Development of an Assessment Model for Sustainable Supply Chain Management in Batik Industry

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Abstract. This research proposes a dynamic assessment model for sustainable supply chain management in batik industry. The proposed model identifies the dynamic relationship between economic aspect, environment aspect and social aspect. The economic aspect refers to the supply chain operation reference model. The environment aspect uses carbon emissions and liquid waste as the attribute assessment, while the social aspect focus on employee’s welfare. Lean manufacturing concept was implemented as an alternative approach to sustainability. The simulation result shows that the average of sustainability score for 5 years increased from 65.3% to 70%. Future experiments will be conducted on design improvements to reach the company target on sustainability score.

Keywords: Sustainable Supply Chain Management, System Dynamics, Lean Manufacturing

1. Introduction
Batik demand in Indonesia increased significantly since UNESCO inaugurated batik Indonesia as the masterpiece of intangible heritage in 2009 [1]. More than 200% of sales volume had achieved in 2011 but for export value decreased 14.71% in 2015 [2]. On the other hand, fierce competition has increased among local and international batik industry such as from China and Malaysia [1]. Sustainability is a necessity for the batik industry [3]. The association between sustainable for internal and external organization is recognized as the concept of Sustainable Supply Chain Management (SSCM) [4][5]. There are three aspects of SSCM, namely economic aspect, environment aspect and social aspect. Several assessment models of SSCM has been proposed. An assessment of SSCM using SCOR 9.0 and Global Supply Chain Forum framework had been conducted [3]. An assessment of SSCM has been conducted using collaboration of SCOR and Base of the Pyramid (BOP) strategies [6]. For Batik Industry in Solo an assessment of SSCM also has been conducted using SCOR method [7]. Among these previous research, the assessment model of SSCM assume a linear correlation between the three aspects which do not consider the dynamic aspect of the system. The objective of this research is to propose a dynamic assessment model for SSCM in Batik Industry. Initial research based on hybrid SCOR 11.0 and dynamic evaluation on economic aspect has been conducted [8]. This paper will discuss not only the economic aspect but also the environment aspect and social aspect. The following chapter will review the reference model. Chapter three describes the proposed model and followed by the result and the discussion of sustainability score. This paper concluded with finding remarks based on the dynamic simulation from 2017 to 2021.
2. Reference Model

2.1. Supply Chain Operations Reference (SCOR)
The SCOR model is a process reference model with standardised terminology developed and endorsed by the Supply Chain Council [9]. The SCOR model has five attributes such as reliability, responsiveness, cost, assets management and agility. The SCOR model version 11 is used throughout this paper. The SCOR model defines two types of attributes performance. The external attributes are divided into reliability, responsiveness, and flexibility, while the internal attributes are cost and assets.

2.2. CO2 Emission and Liquid Waste Management
In case of batik industry, the assessment of environment aspect is conducted through measuring carbon emission and liquid waste. The attribute for measuring liquid waste such as chloride, sulfate, nitrite, nitrate and alkalinity were not filtered and kept in 50 ml PE bottles. These attributes were analyzed according to standard methods APHA, 1998 [10]. The regulation of the local government of Central Java Province also arranges about the standard attributes of liquid waste by using Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Suspend Solid (TSS), power of Hydrogen (pH), and temperature that can be delivered to the surrounding environment [11]. The assessment of liquid waste in Batik Industry was conducted by Immawan [1] and then for carbon emission was conducted by Saleh [12]. Carbon emissions is measured from consumption of electricity, kerosene and solar refer to IPCC.

2.3. Employee’s Welfare Management
Social aspect is one of the main aspects of SSCM, as well with the economic aspect and environment aspect. Therefore, sustainability has become an important issue in both managers and researches, since managers will increasingly play a major role in writing and instituting CSR policies and code of conduct [13]. Stakeholder perspective suggests that firms need to meet the needs of the stakeholders in addition to the shareholders [14]. According to this perspective, stakeholders are critical for the existence of the firm. The basic idea of the stakeholder perspective is that a firm’s success depends on how it is able to manage relationships with key groups, such as customers, employees, suppliers, communities, politicians, and owners, each of which can affect its ability to reach its goals [15]. The previous research has been elaborated a research about an attempt to identify welfare facilities and employee’s satisfaction level about welfare facilities [16]. Employee welfare facilities in the organization effect on the behaviour of the employees as well as on the productivity of the organization.

2.4. Lean Manufacturing
Lean Manufacturing is a popular paradigm in the US to identify value and reduce waste begun with the Toyota Production System (TPS) in Japan [17]. To remove waste from plan activity to return of finish good from the customers, Value Stream Mapping (VSM) is used to map the activity at the manufacture and the result is ratio of value added and non-value added time [18].

