sustainability performance.

3 Literature review

3.1 Multiple criteria decison making (MCDM)

Multiple criteria decision making is defined as a formal approach to types of problem solving (or mess reduction), lies in attempting to represent such imprecise goals in terms of a number of individual (relatively

precise, but generally conflicting) criteria.[17]. The first stage of the development of multi-criteria decision theory was characterized by the methodological principle of multi-criteria decision-making (MCDM). A classical multi-criterion problem is still presented in the form of an optimisation problem. Thus a classical MCDM is formalized in term of mathematical model and the main objective of decision-making is to discover the optimal alternative among feasible alternatives.

Because of the main objective in traditional MCDM principle is to find a solution from the existing alternatives regarding to the way the problem is stated. So, decision maker has to clearly identify a set of feasible alternatives, a well-constructed preference model by enhancing a set of criteria, which relates to the problem. Moreover, if the rationality corresponding to axioms is accepted, decision maker must agree with the solution obtained. However real world problems are more complicate than making a decision based on only existing feasible alternatives or formulated a well-defined preference model. In practice, many decision-making situations relate to several people who take part in the decision process, a fuzzy boarderline between defining feasible alternatives, and uncertainty or imperfect data to evaluate performance of alternative. Hence, researchers in multi-criteria decision field have been developed a new perspective, which called *decision-aiding*, in order to help decision maker to make a better decisions subject to the presence of ambiguity, uncertainty and contradiction in a real world problem.

3.2 Multiple criteria decision aid (MCDA)

The principal aim of decision aiding (DA) is not to discover a solution, but to construct or create something that is viewed as liable to help "an actor taking part in a decision process either to shape (and/or to transform) his preferences, or to make a decision in conformity with his goals" [5]. Roy [6] referred his work on 1996 to the definition of DA as "the activity of the person who, through the use of explicit but not necessarily completely formalized models, helps obtain elements of response to the questions posted by a stakeholder in a decision process". The concepts of DA has been developed in order to meet the characteristics of complicated situation in the real world, which are e.g. involved with multi-decision maker, much of data are imprecise, uncertain, or ill-defined, nonrestrictive of feasible alternatives.

Meanwhile, the traditional decision making (DM) problems are formalized on three basic bases: (1) a well-defined set of feasible alternatives, (2) a model of preferences is clearly defined in decision maker's mind, and (3) a well-formulated mathematical problem. These basic characteristics of traditional DM problems can be considered as the limitations for complicated problems. Hence, DA context has been increasingly recognized from researchers in decision-making area.

Decision problem usually falls in multi-criteria problem because of decision making process is generally a multi-actor process and it is difficult to clearly define the most important criteria as a single. In addition the context of sustainability performance relate to multi-dimension, which are economic, environment and society [14] and from the previous work we found that our research problem is a multi-criteria (in term of multi-indicators) problem. Hence, a monocriterion problem is not considered in our research work.

The differences between MCDM and MCDA have been discussed by Roy [5] and have been summarized as shown in Tab1. There are three different point of views between MCDM and MCDA which related to a set of alternatives, a set of criteria and problematic.

Table1 Differences between multi-criteria decision making (MCDM) and multi-criteria decision aiding (MCDA)

Characteristic	MCDM	MCDA
Alternative A is a set of alternatives a . The alternatives for decision problem can be denoted as: $A = \{a_1, \dots, a_n\}$	A set of <i>feasible alternatives</i> (A) is supposed to be a well-defined set by means of mathematical formulations (in case of continuous alternatives) or by a list of alternatives (in case of discrete alternatives).	The term of <i>potential action</i> is used in the same way as <i>alternative</i> . But a set of potential actions (A) is positively imposed and need not to assume as a stable set. An action is qualified as potential when it is deemed possible to implement it. In addition, there are cases where appropriate potential actions can be modelled by jointly implementing of other actions.
Criterion A criterion g is a tool constructed for the purpose of comparing and evaluating alternatives (or potential actions). The evaluation $g(a)$ of alternative (or action) a on a criterion g is called a performance of criterion g .	Decision maker is a person who constructs a preference model based on criteria of decision problem. A set of criteria G and a preference model are supposed to be clearly defined in decision maker's mind. The comparison between two alternatives a and a' is done by comparing the	The preferences can be formalized from one or several actors. The actors are either decision maker(s) or stakeholders who involve with decision process or consequence. Each criterion must take into account one or more precise attributes. Thus, the term of <i>family of criteria</i> is used

