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A Prototype Decision Support System for Sustainability Performance Measurement in Furniture Industry

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Abstract. In measuring sustainability performance of a manufacturing system, a manager needs a practical tool to assess relevant sustainability indicators. This research aims to develop a decision support system (DSS) to measure, evaluate and improve the existing manufacturing operations toward sustainability goals. The DSS incorporates a manufacturing sustainability model that measures current manufacturing performance in Triple Bottom Line aspects comprehensively. The system provides a single index with workable indicators encompassed economic, environmental, and social dimensions. These indicators generated specifically for furniture industry in Indonesia. The DSS prototype, called EvaSus, designed as an interactive tool that helps manager to get comprehensive evaluation of the manufacturing sustainability, thus providing a way to improve the business processes.

1. Introduction

The furniture industry uses abundant natural resources in their manufacturing process, without strict control and regulation this can have an impact on environmental damage and sustainability. A new concept known as sustainable manufacturing had introduced in this industry, the production of goods in such a way that utilizes minimum natural resources and produces cleaner and environment-friendly products at an affordable cost. The implementation of this concept, need a continuous assessment to maintain the sustainability performance of a manufacturing organization periodically.

Sustainability includes environmental, economic, and social dimensions, the Triple Bottom Line. Hence, the assessment of sustainability must measure those indicators in a holistic approach [1]. Although manual calculation of sustainability performance is feasible, the process consumes time and usually mistake prone. The manager needs an easy and practical tool to assess relevant sustainability indicators aided by a computerised system. This system will assists the managers to measure, evaluate and improve the existing manufacturing operations toward sustainability goals by focusing on crucial indicators of sustainability aspects.

Performance assessment is important part for decision maker to review sustainability process. This process is needed to ensure the sustainability process and help decision makers to improve their operation in operational, tactical as well as strategic level [2]. Some researchers have developed several tools with various of models involved to measure the sustainability performance in the strategic level or corporate [3] but their lack proper model in measuring the sustainability at the operational level.

Hartini et al [4] has introduced a sustainable model for the shop floor that portrays the manufacturing process performance in a single score, called manufacturing sustainability index (MSI). MSI could be



embed in a such system, that easy to operate and interactively help the manager to get comprehensive pictures of the manufacturing sustainability, thus providing a way to improve the business processes.

A kind of system that able to support the manager during their decision-making process is decision support system (DSS). A DSS can use internal information available in databases and it can use external information from such sources as experts. The main function of DSS is to save various data and to assess current performance of the system sustainability. Here, the research question is how to build an appropriate DSS that embed MSI model for performance assessment of sustainability at operational level.

2. Method of the Research

2.1. Manufacturing sustainability indicators

Recently, many research has been done on the evaluation of sustainability performance. In 2003, a multi-criterion framework was presented by Munda [5] for assessing sustainability. In 2004, an initiative was taken by Pope et al [6] to achieve triple bottom line by an integrated assessment process laying emphasis on minimizing unsustainability. Lee and Huang [7] presented the idea of sustainability index in Taipei. Another research have continued and applied this concept in broader scope from the company until the supply chain in constructing their performance assessment model.

The first step in development of performance assessment model is determining indicators and formulating indicators judgment. Hartini et al [8] has been formulated sustainability indicator specifically for furniture industry. This indicator is grouped in three aspect, namely economics, environmental and social which is combined to form manufacturing sustainability index. The economic aspect use four indicators, that are efficiency of time, cost, inventory and quality. The environment aspect include three indicators, material consumption, energy consumption and recycling of waste. The social aspect consists of employee's satisfaction rate, healthy rate, safety rate and training efficiency. These indicators can be structured hierarchically as seen in Figure 1.

