Measurement Model for Supply Chain Performance of Shallot

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Abstract. Supply chain is an important key for any businesses’ existence and development, since this concept can be a solution for them to hold efficient operational practices, minimizing cost, and on time delivery. Therefore, appropriate management practices on supply chain of agricultural commodity could be a substantial matter since it has been facing problems in efficiency, supply, and minimizing cost. The higher the economic value of a commodity, the more important the role of management on its supply chain. One of Indonesia’s strategic and high valued commodity is shallot due to its high consumption and great contribution on regional economic development of production areas. Performance of shallot supply chain may impact on the parties involved, as farmers, traders, and suppliers. Thus, in order to formulate an accurate strategy to improve shallot supply chain performance, a measurement model is needed. This research employed Supply Chain Operations Reference (SCOR) method to identify the model, while analytical hierarchy process (AHP) was used to determine the weight of each indicator in the model. Findings of this research indicate that production is the key aspect on shallot supply chain. Furthermore, quality and order-fulfilment the most significant parameter in defining its performance is quality. Cost and order-fulfilment are proven as the highest weight-scores attribute and indicator, respectively, in measuring the performance of shallot supply chain.

1. Introduction

Supply chain refers an alignment among material procurement, production, up to product delivery in which some activities involving suppliers and distributors. As in any network, supply chain in agribusiness includes the strategic management of a network that is aimed at delivering to its demands or customers, in achieving efficiency and competitive advantage. Several studies have shown that supply chain is linked up with product competitiveness, which can be improved through increasing understanding on capacity, capability, even limitation of any entities involved in a supply chain [1-10]. The Indonesian government has made financial and policy support to increase the development of agricultural sector through its Nawacita Plan (which refers to nine priority program). One of such program is revitalization on food sovereignty, in which shallot is pointed out as one of strategic commodity, due to its economic value and high demand. Fluctuation on its price often is a leading indicator of national inflation since its price is able to give a quick response to any both economic and non-economic “shock” on general condition of national economy, such as aggregate demand shock or natural disasters that might obstruct the commodity’s distribution [11]. In the other hand, cultivating this commodity requires high cost to provide, as both investment and operational spending, but it might not promising high revenue for farmers at the same time, caused by gap on its demand and supply. Even its consumption is always high, which reaches 2.55 kg/capita/year [12], but it is only can cultivated in certain areas which are concentrated in Java island, especially in Nganjuk (East Java), Brebes (Central Java), and Cirebon (West Java). Regarding to basic characters of agricultural commodity, including shallot, which are: perishable, seasonal, inconsistent on quality, and bulky, then it is reasonable that a good practice on supply chain management holds an important role to solve those congenital issues in order to prevent any price fluctuation and disequilibrium on shallot market.
Moreover, researches on SCM performance modelling were also conducted and developed by employing varied methods, such as balanced scorecard (Bhagwat and Sharma, 2007), multi-criteria analysis [13], Data Envelopment Analysis/DEA [14,15], activity-based costing ([16], and Supply Chain Operations Reference/SCOR [17,18,19]. In measuring the performance of supply chain, most of studies have applied SCOR method since it provides a standard description of supply chain processes, performance metrics, best practice, and enabling technologies [20]. The basic structure of the SCOR model including five processes: Plan, Source, Make, Deliver and Return.

This paper aims to design a measurement model for shallot supply chain performance by developing any criteria and alternatives to increase its performance, as well as identifying shallot supply chain. The data was collected from 91 shallot farmers and 36 agents involved in the supply chain in East Java Province for empirical analysis. The agents included input suppliers, penebas (marketing agents), traders at city-level and province-level (merchants), port-traders, to the retailers.

2. Overview of Shallot Supply Chain in Indonesia

Shallot has been cultivated intensively by Indonesian farmers since its demands for this commodity tends to increase in line with the increase of the population number, due to there is no substitution commodity for it, both of as spice or herb. Besides domestic demand, demand for shallot in international market is also high. During 2009-2013, Indonesia was the fourth biggest exporter country for shallot, after New Zealand, France, and Netherland [21]. Shallot production in Indonesia is mainly in Central Java (Brebes) and East Java Province (Nganjuk and Probolinggo). In particular, East Java Province covers for 23.16% of total production in 2015.