Characteristic	MCDM	MCDA
Multicriteria decision problem can be denoted a set of criteria g as: $G = \{g_1, \dots, g_k\}$	value of $g(a)$ and $g(a')$. And decision maker prefers a over a' if and only if the values of $g(a')$ is greater than $g(a)$.	for considering criteria in decision problem. Moreover, in MCDA can take uncertainty, imprecision and inaccurate determination criteria into account.
Problematic	A well-formulated mathematical problem leads to find a solution by discovering an optimal alternative a^* , which contains a maximum value of an aggregated performance of criteria, in a set of feasible alternatives.	MCDA does not lead to a well-stated optimisation problem. But leads to an ill-defined mathematical problem, which provides four problematic perspectives; (1) choice problematic (P. α), (2) sorting problematic (P. β), (3) ranking problematic (P. γ), and (4) description problematic (P. δ).

Source: Summarized from [6] and [5]

According to Tab1, MCDA perspective is more flexible than MCDM. The set of alternatives (or potential actions) in MCDA allows decision maker (or actor) to create new potential actions by combining other actions. Moreover, MCDA takes into account of a board range of requirements among relevant actors, preserves the original evaluations for each actor by making a family of criteria, which has been built by considering each criterion in a perspective of each stakeholder, comparing potential actions with each criterion, and considered all criteria together to satisfy the problem requirements mean while a set of criteria in MCDM is constructed by stakeholder's preferences. Finally, the problematic in MCDA is used as a way in which DA may be envisaged. DA does not attempt to formulate any instructions or recommendations but to help decision maker (or actor) clearly understanding the purpose, type of results, and appropriate procedure to investigate of the problem. Other expressions, such as statement, problem formulation, or problem type have seldom been used as substitute but may lead to misunderstanding.

3.3 Decision aiding process of MCDA

Roy (1985, cited by [5]) introduced a general framework of decision aiding process consists of four levels as shown in Fig2. In the first level stage, the decision problematic is determined i.e. choice of best alternative, ranking of the alternatives from the best to worst, classification/sorting of the alternatives into appropriate groups, or description of the alternatives. The next level involves identification of relevant criteria (or attributes) in decision in term of a family of criteria. A consistent family of criteria can have a one of three properties ; monotonicity, completeness, or non-redundancy. When a consistent family of criteria has been specified, the third step is to proceed with either the multiple criteria aggregation procedure (MCAP) (in case of a synthesize preference approach or descriptive approach) or an exploitation procedure (in case of outranking approach). Finally, the meaningful information is provided to help decision maker analysing and justifying the appropriate actions regarding to the model's consequences.

Tsoukias [1] enhanced four cognitive results from the decision aiding process based on Roy's framework;

- *A representation of the problem situation:* is an important result to help decision makers clearly understand the problem situation and their position within the decision process by defining the relevant actors, objectives, expected results after making decision, considering relevant criteria.
- *A problem formulation:* is a formulating process by using informations from the previous step to construct a problem model. This is an effort to translate descriptive information to a formal problem. Set of feasible and realistic alternative actions are proposed in this process. Decision makers have to identify which problem category will be applied in their problem, e.g. predefined, chosen one, ranking, sorting, classification, etc. In order to formulate problem model, it is possible to choose more than one category regarding to the problem characteristics and the stakeholder requirements.
- *An evaluation model:* is constructed by choosing the method, which produces the result of the problem. The constraints should be applied here. Decision makers can choose more than one method depending on the typed of procedure. In addition, they can construct more than one model and then compare the result in each model.
- *A final recommendation:* represents the return to reality for the decision aiding process. To guarantee that the result from an evaluation model is consistent with the stakeholder's concern. Before decision makers formulate the final recommendation, at least three precautions should take into account; sensitivity analysis, robustness analysis, and legitimation.

The context of this paper focuses on the first and second step. Problem situation and problem formulation are enhanced as the results. Moreover, the preliminary methods to construct an evaluation model are presented in a conclusion section.

