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	Opening Ceremony • Report by **Assoc. Prof.Dr.Duangpun Kritchanchai**, OSCM General Co-Chair, Mahidol University, Thailand and **Prof.Nyoman Pujawan**, OSCM General Co-Chair, InstitutTeknologiSepuluhNopember (ITS), Indonesia • Welcome address by **Assist. Prof.Dr.Yodchanan Wongsawat**, Vice Dean for Graduate Studies and International Relations of the Faculty of Engineering, Mahidol University • Opening address by **Mr. Teera Anantaseriwidhya**, Vice Governor of Phuket Province			
	Group Photo			
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			Paper 46: Drug Inventory Modelling for Internal Supply Chain in the Hospital *Prita Meilanitasari, Iwan Vanany and Erwin Widodo*	**Paper 39:** Cost of Quality, ISO 9001 and its Impact on Corporate Performance: A Literature Review *Muhammad Rosiawan, Moses L. Singgih and Erwin Widodo*
			Paper 101: A Literature Review on Different Models and Solution Approaches on Order Picking Problem *Shirsendu Nandi and Patanjal Kumar*	**Paper 187:** The Role of Stakeholder Engagement in External Assurance of Sustainability Reporting *Yahaya Yusuf, Emmanuel Olasanmoye, Louise Mc Ardle, Wendy Auchterlounie and Masha Menhat*
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MODEL DEVELOPMENT OF SUPPLY CHAIN NETWORK FOR FRESH AGRICULTURAL PRODUCTS IN EAST JAVA BY CONSIDERING THE LEVELS OF PRODUCT QUALITY

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ABSTRACT

East Java is one of the contributing provinces, the largest in Indonesia, for fresh agricultural products, such as fruits and vegetables. Fresh agricultural products are category of perishable product. Perishable products will decrease the level of quality and value of products in line with increasing time. In order for fresh agricultural products produced by farmers can be consumed by consumers in the right quantity, right quality, right place, right time and right price, it is necessary to design a supply chain network model for fresh agricultural products by taking into account the level of product quality. This paper discussed the model development of supply chain network for fresh agricultural products in East Java by considering the level of product quality. Supply chain of fresh agricultural products consists of farmers, wholesalers, distributors and retailers. Supply chain network optimization model has an objective of maximizing the total supply chain profits. A numerical example is presented as the application of supply chain network optimization model for fresh agricultural products. The optimal result of supply chain network can be a recommendation to the East Java provincial government in the regulation of the distribution system of fresh agricultural products.

Keywords: supply chain network design, fresh agricultural products, the level of product quality

1. INTRODUCTION

Logistics is part of a supply chain that is associated with the movement and storage of goods at the same time with regard to the flow of money and information. Based on this insight, it is known that the logistics are much related to the ease of supply of goods in the region. It also indicates that, logistics plays a key role in the growth of industry and the economy of a region. A key role is also occur because logistics is a major cost component for businesses and intertwined with many other economic activities.

The key success factors in a holistic logistics management become an important requirement which directly or indirectly have an impact on economic growth in the region. Indicators of success of logistics management in general can be viewed from the aspect of availability, flexibility and cost efficiency. The indicators related to the availability of goods and services at the right time and place while still having the flexibility amount and timing of the distribution in a region of the logical price. However, these three indicators of the success of the logistics often becomes irrelevant for fresh agricultural products due to the following factors: a. availability of goods is influenced by the short time gap between the time supply of the product by the producers to the time of consumption; b. Total supply is inconsistent because of the influence of the season; c. Prices fluctuate according to the season and d. Local government policy towards fresh agricultural products.

Fresh agricultural products are products that should be consumed immediately to prevent damage without the need for advanced preservation process, because the logistics system including distribution and transportation are the factors that need to holistically design to increase the range of the location of demand for agricultural products fresh while increasing the benefits for consumers and producers. Fresh agricultural products can be categorized into groups of vegetables and fruits.

