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Efficiency Analysis of Indonesian Coffee Supply Chain Network Using A New DEA Model Approach: Literature Review

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Abstract

A position of Indonesia as the world's biggest producer of robusta coffee has declined. Currently, Vietnam is the main producer of robusta coffee in the world. A decline in Indonesia's position is due to saturation of the Indonesian coffee export destination countries which results in declining demand for export of Indonesian coffee. The quantity of Indonesian robusta coffee supplied to the international market depends on secured supply of domestic raw materials and the efficiency of supply chain network. Efforts to ensure the domestic coffee supply is done through efficiency analysis on each member of the supply chain that forms the supply chain network. Efficiency measurement in supply chain network is performed using the New DEA Model developed by Liang et al. The measurement technique of DEA is gradually the efficiency of the production unit (product flow) of each actor (seller and buyer) on the supply chain. The efficiency level of each actor can determine the efficiency of the supply chain network. This is because of the relationship of input and output between seller and buyer so that the final output of supply chain network will produce. New DEA model is more appropriate to use in supply efficiency mechanism that can be cooperative.

Keywords: efficiency, New DEA Model, supply chain

1. Introduction

Coffee is one of main export commodities in Indonesia. During 1990-1996, Indonesia was a major producer of world robusta coffee. According to International Coffee Organization (2016) the position of the major producer of robusta coffee is occupied by Vietnam since 1997 until now (International Coffee Organization [ICO], 2016). The decline in Indonesia's position is caused by the saturation of Indonesian coffee export destination countries which results in declining demand for Indonesian coffee exports (Meiri, Nurmalina, & Rifin, 2013). In 2014, Indonesian coffee supplied for about 4.22 percent of the world requirement (ICO, 2016). The quantity of Indonesian Robusta coffee supplied to the international market depends on secured supply of domestic raw materials and the efficiency of supply chain network. Efforts to support the secured supply of raw materials involve various parties (seller and buyer) including farmers as the main suppliers of raw materials, village traders or sub-district traders as intermediary of raw materials, processors as consumers of coffee beans at the local level, and exporters who play a role as consumers of coffee beans at the level of foreign countries.

However, there are complex problems between the actors involved in the supply chain. Farmers as the main supplier of raw materials harvest from June to August. During the harvest season, the supply of raw materials is available. Yet, the supply of raw materials begins to decrease out of the harvest period. Usually, farmers who own smallholding immediately sell coffee beans during the harvest season. Policy to hold stock (of production) is difficult to implement since farmers are urged to meet the daily needs by selling their coffee as soon as possible (Dradjat, Agustian, & Supriatna, 2007). Conversely, farmers who own large area will sell coffee beans during the harvest season besides keeping them as stocks which will be sold when the selling price is high. High and low price of coffee beans is determined by several things, namely: a) the price of coffee in the world market (London), b) grade (foreign matter, black seed, broken seed, moisture content), and c) partnership. In general, farmers sell coffee beans with moisture content above 12 percent which will have impact on low selling price received by farmers. As it takes 5 to 10 days of sun drying time to obtain coffee beans with moisture content of less than 12 percent, this process becomes an obstacle due to unpredictable weather conditions because farmers

need money immediately to meet their daily needs. Selling coffee beans with moisture content of more than 12 percent will result in lower farmer income. Moreover, the government applies Value Added Tax (VAT) of 10 percent for coffee beans (dried and roasted). This creates impact on the decreasing motivation of farmers due to compensation of VAT payments by large traders or exporters which is imposed on farmers. Thus, the price received by farmers is lower than it should be.

Other actors involved in the coffee supply chain are traders. Traders function as intermediary in purchasing raw materials which further sold to other traders at higher level which is up to the level of exporters. Action of farmers who do not continuously sell the raw materials will affect the traders whose input is directly obtained from farmers. Later, this leads to problem so that the income of traders (village or sub-district) will depend on the amount of coffee beans sold by the farmers to the traders. Generally, village traders will buy coffee beans from farmers in the form of *asalan* (unsorted and ungraded) which has moisture content of more than 12 percent, while coffee beans with moisture content of less than 12 percent are generally sold by farmers directly to export partners. Limited raw materials at the farm level lead to competition at the level of village or sub-district traders to obtain the coffee beans.

