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Sustainability Industrial Symbiosis Model in Automotive Supply Chain (Study Case: Steel Material in Fast Moving Component Supply Chain)

Engineering

KEYWORDS : industrial symbiosis, the automotive supply chain, steel, material, energy, byproducts, water.

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ABSTRACT

Industrial syimbiosis could be as an approach for environmental management in the automotive industry, which applies in the automotive industry supply chain network. Automotive industry supply chain network reflects the synergy in the supply of industrial raw materials, involving many and varied components suppliers of raw materials. This research aims to develop environmental management approaches using industrial symbiosis in the automotive supply chain for the steel material in fast moving components. Samples are suppliers of automotive components company PT Astra Daihatsu Motor or located in Java Island. The number of samples is 33 randomly selected companies and data collection is done by using a questionnaire. The collected data were analyzed using PLS (Partial Least Square) to address the correlation between latent variables. The results showed that establishment of industrial symbiosis does not require the proximity of the location (geographic proximity). In the formation of industrial symbiosis model of exchange of material, energy, byproducts and water views influence on sustainability. Model of industrial symbiosis obtained is a model that shows the water exchange between the company's environmental management towards sustainability.

1. Introduction

Industry activity is often as a cause of environmental degradation. Consumers, through the market has been demanding industry to pay attention to environmental aspects in addition to economic aspects [4]. For industry, environmental management means expenses. Therefore if the environmental management conducted jointly between several companies, then the costs can be shared. Industrial ecology approach is one approach to environmental management is done jointly. Environmental management approach that involves many companies to reduce environmental impact, improve economic efficiency and enhance the company's competitive advantage is called industrial ecology approach [5]. Industrial ecology approach menganalogikan industry activities with nature activities. In the industrial ecology approach, the development of industry is seen as a systemic change, namely industrial system which follows the natural system [8].

Symbiosis industry is one of the methods of environmental management in industrial ecology. In the natural system, known mutual symbiosis known as symbiosis mutualisma. Simbosis industry according [1] is a part of industry-related ecological cooperation among industry, to enhance the comparative advantages through a joint approach, the exchange of materials, energy, water and byproducts. According to [7], symbiotic industry is the environmental management measures implemented by many companies that provide environmental management impacts better, than if done individually.

On the implementation of these two approaches simbisosi industry indispensable, namely the collaboration and synergy among different companies that may occur due to the proximity of the location [2]. However, according [9], the collaboration and the synergy between the companies are not only available because of the proximity of the location, but also occurred in the supply chain, including the automotive supply chain. The Company is incorporated in the automotive supply chain is a company that works for supply raw materials production. In the automotive industry there are so many components and sub-components produced by the automotive components company.

If you look at the definition of industrial symbiosis according [2], said that the collaboration and synergy occurs hence the proximity. However, according to [6], industrial symbiosis is not only determined by the proximity of the location. The distance between the company did not correlate significantly with the value of the resource. At companies that are located in a specific industry network may be possible for the industry symbiosis. Geographical proximity associated with the transport costs directly caused by distance, but transportation costs will be less than the benefits of the synergy that occurs between companies [6]. Hence the importance of geographical proximity economically determined but not typical for the application of industrial symbiosis [3]. Proximity is considered to be a guarantee for the collaboration and synergy among the company, the experience of the construction industry in the area of industrial symbiosis is not always the case.

In the automotive supply chain, material flows consist of 10 kinds, such as textiles, glass, steel, aluminum, plastic and so on. Of the material contained ten steel material which is a nonrenewable resource. Steel material used in the automotive industry is the largest material (± 90 percent). Steel is a material consisting of iron and carbon and other materials required in accordance with the designation of the steel. Iron, as a renewable natural resource, its availability in nature of course limited and can not be added. Availability of steel will be largely determined by the availability of iron in nature. Therefore, the preservation of the availability of steel is done by preserving the availability of iron. In this study only exchanged material is made from steel raw material and components are contained in a short shelf life, or so-called fast moving components.