In general, fresh agricultural products produced in East Java province, including the largest in the country. The products come from centers of different manufacturers, such as fruits of Batu, Pasuruan, Probolinggo and Blitar while the vegetables come from producers in Batu Sentra, Lumajang, and Bondowoso. That means handling of fresh agricultural products need special attention. Special attention is that its impact can be felt by the actors in the supply chain is the improvement of logistics systems able to provide mutual benefit to the parties involved in the supply chain of fresh agricultural products. Based on the above background can be expected, there are several factors that affect the availability of fresh agricultural products in East Java. That means the main issues addressed in this study is to design a supply chain network model for fresh agricultural products that can improve the welfare of society and the economy of the region.

The remainder of this paper is organized as follows. Section 2 will discuss the literature review related to supply chain network of fresh agriculture product as perishable products. Section 3 presents problem statements to be solved. In section 4 we develop the optimization model for supply chain network design for fresh agriculture products by considering the product quality level. A numerical example is provided in Section 5, to illustrate the application of the models, and discuss the results. In Section 6, we present our concluding remarks.

2. LITERATURE REVIEW

Some research has been done by Parung associated with the discovery models to improve the contribution of the perpetrators of the supply chain (supply chain) and increase added value as a consequence of cooperation in the supply chain. Various studies have been published in the journal Parung International and national journals as well as in international and national seminars. The topics supply chain including how to create added value within a supply chain (Bititci et al., 2004), how to manage synergies in a supply chain to increase the value (Bititci et al., 2007), to assess the role of intellectual capital in a business cooperation to improve value (Parung, 2008), then design the measurement model to determine the contribution of supply chain actors and factors affecting the sustainability of cooperation in the supply chain (Parung and Bititci, 2006). Furthermore Parung to study future trends in supply chain (Parung, 2013) which shows that the logistics and supply chain food supply chain is the main trend of the present and the future that it becomes a priority concern for humans until 2050. This is supported by data from the FAO said, that the world requires a 70% increase in global food production to the needs of a growing population of 2.4 billion. But at the same time a lot of the land has been converted into housing and infrastructure facilities.

Currently the world population reached 6.7 billion people. This population is expected to grow 30% to reach a total population 9 billion in 2050. But it is regrettable that 15% of the world population still difficulties in meeting their basic needs despite the global production amount are still insufficient. Factors that cause food products are not well distributed logistics system that is not well ordered. Studies conducted Parung in 2013 need to be developed specifically to understand fresh agricultural products.

Ahumada and Villabolos have studied a major contribution in the areas of production and distribution planning for agricultural products. They focus primarily on models which had been successfully implemented. Models are classified in according to relevant features, such as optimization approach used, the type of plants modeled and planning scope. Through their analysis of the state of current research, they diagnose some future needs for modeling the supply chain of agricultural products. (Ahumada and Villalobos, 2009)

Research conducted by Yu and Nagurney focus on the quality of perishable products between production and consumption locations that pose unique challenges for supply chain management. In particular, they developed a network-based agriculture supply chain model in oligopolistic competition with a concentration in fresh agricultural products, such as vegetables and fruits. Every company involved in the agriculture supply chain activities such as the production, processing, storage, distribution, and even the disposal of food products, will attempt to determine the optimal amount of product flow along the supply chain, to maximize the total profit (Yu and Nagurney, 2013). Borodin et al. has mastered the latest advances and developments in the application of operations research methodology to deal with the uncertainty that occurs in the agricultural supply chain management issues. (Borodin et al., 2016). In addition, An and Ouyang have developed a bi-level robust optimization model, where a food company to maximize profits and minimize post- harvest losses by deploying processing yields / storage facility and determine the purchase price, while a group of spatially distributed farmers' non-cooperative determine the time of harvest, shipping, storage, and market-decisions under yield uncertainty and market equilibrium (An and Ouyang, 2016).

3. PROBLEM STATEMENT

Supply chain network for fresh agriculture products consist of several entities, i.e.: all of farmers, wholesalers, distributors and retailers. The wholesalers will contact farmers to negotiate the price and the number of crops that will be purchased for any time period. Fresh agriculture product which harvested by each farmer is a product with the highest quality level (the first quality level). Farmers will harvest a certain number of products according to the order quantity resulting from the negotiations with the wholesalers, which do not exceed the maximum amount of product that can be harvested by each farmer, so no crop is left at the farm level in each time period.