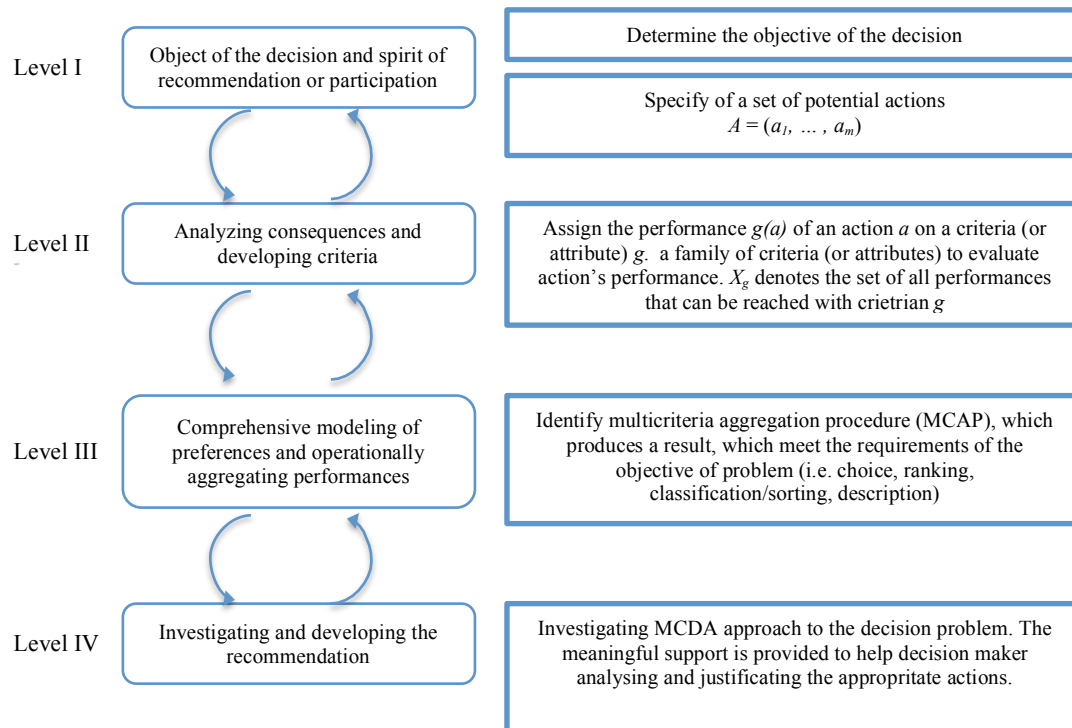


Figure2: The framework of decision aiding process in MCDA (adapted from Roy, 1985)

3.4 MCDA methods

MCDA methods can be categorized by means of operational approach in decision process. Roy [9] divided multiple criteria methods into three operative approaches:

- (1) methods based on the use of a single synthesizing criterion without incomparability i.e. multi attribute utility theory (MAUT), simple multibute rating technique (SMART), analytical hierarchy process (AHP)
- (2) methods based on the synthesis by outranking with incomparability i.e. evaluation ELECTRE methods, PROMETHEE, novel approach to imprecise assessment and decision environment (NAIADE) and
- (3) methods based on interactive local judgements with trial-and-error iteration. The first and the second approaches provide a clear mathematical structure, but the third does not use any formal model of the decision maker's preference system.

The third approach is based on a formal procedure organising a dynamic sequence of questions that the decision maker must answer.

Another point of view to divide MCDA methods is based on the set of alternatives characteristic [8]. If the set of alternatives is finite, it would be categorized as discrete methods, which corresponds with single synthesizing criterion and outranking methods. If the set of alternatives is infinite, it would be categorized as continuous methods (programming methods). The MCDA method characteristics in each category are summarized in Tab2.

Table2 Characteristics of each MCDA category

Category	Characteristics	Examples
Discrete Methods		
Single synthesizing criterion methods	<ul style="list-style-type: none"> - Each performance of alternative a on g criterion is defined to assign a well-defined degree; - The aggregation procedure is addressed in this approach leads to defining a complete pre-order on set A; - Most often, the formal rules consist in mathematical formulas is used to define and explicit definition of a unique criterion; - Excluding the existence of any incomparability and to imposing the 	<ul style="list-style-type: none"> - MAVT - MAUT - SMART - TOPSIS - MACBETH - AHP

Category	Characteristics	Examples
	transitivity of preferences and indifferences; - Taking account of imperfect knowledge and ill determination essentially through probability distribution, fuzzy numbers, or in some cases through rough set theory; - Never through preferences or indifference thresholds	
Outranking methods	- The aggregation procedure does not be addressed in this method - Based on less 'strong' assumptions than single criterion methods - Encourage interaction between model and decision maker by avoiding complete ranking being identified too early - Facilitating the identification of compromise solutions in a transparent and fair way	- ELECTRE - PROMETHEE - Regime - NAIADE
Continuous Methods		
Programming methods	- Not choose from a finite number of alternatives; - Alternatives are generated during the solution process on the basis of a mathematical model formulation	- MOP - GP