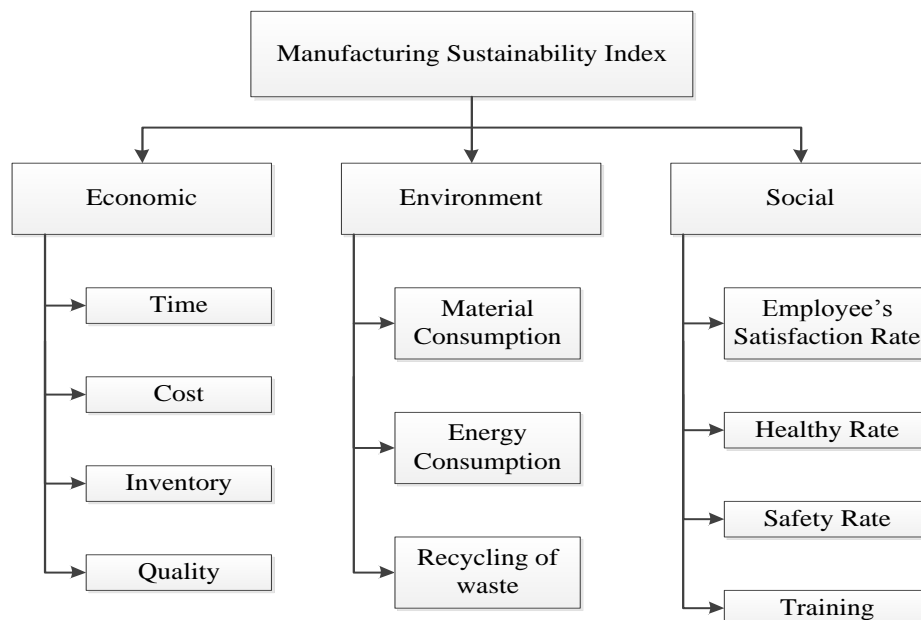


Figure 1. Hierarchy of indicators for manufacturing sustainability index

2.2. Performance parameter

Score of indicator is determined by using the concept of efficiency that is the comparison between the use of the sources with added value towards the total use. The common formula of efficiency used is ratio between the use of resource and total resource. Every indicator have several parameter taken into account in determining the performance score. List of required parameters shown in Table 1.

Table 1. Performance parameter for sustainability

No	Indicators	Performance parameter
1	Time efficiency	Value added time Total time
2	Cost efficiency	Non-value added time Value added cost Non-value added cost Total cost
3	Inventory efficiency	Number of inventory Total material
4	Quality efficiency	Number of defect Total material
5	Material efficiency	Value added material Total material used
6	Energy efficiency	Non-value added material Value added energy Non-value added energy Total energy
7	Efficiency of waste recycling	Total waste
8	Satisfaction efficiency	Number of waste to landfill Number of employee turnover
9	Health efficiency	Number of employee Number of employee absent
10	Safety efficiency	Number of employee Number of activity with risk
11	Efficiency of employee training	Number of activity Number of employee training Number of employee

Manufacturing sustainability index is approached by adding all weighted economy index, environment and social as shown in Table 2.

Table 2. Manufacturing Sustainability Index

No	Dimension	Input	Formula
1	Economic index (Ec_I)	w_i : weight of indicator i E_i : score of economic indicator i	$Ec_I = \sum_{i=1}^{n=4} w_i . E_i$
2	Environment index (En_I)	w_i : weight of environment indicator i E_i : score of environment indicator i	$En_I = \sum_{i=5}^{n=7} w_i . E_i$
3	Social index (S_I)	w_i : weight of social indicator i E_i : score of social indicator i	$S_I = \sum_{i=10}^{n=13} w_i . E_i$
4	Manufacturing Sustainability Index (MSI)	α : weight of economic dimension β : weight of environment dimension γ : weight of social dimension S_I : social index	$MSI = (\alpha . Ec_I + \beta . En_I + \gamma . S_I)$

2.3. Decision support system

A decision support system (DSS) is an information system that process data into useful information to support decision-making activities. The main role of DSSs serve person in strategic, tactical, and

operational levels of an organization and help to make decisions in not well structured situation. Brunner and Starkl [9] stated the importance of a decision aid system in estimating sustainability. DSS not only database driven, but also model driven that some models must be embedded. This research focus in developing a prototype DSS that using MSI model to measure the sustainability performance in furniture industry. The prototype generated uses a rapid application development tool that provides speed and flexibility in accommodating user requirement for ease of use. By using user-centred development, tremendously decrease user learning time in using the DSS.