After negotiating the price and order quantity to be purchased, the wholesalers do the retrieval yields in some farmer locations using a vehicle owned. Each farmer will be visited by a maximum of one vehicle from several vehicles owned by the wholesaler. Each vehicle is used as efficiently as to some farmer locations and brought back to the wholesaler location to be inspected, cleaned and packed according to the capacity of the wholesaler in each time period.

Furthermore the wholesaler will make deliveries of fresh agricultural products to several distributors according to the price and the order quantity for each product quality level. Unsold products will be stored and decreased the level of product quality at the next time period. Decreased levels of product quality will be followed by a decrease in the sales value of the product. At each time period, the retailer will be supplied by a maximum of single distributor.

Retailers will go to the distributor to purchase products for selling in traditional markets. While demand for fresh agricultural products at the retailer level unfulfilled will be considered as lost sales. At the level of wholesalers, distributors and retailers, there are a limitation of warehouse storage capacity for products that have not been distributed to the next downstream level. The distribution mechanism in a supply chain network for fresh agriculture products is shown in Figure 1.

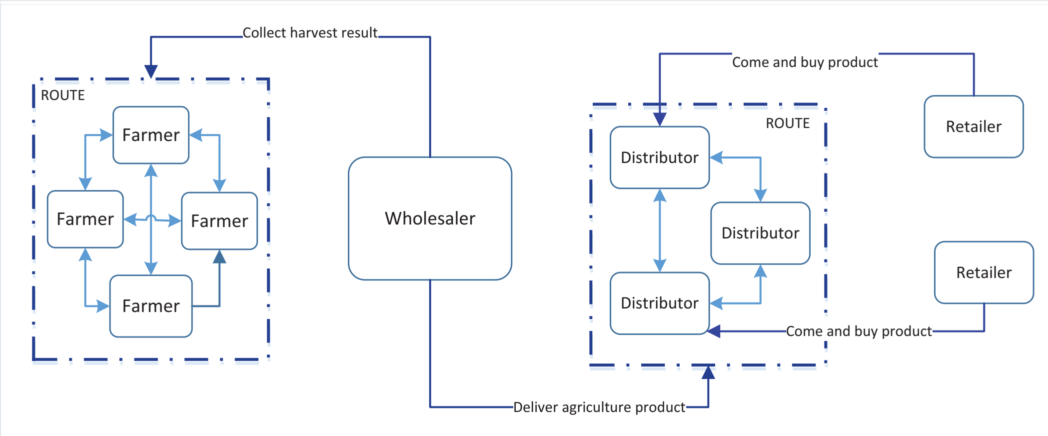

Figure 1. Supply chain network for fresh agriculture products

4. MODEL DEVELOPMENT

The model development of supply chain network for fresh agriculture products in East Java is based on the mechanism of the yields distribution system of farmers through wholesalers, distributors and retailers, as described in the above problem statements. The notation of mathematical model consists of the indices, model parameters, decision variables, objective function and the constraints that need to be considered in the supply chain network model for fresh agricultural products.

Indexes:

F : sets of farmers
W : sets of wholesalers
D : sets of distributors
R : sets of retailers
V : sets of wholesaler's vehicles
T : sets of time period
Q : sets of product quality levels

Model Parameters:

DM_{rt} : Product demands at retailer *r* in time period *t*
P_{rqt} : Selling price of products with the quality level *q* at retailer *r* in the time period *t*.
$q = 1$ for the best of product quality levels
CL_{rt} : Lost sales cost at retail *r* in the time period *t*
CO_{fw} : Ordering cost from wholesaler *w* to farmer *f*
CO_{wd} : Ordering cost from distributor *d* to wholesaler *w*
FC_f : Fixed costs occurred at farmer *f* for harvesting in a time period

