

PROFIT EVALUATION OF MILKFISH DOWNSTREAM SUPPLY CHAIN FOR LOCAL MARKETS: SYSTEM DYNAMIC APPROACH

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ABSTRACT

Milkfish is an aquaculture product and has a role in supporting food security and nutrition in Indonesia. The reliability of milkfish farming will be able to increase the income of small and medium-scale farmers. Milkfish farmers in SMEs level experience problem of declining prices in the period of oversupply in farming. Moreover, the profit earning by the farmers tend to decrease time to time. This research was mapping the structure of milkfish downstream supply chain using system dynamic simulation. The first step in mapping process was identifying the actors in the milkfish downstream supply chain. The next stage was defining activities and variables that affect supply chain milkfish profit. The activities and variables were used to develop a causal loop diagram (CLD). Furthermore, stock and flow diagram was constructed based on CLD and used as system dynamic simulator of milkfish supply chain. The result of system dynamic simulation showed the profit obtained by each actor in milkfish supply chain and a total profit of the entire supply chain. The profit, gained by supply chain in current configuration, during the period 2016-2020, is Rp72.615.608.004,00. According to the simulation result, the proposed scenario will be able to increase the profit of supply chain up to 27,58%.

Keywords: *milkfish, system dynamic, supply chain*

1. INTRODUCTION

Indonesia is a country that has a great maritime potential. With existing geographical circumstances, Indonesia has a great potential for marine industry. Fisheries and aquaculture sector is a potential commodity in Indonesian to be the driving force of regional and national economy. However, the fisheries sector is still

facing problems, both upstream and downstream. Upstream fisheries industries still have problems in increasing production performance of raw materials and fresh fish. The downstream fisheries industries have constraints in developing product diversification. The competition in this sector is increasing in both local and global market. The customer requirement of quality and traceability is getting higher. These conditions require well management system in the whole supply chain of fisheries and aquaculture sector. Otherwise, it will affect the revenue of supply chain, especially farmers of fisheries and aquaculture products. Nationally, it will affect the magnitude of fisheries and aquaculture sector's contribution to overall economic development. If the sector is handled properly, it will increase the productivity of national food sector so as to contribute to national food security.

The supply chain coordination and collaboration is a strategy to improve the productivity of fisheries industry. Currently, businesses in the supply chain of fisheries and aquaculture industry are independent. Collaboration among actors in the supply chain is not common strategy. The impact of independent plans and operations in the supply chain is the acquisition profit in only few parties, and higher risk in other parties. It is one of factors caused stagnant and less competitive fisheries sector in Indonesia. Therefore, supply chain approach is needed as a solution for this sector. The first step that needs to be done is to develop a supply chain configuration of the fisheries sector. The simulation of scenarios to improve performance on the design of the supply chain configuration can be done subsequently. This research is focused in the development of supply chain design and formulation of strategies to improve supply chain

performance efficiency parameters and profit in the supply chain of fisheries products.

The potential of Indonesian fisheries and the complexity of supply chain require intensive study to support the development in this field. Widodo (2011) proposed Product Relationship Matrix approach to improve fisheries supply chain. Muninggar (2008) analysed the distribution of fish in a port using supply chain approach. However, the profit analysis of fisheries supply chain involve manifold factors. The profit in certain commodities such as food, oil and gas, and mining product can not be defined simply by financial factors, i.e. cost and revenue. Otherwise, the nonfinancial factors affect the profit sharing in the supply chain significantly.

Therefore, a dynamic approach is needed to describe and solve the complex problem of profit in supply chain. The characteristics of supply chain work with the principles of system dynamics as developed by Forrester (1961) which enables to explain the behavior and instabilities of a system. In addition, system dynamics make possible the use of variety of mathematical functions which become a strong point of the model (Langroodi & Amiri, 2016).

Minegishi & Thiel (2000) justified and explained the complex logistic behavior of an integrated of poultry supply chain by using system dynamics principles. System dynamics was enabled the study of the conflicting in supply chain of Banana and the effect of actions to overcome the lack of coordination (Arvitrida et al, 2008). This study develops both models to elucidate the behaviour of profit in fisheries. The object of supply chain design of Indonesia's fisheries sector in this study is milkfish industry. This is due to the contribution of milkfish products is third-largest in National fisheries production and second-largest in East Java.

Design and experimentation policy scenarios on the supply chain is done by using the dynamic systems simulation. The dynamic systems simulation accommodate a system consist of many actors with different characteristics and illustrate the relationship both quantitatively and qualitatively.

The rest of the paper is organized as follows. Section 2 describe the supply chain of milkfish industry in Indonesia. The relevant literature is reviewed in Section 3. The system dynamic approach to define the model of profit in milkfish supply chain is discussed in Section 4. Section 5 discuss the proposed scenarios to increase the profit of milkfish supply chain. Finally, the main conclusions are given in Section 6.