3. Result and Discussion

The prototyping process uses Delphi Community Edition to rapidly develop an initial user interface. Users involved in the prototyping process are managers from several furniture companies located in Jepara, Middle Java, Indonesia. This process uses throwaway prototyping which first gets the initial requirement and interface expectations from the manager iteratively. After gaining the initial prototype, formal analysis is carried out based on identified requirements. The DSS prototype named EvaSus which mean Evaluation of Sustainability.

Results of the prototyping process are a database performance, some user interfaces including input and output, and application that embed the MSI model. The database store every input relating to the performance indicators such as weight, measurement and performance score. This database managed by MySQL, a database management system, which eases to accommodate further requirement. The user interface consists of an interface for input indicators that show achievement and standard to be analyzed. The weight of indicators also inputted by the manager based on expertise. Outputs are results from data transformation showing the performance score of every aspect. The DSS facilitate communication between the user and the application in several interfaces.

Here some explanations of the interface created in EvaSus prototype. First, there is the main form of EvaSus that facilitates accessing five primarily function that is as follows Weighting, Measurement, Performance, MSI Index and Report. It is designed to make easy in completing the assessment process by just pressing the appropriate button. The proposed design can be seen in Figure 2.



Figure 2. Interface EvaSus DSS Prototype

Subsequently, detail interfaces of EvaSus function can be depicted as follows. Figure 3, the weighting interface, an interface to input the weight of three bottom-line indicators. This interface can

accommodate the changing preference of decision makers. Figure 4, the measurement interface, it is the base function of EvaSus. Its record raw data about the shop floor activities. Input is saved in a particular period in accordance with the manufacturing system, e.g. monthly or quarterly. These two interfaces shown in the following figures:

Category	Indicator	Value
Economic	Time	0.16
	Cost	0.24
	Inventory	0.28
	Quality	0.32
Environment	Material Consumption	0.33
	Energy Consumption	0.33
	Recycling of Waste	0.33
Social	Satisfaction Rate	0.08
	Healthy Rate	0.27
	Safety Rate	0.15
	Training	0.50

Figure 3. Weighting for the three bottom line indicators

Activity - 1	Time	Cost	Material	Energy
Value Added				
Non Value Added				
Number of Inventory			Waste to Landfill	
Number of Defect			Total Waste	
Total Material			Activity with Risk	
Employee Turnover			Number of Activity	
Employee Absent				
Employee Training				
Number of Employee				

Figure 4. Input interface for measurement process

Next, are the performance interface and MSI Index interface. Performance interface shows the performance score computed by MSI formulas, while MSI Index interface states the Manufacturing Sustainability Index of the system for the current period. Both are shown in Figure 5 and Figure 6. And the last is Report interface that shows report of all data and performance recorded.