Coffee supply chain also involves exporter as the main consumer of coffee beans. The problem exists in exporter is the implementation of VAT of 10 percent on coffee commodities since 2014 which is based on Circular Letter of Directorate General of Taxation No.24/PJ/2014 towards the Decision of Supreme Court No.70/HUM/2013 concerning VAT on agricultural goods produced from agricultural and plantation business activities. VAT is imposed on tax payer/businessman, either personal or entity conducting the delivery of agricultural goods that are taxable goods, must be confirmed as Taxable Entrepreneurs (PKP, *Pengusaha Kena Pajak*) except for small entrepreneur who performs the delivery of Taxable Goods (BKP, *Barang Kena Pajak*) for a book year with the amount of gross revenue of Rp.600,000,000.00 at the most. As a tax payer, coffee bean exporters must pay VAT. however, the payment is charged to farmers through the decreasing purchase price from farmers. This situation will decline the supply of raw materials from farmers which potentially decreases the export volume of coffee beans. Another problem found in exporter is the limitation of raw materials due to competition with local companies and other exporters. Furthermore, there is also a quality requirement set by the International Coffee Organization (ICO) at the insistence of consumer country (Dradjat et al 2007). Other actors found in the coffee supply chain are processors. In general, small-scale coffee processors in Indonesia still use simple machines. Raw materials used are generally obtained from farmers in the surrounding area. The quality of coffee beans as a raw material is highly varied. Most of the processors get coffee beans from farmers with *asalan* quality (moisture content of more than 12 percent). Coffee beans with a moisture content of less than 12 percent will be selected by farmers to be sold to export partners since farmers received higher price by selling the coffee beans to exporter than to processors. Another reason is that processors use raw coffee bean (*asalan*) as raw material because it can be mixed with other cheaper raw materials such as corn and soybeans. However, there are some of the farmers who sell raw materials that are still in the form of good quality red cherry to the processors. They do not want to dry the red cherry until it turns to be coffee beans since it takes 5 to 10 days for drying, while farmers are urged to meet the daily needs. This will result in labor costs for drying activities. Hence, processor faces the competition of raw materials, both with other coffee processors and exporters. Another problem faced by a processor is the implementation of Value Added Tax (VAT) of 10 percent in 2014 for dry coffee beans and roasted coffee. Later, it has an impact on the increase in costs paid by the processor for processing activities (roasted coffee beans) which directly decreases the coffee demand due to increase in roasted coffee price. In addition, import duty on imported goods of processed coffee products (roasted coffee, ground coffee, instant coffee, coffee mix) from 5 to 20 percent of the base price through the Regulation of the Minister of Finance No.132/PMK.010/2015 becomes a problem for processors using the imported raw materials. This generates an increase in costs paid by processor thus resulting in decreasing output quantity.

The actors involved (seller and buyer) have different interests. However, on the other hand, they are related to each other in coffee selling activity to consumers. Based on the above, it is necessary to analyze supply chain efficiency by using appropriate efficiency measurement. The analysis is based on the input and output variables that are present in the activities of each actor (seller and buyer) so that the supply chain is efficient

2. Supply Chain

Supply chain is the flow and transformation of products, flow of information and finance from the stage of raw materials to the end users (Handfield, Ernest, & Nichols, 2002). It involves all parties, either directly or indirectly, to meet customer demand. Parties involved are not only producer and supplier but also transportation, warehousing, retailer, and customer with aim to achieve fast response and effective cooperation in quality control and cost reduction (Chopra & Meindl, 2007). Moreover, according to Nurmalina et al. (2015), the purpose of

supply chain is to maximize the value of supply chain produced. Summer (2009) defined that supply chain is an organizational network involved in transfer of material, information, and money as the flow of raw material from each source through the production process until raw material is delivered as end product or service to final consumer. The supply chain should be seen as a unity between the involved actors (Jarzebowski & Jarzebowska, 2016).