2. SUPPLY CHAIN OF MILKFISH INDUSTRY

The supplies of milkfish for the local market in Indonesia are dominated by Small Medium Entreprises industry. The supply chain of milkfish aquaculture is formed of some actors. Figure 1 presents actors of milkfish supply chain at SME level. The focal company in this supply chain are farmers of milkfish which located in coast area. This supply chain has only one tier of supplier, which consist of the supplier of seed, the supplier of fertilizer, the supplier of feed and nutrients. Furthermore, the harvest of milkfish from the farmers are sold to a wholesaler. There is one wholesaler for one area which has roles as the main buyer of milkfish from farmers as well as financial support for them. The wholesaler has the power to determine the price both to the farmers and to the retailers. Retailers with a large quantity of selling serve demand from either other retailers and/or end customers.

Fish farm of milkfish has potential markets in the local, regional, and global market. It is a popular food in Asia, including Indonesia, Filipine, and Taiwan (Lee et al, 2016). In Indonesia, the local markets of milkfish have a significant number of consumers. Therefore, the farmers of milkfish aquaculture always able to sell their harvest. The problem in this supply chain is the prices of milkfish vary significantly. There are some factors affected the various of prices of milkfish, e.g. season, and competition among areas of supplies. The unstable prices of milkfish in the market affect the profit of supply chain and mostly to the farmers. Farmers as the center in this aquaculture industry have no power to control the price but bear most of the costs in the supply chain.

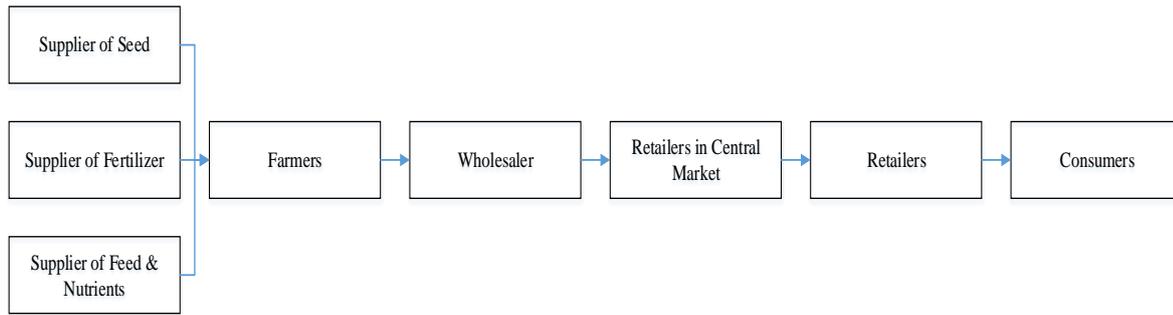


Figure 1. Supply chain of milkfish SME in Indonesia

Total review of performance in upstream to downstream of Fisheries Product supply chain is necessary to improve its competitiveness. Therefore, it is necessary to identify activities of every parties in the supply chain. The fish supply chain consists of supply from seed which distribution centre located in Gresik, and the supplier is in Bali. The cultivation process for SMEs level is semi traditional with high dependencies in natural resources for water supply and temperature which are related to climate.

Milkfish farming can be in form of aquaculture using either fresh, brackish, or marine water. In this research, ponds are located near to the sea and use brackish water for the cultivation process sourced from river. The ponds get the supply of water when the high tide occur. Meanwhile in dry season, the farmers use pump to supply the water since the river flow is decreased. The temperature for the cultivation process is set naturally. Dry season is the best condition to raise the fish for the water temperature is warmer and the fish will grow faster. In the opposite, the fish will raise slower in the rainy season. Therefore, the number of production is affected by the climate.

In addition to farming process problem, the problems of milkfish aquaculture include the number of production, distribution and range of market, unstable price, and other problems triggered by poor management of SMEs and coordination of the supply chain. The number of fish farming hatchery in the SMEs level is decided intuitively by the farmer, which

caused the uncertainty of seed's supply and do not meet the market demand.

3. LITERATURE REVIEW

3.1 Supply Chain

Supply chain is defined as a set of information and business process which provides product or service from a supplier by means of manufacture process and distribution to end customer (Sehoeder, 2003). Actors involved in supply chain are supplier, production center/manufacture/plant, distributor, wholesaler, retailer, and end user. The structure of supply chain can be divided into three layers namely as following.

1. Upstream supply chain, this layer consists of suppliers starting from first-tier supplier to end-tier supplier before entering the manufacture.
2. Internal supply chain, this layer consists of all series of process that happens in the manufacture or organization to change or transform the input from supplier to be valuable output.
3. Downstream supply chain, is the highest layer of all series of process to deliver product to end customer.

Three flows have to be managed in supply chain are:

1. Material flow, such as raw material, component, finished product.
2. Financial flow, such as invoice, payment term.
3. Information flow, such as capacity, delivery status, quotation.