CP_f : Variable cost at farmer *f* for harvesting in a time period
CP_{wq} : The inspection, sorting, cleaning and packaging costs per ton for each level of product quality *q* at wholesaler *w*
CP_{wq} : The inspection and re-packaging costs per ton for each level of product quality *q* at distributor *d*
CH_{rq} : Carrying inventory cost for each level of product quality *q* at retailer *r*
CH_{dq} : Carrying inventory cost for each level of product quality *q* at distributor *d*
CH_{wq} : Carrying inventory cost for each level of product quality *q* at wholesaler *w*
FC_{wv} : Fixed transportation cost of using vehicle *v* that owned by wholesaler *w*
CT_{fwv} : Transportation cost from wholesaler *w* to farmer f by using vehicle *v*
CT_{wdv} : Transportation cost from wholesaler *w* to distributor *d* by using vehicle *v*
CT_{dr} : Transportation cost from retailer *r* to distributor *d*
I_{orq} : Initial inventory of product quality level *q* at retailer *r*
I_{odq} : Initial inventory of product quality level *q* at distributor *d*
I_{owq} : Initial inventory of product quality level *q* at wholesaler *w*
KG_r : Warehouse storage capacity at retailer *r*
KG_d : Warehouse storage capacity at distributor *d*
KG_w : Warehouse storage capacity at wholesaler *w*
KP_{dq} : Re-packaging capacity for each product quality level *q* at distributor *d*
KP_{wq} : Inspection, sorting, and packaging capacity for each product quality level *q* at wholesaler *w*
KP_{ft} : Harvesting capacity of farmer *f* in time period *t*
KP_{wv} : Capacity of vehicle *v* that owned by wholesaler *w*

Decision variables:
SD_{rqt} : Number of satisfied demands for product quality level *q* at retailer *r* in time period *t*
SD_{rt} : Number of satisfied demands at retailer *r* in time period *t*
L_{rt} : Number of lost sales units at retailer *r* in time period *t*
I_{rqt} : Inventory level of product quality level *q* at retailer *r* in time period *t*
I_{dqt} : Inventory level of product quality level *q* at distributor *d* in time period *t*
I_{wqt} : Inventory level of product quality level *q* at wholesaler *w* in time period *t*
Z_{drt} : Binary decision variables, equal to 1 if retailer *r* supplied by distributor *d* in the time period *t*
Z_{wdt} : Binary decision variables, equal to 1 if distributor *d* supplied by the wholesaler *w* in the time period *t*
Z_{wdvt} : Binary decision variables, equal to 1 if distributor *d* supplied by the wholesaler *w* by using vehicle v in the time period *t*
Z_{wvt} : Binary decision variables, equal to 1if vehicle *v* that owned by wholesaler *w* is used for delivering products to distributors in time period *t*
Y_{wvt} : Binary decision variables, equal to 1 if vehicle *v* that owned by wholesaler *w* is used for taking products from farmers in time period *t*
Z_{wfvt} : Binary decision variables, equal to 1 if wholesaler *w* supplied by farmer *f* and taken products by using vehicle *v* in time period *t*

Z_{wft} : Binary decision variables, equal to 1 if wholesaler *w* supplied by farmer *f* in time period *t*

Z_{ft} : Binary decision variables, equal to 1 if farmer *f* harvests the products in the time period *t*

U_{wvt} : Number of products delivered from wholesaler *w* to distributors by using vehicle *v* in time period *t*

X_{wvt} : Number of products taken by wholesaler *w* from farmers by using vehicle *v* in time period *t*

Q_{ft} : Number of products harvested by farmer *f* during the time period *t*

Q_{fwvt} : Number of product yields from farmer *f* that purchased by wholesaler *w* and transported by using vehicle *v* in time period *t*.

Q_{wdqvt} : Number of products with quality level *q* that delivered from wholesaler *w* to distributor d by using vehicle *v* in time period *t*.

Q_{wdvt} : Number of products delivered from wholesaler *w* to distributor *d* by using vehicle *v* in time period *t*.

Q_{drqt} : Number of products with quality level *q* that delivered from distributor *d* to retailer *r* in time period *t*.

Supply chain network optimization model for fresh agriculture product has the objective function of maximizing the total supply chain profits (*TPSC*) where Total supply chain profit is the difference between total sales revenues (*TRSC*) of all of product quality levels and total supply chain costs (*TCSC*).

$$Max \quad TPSC = TRSC - TCSC \tag{1}$$

Total sales revenue of the overall product quality levels is the total sales value of satisfied demand from each quality level of fresh agricultural products

$$TRSC = \sum_r \sum_q \sum_t P_{rqt}\, SD_{rqt} \tag{2}$$

Total supply chain costs consist of the total costs across the agriculture supply chain members, starting from the farmers (*TCF*), wholesalers (*TCW*), large market (*TCD*) to traditional markets (*TCR*)

$$TCSC = TCF + TCW + TCD + TCR \tag{3}$$

Total farmers costs consist of total fixed costs if farmers harvest in a period and the total variable cost which depending on the number of agriculture products harvested by farmers during the entire planning horizon.