Environmental management in the automotive supply chain can be implemented by carrying out industrial symbiosis. The establishment of industrial symbiosis requires collaboration and synergy between the companies. In the automotive supply chain, collaboration and synergy has occurred. Thus the formulation of the problem in this research is industrial symbiosis has not been used in environmental management in the automotive supply chain, whereas the collaboration and synergy is the crew of industrial symbiosis has occurred. Environmental management by using industrial symbiosis in the automotive supply chain is expected to be an overview of the implementation of industrial symbiosis in the supply chain. Therefore it is necessary to build a model of industrial symbiosis in the automotive supply chain. Based on these problems, the research questions to be answered are:

1. How does the exchange of material, energy, water, and byproducts that occur in the automotive supply chain?

2. How to build and analyze models of industrial symbiosis that occurs in the automotive supply chain by taking into

account the exchange of material, energy, byproducts and water in industrial symbiosis for sustainable industrial resource efficiency?

The general objective of this research is to develop a model approach to environmental management by industrial symbiosis. Industrial symbiosis in the automotive supply chain is becoming an environmental management approaches in automotive components company. The general objective of this research is achieved through the following specific objectives:

1. To analyze the exchange of material, energy, byproducts and water on the automotive supply chain.

2. Build and analyze models of industrial symbiosis in the automotive industry supply chain by taking into account the exchange of materials: steel, energy, water, and byproduct in the manufacture of steel components are fast moving.

To maintain the quality of the environment required good management. Good environmental management will make the construction carried out will provide economic benefits, social and environmental. Construction of a third considering this benefit is referred to as an environmentally sound development. Thus the development of environmentally sound will consider the availability of natural resources are utilized in order to remain available for future generations. One approach that can be done to manage the environment is a symbiosis of industry which is an approach to the ecological industry. The theoretical framework in this study is shown Figure 1.

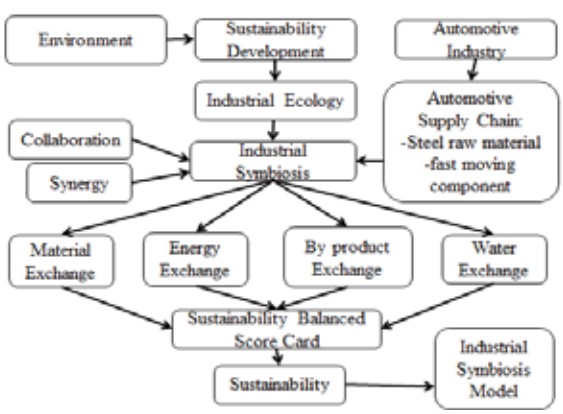

Figure 1. The theoretical framework

Industrial symbiosis according [1] occurred in the presence of a physical exchange, namely matter, energy, byproducts and water among companies which are in nearby locations. According to [6] exchange between companies is not only a physical exchange, but the exchange of knowledge and can occur between companies that are not necessarily adjacent but on a shared network.

Industrial symbiosis in the supply chain is seen from the exchange of material, such as steel that has been considered waste, because the exchange of input material as it is definitely happening. Steel materials that have become waste companies in tier 1 automotive components for example can be the raw material for the company in tier 2. Further industrial symbiosis in the automotive supply chain is seeing an exchange of energy, water and byproducts. The exchange of material, energy, water, and by-products is seen sustainability, so that industrial symbiosis that occurs can be a good alternative in the management of industrial environments. Indicators that reflect the performance of sustainability used is sustainability indicators of sustainability balanced scorecard. To show the relationship between variables in this study, it can be seen in the framework of the concept of research in Figure 2.

The establishment of industrial symbiosis can be identified by the exchange of material, energy, water, and byproducts between companies. Companies that seen in the study is a company present in the automotive supply chain, the company's automotive components at tier 1, 2, and 3. an occurrence exchange of material, energy, byproducts and water indicated by the formative indicators forming the occurrence of such exchanges.

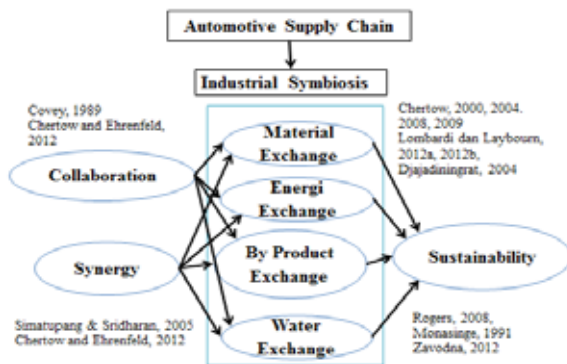

Figure 2. The Framework Concept

Model of industrial symbiosis built consisting of 3 variables reflective, namely collaboration, synergy and sustainability performance. These types of variables are taken with the consideration that this variable has existed in the supply chain (variable synergy and collaboration) as well as the industry has existed in symbiosis (variable sustainability performance). For variable exchange of material, energy, water, and by-products remains to be seen whether it has happened or not. Therefore, for variable exchange of material, energy, byproducts and water use formative variable types. Based on the analysis of the conceptual framework of research, can be formulated hypotheses as presented Figure 3 below.