3.2 Fish Supply Chain

Fish supply chain is described as a set of fishermen, agent, fish processor, distributor, and fish product plant which are inter-dependent and work together to provide fish product to consumer. No organization in fish supply chain is isolated. An action conducted by a member of supply chain can affect the whole supply chain, but specifically impact the life of fishermen whose only source of income is through fishing in both developed and developing country. In practice, there are some distinction in supply chain between countries in regards to its economy situations, environments, and cultural differences. Differences also arise related to fish species with its product and production technique (industrial production, artisanal production, conservation, or fishing).

The length of supply chain varies depending on the product, the origin country and destination of the product (export or local consumption). The shorter the distance between producer and consumer, the shorter and transparent is the supply chain. Even so, actions such as smoking, salting, and canning are included in fish supply chain even for local market product. Fish supply chain varies in terms of complexity from one company to another, depending on the level of integration from different relation and ownership system of whole production process.

Several researches on supply chain design on food products, both perishable and non-perishable, are done by Niemi, Pekkanen, Huiskonen (2007), Van Donk, Akkerman, Van der Vaart (2008), Zhang, Habenicht, Spieß (2003), Ahumada, Villalobos (2009), Hudnurkar, Jakhar, Rathod (2014). However, none of them designed for fish product. Research about supply chain in fish product is discussed by Muninggar (2008) and Widodo (2011). This shows a gap thus the need of this research. Based on previous research, the initial picture of fish supply chain can be seen. From the view point of business actor in this sector, a uniqueness is found due to domination of small and medium entrepreneur.

3.3 Potential of Milkfish in Indonesian Fishery

In order to conserve marine resources, fish conservation is a strategic way that needs to develop because it will produce continuously and increasingly, the conservation of marine resources will also be maintained. Milkfish is one of important fish commodity with a high economy value. Demand of milkfish has shown significant increase through the years. It is quite high in Asia market including ASEAN countries mainly Hong Kong, China, Singapore, Taiwan, and Japan.

Conservation of milkfish has a great chance due to its strategic environment and existing development potential. Recent ways of conserving milkfish mostly use floating net system and in-pond growth. Tiger grouper (*Epinephelus fuscoguttatus*) is a type of commercial fish conserved by many for hatchery and growth due to its promising prospect. Other types of milkfish in conservation are Leopard or Spotted Coral Grouper (*Plectropomus leopardus* and *P. maculatus*), Humpback grouper or Panther grouper (*Cromileptes altivelis*), Orange-spotted grouper (*Epinephelus coioides*), Brindlebass or giant grouper (*Epinephelus lanceolatus*).

Tiger grouper is the most conserved due to its fast grow. It can reach 5-6 oz. in 12 months. Brindlebass also has a good prospect because it grows faster than tiger grouper, but its seed have not been produced massively. Indonesia is the biggest milkfish seed producer, while the largest hatchery center with large number of hatchery business and production number is in Situbondo, East Java. Listed below is the number of fish production from marine cultivation in East Java during 2010.

3.4 Dynamic System Simulation in Supply Chain

System Dynamic (SD) is a method to describe, model, and simulate a dynamic system (gradually changes from time to time). SD taught to have system thinking, that is to view a problem and its impact on everything related to it. Sterman (2000) defined SD as a method to improve learning in complex system. Moreover, this method is illustrated as simulation in plane cockpit for the management to understand complex dynamic, resistance source in policy, and design

effective policy. To understand its complexity, dynamic system is based on nonlinear dynamic theory and feedback control which are developed in disciplines such as math, physic, and engineering. SD models are particularly unique in their ability to reveal important, and often counterintuitive, behaviour in systems, which can be a helpful contribution to policy making (Ghaffar zadegan et al., 2010). The distinction between dynamic system and other approaches lays on the use of feedback loop, stock, and flow to help describing how a system connected by feedback loop may cause nonlinearity found in problems arise nowadays. The dynamic behavior is created by tracking the change in the values of stocks and flows over time. Meanwhile, the information transfer among stocks and flows model the feedback interactions (Sterman, 2000).

In accordance to the result of alternatives, two means may be used to compare the results:

1. Verification, to see whether a model can describe the real problem by asking an expert related to the model problem.
2. Validation, to see whether or not the model is in line with the reality. This can be done by inserting extreme number in the model to see if the model shows a different result in comparison to the reality.

It is best not to think locally when facing a problem. Thinking locally will lead to cause-effect oriented thinking and best solution won't be found because everything has its own cause and another effect from that cause, so the circle goes on and on. Cause-effect oriented thinking is reduced as much as possible by using dynamic system. A model is based on its relationship chart and structure of the system is based on its relationship. Doing this resulted in a loop of feedback. This loop is called causal loop diagram.

With the aforementioned characteristics, approach using SD simulation is appropriate in supply chain design. SDs is used to represent the dynamic behavior of complex system including sociaecology (Elsawah et al, 2017), and supply chain (Pan et al, 2017). Several researches related to supply chain design using SD are done by Minegishi and Thiel (2000), Arvitrida et al (2007), Perdana and Kusnandar

(2012), Eunike et al (2014), Pan et al (2017). These researches design supply chain by identifying relationship between actors by using causal loop diagram (CLD) which later transformed into stock and flow diagram as simulator for the experiment of scenarios. Based on the experiment, supply chain performance improvement strategy can be defined.