$$TCF = \sum_f \sum_t FC_f Z_{ft} + \sum_f \sum_t CP_f Q_{ft} \tag{4}$$

Total costs at the wholesalers consist of the total ordering cost to the farmers, the total transportation fixed costs and the total transportation variable cost from the wholesalers to the farmers, the total cost of inspection, cleaning products and packaging for each level of product quality, total holding inventory cost for all of product quality levels.

$$TCW = \sum_f \sum_w \sum_t CO_{fw}\, Z_{fwt} + \sum_f \sum_w \sum_q \sum_v \sum_t CT_{fwv}\, Z_{fwvt} + \sum_w \sum_v \sum_t FC_{wv}\, Y_{wvt} + \sum_w \sum_q \sum_t CP_{wq} \sum_f \sum_v Q_{fwqvt} + \sum_w \sum_q \sum_t CH_{wq}\, I_{wqt} \tag{5}$$

Total costs at the distributors consist of the total ordering cost to the wholesalers, the total transportation fixed costs and the total transportation variable cost from wholesalers to the distributors, the total cost of weighting and re-packaging for each level of product quality, total holding inventory cost for all of product quality levels.

$$TCD = \sum_{w}\sum_{d}\sum_{t} CO_{wd}\, Z_{wdt} + \sum_{w}\sum_{d}\sum_{q}\sum_{v}\sum_{t} CT_{wdv}\, Z_{wdvt} + \sum_{w}\sum_{v}\sum_{t} FC_{wv}\, Z_{wvt} + \sum_{d}\sum_{q}\sum_{t} CP_{dq} \sum_{w}\sum_{v} Q_{wdqvt} + \sum_{d}\sum_{q}\sum_{t} CH_{dq}\, I_{dqt} \quad (6)$$

Total costs at the retailers' level consist of the total transportation costs from retailers to distributors, the total holding inventory costs of all product quality levels and total lost sales costs

$$TCR = \sum_{d}\sum_{r}\sum_{t} CT_{dr}\, Z_{drt} + \sum_{r}\sum_{q}\sum_{t} CH_{rq}\, I_{rqt} + \sum_{r}\sum_{t} CL_{rt} I_{rt} \quad (7)$$

Farmer stage;

Total number of harvest products of each farmer at any time period will be sold out by wholesalers so there are no excess crops stored by farmers as an inventory for the next period. The amount of products harvested by each farmer does not exceed the harvesting capacity at each time period. There are a minimum number of harvested products at each farmer which depend the harvest capacity at any time period.

$$\textstyle\sum_w \sum_v Q_{fwvt} = Q_{ft} \qquad \forall f,t \quad (8)$$

$$Q_{ft} \le KP_{ft} Z_{ft} \qquad \forall f,t \quad (9)$$

$$Q_{ft} \ge 0{,}5\ KP_{ft} KZ_{ft} \qquad \forall f,t \quad (10)$$

Wholesaler stage;

Maximum single vehicle will be used to transport products harvested from every farmer and every vehicle can be used for transporting the harvest purchased from some farmers in the capacity of the vehicle used by the wholesaler. Each wholesaler can be supplied by more than one farmer at each time period. Products purchased by wholesalers from each farmer is a product of the highest quality level, and will decrease the level of product quality if it is not sold and stored as inventory for the next period. All products purchased from farmers will be packed in accordance with the capacity limits at every wholesaler and excess unsold products will be stored in a warehouse with a certain storage capacity.

