Development of supply chain models of natural rubber products by considering quantity-discounts and environmental factors

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Abstract. The inevitable increase in environmental pollution and transportation activities in order to meet human needs is a dilemma. The purpose of this study is to find novelty in the field of supply chain management that is obtained by classifying supply chain management references into certain attributes such as quantity discount, centralized strategy, decentralized strategy, multi items, multi echelons, multi objectives and environmental factors especially greenhouse gas emission. Another way to do this is to study the company to find out how the supply chain system is carried out by the company i.e. the company uses 2 echelons, single item, single objective, centralized strategy, and no quantity discount. From the references studied, the included environmental model reference which has 4 echelons attributes, multi objective, multi-item, and centralization can be taken as the basic model. It requires developer models with quantity discounts, multi stages, multi items, centralized strategy, multi objectives in order for the basic model that can approach the company’s system. The developed model is supply chain models in natural rubber products by considering quantity-discounts and environmental factors with quantity discounts, 3 echelons, centralized strategy, multi-items, and multi-objectives.

1. Introduction
Rubber, one word has many benefits. We encounter many rubbers in our daily lives in different forms such as car tires, motorcycle tires, gloves, children's toy balloons, rubber bands, sandals, shoes, basketball, pencil erasers, water hoses, rubber boats, and others. This rubber commodity is produced from rubber raw materials, namely latex. Indonesia is one of the largest rubber producing countries in the world, which is ranked second after Thailand [1].

Judging from Indonesia's state revenue, the rubber sector occupies the top ten position in terms of contributing to the country's foreign exchange, namely occupying the ninth-largest position [2]. The rubber commodity is produced by plantations in Indonesia where the plantations are grouped into State Large Plantation (SLP), Large Private Plantation (LPP), and Smallholder Plantation (SP) [3]. PT Perkebunan Nusantara IX (PTPN IX) headquartered in Semarang, Central Java is one of the companies included in the State Large Plantation (SLP).
In principle, a supply chain is a group consisting of independent organizations that are linked together through products and services that provide added value both collectively and independently in order to be delivered to end consumers [4]. Supply chain management is an integrated philosophy that is used to manage the total flow of products or services from suppliers to end users. Another meaning is the management of a chain or operations and centers through which supplies pass from the source of supply to the final customer [5].

It is common practice for suppliers to offer lower unit prices on orders for larger quantities as an economic incentive for buyers to purchase larger lot sizes. Sellers benefit from sales in larger quantities by reducing the cost of processing and setting orders per unit and by (at least temporarily) increasing volume. The buyer benefits both by reducing the per-unit ordering cost and by paying a lower unit price, but at the expense of having more inventory. The problem faced by buyers is identifying lot sizes that minimize total costs [6]. The Economic Order Quantity (EOQ) of the inventory model assumes that unit costs are constant, no matter what quantity is purchased. In fact, suppliers can persuade their customers to order more by offering quantity discounts. If the quantity purchased is greater than the specified "price gap" quantity, the unit cost is reduced. It is common practice to include this discount policy in published pricing schedules [7].

We as humans, in carrying out our daily activities, must protect and preserve the environment. If we do not protect the environment, environmental damage will affect the quality and health of our lives. Environmental damage can be in the form of air pollution and others. According to a Bloomberg report, Indonesia is ranked 8th out of 15 countries with the deadliest pollution level [8].

The Environmental Quality Index of the Indonesian Ministry of Environment shows that not all regions are in a very good predicate and there has been a change in the predicate, either an increase for the better or a decrease in a bad direction. For this reason, efforts are needed to maintain the predicate of good environmental quality and improve it towards the very good predicate [9]. From year to year, the growth of motorized vehicles continues to increase, which means increasing air pollution because the exhaust fumes released by motorized vehicles also increase [10].

With the growth of industrialization in the world, the environmental and ecological impacts on products have become major issues. By only considering the economic impact and ignoring the ecological impacts this will threaten the lives of humans and animals such as global warming, a toxic environment, depletion of the ozone layer, and a decrease in the quality of natural resources. Therefore, consideration of environmental impacts in taking industrial interests plays an important role in environmental preservation [11]. From the above literature, it can be inferred that the problem is the development of the supply chain model by considering quantity discounts and environmental factors. The purpose of this study is to find novelty in the field of supply chain management that is obtained by classifying supply chain management references into certain attributes.