4. SYSTEM DYNAMIC FOR MILKFISH DOWNSTREAM SUPPLY CHAIN PROFIT

4.1. Model Development

The study and observation evaluate factors which affect the profit of Milkfish Supply Chain. The factors include the quantitative and qualitative ones. The quantitative factors consist of factors which generate revenue and cost to perform the profit, such as cultivation capacity, cost of cultivation process, season factors, number of supply, number of demand, and price. The qualitative factors are the factors which define the behaviour of the system, such as nature of markets, interaction between parties in supply chain, farmer's management system, knowledge and technology of farmer, and government support. The relationship and feedback effect of the factors relate to the profit of milkfish' supply chain are drawn in the causal loop diagram (see Figure 2).

The expense of milkfish supply chain generates by total cost which spend by all players in the supply chain. The expenses in the supply chain decrease the profit. The cost consists of variable and fixed cost. The variable cost is expense that varies to number of fish produce by the farmers which affected by fishponds' capacity and cost related to raw material (seed, fertilizer, nutrients) from the suppliers. The distribution network design of raw material supply affects both variable cost and fixed cost of supply chain, i.e. inventories, transportation, facilities and handling, information. Fixed cost is a cost that does not change with the number of fish harvested from the ponds, both related to production and marketing activities. On the other hand, season is also affect the number of fish harvested. The number of fish is higher in the dry season

compare to in the rainy season. The government support, in term of regulation in

taxes and subsidy for prices of seed or fertilizer.

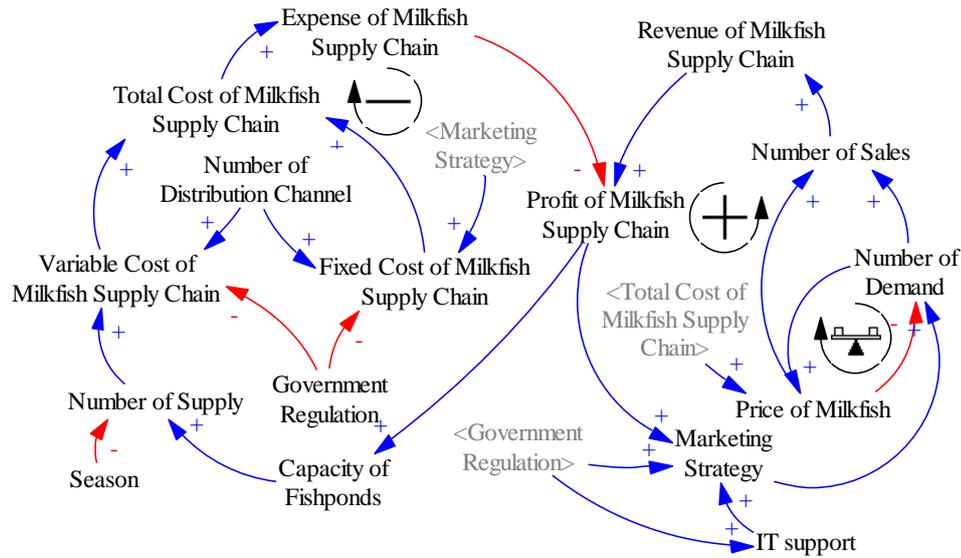


Figure 2. Causal loop of milkfish' supply chain profit

The revenue of the milkfish supply chain is generated from number of sales to fulfill the demand of customer. The number of sales are affected by price of milkfish which related to number of demand. The increase of price will lead to the decrease of demand and vice versa. Marketing strategy is a way to turn a business around to improve number of demand (Wang, 2016). Marketing for SMEs will need support of government including the using of technology such as IT and e-Commerce (Rahayu, 2015).

Figure 2 describes the behavior of all stages in the supply chain. The stages of supply chain will affect the overall profitability of supply chain. The downstream supply chain consists of firms from the focal company to the stage which directly interact to the end customers. In the milkfish supply chain, the players of downstream supply chain are farmers, wholesaler, retailers in central market, and retailers. Afterward, the model describes the activities which trigger cost and revenue in every stages in the downstream supply chain.

The stocks and flows is used to analyze behavioral changes of key variables and apply a series of simulated exercises related to the activities which generate cost and revenue in downstream milkfish supply chain. This paper applies the system dynamic module in

POWERSIM STUDIO 10 to establish a model of profit in milkfish downstream supply chain.

Figure 3 to 5 present the POWERSIM model of downstream supply chain. □ represents layer, ○ represents variable, ◇ represents constant, ☁ represents mass flow between undefined source or destination, → represents functional relationship between one variable and another. Figure 3 illustrates the activities in the farmers' level. Figure 4 illustrates activities in the wholesalers which generate cost and revenues. Figure 5 presents the activities in retailers, both for retailers in the central market and retailers which directly sell product to end customers.