3.5 The criteria for selecting MCDA

MCDA methods differ in the way of the idea of multiple criteria is operationalised. There is no the best method which can be used in all problems. Each method shows its own properties with respect to the problem characteristics i.e. the way of constructing criteria, the application and computation of weights, the mathematical algorithm utilised, the model of preferences, the data characteristics, and stakeholders who participate in the decision process. So, decision maker has to select an appropriate MCDA method, which respects to the problem situation, to utilize the results of decision making to meet decision maker's objective.

De Montis et al. [3] proposed the criteria for selecting MCDA method divided into three categories. The first is criteria concerning the theoretical foundations of operational component elements. The second is criteria concerning the user context. And the last one is criteria concerning problem structure. In each category consists of sub-criteria to analyze the decision problem situations. Table 3 shows the sub-criteria in each quality criterion.

Table3 Guideline to analyse characteristics of decision problem for selection MCDA method

Criteria: Operational Components of Methods	
Criteria characteristics	<ul style="list-style-type: none"> Decision maker should identifies the quality of criteria in the context of three possible characteristics, which are interdependence of criteria, sensitivity of the results with respect to the completeness of criteria, and possibility for the consideration of non-linear preferences.
Weight of criteria	<ul style="list-style-type: none"> Transparency of the weighting process is explicitly or implicitly? The meaning of criteria's weight is an importance or trade-off?
Solution finding procedure	<ul style="list-style-type: none"> Decision maker has to define the solution finding procedure. It is selecting, sorting, ranking, non-dominated options or a mixture of different procedure.
Issues addressed by results	<ul style="list-style-type: none"> This feature helps decision maker to consider future perspective after getting the result from decision process. Decision maker should provide solutions for idle issues or consider different concurrent or opposite aspects.
Criteria: User Context	
Project constraints	<ul style="list-style-type: none"> Decision maker should select MCDA method, which is suitable subject to costs of method application and time constraint to implement the method.
Problem solving process	<ul style="list-style-type: none"> Stakeholder participation Suitability for structuring problems Applicability for learning about the problem structure Transparency of decision processing and results Possibility for communication between different parties
Criteria: Problem Structure	
Indicators Characteristics	<ul style="list-style-type: none"> MCDA methods selection depends on flexibility of the methodology to different characteristics of indicators. Decision maker should consider geographical scales of indicators, linkage between actors on different level, societal and technical problems and combination with other methods.
Data situation	<ul style="list-style-type: none"> Decision maker should identify the data situation in preferences system. The sub-categories in this sub criterion are type of data (quantitative, qualitative, crisp, fuzzy), uncertainties of data, and amount of data processing.

4 Identify problem situations in the context of sSCM performance measurement.

According to the objective of this paper, which is selecting MCDA method to evaluate sustainability performance in supply chain context, we use the framework of decision aiding process (Fig2) as a framework to identify problem situations.

4.1 Determining objective of decision problem

This step involves the context of defining decision maker's objective, preferences model characteristics, which relate to potential actions (or alternatives); criteria building procedure; data characteristics, and expected result from decision process.

There are two research questions of our research work, which are (1) how to measure sustainability of supply chain, and (2) how to improve sustainability performance. Moreover, we focus on electronic industry in Thailand and consider the activities in sourcing process ([14], [15]). Hence, the research objective is to develop a sSCM performance evaluation model which can enhance the level of sustainability performance and gives a direction to improve sustainability to company among the supply chain.

The expected result is divided into two stages regarding to the research questions. The result of first stage is level of sustainability performance of organisation. The managers of organisation can benchmark their overall sustainability with other competitors or other companies in the supply chain. Thus, the problematic in this stage falls in *ranking problematic* area. After that, the result of second stage will support the recommendation for organisation's manager on how to improve sustainability performance to a higher level. Hence, the second results should provide the information of important factors which effect to overall sustainability performance and how to increase the performance of each factors. The second preference model is an extension analysis regarding to the results of first model. Hence, in this paper, we will focus on the first preference model and will work on the second preference model later in the future work.