The structure of shallot supply chain in Indonesia involves some agents, from farmer, marketing agent, trader, kiosk/barn, central market, retailer, to consumer (Figure 1). This structure made the farmers received small income caused by too long chain. Farmers cannot maximize their margin share from added value process since too many agents involved and take their own shares. At the same time, the price of inputs tends to increase, especially for seed, fertilizer, and pesticide. In the long run, this condition will be a driving factor that caused farmer is not being able to cultivate shallot anymore since they cannot perform a capital accumulation for next production.

![Commodity flow in shallot supply chain](image)

**Figure. 1.** Commodity flow in shallot supply chain.
These production and marketing constrains is reasonable enough for emerging the need for a good practice on shallot supply chain in order to maintain the continuity of this chain. Most of activities on shallot supply chain are held in central market, at which farmers, traders, even retailers meet, share any information, and make transaction. Roles and activities conducted by each agency involved in shallot supply chain will be discussed as follow:

- **Input supplier**
  Inputs used include seed, fertilizer, pesticide, and machineries, which are supplied by farm shops/kiosks. Farmers used to get seed from other farmers (breeder farmers), who live at the same town or at the other town. Some farmer groups even provide all inputs for their members. All transaction is made in cash, but some farmer groups usually allow their member to buy input by credit.

- **Farmer**
  Most of farmers sell their dried crops directly from their fields to *penebas* (marketing agents) or to trader. Price of shallot received by farmers is determined by the quality of the bulbs that could be measured from their size and color. Farmers usually get their revenue paid off on the day the buyer (trader) loads the shallot to his barn.

- **Penebas** (marketing agent)
  *Penebas* usually defines as local traders, who buy dried shallot only from farmers in their district, then sell them directly to a trader/merchant or send them to the nearest central market, so they are available for bidding.

- **Trader/Merchant**
  This kind of trader collects shallot from some local traders (but sometimes they buy from farmers directly), since they have more capital. After did some handling activities, such as: cleaning, sorting, and packaging, they send the shallot to other merchants at the other town, or even at the other island (especially Kalimantan, West Papua, and Sumatra) that called as port-trader. Some merchant sell small amount of their shallot to local retailers in the traditional market, and some also sell to an exporter for foreign market, such as Thailand, Taiwan, Vietnam, Singapore, and Malaysia.

- **Port-trader**
  Port-traders act like importers, who buy shallot from other town (or island) then load them to local central market for auction. Sometimes they sell their shallot directly to the local merchants and retailers.

- **Industry**
  There are two kinds of industry involved in shallot supply chain, they are: home-industry of fried onion and food manufacturing. Home industry of fried onion usually runs by local small scale enterprise (SME), who sells their product, to traditional restaurant nearby. In the other hand, food manufacturing refers to big factory which has shallot as component for their production.

- **Retailer**
  Retailers are the last chain of shallot supply chain, at which consumer buy shallot for consumption. Kiosks, grocery shops, vegetable stalls, and even supermarkets can be categorized as retailers since they sell shallot directly to the consumer (household).

### 3. Data
The data used in this study was collected from all agents involved in shallot supply chain in East Java Province who were determined by multistage sampling procedure, from October to December 2016. First stage, Nganjuk Region and Probolinggo Region were purposively selected based on their contribution on shallot national production. Second stage, respondents at each region were identified used snowball sampling, based on information from key informants (farmers) to identify all agents involved in shallot supply chain, from input suppliers, *penebas* (marketing agents), traders at county-level and province-level (merchants), port-traders, to the retailers. Ninety one farmers and thirty six agents was counted as respondents of this study.
Table 1. The Characteristics and structures of Respondents.