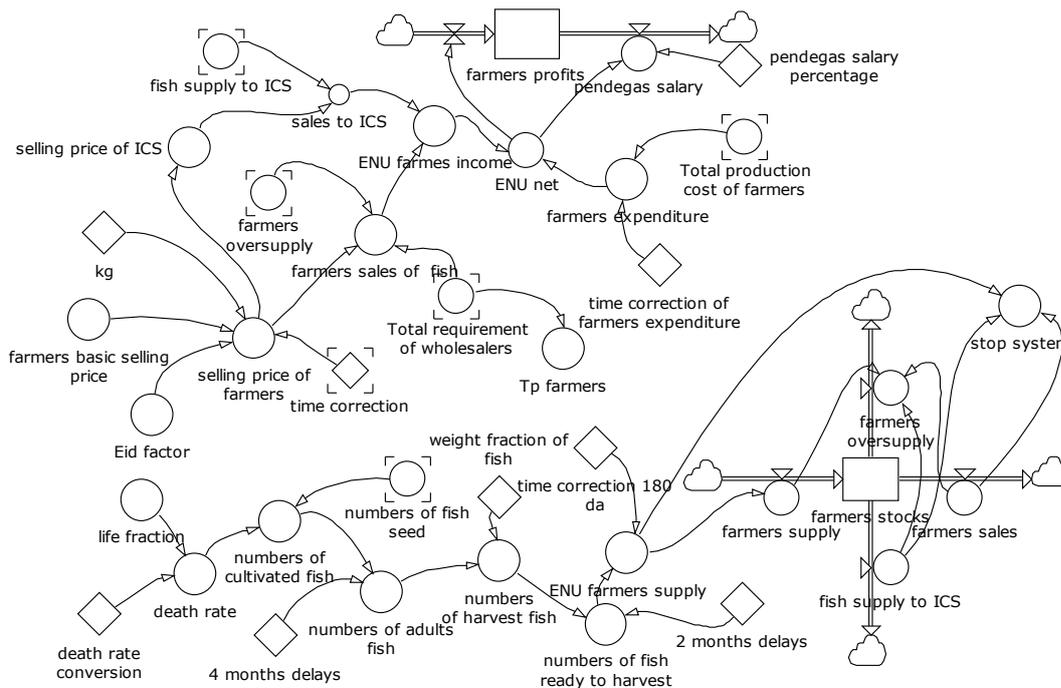
Figure 3 consists of variables which represent activities in the cultivation process of milkfish. In the SMEs level, the cultivation process is categorised as semi-traditional process, for which it used both nutrient and fertilizer at the same time. The cost at fisher level come from the cost of seed, fertilizer, and nutrient, cost of labor and the preparation of tools to cultivate fish, provision of fish seed, provision of medicines, supply of fertilizers, preparation of medicines, and the provision of supplementary food needed in the cultivation of milkfish.

After the process of fishing, the fresh fish will be directly sold to the fish collectors.

Furthermore, the fish that have been purchased by collectors will then be marketed/traded to the wholesalers in the market in the area or the other city in the same region of the ponds as described in Figure 4. The profit of wholesalers is defined by the difference of revenue and cost from business' activities in the wholesalers.

In addition, there is also a fish processing performed by SMEs in the area of ponds. The process produce processed products of fish, namely presto milkfish, smoked milkfish and milkfish pull thorns. After that, the processed

products will be marketed to SMEs shop in the area and send it to retailers in the city and other cities nearby. Milkfish consumption by end consumers can be either in the form of fresh fish or processed fish products. The retailers distribute milkfish from wholesalers to end customers by retailers. The retailers can be divided into two types, the retailers which have high number of sales placed in central market, and the smaller retailers. Figure 5 presents the activities related to profit in the two types of retailers.