The whole supply chain members form a chain called supply chain structure which consists of suppliers to final consumers. Business process in supply chain which is an activity to meet the final consumer order involves three flows found along the supply chain (Nurmalina et al., 2015). The flow moves from one supply chain member to other supply chain member (Figure 1.) The product flow moves from suppliers to consumers, while financial flows move oppositely. Information flow is open and moves in two directions indicating that information is required from logistics member and the information can be accessed by other members. In addition, imperfection of information may lead to bullwhip effect which results in a shortage or excess of inventory.

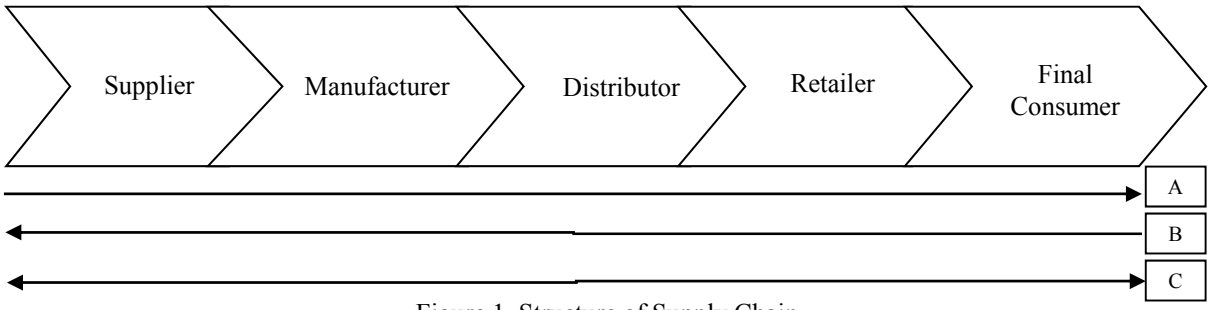

Figure 1. Structure of Supply Chain

(Chopra & Meidl (2007), Nurmalina (2015))

Description:

A = Product Flow

B = Financial Flow

C = Information Flow

According to Chandrasekaran and Raghuram (2014), supply chain network involves organizational relationships which aim to serve consumer demand and in the process of achieving efficiency through the role of the players and their various activities (Figure 2). Players in supply chain consist of:

a. Resources owners. Resource owners are not always involved in production but they are able to put the resources to others for rent. Resource management is a key aspect of the agribusiness supply chain
b. Input providers. The function of agricultural production requires inputs such as seeds, fertilizers, pesticides, irrigation and equipment, and capital equipment. Input efficiency will bring supply chain efficiency. The relationship between input provider and value creation may influence supply chain, not only in term of price efficiency but also production efficiency
c. Production resource and input are used to produce agricultural products for direct consumption and the creation of value added. Production is the availability of resources and production factor including agro climate condition
d. Market for direct consumption. Farmers sell the output through the market or intermediary and final consumer can buy the products later
e. Processors. Most of agricultural products will be processed into products until they are received by consumers. The processor determines the margin and conversion cost
f. Open market. Open market has an important role in the supply chain since it can define the power and profit sharing in the entire supply chain network
g. Retailers. Organized retailer will obtain the benefit of efficiency in the supply chain since the government protects small traders
h. Consumers. Consumer is in the last position in the supply chain network.

i. Financial agents. Most farmers have limited fund in performing farming activities. This weakness is benefited by some parties to take advantage by setting low selling price of agricultural products. The parties are loan sharks and middlemen.