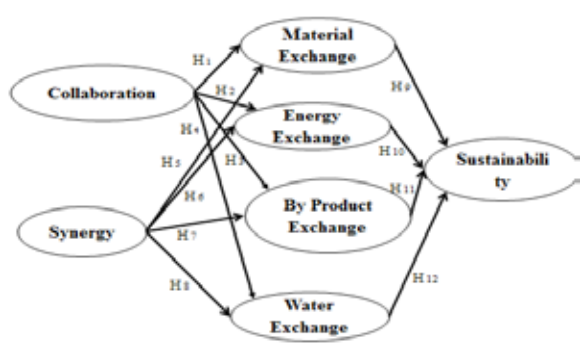

Figure 3. Hypothesis research

2. Research Methods

The approach in this research is quantitative, by measuring the automotive components company as a unit of analysis. Long implementation of the study is 15 months, ie from July 2013 to the month of September 2014. Locations were selected intentionally, yatu Java., Which indeed is not most

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companies locations automotive components in Indonesia. Production company principal activities conducted at PT Astra Daihatsu Motor (ADM PT) which is one of the Astra group. To determine the condition of the company in the production of automotive components company, selected intentionally Trimitra Chitrahasta PT and PT Nisaka Logamindo.

Of the overall population, namely automotive component company in the island of Java, randomly selected automotive components company a total of 33 companies. The number of samples is sufficient to be able to be analyzed by using Partial Least Square (PLS). In collecting data that will represent the company's automotive components as the data source is a minimum of a section or department manager is responsible in the use of raw materials of steel. Energy, byproducts and water.

Data collected by using a questionnaire distributed by sending an email through the link: http://docs.google.com/forms/d/1hWc6xcFbfsuCXWn5d34U4DG1w7vnbV0eNuI0P7PM/viewform?c=0&w=1&usp=mailformlink.

Data were analyzed by using Partial Least Square - Path Modeling (PLS_PM) using SmartPLS. PLS analysis is an analysis method of Structural Equation Modeling (SEM) based variant. The main characteristic of this is the PLS method does not require the normality of the data, the number of samples of at least 30. It can estimate the complex models (<1000 indicator) and the relation between latent variables and indicators can be shaped normative and reflective. Built structural models in this study is shown in Figure 4.

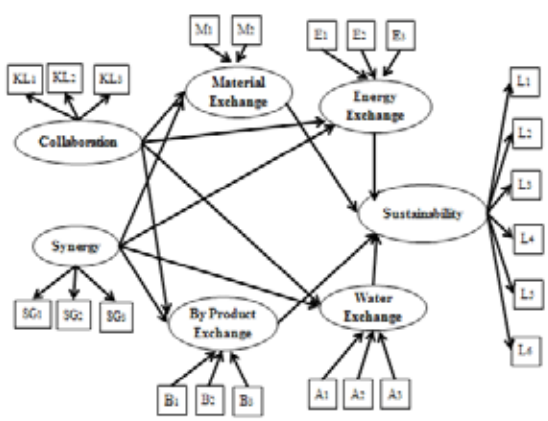

Figure 4. Structural Model (Outer Model)

3. Result and Discussion

1. Test Measurement Model

Test carried out on this measurement model to see the validity of the measured variables in measuring the latent variables. Tests performed are:

1. Test Statistics T.

This measured variable significance test using the t test, and the result that the measured variable E2, B3 and A3 are not significantly so that all three measured variables are then not used again. Having eliminated the variables measured were not significant, then the measurement model (outer model) becomes as shown Figure 5.