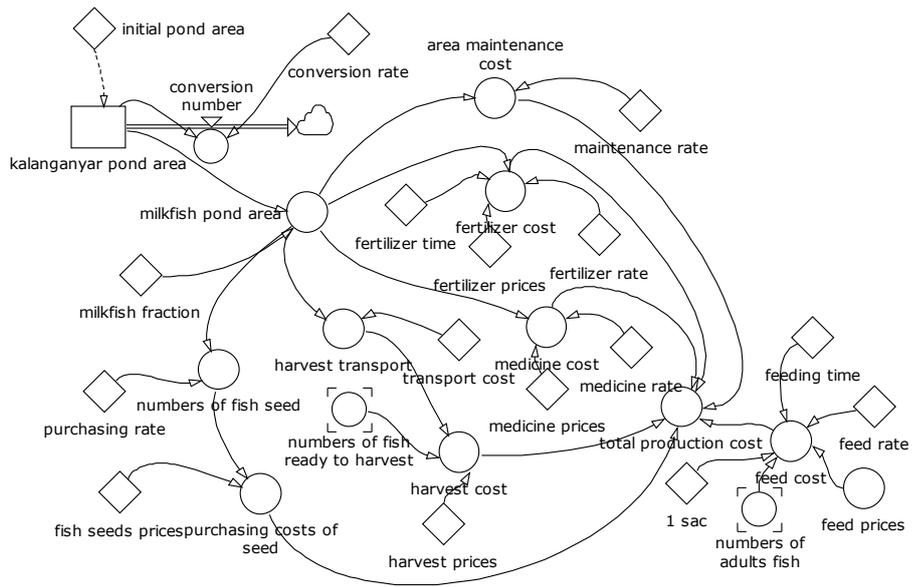
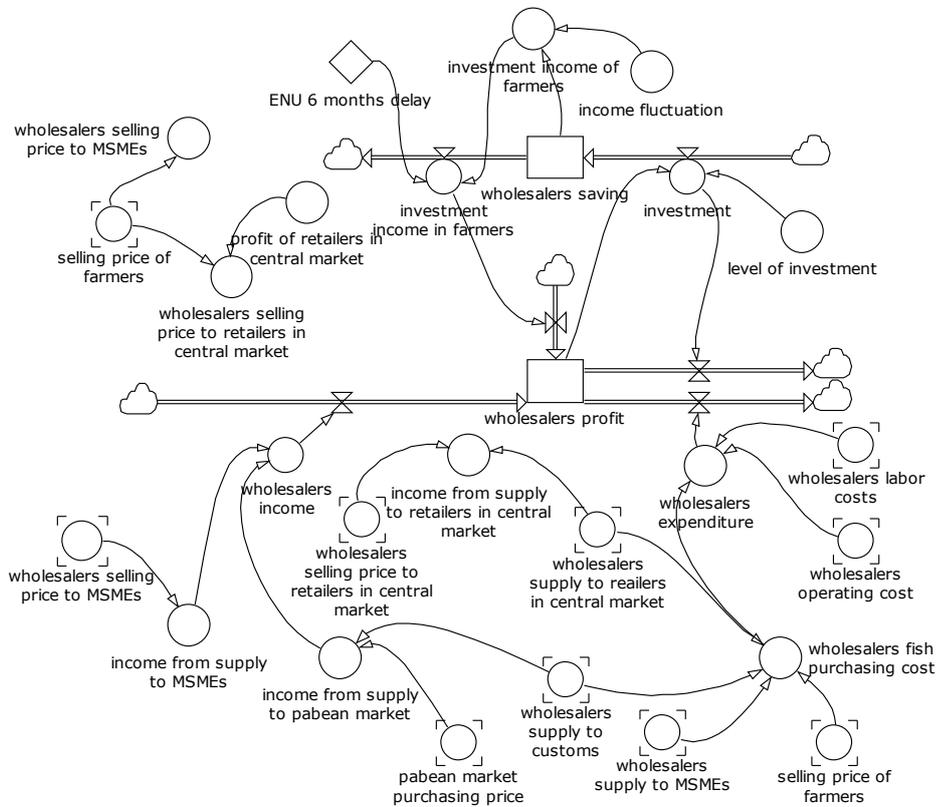