2. Materials and Methods
The method used is a systematic review by looking for references in science direct, emerald, ProQuest, Ebsco, IEEE, and google scholar. In accordance with the title of this article, the steps taken are successively looking for references with the keyword supply chain and the attributes of each model such as supply chain AND quantity discounts, supply chain AND centralized, supply chain AND decentralized, supply chain AND multi-item / multi-product, key supply chain AND multi-echelon, supply chain AND multi-objective, supply chain AND green. The references obtained are entered into groups of each model attribute such as quantity discount, centralized, decentralized, multi-item, multi-echelon, multi-objective, and green supply chain where these attributes are useful as developer model.

PTPN IX as one of Indonesia's natural rubber plantation companies is useful as an example of natural rubber supply chain management and as an object for a practical contribution. PTPN IX is a company that manages rubber where this company has a supply chain with multi-items, 3 echelons, centralized strategy, single objective function (namely economic factors only), and has not implemented quantity discounts. The basic model used is a reference with title The use of an optimization model to design a green supply chain: A Case Study of the Thai rubber industry that has 4 echelons, multi items (Ripped-
manufacturing process, along with their distribution and transportation can be improved.

Smoke Sheet / RSS, block rubber / STR, latex concentrate / LCT), multi-objective function (namely economic and environmental), centralized strategy, not yet involving quantity discounts [12].

By looking at the PTPN IX practice, the developer model, and the basic model used in model development, the multi-item attributes in the developed model are the same as the multi-item attributes in the PTPN IX practice and the basic model that is 3 items. Meanwhile, for the model attribute which is multi-echelon, the developed model uses 3 different echelons from the practice of PTPN IX, namely 2 echelons and the basic model, namely 4 echelons. For other attributes, namely multi-objective, the model developed uses the same 2 objective functions as the basic model, namely the economic objective function and the environmental objective function, but is different from the practice of PTPN IX which uses only economic objective functions. As for the strategic attributes, the model developed uses the same centralized strategy as the basic model and practices of PTPN IX. Another attribute, namely quantity discount, is used in the developed model, whereas in practice PTPN IX and the basic model have not used quantity discounts.

3. Results and Discussion

The supply chain references yield using the above method, then classified into some attributes as can be seen in Table 1. According to Table 1, especially in the quantity discount section, there were quantity discount models. For example, all unit quantity discount single breakpoint was a discount quantity model based on the number of units purchased (and exactly for all units) with one quantity as the limiting quantity to determine the quantity discounted quantity. For volume discounts, the quantity was based on the value of the product of the quantity times the dollar or rupiah value. For the incremental discount model, the amount of the discount depends on the discount interval.

In the centralized strategy section, some actors or stakeholders play a role in determining the strategy, which in the centralized strategy, there was one determining stakeholder while other stakeholders follow the determining stakeholder. In the decentralized strategy section, some stakeholders play a role in determining the strategy where all stakeholders play a joint role in determining the strategy. In the multi-item section, there were many items or products involved in the model. In the multi-echelons section there were many echelons or in other words the number of units or links in the supply chain model. In the multi-echelons section there were many echelons or in other words, the number of tiers or links in the supply chain model. In the multi-objective section, there were many objective functions and what were the objective functions in the supply chain model. In the green supply chain, there were main or main things in the green supply chain model. In line with the research objectives, namely the development of a supply chain model for natural rubber products by considering quantity discounts and environmental factors, a developer model was needed which was obtained from the attributes of the supply chain model.

These attributes function as a developer model where the developer model was one element that was combined with other elements, namely the basic model and company practices to produce the developed model. The developer model in Table 1 was combined with the basic model and company practices to produce a developed model as shown in Figure 1.

Model development that can be seen in Figure 1 was carried out by combining the basic model (where there were 3 items, 4 echelons, centralized strategy, 2 objective functions) with the PTPN IX supply chain practice (3 items, 2 echelons, centralized strategy, economic objective function) and with the developer model that yield developed model having attributes of multi items (RSS, concentrated latex and lump latex), 3 echelons (plantation—central manufacturer—distributor—customer), centralized strategy, economic objective function & environmental factor, and applying quantity discounts.