| Variables               | Farmers (%) | Agents (%) |
|-------------------------|-------------|------------|
| Age: under 50 years old | 62.63 (57)  | 80.56 (29) |
| Age: more than 50 years | 37.37 (34)  | 19.44 (7)  |
| Education: Elementary   | 80.22 (73)  | 72.22 (26) |
| Education: High school  | 19.78 (18)  | 27.78 (10) |
| Experience: ≤ 20 years  | 74.73 (68)  | 58.33 (21) |
| Experience: > 20 years  | 25.27 (23)  | 41.67 (15) |

Table 1 show three main characteristic of samples used in this study. It can be observed from the table that most farmers and agents involved in shallot supply chain are aged less than 50 years old, showing that the majority of actors in shallot supply chain are at productive age. Table 1 also indicates that educational background of farmers is contrary to the agents, in which most farmers finished only their elementary school, while most agents’ education background are high-schooled (junior high, senior high, and undergraduate). Agents have larger possibility to adopt any technology and innovation, which represents more access to marketing and production information. Even though, they have higher educated rate, but the data on Table 1 presents most agents was less experienced than farmers.

4. Model Specification

Performance measurement system is needed in order to optimize the supply chain network of shallot. Performance measurement is aimed to support goals designing, performance evaluating, and formulating future mission at operational, tactical, and strategic level [22]. In this study, designing model for measuring supply chain performance was divided into two stages, those were: (1) designing measurement model by adopting Supply Chain Operations Reference (SCOR) method; and (2) calculating matrix weights used Analytical Hierarchy Process (AHP) technique. The steps to employ AHP are: (1) comparing scores of each parameter; (2) developing comparison matrix; (3) solving the Eigen values; (4) multiplying among matrixes; and (5) determining Consistency Ratio (CR).

5. Supply Chain Operations Reference (SCOR)

SCOR defines as reference model to describe the operation process of a supply chain [23] This model is usually used to measure the performance of company’s supply chain, to develop its performance, and to communicate it to each party involved. It combines some elements (e.g., business techniques, benchmarking, best business practices) and applies them on supply chain system in the form of comprehensive framework as a reference to increase the performance of supply chain management. This model differentiates supply chain process into five main activities as follow.

- Plan
  Plan is defined as processes that balance demand and supply of shallot to develop the best practice to meet the procurement, production, and delivery needs. This process includes distribution need forecasting, capacity planning, stock planning and controlling.

- Source
  Main objective of source process is to meet planned or actual market demand, by providing input and services needed to cultivate shallot, includes shipping scheduling from input supplier, receiving, purchasing, choosing a supplier and evaluating its performance.

- Make
  Concept of “make” process in this study is defined as cultivation process, includes scheduling production, quality control, pest management, and equipment maintaining.

- Deliver
Delivery process is aimed at delivering the final product to meet market demand of shallot by managing order, transportation, and storage, in order to maintain shallot quality until it is in the hands of consumer, in the local and even foreign market.

- **Return/Process**
  Product return activities include identifying product quality and post-delivery customer support.

6. **Matrix design for performance measurement**

Hierarchy structure for measurement matrix of shallot supply chain used in this study consists of four levels, which were: (1) supply chain process; (2) performance parameters; (3) performance attributes; and (4) performance matrix. Level 1, supply chain processes, was adopted from SCOR method which included: Plan, Source, Make, Deliver, and Return. Parameters used to measure the performance for each process above were: Added value, Quality, and Risk. Furthermore, this study employed Reliability, Flexibility, Cost, Responsively, and Asset as performance attributes, to analyze, to evaluate, and to compare one supply chain with other chain. Whereas, five variables were used to formulate the performance matrix, they were: Shipping Performance (SP), Orders Fulfilments (OF), Lead-time Order Fulfillment (LTOF), Cash to Cash Cycle Time (CCCT), and Daily Stock (DS). These variables were chosen by considering the real condition of shallot supply chain at the study sites. Figure 2 show hierarchy structure of each level on measuring shallot supply chain.