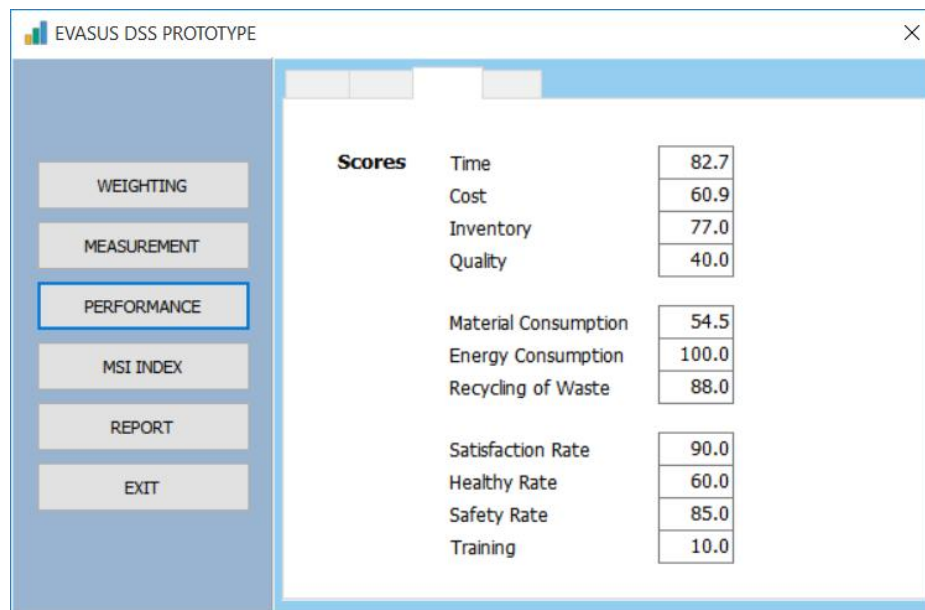


Figure 5. Performance scores

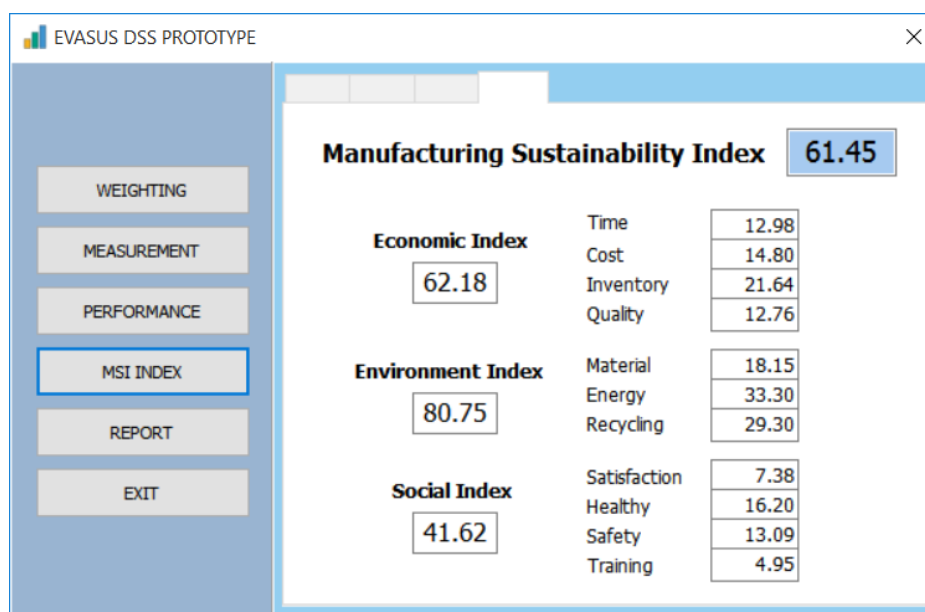


Figure 6. The Manufacturing Sustainability Index

4. Conclusion

We have designed a DSS prototype for performance assessment of the manufacturing system in the furniture industry. The designed DSS has included a period to facilitate decision maker in evaluating performance periodically. Sustainability model used in designed DSS that provides a single index representing the manufacturing sustainability performance. This capability is a manifestation of the evaluation phase in the performance assessment. Performance assessment is key to achieving sustainability goals. The computer-aided tool in performance assessment can provide support to make decisions effectively. Decision makers can view overall factors and may browse indicators that have contributed to increasing or decreasing performances. The prototype built with a rapid application development tool that incorporates user intensively results in minimum training needs.

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