4.2 Determining a set of feasible alternatives

According to the definition of feasible alternatives (or potential actions), which is introduced in section 2.2, is considered as the solution of decision problem. But our research work considers a set of feasible alternatives as set of the companies that we want to evaluate their sustainability performance. Hence we use a term of *considered* companies as a same meaning as *feasible* alternatives. A is a set considered companies a_i consisting of m companies can be denoted as ; $A = (a_1, \dots, a_m)$.

Because of set A in our context is a discrete set, the characteristic of MCDA approach falls in a discrete method and the aggregation of overall sustainability performance is required to address in our model. So the feasible MCDA methods for our problem will based on the use of a single synthesizing criterion without incomparability. The summarized characteristics of our research problem are shown in Tab4.

Table4 Summarized of problem characteristics in the first stage

Level of decision process	Problem characteristic	MCDA method required properties
Level I	<ul style="list-style-type: none"> - A set of feasible alternatives is finite - Problematic determination: Ranking problematic 	<ul style="list-style-type: none"> - Discrete methods - Aggregation procedure is required to address

4.3 Analysing criteria characteristics

A set of criteria (or attributes) can be considered as relevant factors which significantly effect to the decision problem. In the context of sustainable supply chain management, the objective of companies is to increase their sustainability performance. The objective value of our research work is an overall sustainability performance, then the sustainability indicators can be considered as the attributes of company's sustainability.

According to sustainability aspects in research work (Fig3), a set of sustainability indicators (attributes) contains both of quantitative and qualitative data. This paper uses the criteria, which proposed by De Montis to analyze preferences model characteristics and the detail of analysis is shown in Tab5

Table5 Characteristics of sSCM performance measurement problem

Criteria: Operational Components of Methods	
Criteria characteristics	<ul style="list-style-type: none"> • Interdependence of criteria: <i>Interdependence</i>

Criteria: Operational Components of Methods	
	<ul style="list-style-type: none"> Completeness of criteria: <i>Complete criteria</i> Non-linear preferences: <i>(have not taken into account yet)</i>
Weight of criteria	<ul style="list-style-type: none"> The meaning of criteria's weight: <i>importance</i>
Solution finding procedure	<ul style="list-style-type: none"> Ranking problematic
Issues addressed by results	<ul style="list-style-type: none"> The aggregated overall performance results lead to the comparison of sustainability performance of organization in the supply chain. Then, the disaggregated from overall performance into economic, environmental and society performance leads to improving direction to be a higher level for the higher level.
Criteria: User Context	
Project constraints	<ul style="list-style-type: none"> Cost and time constraints have not been taken into account yet
Problem solving process	<ul style="list-style-type: none"> Stakeholder participation: <i>participate with several stakeholders</i> Set of family of criteria (or attributes) = <i>sustainability indicators</i> Evaluating sustainability performance by organization's self assessment. The assessment process involves linguistic variables and fuzzy assessment. Need a transparency property to enhance sustainability performance
Criteria: Problem Structure	
Indicators Characteristics	<ul style="list-style-type: none"> A set of indicator consists different geographical scales. The linkage between actors has not been taken into account yet It possible to taking both societal and technical indicators Model does not consider to combine with other methods
Data situation	<ul style="list-style-type: none"> Model contains both qualitative and quantitative data There are both fuzzy and crisp data in term of performance of alternative The model has not identified amount of data processing yet

5 Selecting MCDA method

According to section 4.1, the MCDA methods which meet the problem characteristics is based on the use of a single synthesizing criterion without incomparability. This section provides the analysis of frequently used methods in a single synthesizing category, which are MAUT, AHP, and EvaMix methods. The comparison of method characteristics following by De Montis et al. [2] and our problem characteristics is shown in Tab 6. The brief descriptions of each method are introduced as follows:

5.1 Multiple attribute utility theory (MAUT)

MAUT is based on utility theory and uses directly assessed preferences with aggregation procedure by using utility function. The concept of utility function is inherently probabilistic in nature. The utility function model can be written as

$$U_i = \sum_j w_j \cdot u_{ij}$$

where U_i is the overall value of the i th alternative, u_{ij} is the utility of the i th alternative with respect to the j th attribute measured by means of the utility function, and the weight w_j is a normalized weight or scaling constant for attribute j , so that, $\sum_j w_j = 1$

5.2 Analytical hierarchy process (AHP)

The AHP method, which was developed by Saaty (1980), is based on three principles; decomposition, comparative judgement and synthesis of priorities.