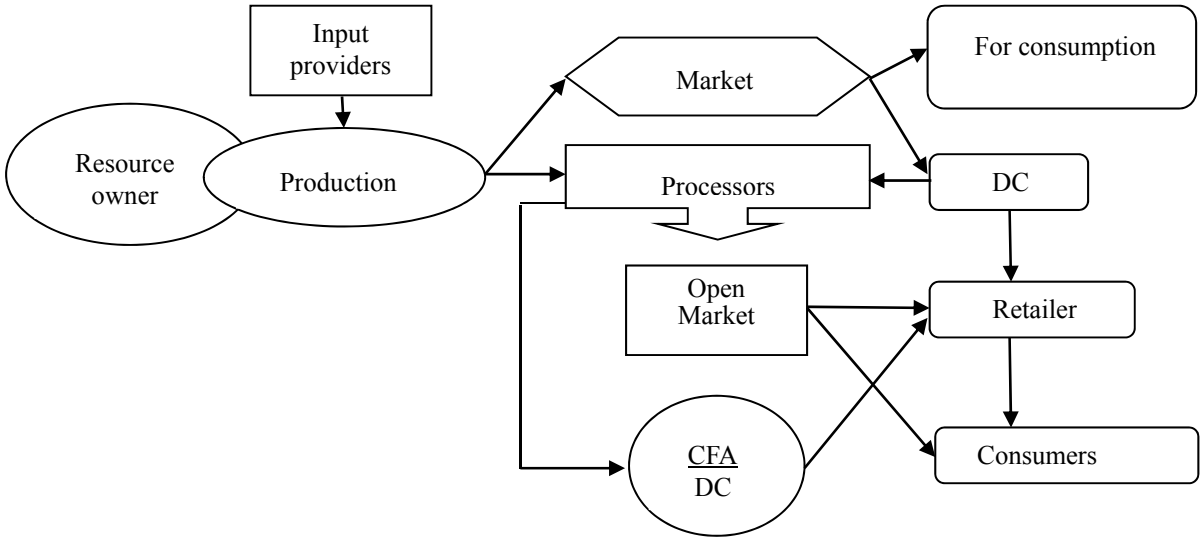

Figure 2. Agribusiness Supply Chain, Distribution Channel (DC),
Carrying and Forwarding Agent (CFA)
(Chandrasekaran & Raghuram, 2014)

3. Supply Chain of Indonesian Robusta Coffee

According to Lukas (2015), actors in the supply chain include: 1) producer (farmer, cooperative, and plantation), 2) processing, 3) exporter (a. large, responsible for storage, transportation, insurance of coffee; b. small, take advantage from rural farmers requiring cash by paying on the spot), 4) importer generally functions as the connector between coffee in the market and the buyer. Several importers are responsible for a number of services such as insurance for coffee and other financial options as well as providing testing for coffee quality, 5) buyer is the most powerful actor in the supply chain. The more concentrated and the larger the company scale, the coffee market will be dominated by buyerwhich isindustrial firm in general, 6) certification organizations & Non Governmental Organizations (NGOs).

Research conducted by Aklimawati, Yusianto, & Mawardi (2014) found that the actor of robusta coffee supply chain in the slopes of Mount Tambora, Sumbawa included several parties namely farmers, collectors, wholesalers, and exporters/manufacturers. Production of farmer coffee beans was sold directly to collectors at the hamlet level. The collectors had middlemen to collect the farmer coffee beans from the village. Collectors directly visited farmers to buy coffee beans. Thus, farmers never sold their coffee in the coffee markets as marketing access to collectors is easier. Limitations of farmers knowledge on market information as well as access to marketing networks motivate farmers to sell coffee beans only to middlemen. Collectors at village level who have supplied coffee beans from farmers and collectors will sell their coffee to large traders located in Sumbawa Besar. In general, collectors perform coffee beans purchasing which depends on the target of purchasing volume from wholesalers and exporters/manufacturers in Surabaya. Generally, actors in supply chain activity will pay focus on the smooth flow of material (coffee beans) from one chain to the following chain in order to make a profit.

In most cases, the main problem faced by coffee industry in Indonesia is the level of production and quality (Ibrahim & Zailani, 2010). This is shown by the fluctuating production level in several production centers and also the poor quality of coffee. Coffee chain is usually complicated and different from one country to another, yet coffee chain in Indonesia generally consists of: farmers, intermediaries, processors, government agencies, exporters, brokers, roasters, and retailers.

Other problems found in coffee farmers in Lampung Province in which one of robusta coffee production centers in Indonesia namely low productivity, coffee bean quality, and bargaining position (Arifin, 2010). Moreover,

specific problems found include guarantee of land ownership and encroachment on protected forests to be production area. These issues become a concern in the sustainability of global coffee supply chain.