$$\textstyle\sum_q Q_{fwqvt} \le KV_{wv} Z_{fwvt} \qquad \forall f,w,v,t \quad (11)$$

$$\textstyle\sum_v Z_{fwvt} \le 1 \qquad \forall f,w,t \quad (12)$$

$$\textstyle\sum_f Q_{fwvt} \le KV_{wv} Y_{wvt} \qquad \forall w,v,t \quad (13)$$

$$\textstyle\sum_q \sum_v Q_{fwqvt} \le M\ Z_{fwt} \qquad \forall f,w,t \quad (14)$$

$$\textstyle\sum_f \sum_v Q_{fwqvt} \le KP_{wq} \qquad \forall w,q,t \quad (15)$$

$$Q_{fwqvt} = 0 \qquad \forall f,w,v,t\ \&\ q > 1 \quad (16)$$

$$Q_{fw1vt} = Q_{fwvt} \qquad \forall f,w,v,t \quad (17)$$

$$Q_{wfvt} \le KV_{wv} Z_{wfvt} \qquad \forall w,f,v,t \quad (18)$$

$$\textstyle\sum_f Q_{wfvt} = X_{wvt} \qquad \forall w,v,t \quad (19)$$

$$X_{wvt} \le KV_{wv} Y_{wvt} \qquad \forall w,v,t \quad (20)$$

$$I_{wqt} \leq I_{wqt-1} + \sum_f \sum_v Q_{fwqvt} - \sum_d \sum_v Q_{wdqvt} \qquad \forall w, q, t > 1 \qquad (21)$$
$$I_{wq1} \leq I_{0wq} + \sum_f \sum_v Q_{fwqv1} - \sum_d \sum_v Q_{wdqv1} \qquad \forall w, q \qquad (22)$$
$$I_{wqt} = I_{w\,(q-1)(t-1)} \qquad \forall w, q > 1, t > 1 \qquad (23)$$
$$\sum_q I_{wqt} \leq KG_w \qquad \forall w, t \qquad (24)$$

Distributor stage;

The products have been packaged by the wholesaler according to each level of product quality will be shipped to distributors in according to the ordered quantities of each distributor. Delivery of products to each distributor uses only one vehicle from the wholesaler. Each vehicle is used to make deliveries to several distributors in limitation of the vehicle capacity. Each distributor can be supplied by more than one wholesaler. Products received by each distributor will do the weighing and repackaging in according to the packing capacity for each product quality level. The same case in wholesaler, any unsold products will be stored as inventories for the next period and will decrease the level of product quality. The amount of stored products does not exceed the capacity of the storage warehouse at each distributor.

$$\sum_q Q_{wdqvt} \leq KV_{wv} Z_{wdvt} \qquad \forall w, d, v, t \qquad (25)$$
$$\sum_v Z_{wdvt} \leq 1 \qquad \forall w, d, t \qquad (26)$$
$$\sum_q Q_{wdqvt} = Q_{wdvt} \qquad \forall w, d, v, t \qquad (27)$$
$$\sum_d \sum_q Q_{wdqvt} \leq KV_{wv} Z_{wvt} \qquad \forall w, v, t \qquad (28)$$
$$\sum_q \sum_v Q_{wdqvt} \leq M\, Z_{wdt} \qquad \forall w, d, t \qquad (29)$$
$$\sum_w \sum_v Q_{wdqvt} \leq KP_{dq} \qquad \forall d, q, t \qquad (30)$$
$$\sum_d Q_{wdvt} = U_{wvt} \qquad \forall w, v, t \qquad (31)$$
$$U_{wvt} \leq KV_{wv} Z_{wvt} \qquad \forall w, v, t \qquad (32)$$
$$I_{dqt} \leq I_{dqt-1} + \sum_w \sum_v Q_{wdqvt} - \sum_{vr} Q_{drqt} \qquad \forall d, q, t > 1 \qquad (33)$$
$$I_{dq1} \leq I_{0dq} + \sum_w \sum_v Q_{wdqv1} - \sum_r Q_{dqr1} \qquad \forall d, q \qquad (34)$$
$$I_{dqt} = I_{d\,(q-1)(t-1)} \qquad \forall d, q > 1, t > 1 \qquad (35)$$
$$\sum_q I_{dqt} \leq KG_d \qquad \forall d, t \qquad (36)$$

Retailer stage;

Product demands in the retailer met from various levels of product quality and shortages that occur are treat as lost sales. Each retailer will purchase products at a distributor and every retailer is only supplied by one distributor in each time period. Purchased products from distributors are used to meet a certain minimum number of total demands that occur at the retailer in any period of time. Overstocks from various levels of product quality are stored as inventory for the next time period, without exceeding the capacity of the storage warehouse at each retailer.