Figure 3. Stock&Flow profit generators of farmers



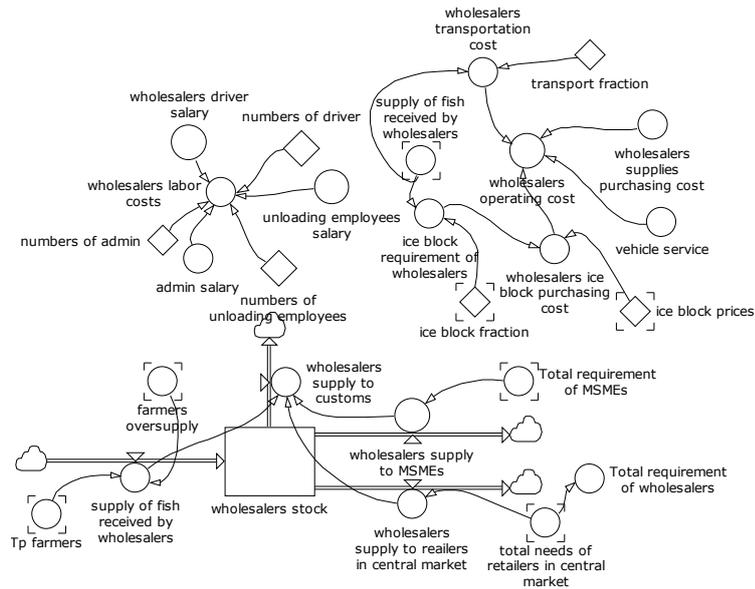
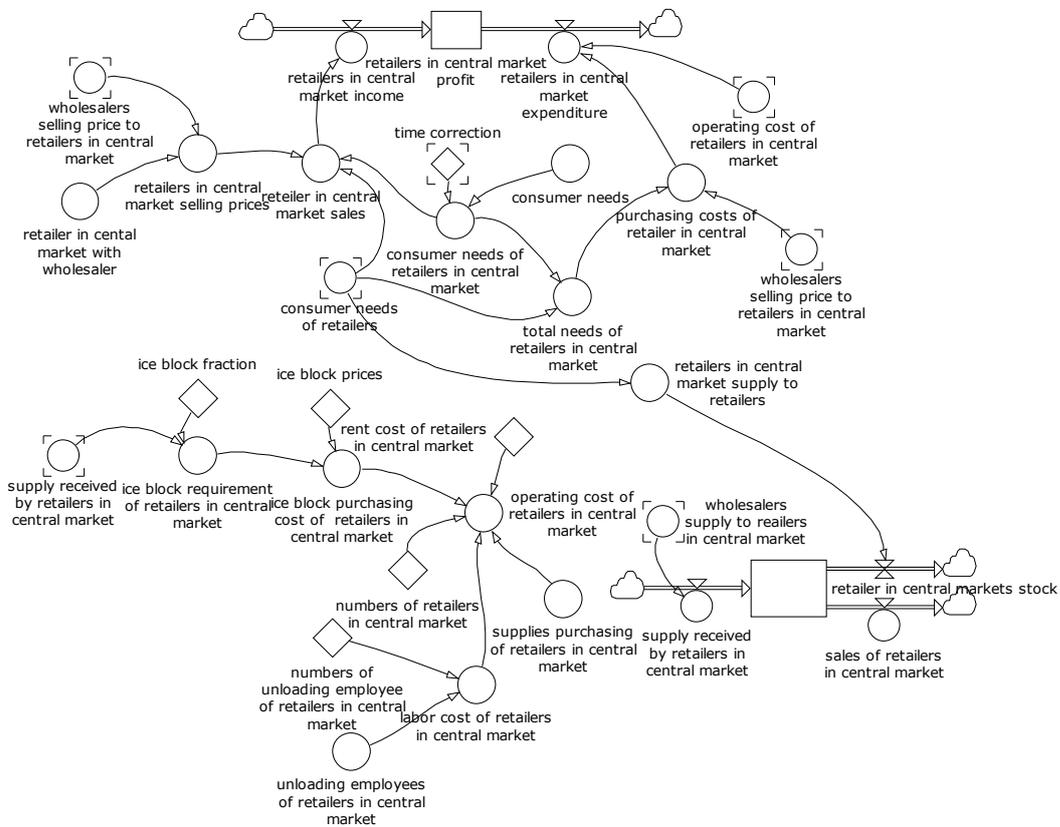


Figure 4. Stock&Flow profit generators of wholesalers



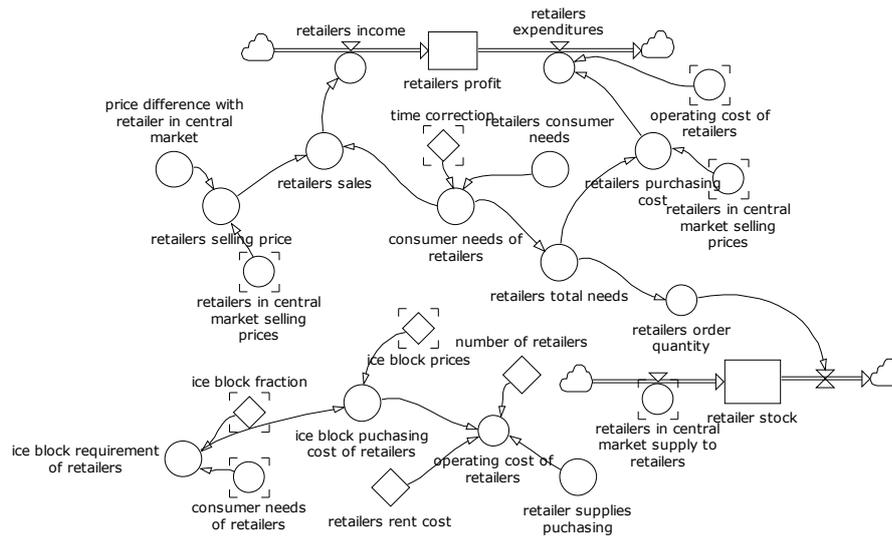


Figure 5. Stock&Flow profit generators of retailers in central market and small retailers

4.2. Simulation

The problem of incompatibility between milkfish supply and market demand are commonly experienced by the farmers of the fish cultivation in the SMEs level. As in the object of this research, the number of fish can be produced by farmers are 14 tons per day in average, while the fix demand is about 8 tons per day, so around 6 tons of fish will be traded to market per day, where the selling price will be determined by the market mechanism, which later causes the selling price to be lower than expected.