- The decomposition principle requires the decision problem to be decomposed into a hierarchy, which can capture the essential elements of the problem
- The principle of comparative judgement requires a pairwise comparisons of elements within a level of hierarchical structure.
- The synthesis principle takes each of the derived ratio-scale priorities in the various levels of the hierarchy and constructs a composite set of priorities.

5.3 EvaMix

The EvaMix method allows to use quantitative as well as qualitative data. This method is typically used to cope with decision making problems at different geographical scales. EvaMix supports stakeholder participation in weighting assignment process. This method consists of five steps, which are (1) make a distinction between ordinal and cardinal criteria; (2) calculate dominance scores for all ordinal and cardinal criteria; (3) calculate

standardized dominance scores for all criteria ; (4) calculate overall dominance scores ; and (5) calculate appraisal scores [4].

Table6 Guideline to analyse characteristics of decision problem for selection MCDA method

		Research Problem	MAUT	AHP	EvaMix
Criteria: Operational Components of Methods					
Criteria characteristics	Allowing of interdependence	Interdependence	Not allowed	Allowed	Not allowed
	Need for the completeness criteria	Complete criteria	Allowed		
	Possibility to express non-linear valuation patterns	N/A	Allowed	Not allowed	Not allowed
Weight of criteria	Type of the procedure to deriving weight value	N/A	Cardinal weight	Cardinal weight	Ordinal weight
	Meaning of weight	Importance	Trade-offs	Importance	Importance
Solution procedure	Type of solution finding	Ranking	Complete ranking		
Criteria: User Context					
Project constraints	Cost	N/A	Depending on numbers of attributes, stakeholders involved, etc.		
	Time	N/A			
Problem solving process	Stakeholder participation	Necessary	Necessary	Necessary	Supported
	Structuring	Via the construction of sustainability indicators and organisation's self assessment	Via the construction of utility functions	Via the construction of suitable hierarchies	Via the construction of the evaluation matrix
	Tool for learning	N/A	Appropriate	Appropriate	Not appropriate
	Transparency	Need transparency property	High		
	Actors communication	N/A	Via the integration of stakeholders		
Criteria: Problem Structure					
Indicators Characteristics	Geographical	Consists of a different geographical scale	Different can be treated		
	Micro-macro link	N/A	Possible		
	Societal/technical issues	Need both societal and technical indicators	Different issues are possible		
	Combination methods	Not need	Possible		
Data situation	Type of data	Consists of quantitative, qualitative, fuzzy and crisp data	Quantitative and qualitative are possible		
	Risk/Uncertainties	Data uncertainties	Risky outcomes; Probabilities, sensitivity analysis	Via sensitivity analysis	Via ordinal criteria only
	Data processing amount	N/A	High	Medium	Low
	Non-substitutability	N/A	Not possible		

According to the comparison of MCDA methods in Tab6, we found that only AHP method meet all of our problem characteristics. MAUT method can not achieve the inter-dependence criteria characteristics and the weight meaning. Meanwhile Evamix method can not achieve the inter-dependence criteria. Hence, the preference model for evaluating sSCM performance will be constructed by AHP method.

6 Conclusion

An evaluation of sustainability performance in supply chain context has faced the challenges to reduce the criticisms of existing approaches because of sustainability involves to multi-dimensional performance. In addition, sustainability in supply chain context consists of more complicated elements i.e. involving with several stakeholders, the complexity of supply chain, uncertainties or fuzzy assessment in evaluation process, etc. Thus MCDA method, which is a tool for support and help decision makers to make a better decision, is taken account to construct an evaluation model.

In order to enhance a meaningful of the consequence, selecting an appropriate method for constructing a preference model is an important process. Starting with a clearly identify relevant issues of sSCM performance measurement problem. An explicit objective of sSCM preference model is to ranking an overall sustainability performance in a set of considered companies. The analysis of sustainability indicators in term of a family of attribute helps us to determine the requirement properties in an expected preference model. And we found that the sSCM performance model is based on a single synthesizing criterion without incomparability. Finally, AHP method is the only method, which achieves all of requirements.

However, this paper has worked on the first and the second level of decision process. In the future work, we have to construct a set of sustainability indicators, identify multicriteria aggregation procedure (MCAP) subject to the data characteristics and implicitly assessment from stakeholders, and investigating sSCM performance measurement model to the case study company.

7 References

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