$$D_{rt} = SD_{rt} + L_{rt} \qquad \forall r, t \qquad (37)$$
$$SD_{rt} \geq SL_r D_{rt} \qquad \forall r, t \qquad (38)$$
$$SD_{rt} = \sum_q SD_{rqt} \qquad \forall r, t \qquad (39)$$
$$I_{rqt} \leq I_{rqt-1} + \sum_d Q_{dqrt} - SD_{rqt} \qquad \forall r, q, t > 1 \qquad (40)$$
$$I_{rqt} \leq I_{rqt-1} + \sum_d Q_{dqrt} - SD_{rq1} \qquad \forall r, q \qquad (41)$$
$$I_{rqt} = I_{r\,(q-1)(t-1)} \qquad \forall r, q > 1, t > 1 \qquad (42)$$
$$\sum_q Q_{drqt} \leq M\, Z_{drt} \qquad \forall d, r, t \qquad (43)$$
$$\sum_d Z_{drt} \leq 1 \qquad \forall r, t \qquad (44)$$
$$\sum_q I_{rqt} \leq KG_r \qquad \forall r, t \qquad (45)$$

Binary variables and non negativity constraints

$$Z_{ft};\ Z_{drt};\ Z_{wvt};\ Y_{wvt};Z_{wdt};\ Z_{fwt};\ Z_{fwvt};\ Z_{wdvt};\ Z_{wfvt}\ \in \{0,1\} \qquad ;\forall f,w,d,r,v,t \qquad (46)$$

$$SD_{rt} \geq 0\ \ \&\ integer \qquad \forall r,t \qquad (47)$$

5. RESULTS AND DISCUSSION

The result of model development of supply chain network model for fresh agricultural products in East Java applied to numerical illustration for product cayenne those involving five farmers, two wholesalers, four distributors and 12 traditional markets as retailers. Tables 1 until Table 16 are the data for cayenne supply chain network design in East Java.

Table 1. Product demand at each retailer for each time period (ton/day)

RETAILER	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
RETAILER 1	78	50	84	77	75	73	82
RETAILER 2	117	113	81	82	107	103	114
RETAILER 3	40	49	49	42	38	41	50
RETAILER 4	76	85	89	79	89	90	100
RETAILER 5	90	65	88	85	86	87	95
RETAILER 6	110	116	92	112	113	117	105
RETAILER 7	69	66	65	50	56	72	85
RETAILER 8	57	52	49	67	58	70	90
RETAILER 9	34	47	38	47	44	21	40
RETAILER 10	113	138	105	102	136	133	138
RETAILER 11	96	113	100	114	94	116	121
RETAILER 12	104	110	51	108	104	93	120

Table 2. Fixed and variable costs while farmers planting over a time period

FARMER	Fixed cost (Rp.)	Variable cost (Rp./ton)
FARMER 1	1,500,000	30,000
FARMER 2	1,800,000	25,000
FARMER 3	2,000,000	28,000
FARMER 4	2,200,000	32,000
FARMER 5	2,500,000	24,000

Table 3. Cost of inspection, sorting and packing per ton for each level of product quality at each wholesaler (Rp./ton)

WHOLESALER	QUALITY 1	QUALITY 2	QUALITY 3	QUALITY 4	QUALITY 5	QUALITY 6	QUALITY 7
WHOLESALER 1	200	195	190	170	155	150	135
WHOLESALER 2	250	240	230	225	215	200	190

Table 4. Cost of inspection and re-packing per ton for each level of product quality at each distributor (Rp./ton)

DISTRIBUTOR	QUALITY 1	QUALITY 2	QUALITY 3	QUALITY 4	QUALITY 5	QUALITY 6	QUALITY 7
DIST 1	450	440	420	400	390	370	350
DIST 2	500	480	470	460	430	410	390
DIST 3	400	370	340	320	290	270	260
DIST 4	350	340	320	300	290	280	260

Table 5. Capacity of warehouse storage at each wholesaler and distributor (tons)

WHOLESALER	WAREHOUSE CAPACITY
WHOLESALER 1	250
WHOLESALER 2	200

DISTRIBUTOR	WAREHOUSE CAPACITY
DIST 1	150
DIST 2	100
DIST 3	125
DIST 4	150

Based on the optimal solution of the supply chain networks model for cayenne product in East Java obtained the total logistics costs that occur at each supply chain member and the maximum total supply chain profits as shown in Table 6. It appears that the greatest percentage of the total cost occur at farmer stage as producers in the supply chain network. The next ranking is the main logistics activity of wholesalers with transportation to farmers and distributors and performing the processes of inspection, sorting and packing.