Supply chain analysis was conducted in West Lampung Regency and Tanggamus Regency as areas contributed to the largest production in Lampung Province (Asmarantaka, Tinaprilla, & Rifin, 2015). Analysis conducted in West Lampung consisted of ten channels in which seven channels were supply chain managements with PT Nestle and PT Indocafco while the other three channels were open and non-cooperation channels. Analysis in Tanggamus was mostly in collaboration with PT Nestle which amounted to 75.48 percent, while the rests were open channels. Analysis result shows that in both regencies, cooperation with PT Nestle was more efficient than with PT Indocafco. This is indicated by the distribution of prices, margins, and more competitive costs. In addition, coaching to farmers was also done by PT Nestle in both regencies.

4. Efficiency Measurement in Supply Chain Network

Supply chain efficiency focuses on the resources utilized along the chain in meeting customer demand (Widayanto, 2013). Concept of efficient supply chain is focused on cost minimizationin which supply chain requires lower input costs in generating more efficient output. An efficient supply chain is explained in certain attributes, namely: 1) main objective, that is the lowest cost of supply demand, 2) product design strategy, that is performance maximization at minimum product cost, 3) pricing strategy, that is lower margin since price is the main driver for customer, 4) manufacturing strategy, that is lower cost through high utilization, 5) inventory strategy, that is inventory minimization for lower cost, 6) lead time strategy, that is reducing but not sacrificing cost, 7) supplier strategy, that is selecting based on cost and quality (Fisher 1997 in Chopra & Meindl, 2007).

The importance of supply chain efficiency includes: a) reducing losses, b) increasing profits, c) increasing value added for actors involved, c) long-lasting, f) increasing income for farmers, g) increasing value added for customers, and h) balance between demand and supply gap (Negi & Anand, 2014). The key in producing supply chain performance is the supply chain drivers that play role as players in the entire supply chain networks (Chandrasekaran & Raghuram, 2014). Drivers are seen as tool to implement strategies in performing activities; thus, efficient supply chain can be achieved. Drivers in supply chain consist of facility, inventory, transportation, information, sourcing, and price (Chopra & Meindl, 2007).

Efficiency measurement in supply chain is done in single channel and supply chain network (Warsito & Suparno, 2008). Efficiency measurement is aimed to maximize output and minimize input (Cooper, Seiford, & Tone. 2006). Measurement of efficiency can be analyzed by Data Envelopment Analysis (DEA). DEA is a linear programming technique to estimate the technical efficiency of a Decision Making Unit (Charnes & Cooper, 1978).

In single channel, efficiency measurement can be done only for each DMU (Decision Making Unit) not on the supply chain network in accordance with the assumption whether the business is in optimal scale or not yet optimal. If the business is assumed to be in an optimal scale, **conventional model** or CCR model (Charness, Cooper & Rodes) or DEA CRS model (Constant Return to Scale) can be used. Moreover, the BCC model (Banker, Charnes, and Cooper) or DEA VRS (Variable Return to Scale) model can be applied if the business is not in an optimal condition due to several reasons such as market structure is not in perfect competition, the existence of government policy, financial constraint, and others.

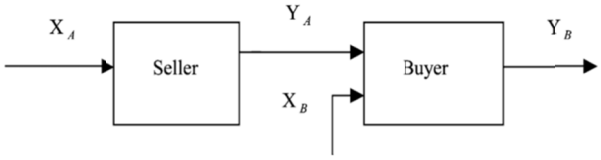

Figure 3. Seller-Buyer Supply Chain

(Liang et al., 2006)

Description:

X_A : Input of seller/supplier

Y_A : Output of seller/ supplier

X_B : Input of buyer/manufacture

Y_A : Output of buyer/ manufacture

Efficiency measurement **in supply chain network** can be done by applying model developed by Liang et al. (2006). **New DEA Model** model is a measurement technique by gradually dividing the efficiency of production unit (product flow) in supply chain. New DEA Model is able to analyze the efficiency of each member of the supply chain and the entire supply chain network that cooperative. Based on cooperative theory, both seller and buyer perform cooperation and profit maximization. The existence of each member's linkage can be seen in Figure 3 where the output of the first actor (seller) becomes the input for the second actor (buyer). Input is a resource used in conducting supply chain activity, while output is the result of supply chain activity done. Based on this, New DEA Model is different from Conventional DEA because it is able to analyze the overall efficiency of supply chain network of each member connected by input and output variables. Determination of input and output in the measurement of supply chain performance is necessary to be performed to determine the efficiency level of an analysis.