7. **Results and Discussion**

7.1. **Level 1: Supply chain process**

The supply chain processes of shallot consist of: (1) planning process (Plan); (2) procurement process (Resource); (3) process of cultivation (Make); (4) shipping process (deliver); and (5) post-delivery process (return). The process of cultivation (Make), is proved as the first priority in improving the performance of shallot supply chains in East Java Province, since its weight was the highest (0.362) (see Table 2). The reason is that, in this process, members of the shallot supply chain are required to always keep the quantity of harvested commodities (products) able to meet market demand amidst predictable natural conditions (especially weather) and significant price fluctuations.

| Process   | Weight | Priority |
|-----------|--------|----------|
| Plan      | 0.095  | 4        |
| Source    | 0.220  | 3        |
| Make      | 0.362  | 1        |
| Delivery  | 0.231  | 2        |
| Return    | 0.092  | 5        |

The shipping process (Delivery) becomes the second most important priority in the supply chain, since most of the shallot production from both production area (Nganjuk Regency and Probolinggo Regency) is sent to other regions (other towns, other islands, and even exported to other countries). This needs to be pursued because the stakeholders (e.g., trading partners, port-traders) want such kind of certainty and continuity of supply to their region to maintain price stability.

7.2. **Level 2: Parameters of supply chain performance**

The most considered parameter in the shallot chain performance assessment is the quality dimension, with weight of 0.511 (presented in Table 3). Quality dimensions include shallot quality from on-farm crops and shallot which is sent to other regions. The quality of freshly harvested shallot will affect the preferences of the merchant or other marketing agents in determining the purchase price and quantity
of product purchased. Assuring quality from farm to fork is one of the key elements of efficient agricultural supply chain management system [24].

While the quality of shallot at the delivery location will affect the loyalty of traders/merchant/port trader that are local merchant trading partners. Therefore, quality parameters become the most important of shallot supply chain performance. Since shallot supply chain tend to take long time to distribute, especially when it has to be sent to other island, it needs an effective supply chain practices which will help ensure the freshness of agro product by helping to reduce the time taken in transportation and by using favourable storage condition and better processes and systems.

Table 3. Weight and priority parameter in shallot supply chain.

| Parameter      | Weight | Priority |
|----------------|--------|----------|
| Quality        | 0.511  | 1        |
| Risk           | 0.307  | 2        |
| Added value    | 0.182  | 3        |

The empiric results on the table also show that supply chain of shallot is a risky business, since the value of risk variable is the second highest weighted parameter of shallot supply chain performance. Two important component of farming risk are market/price and production risks [25]. Market risk is related to uncertainty about the prices of outputs (and sometimes inputs, too) at the time production decisions were taken. Therefore, production risk is determined by weather condition and animal or plant diseases.

7.3. Level 3: Attributes of supply chain performance
Performance attributes consist of supply chain reliability, supply chain flexibility, supply chain responsiveness, supply chain costs, and management of supply chain asset. Cost attribute affects the size of profits to be gained, for both of production and transportation costs. From production side, seed and fertilizer are inputs that highly price-sensitive. Moreover, any changes in government support for fertilizer prices in form of subsidy would affect its demand and supply [24]. Furthermore, another kind of cost that should be considered more is transportation cost. Geographically speaking, the majority of shallot production activities take place in the Java Island. Often, hundreds tons of shallot from Java is moved by ships to other island of the country, which is a quite challenge. Therefore, cost becomes the most priority attribute with the weight of 0.286 in making the decision to improve the performance of the shallot supply chain.

Table 4. Weight and priority attribute in shallot supply chain.

| Attribute     | Weight | Priority |
|---------------|--------|----------|
| Reliability   | 0.283  | 2        |
| Flexibility   | 0.114  | 5        |
| Cost          | 0.286  | 1        |
| Responsiveness| 0.131  | 4        |
| Asset         | 0.186  | 3        |