Some of the supply chain models in natural rubber are as follows [12]. This paper aims to take the first steps in completing the environmental supply chain management problem. It proposes a green supply chain management (GSCM) model that will provide environmental benefits to the Thai rubber industry. For this purpose, GSCM an optimization model is formulated, in which the rubber product manufacturing process, along with their distribution and transportation can be improved.
Table 1. Supply chain attributes.

| Quantity Discounts | Centralized Strategy | Decentralized strategy |
|---------------------|----------------------|------------------------|
| [13]: all unit-quantity discounts, single breakpoint. | [19]: producers, distribution centers, retailers, markets. | [24]: manufacturers, retailers and consumers. |
| [14]: volume discounts. | [20]: supplier, buyer. | [25]: supplier, buyer. |
| [15]: all unit-quantity discounts, several breakpoints. | [21]: An original approach to optimal Distribution Planning for an upstream centralized network with uncertainty and structure dynamics considerations has been developed in this paper. | [26]: supplier, manufactur, market |
| [16]: incremental quantity discounts. | [22]: pharma distributor, pharma retailer. | [27]: provider, client |
| [17]: all unit-quantity discounts are based on the aggregated annual order quantities. | [23]: spareparts distributor, its dealers. | [28]: supplier, retailer, customer |
| [18]: quantity discounts are based on the aggregated annual order quantities. | [29]: farmer, distributor, retailer, end customer. |
| [30]: 2 items | [33]: 2 echelons | [38]: minimization cost of transportation and maintenance, minimization cost of pickup & delivery, minimization sum of fix, variable & cooperation cost. |
| [31]: 3 items | [34]: 2 echelons | [39]: maximization of profit, maximization of sales, minimization of risk |
| [32]: 6 items | [35]: 2 echelons | [40]: maximization of profit, minimization of risk, minimization of emission |
|         | [36]: 2 echelons | [41]: maximization of profit, minimization of risk |
|         | [37]: 2 echelons | |

Green supply chain

[42]: impact of jointly optimizing strategic network design and tactical inventory planning on the cost and CO2 emissions
[43]: the methodology: Life Cycle Assessment, Multi objective optimization, Multi criteria decision making
[44]: intermediary: distribution center and retailer
[45]: the impact of credit strategy on the green supply chain performance
[46]: environmental as one of criterias.

The expected result is that total greenhouse gas emissions will be minimized and environmental performance is maximized [47]. The research is aimed at increasing the competitive advantage of companies by designing a supply chains framework with profit sharing system to ensure material
availability. Determination of the purchase price of the rubber material was done by using the trend of the average price of rubber so that the purchase of rubber material flat.

**Figure 1.** Conceptual model of the developed model of the supply chain.

To create trust in the supply chain, a revenue-sharing system is used so that suppliers will provide exact and consistent quantity, quality, and delivery time [48]. This study examines the supply chain of natural rubber production in Indonesia and assesses price transmission to rubber farmers and recommends suitable schemes that will help ensure high production standards and returns / or sustainable production of natural rubber. The framework for examining the performance of the rubber marketing supply chain rests largely on the efficiency of the natural rubber marketing system, including the value chain principle in marketing margins, and the disclosure of price transmission from consumers to farmers.

The model developed is a supply chain model for natural rubber which has a novelty which lies in the following attributes, namely multi-items (namely RSS, concentrated latex, and lump rubber), 3 echelons (plantation-central manufacturing-distributor-consumer), centralized strategy, function of economic objectives and environmental factors, and apply quantity discounts.

4. Conclusions

According to the research objective that is the development of supply chain model of natural rubber products by considering quantity discounts dan environmental factors, the developed model (with quantity discounts, 3 echelons, centralized strategy, multi-items, and multi-objectives) could be yielded by combination among the model developer, company practice and basic model. This model developer is obtained by classified supply chain management references into certain attributes such as quantity discount, centralized strategy, decentralized strategy, multi items, multi echelons, multi objectives and environmental factors especially greenhouse gas emission, especially from vehicles.

The company’s practice on supply chain is 2 echelons, single item, single objective, centralized strategy, and no quantity discount (nor in form of all-unit quantity discount or in form of incremental quantity discount). The basic model reference used has 4 echelons, multi-objective, multi-item, and
centralization. From the supply chain model developed and from the model development process, it is known that there are 3 main components in the development of the supply chain model, namely the basic supply chain model used, the attributes in the developer model, and supply chain practices in the company. By modifying one or more of these components, it is expected to result in the development of other supply chain models. For example, by modifying the attributes of the developer model, such as increasing the number of items, increasing the number of echelons, adding the objective function or applying a quantity discount of a different type. The development of the supply chain model can also be done by applying it to different companies and using different basic models.

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