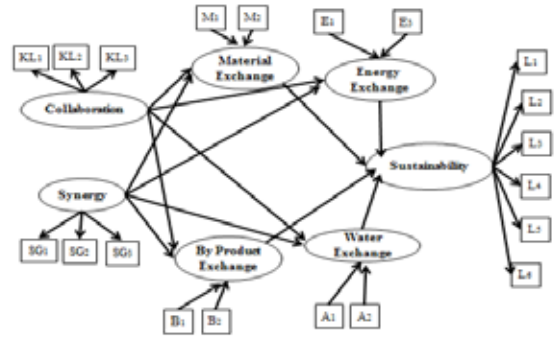

Figure 5. Model Measurement after test validity

2. Standard Loading Factor (SLF).

SFL value of each variable measured against the latent variables are presented Figure 6. Based on the value of SLF in Figure 6 shows that all significant variables (> 0.5) and the higher value of SLF showed higher validity as well.

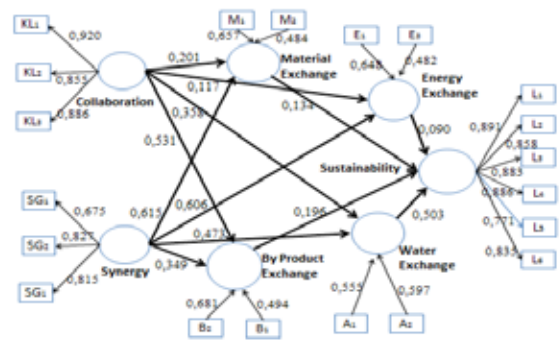

Figure 6. Diagram Tracks Structural Model Research

3. Average Variance Extracted (AVE).

AVE value indicates variance obtained from each of the latent variables. AVE value is only for the latent variables are reflective only and value AVE of three latent variables reflective shown Table 1. According to Table 1, the highest value obtained from the variable AVE synergies, the lowest of collaboration variables. This indicates that the variable synergy to provide more information on the model, followed by the variable of sustainability and collaboration.

Tabel 1. Nilai Average Variance Extracted (AVE) dari Variabel Laten Reflektif

No	Variabel Laten	Nilai AVE
1	Sinergi	0,787
2	Kolaborasi	0,601
3	Keberlanjutan	0,731

Sumber: Olahan dengan PLS PM

4. Composite Reliability and Cronbach Alpha.

The second test showed the level of reliability of any latent variables. Value Composite Reliability and Cronbach Alpha shown Table 2. Value Composite Reliability and Cronbach Alpha is expected to> 0.7, the higher will be the higher relaibilitasnya. Based on Table 2 shows that the variable has a value of collaboration Composite Reliability and Cronbach Alpha very close to the value of 0.7, but if rounded so they obtained a value of 0.7. Therefore all latent variables reflective said to be reliable.

Tabel 2. Nilai Composite Reliability dan Cronbach Alpha dari
Variabel Laten Reflektif

No	Variabel Laten	Composite Reliability	Cronbach Alpha	Keterangan
1	Sinergi	0,917	0,866	reliabel
2	Kolaborasi	0,818	0,665	reliabel
3	Keberlanjutan	0,942	0,926	reliabel

Sumber: Olahan dengan PLS PM

The tests have been done on the structural model, the final model is obtained as shown Figure 5 in accordance with the previous validity test. Test against formative latent variables used 2 test, namely:

1. Test Significance of weights.
The test is to see that a significant formative indicators used to measure latent variables. Based on Table 3, all variables measured on a significant formative latent variable measuring latent variables. Thus all these measurable varaibel can be used to menformasikan latent variables.

Tabel 3. Nilai T pada Outer Weight Variabel Laten Formatif

No	Variabel Laten Formatif	Variabel Terukur	Nilai T	Nilai P value	Keterangan
1	Materi	M_1	4,292	0,000	Signifikan
		M_2	2,728	0,007	Signifikan
2	Energi	E_1	3,683	0,000	Signifikan
		E_3	2,770	0,006	Signifikan
3	Produk Samping	B_1	6,925	0,000	Signifikan
		B_2	4,019	0,000	Signifikan
4	Air	A_1	4,091	0,000	Signifikan
		A_2	3,969	0,000	Signifikan

Sumber: Olahan dengan PLS- PM

2. Multicollinierity.
Multicollinierity test is to determine whether there is a strong correlation between the measured variable (No multicollinierity). If found multicollinierity then one of the measured variables should be eliminated in order not to disturb the measurement. Multicollinierity test uses VIF (Variance Inflation Factor), if VIF between 5-10 means there multicollinierity. VIF value of the measured variable shown Table 4 below.