Based on the explanantion, differences in the application of Conventional DEA Model and New DEA Model in supply chain analysis can be seen in Table 1.

Table 1. Differences Between Conventional DEA Model and New DEA Model in Supply Chain Analysis

No	Conventional DEA Model	New DEA Model
1	Analysis in single channel	Analysis in the supply chain network
2	Measurement of supply chain performance (efficiency) of each member can not be done directly since there is intermediary functions as connector	Measurement of supply chain performance (efficiency) between the involved members is evaluated simultaneously
3	Cannot calculate the efficiency of multi-member supply chain because the determination is performed on each member	Can calculate the efficiency of multi-member supply chain

Source: Liang et al. (2006)

In this research, output of seller (farmer group or collectors), that is the amount of coffee bean supply to be the input of buyer, in this case is the buyer centre (export partner). According to the statement, efficiency value of supply chain can be obtained through the average efficiency value from seller and buyer. Supply chain is said to be efficient if V_p=1. Efficiency measurement in supply chain network is presented in the equation as follows:

$$Max\frac{1}{2}\left(c_A^T Y_{A0} + \mu_B^T Y_{B0}\right) = V_p \quad (1)$$

$$s.t.\,\omega_A^T X_{Aj} - c_A^T Y_{Aj} \geq 0\,, j = 1,2,\ldots.n \quad (2)$$

$$\omega_B^T X_{Bj} + k \times c_A^T Y_{Aj} - \mu_B^T Y_{Bj} \geq 0, j = 1,2,\ldots.n \quad (3)$$

$$\omega_A^T X_{A0} = 1 \quad (4)$$

$$\omega_B^T X_{B0} + k \times c_A^T Y_{A0} = 1 \quad (5)$$

$$\omega_A^T, \omega_B^T c_A^T, \mu_B^T, k \geq 0 \quad (6)$$

Description:

X_{Aj}	Input j for seller to DMU k	ω_A^T	Weight for input of seller
Y_{Aj}	Output j for seller to DMU k	ω_B^T	Weight for input of buyer
X_{Bj}	Input j for buyer to DMU k	c_A^T	Weight for output of seller
Y_{Bj}	Output j for buyer to DMU k	μ_B^T	Weight for output of buyer
$C_A^T Y_{A0} = \theta_A^* = E_{AA}^*$	Efficiency value of seller	$\mu_B^T Y_{B0} = \theta_B^* = E_{BB}^*$	Efficiency value of buyer
$V_p = \frac{1}{2}(E_{AA}^* + E_{BB}^*)$	Efficiency value of supply chain		

Table 2 shows variables used to analyze efficiency in supply chain network. Those variables consist of input of seller variable, output of seller variable which becomes input of buyer variable, other input variable for buyer, and output of buyer variable.

Table 2. Distribution of Input-Output of Seller Variable (Farmer Group or Collector) and Buyer (Export Partner)

No	Seller (input)	Seller (output), Buyer (input)	Buyer (other input)	Buyer (output)
1	Daily inventory to supply	Supply quantity	Total cost	Delivery performance
2	Total cost	-	Fulfill Order	Quality
3	Fulfill Order	-	Lead Time	Fulfill Order
4	Quality (Water content)	-	Flexibility	Profit
5	Distance	-	Daily inventory to supply	-
6	-	-	Cash to cash cycle time (day)	-

Moreover, definition and formula of input and output variable used in the efficiency measurement of supply chain network on seller and buyer can be seen in Table 3.