The second priority is reliability, with a weight of 0.283. Reliability of the supply chain is strongly connected to the concept of risk [26]). This attribute has a great influence in maintaining a supply chain, particularly in shallot supply chain, since it helps emerging a long-term relationship among supply chain members, especially between traders and consumers. Reliability of farmers and traders in ensuring the continuity of shallot supply in the market indicates the performance of it supply chain. In contrast, the results showed that performance of flexibility on shallot supply chain was weak since its weight was only 0.114. This kind of performance mainly occurs at farmer level, due to lack of grading and opportunity on trading in small quantity.
7.4. Level 4: Indicators of supply chain performance
The results proved that order fulfilment was the main indicator in assessment of supply chain performance. The number of shallot production in East Java Province tends to fluctuates, due to weather constraint that is not suitable to cultivation process. A delayed cultivation will lead to smaller volume of yields and delivery, causing traders and processors to be unable to fulfil the quantities contracted with other traders (e.g., merchants, traders, or port traders). So, it is important to maintain the performance of order fulfilment process because it helps delivering qualified product at the right time and right place, and also handling uncertainties from environmental factors [27].

Table 5. Weight and priority indicator in shallot supply chain.

| Indicator                                | Weight | Priority |
|------------------------------------------|--------|----------|
| Shipping performance (SP)                | 0.231  | 2        |
| Order fulfilment (OF)                    | 0.284  | 1        |
| Lead-time order fulfilment (LTOF)        | 0.170  | 4        |
| Cash to cash cycle time (CCCT)           | 0.213  | 3        |
| Daily stock (DS)                         | 0.102  | 5        |

Shipping performance becomes the second most important indicator of shallot supply chain performance, since most of shallot is produced in certain production area in Java Island, which is going to deliver to vary consumer places. On time delivery, accuracy of the type of transportation used, as well as the accuracy of the storage method used during the shipping process, determines the performance of this indicator. These factors are important because they affect the income of traders who are being partnered with traders from other region. Lack on shipping performance would increase logistic loss on agricultural product, so it is difficult to gain benefit along a supply chain [28].

Figure 2. The Hierarchy structure of each level for performance measurement of shallot supply chain.

Table 5 also presents that Cash to cash cycle time (CCCT) is the next top priority in the shallot supply chain assessment, with a weight of 0.213. CCTC is based upon the strategic elements of inventory.
management, the determination of terms in trading contracts, and the role of cash in the relationship among all parties involved in shallot supply chain, which depends on a payment cycle that will be used for next transaction. The last indicators influenced the shallot supply chain performance are Lead-time Order Fulfilment (LTOF) and Daily Stock (DS), which have weights of 0.170 and 0.102 respectively.

8. Conclusion
This study identified supply chain network of shallot in East Java Province as the second biggest production area in Indonesia, as well as formulated a measurement model for its performance. This study collected data from a randomly selected sample of 91 farmers, and selected sample of 36 marketing agents involved in this supply chain, included traders/merchants, port-traders, industries, and input suppliers, which were determined by snowball sampling procedure. SCOR approach was chosen to build up model and matrix since it already provided parameters and indicators for measuring the supply chain performance. The results made up a four-levels-hierarchy structure of performance measurement model for shallot supply chain. The results reveal that cultivation process of shallot (Make) was the most important process in this supply chain, in which variable of Quality as the main parameter. Therefore, the government should improve farmers’ access to information of technology and innovation on shallot farming to increase the crop quality. Furthermore, Cost was proved as an attribute that need to be considered the most in order to maintain the supply chain performance. This finding shows that efficiency on production and marketing cost will enhance the performance of supply chain. The government should continue supporting stabilization of input prices (especially for seed, pesticides, and fertilizers), and other facilities (e.g., transportation and credit access) to maximize the efficiency along the supply chain. Then, Order Fulfilment (OF) became the main indicator in assessing supply chain performance of shallot. So that, each parties involved in this chain should be cooperative in balancing demand and supply of shallot, rather than carry out any market consolidation that leads to collusive behaviour. The implications from this result could be related to synchronization of processes along the chain, cost reduction, transparency and responsibility among parties involved in shallot supply chain in order to improve its performance.