3. Model Development
Previous research was conducted by developing a model to just identify the relationship among the five attributes assessment on economic criteria namely reliability, responsiveness, cost, asset management and agility [8]. This research propose an additional two assessment attributes for environment, namely carbon emissions and liquid waste and one attribute assessment for social aspect namely employee’s welfare. The development of conceptualization model in form of causal loop diagram is illustrated in Figure 1.
After causal loop diagram created, the relation of variables in the system will be converted into the flow diagram as illustrated in Figure 2. The propose model is validated using U-Theil statistics by comparing the simulation result to the actual data. The U-Theil test is 0.18, which indicates a good forecasting accuracy [19]. In this case, the model is valid.

Figure 1. Causal Loop Diagram.

Figure 2. Flow Diagram.
4. Result and Discussion
Assessment of SSCM has been conducted using the proposed model. Assessment of the five attributes SCOR for economic aspect, two attributes (liquid and carbon emissions) for environment aspect and employee’s welfare for social aspect for 5 years started from 2017-2021 shows in Table 1.

Table 1. Simulation Result during 5 Years (2017-2021)

| No | Years | Average |
|----|-------|---------|
| 1  | Economic Aspect | 52.1% 56.7% 55.8% 62.7% 58.2% 57.1% |
| 2  | Environment Aspect | 2.0% 2.0% 2.0% 2.0% 2.0% 2.0% |
| 3  | Social Aspect | 5.9% 6.0% 6.1% 6.1% 6.0% 6.0% |
|    | SUSTAINABILITY SCORE | 60.1% 64.8% 64.0% 70.9% 66.3% 65.3% |

The average sustainability score is 65.3% which is below the company target. Thus, improvement is required in improving the sustainability score. In this research improvement is conducted through lean manufacturing. Waste identification for lean manufacturing is conducted in the chain of planning, source, manufacture, delivery until return activity. Value Stream Mapping (VSM) is used to map the operating conditions at the company. The mapping process was carried out by interview and observation. Batik Industry has two types product, “batik tulis” and “batik cap”. Figure 3 and Figure 4 illustrates VSM for “batik tulis” and “batik cap” in the state before and after implementing lean manufacturing concept.

![Figure 3. VSM for “Batik Tulis”](image)

![Figure 4. VSM for “Batik Cap”](image)
The VSM in Figure 3 and Figure 4 describe all activities in manufacturing system from planning activity to return activity in Batik Industry. The wastes in Figure 3 occurred in production activity such as waiting, inappropriate processing and defect. Waiting occurred in QC process and drying process. Inappropriate processing occurred in colouring process by the operator with imbalance skill. Defect occurred in canting process. The desired value of the company is a smooth flow of production. To reach the value, the company must eliminate the waste. The proposed elimination of waste can be done with several actions. For example, using information technology to select the colour in colouring process which is previously used manually by visual. Previously, in colour selection requires 4 hours, if using information technology to select the colour where one colour as one minute for one product, then for 1 batch as 110 products, require only 110 minutes from the previous one needs 4 hours to select the colours. This proposed action to eliminate waste can reduce the production cycle time. The cycle time of “Batik Tulis” for initial production activity is 123.6 days and reduced to 100.8 days after lean manufacturing implementation by eliminating the waste. Figure 4 illustrates cycle time of “Batik Cap”, the initial production activity is 36.1 days and reduced to 27.6 days after lean manufacturing implementation. Waste removal occurred in the return activity for “batik cap” from initial 2.5 days reduced to 1 day after lean manufacturing. Figure 3 and Figure 4 also illustrates the different cycle time between “Batik Tulis” and “Batik Cap”.

Based on the lean manufacturing activity mentioned above, the simulation model was run to simulate the effect of lean manufacturing. The result reveals an increase average sustainability score from 65.3% to 70.0% as shown in Table 2.

Table 2. Simulation lean manufacturing during 5 years (2017-2021)

| No | Years | Average |
|----|-------|---------|
| 1  |       |         |
| 2  |       |         |
| 3  |       |         |

5. Conclusion
This paper proposed a dynamic assessment model for sustainable supply chain management in Batik Industry. The model covers three aspects: economic, environment and social. Initial assessment reveals that the sustainability score of batik industry is below expectation. Lean manufacturing concept was stimulated in the batik industry as an approach to achieve sustainability. The assessment reveals an increase of the sustainability score. Future experiments will be conducted to design improvements for the company to reach their target of sustainability score.

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