Table 6. Distribution of the total cost and total supply chain profits

Factors	Total	Percentage
Total sales revenues	Rp. 725.647.800	
Total Costs		
Total cost at famers	Rp. 243.069.000	43%
Total cost at wholesalers	Rp. 189.781.300	34%
Total cost at distributors	Rp. 101.508.500	18%
Total cost at retailers	Rp. 27.330.040	5%
Total Supply Chain Costs	Rp. 561688.800	100%
Total supply chain profits	**Rp. 163.958.960**	

Optimal decision for the number of satisfied demands at each retailer for each time period are shown in Table 7.

Table 7. Total satisfied demands at each retailer in each time period (tons)

RETAILER	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
RETAILER 1	78	50	84	77	75	73	58
RETAILER 2	117	113	81	82	107	103	80
RETAILER 3	40	49	49	42	38	29	35

RETAILER	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
RETAILER 4	76	85	89	79	89	63	70
RETAILER 5	90	65	88	85	86	87	67
RETAILER 6	110	116	92	112	113	85	74
RETAILER 7	69	66	65	50	40	51	60
RETAILER 8	57	52	49	67	58	70	82
RETAILER 9	34	47	38	47	44	21	28
RETAILER 10	113	138	105	102	136	133	97
RETAILER 11	96	113	100	114	94	82	85
RETAILER 12	104	110	51	108	85	93	84

The number of products taken from farmers and delivered to the distributor by the respective wholesalers at each time period is shown in Table 8 and Table 9.

Table 8. Number of products shipped from wholesalers to distributors using a certain vehicle in each time period

WHOLESALER	VEHICLE TO DISTRIBUTOR	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
WHOLESALER 1	VEHICLE 1	290	299	294	276	164	283	205
	VEHICLE 2	198	181	198	289	329	227	395
WHOLESALER 2	VEHICLE 1	0	163	0	0	192	0	0
	VEHICLE 2	364	361	399	400	280	380	220

Table 9. Number of products taken by wholesalers to each farmer using a certain vehicle in each time period

WHOLESALER	VEHICLE TO FARMER	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
WHOLESALER 1	VEHICLE 1	200	190	185	270	235	300	225
	VEHICLE 2	263	290	307	295	258	210	375
WHOLESALER 2	VEHICLE 1	0	189	130	145	192	115	185
	VEHICLE 2	349	335	269	255	0	265	0
	VEHICLE 3	0	0	0	0	280	0	35

The optimal decisions for the number of products harvested by each farmer in each time period are shown in Table 10.

Table 10. Number of products harvested by each farmer in each time period

FARMER	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
FARMER 1	349	335	307	295	280	265	240
FARMER 2	0	0	130	110	90	70	65
FARMER 3	263	290	269	255	235	210	195
FARMER 4	0	189	0	145	205	195	185
FARMER 5	200	190	185	160	155	150	135

The optimal solution of the model supply chain network that has been developed for fresh agricultural products by taking into account the level of quality of the product can be used as a recommendation for allocation decisions crops from each farmer to wholesaler and the distribution decision of products through distributors and retailers such that customers can obtain products with the level of product availability and good product quality with competitive price.

6. CONCLUSION

The optimal decision for the determination of the amount of products harvested by farmers and purchased by wholesalers as well as the number of products distributed through distributors to each retailer to take into account the decrease in the level of product quality over time can be obtained through supply chain network model for fresh agricultural products, that have been developed in this research. The optimization model has the objective of maximizing the total supply chain profits. The result of optimal decision could be used as a reference for policy makers related to the distribution system of fresh agricultural products in East Java, to ensure the availability of products, with superior product quality level and at a competitive price.

Further research can be done by developing the supply chain network for fresh agricultural products by taking into account the uncertainty in the number of crops at the farmers' level and the demand uncertainty at the retailers' level. In addition, the development of stochastic optimization could be applied to obtain a powerful solution for the problem of the distribution systems of fresh agricultural products by taking into account those uncertainty factors.

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