References
[1] Barratt M and A Oliveira 2001 Exploring the experiences of collaborative planning initiatives International Journal of Physical Distribution and Logistics Management 31(4), pp. 22.
[2] Boyer KK, G K Leong, P T Ward and L J Krajewski 1997 Unlocking the potential of advanced manufacturing technologies. Journal of Operations Management pp. 331-347.
[3] Das A and R Handfield 1997 Just-in-time and logistics in global sourcing: An empirical study International Journal of Physical Distribution and Logistics Management 3(27), pp. 244-259.
[4] Dewett T and G R Jones 2001 The role of information technology in the organization: a review, model, and assessment Journal of Management pp. 313-346.
[5] Frohlich M T and R Westbrook 2001 Arcs of integration: An International study of supply chain strategies Journal of Operations Management, pp. 185-200.
[6] Hill C A and G D Scudder 2002 The use of electronic data interchange for supply chain coordination in the food industry Journal of Operations Management, pp. 375-387.
[7] Lejeune M A and N Yakova 2005 On characterizing the 4C’s in supply chain management Journal of Operations Management, pp. 81-100.
[8] Mentzer J T, J H Foggins and S L Golicic 2000 Collaboration: The enablers, impediments and benefits. Supply Chain Management Review (September-Oktober), pp. 52-58.
[9] Shah R, S Meyer-Goldstein and P T Ward 2002 Aligning supply chain management characteristics and inter-organizational information system types: An exploratory study. IEEE Transactions on Engineering Management 49(3), pp. 282-292.
[10] TangK and J Tang 2002. Time-based pricing and leadtime policies for a build-to- order manufacturer. Production and Operations Management 11(3), pp. 374-392.
[11] Rizaldy, Dicky Zunifar 2017 The impact of commodity prices on inflation in Malang: Case study on shallot and red chilli. UMM Repository (in Bahasa), Malang.
[12] Centre for Horticulture 2013 Study on food crop production. Bogor: IPB Repository.
[13] Romero C dan Rehman T 2003 Multiple criteria analysis for agricultural decisions. Elsevier, Amsterdam.
[14] Zhu J 2003 Quantitative models for performance evaluation and benchmarking: data envelopment analysis with spreadsheets and DEA Excel solver. International Series in Operations Research and Management Science.
[15] Wong WP, dan Wong KY 2007 Supply chain performance measurement system using DEA modelling. *Journal of Industrial Management and Data Systems* (107), pp. 361-381.
[16] LapideL 2000 What about measuring supply chain performance? ASCET 2.
[18] Lai KH, Ngai EWT, dan Cheng TCE 2002 Measures for evaluating supply chain performance in transport logistics. *Logistics and Transportation Review* (38), pp. 439-456.
[19] Supply-Chain Council 2004 SCOR. Available: [http://www.supply-chain.org/index.ww].
[20] Delipinar G E and Kocaoglu B 2016 Using SCOR model to gain competitive advantage: A literature review. *Procedia-Social and Behavioral Sciences* (229), pp. 398-406.
[21] Ministry of Agriculture 2016 Outlook on Shallot. Jakarta: Data Centre and Information System for Agriculture (in Bahasa).
[22] Van der Vorst JGAJ 2006 Performance Measurement in Agrifood Supply Chain Networks: An overview. on: C., A J. Wijnands, R. Huime, O. van Kooten (ed.). *Quantifying the agri-food supply chain*. Springer Science Business Media, Netherland.
[23] Marimin and Magfiroh 2010 Application for decision making for supply chain management. Bogor: IPB Press (in bahasa).
[24] Chandrasekaran N and G Raghuram 2014 Agribusiness supply chain management. CRC Press, Boca Raton.
[26] Nowakowska M and A Tubis 2015 Reliability of the cut flowers; supply chain. *Safety and Reliability of Complex Engineered System*, pp. 1755-1762.
[27] Goldman S L, Nagel R N, and Preiss K 1995 Agile competitors and virtual organizations: Strategy=ies for enriching the customer. Van Nostrand Reinhold, New York.
[28] Ouyang Huanhuan 2102 Supply chain performance measurement: The integrated project of Shenda market chain and Lijin Agricultural base. Thesis. HAMK University of Applied Science. Forssa.