Table 3. Definition and Formula on Variable of Input (I)-Output (O)

No	Variable	I	O	Definition	Unit	Description	Source
A. Farmer group/collector							
1	Daily inventory to supply	v		The length of time required from postharvest process until the coffee beans are delivered to buyer	Day	Time required to send the coffee beans to consumer (export partner)	Setiawan (2009)
2	Total cost	v		Cost incurred by farmer group in handling postharvest of coffee beans until they are sold to consumer (export partner)	Rp/year	Postharvest cost + transportation cost + labor cost + loading and discharging cost + cost for finding information	Liang et al (2006) Saputra (2012) Setiawan (2009) Herawati (2015)
3	Fulfill Order	v		Period of the ability of farmer group to meet the supply of consumer (export partner) at a certain amount. Time period is when the coffee is finished picking	Hour/ha	Time required to pick coffee per unit area	Saputra (2012)
4	Quality (Water content)	v		Level of dryness in coffee bean	%	Percentage of dryness in coffee bean	Herawati (2015)
5	Distance	v		Distance required to deliver the coffee beans to the place to sell	Km	Distance from place to store the coffee bean to place to sell it	Herawati (2015)
6	Inventory quantity		v	The quantity of coffee beans delivered by farmer group to export partner	Kg/year	Quantity of coffee beans delivered by farmer group to export partner	Liang et al (2006) Saputra (2012)
B. Export partner							
1	Total cost	v		Cost incurred by export partner in handling raw material until it is sold to exporter	Rp/year	Shipping cost + refund fee	Saputra (2012) Setiawan (2009) Sari., Nurmalina., & Rifin (2014)

No	Variable	I	O	Definition	Unit	Description	Source
2	Fulfill Order	v		Period the export partner's ability in fulfilling supply to exporter at a certain amount.	Day	Standard of delivery quantity (kg) of coffee bean in certain period	Saputra (2012)
3	Lead Time	v		Time required for export partner to fulfill exporter demand from farmer to consumer	Day	Number of day counted from postharvest handling until coffee beans are delivered to consumer (exporter)	Setiawan (2009) Sari et al (2014)
4	Flexibility	v		Time required to respond the supply chain when there is unexpected order	Day	Number of day to find coffee bean + number of day to deliver coffee bean +leadtime	Setiawan (2009)
5	Daily inventory to supply	v		Time required until the coffee bean delivered to exporter	Day	Time required until coffee beans are delivered to exporter	Setiawan (2009)
6	Cash to cash cycle time	v		Velocity of money, from payment for coffee beans to supplier until payment done by exporter	Day	Average inventory (per day)+Average exporter pays (day)-average buyer centrepays to supplier (day)	Setiawan (2009) Sari et al (2014)
7	Inventory quantity	v		Quantity of coffee bean received from seller	Kg/year	Quantity of coffee bean received from seller	Liang et al (2006)
8	Delivery performance		v	Percentage of on-time delivery in accordance with the date of exporter's order	%	Quantity of coffee bean ordered on-time/Total exporter's order	Setiawan (2009)
9	Quality		v	Suitability with quality standard	%	Proper quantity of delivery/quantity of delivery	Setiawan (2009) Sari et al (2014)
10	Fulfill order		v	The ability of export partner in fulfilling exporter's order	%	Demand of exporter/Total Demand	Setiawan (2009) Sari et al (2014)
11	Profit		v	Difference between total revenue and total cost of coffee beanselling	Rp/kg	Total revenue-Total cost	Liang et al (2006)

5. Conclusion

Efforts to ensure the supply of robusta coffee in the country is done through efficiency analysis of the actors (seller and buyer) and supply chain network. Efficiency analysis is performed by using New DEA Model where analysis is done throughly on supply chain network which is connected by input and output variables where the output of the first actor (seller) becomes input for the second actor (buyer). New DEA Model is a measurement technique by dividing the efficiency of the production unit (product flow) on a supply chain that can accommodate the inter-channel interests that are cooperative. This can encourage supply chain improvement efforts more precisely because the analysis is done thoroughly so that the robusta coffee supply chain of Indonesia becomes more efficient.

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