Tabel 4. Nilai VIF Variabel Terukur Dari Variabel Laten Formatif

No	Variabel Terukur	VIF	Keterangan
1	M_1	1,376	Tidak ada *multicollinierity*
2	M_2	1,376	Tidak ada *multicollinierity*
3	E_1	1,447	Tidak ada *multicollinierity*
4	E_2	1,447	Tidak ada *multicollinierity*
5	B_1	1,232	Tidak ada *multicollinierity*
6	B_2	1,232	Tidak ada *multicollinierity*
7	A_1	1,344	Tidak ada *multicollinierity*
8	A_2	1.344	Tidak ada *multicollinierity*

Sumber: Olahan PLS PM

4. Structural Test Model
Against structural models performed several tests, namely:

1. T Statistics.
Structural model analysis performed to see whether the hypothesis is made acceptable or not. The test used is the T test, and the results are shown Figure 6.

2. R Square.
R Square value is calculated against endogenous latent variables, which is the coefficient of determination for the endogenous latent variables. R Square value shown Table 5 below.

R Square value indicates the ability of each of the variables will form the overall model

Tabel 5. Nilai R Square untuk Variabel Laten Endogen

No	Variabel Laten Endogen	R Square	Kriteria
1	Materi	0,585	Kuat
2	Energi	0,458	Substansial
3	Produk Samping	0,672	Kuat
4	Air	0,590	Substansial
5	Keberlanjutan	0,664	Kuat

Sumber: Olahan PLS PM

5. Development of Industrial Symbiosis Model in Automotive Supply Chain
The model is a simplification of the industrial symbiosis made to the industrial symbiosis that occurs. Exchange of material, energy, byproducts, and water that occurs in the automotive supply chain related to the collaboration and synergy. This happens exchange begins with the collaboration and synergy in the automotive supply chain. Collaboration and synergy makes automotive components company to cooperate and get the added value of exchanges that occur.

As mentioned earlier, to build a model of industrial symbiosis, exchanges that occur need to be seen to do with sustainability. Exchange relationships material, energy, byproducts, and water with sustainability is to ensure that the exchange is happening is that the exchange will form industrial symbiosis.

Based on hypothesis testing found that, only water exchange that influence the sustainability whereas the exchange of material, energy, and the byproducts are not related to sustainability. Exchange of material, energy and byproducts in the automotive supply chain is caused more by economic considerations alone, not to take into consideration environmental and social aspects. In sustainability, this exchange should be based on economic considerations, social, and environmental.

Water exchanges related to sustainability shows that water is a resource that can be utilized from the company that is still a source of public goods. Utilization of public goods requires awareness for users to consider its availability in nature. Uncontrolled water use can lead to lack of water throughout the year. Underground water reserves will increasingly shrink, especially in the dry season and will be wasted by flooding in the rainy season. Conservation and preservation of water resources can be made by automotive components company itself but the effect will be felt together. By doing water saving measures in each company will affect the overall water availability.

Model of industrial symbiosis in the automotive supply chain shows that environmental management by companies of automotive components is done by conservation and utilization of water savings both for production and for other supporting activities. If this model will be applied in the automotive supply chain collaboration and synergy that occurs should take into account the social and environmental aspects in addition to economic aspects. Exchange of material, energy, byproducts, and water should be implemented by making all parties to maximize the utiliza-

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tion of natural resources, suppress the waste generated, utilizing byproducts produced.

4. Conclussion

From the analysis it can be concluded that the model of industrial symbiosis derived from the automotive supply chain for raw material of steel in fast moving components, is a model that only considers the exchange of water. Exchange of matter, energy and by-products do not contribute to this management model. In more detail can be summarized as follows:

1. The exchange of material, energy, and by-products do not contribute to environmental management using industry symbiosis. Which determines the exchange of water environmental management in the automotive supply chain.

2. The model of industrial symbiosis in the automotive supply chain made from steel components for fast moving environment management occurs in the presence of water exchange. This model shows that the management of the environment by industrial symbiosis in the automotive supply chain is indicated by the exchange of water. Water exchange occurs has considered the economic, social, and environmental.

5. Sugestion

Advice can be given from this research are:

1) Research which saw the exchange of other raw materials used in the automotive industry will provide a more complete model of the development of the automotive industry environmental management.

2) The type of components in the automotive component industry are many and have different characteristics. Research on other types of components that will enrich environmental management approach in the automotive supply chain.

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