Due to the amount of excess production experienced by the farmers in SMEs level, they have to find an alternative that will be able to improve the welfare of the farmers. This needs to be considered by the local Government and private sector in order to improve the the added value of processed fish products so that the welfare of society in the area is increasing. The simulation process of existing system is present in the following part of the paper. The validation process is important to ensure the result of the simulation represent the real system and can be use to analyze the behavior of the system.

a. Validation Model

The simulation model is validated in the four following methods:

- 1) Model Structure Test
This test involved several experts who know about the existing condition of the downstream supply chain system of

commodity fish. The validation process used brainstorming and discussion regarding the components contained in the system as a party to assess the model structure. In the downstream supply chain system model of fish commodities have been discussed to the parties concerned in the system (farmers, wholesalers, retailers, government, and consumers). Therefore, the model has been declared valid qualitatively.

- 2) Extreme Condition Test
Test of extreme conditions confirm the robustness of model. The test was designed into two extreme conditions. Extreme condition 1 was changing the selling price in the model to 50,000 IDR/kg, and extreme conditions 2 was changing the price into 5,000 IDR/kg. Figure 6 and Figure 7 present the results of two conditions respectively.

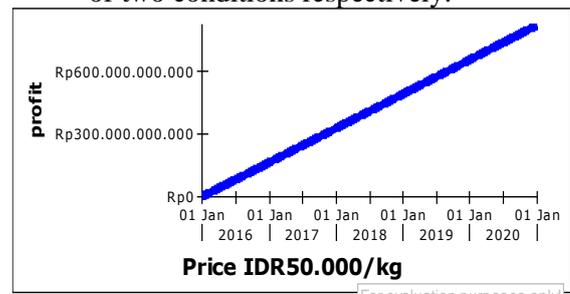


Figure 6. Price Milkfish IDR.50.000/kg

- 3) Parameters Model Test
The variable which tested in a test of this parameter was the high cost of raw

material and production costs of SMEs. The model is valid if the cost of the raw materials used, the high production costs of SMEs is high and vice versa. Figure 8 presents the results of the parameters test.

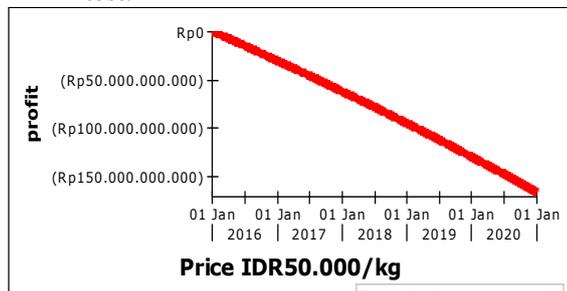


Figure 7. Price Milkfish IDR.5.000/kg

- 4) Quantitative test
 Barlas' model was used to test the validity of the model. The model is valid when the mean error (E1) is less than 5% and mean variance (E2) is less than 30%. (Barlas, 1996).

$$E = |(S - A) / A| \quad (\text{Eq.1})$$

Where:

A = Actual data

S = Simulation Output

Error Mean and Error Variance

$$\begin{aligned} \text{Error Mean (E1)} &= \frac{(14988,89 - 14904,44)}{14904,44} \\ &= 0,005665722 \\ &= 0,5665722\% \end{aligned}$$

Error Variance (E2) =

$$\begin{aligned} &\frac{(1226468,88 - 1152369,14)}{1152369,14} \\ &= 0,064302 \\ &= 6,4302\% \end{aligned}$$

Based on the statement, the model is valid quantitatively.

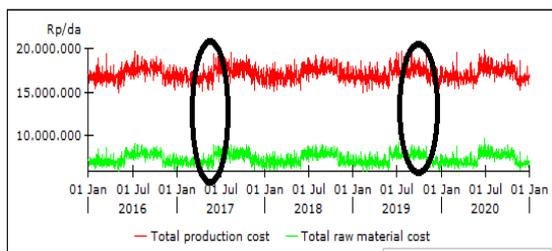


Figure 8. Test Parameters Model

b. Result of Simulation

The following is the result of a dynamic simulation model downstream supply chain of milkfish. Powersim software simulation results showed that each actor in the supply chain has a different trend of profit. However, the differences were not significant for some actors. Table 1 shows the profit of each party to the existing system.

5. SCENARIOS TO INCREASE PROFIT OF SUPPLY CHAIN

This scenario was used to evaluate the changing behavior of profit in the supply chain when the structure was changed. The scenario was designed with add one actor which will have role to manage the excess product which not able to absorb by the market at the same day of its harvest time. The new cold storage industry that will process the fish with cold storage processes. The aims of this scenario is to stabilize the price and extend the lifetime of milkfish.

In this scenario, total profit earned by the retailers are constant, there was not any changes in net income due to the policy. On the other hand, the party experiencing the change in net income due to the implementation of the policy scenario are farmers and wholesalers. In addition, overall profit in the supply chain has significantly increased. Comparison of profit between existing condition and proposed scenario for each party in the supply chain are presented in Table 1.

Table 1. Comparison of Profit Supply Chain between Existing Systems and Policies Scenario Systems.

Stackholder	Profit (IDR)	
	Existing	Scenarios
Farmers	50.386.863.785,00	59.751.942.167,00
Wholesalers	716.340.308,00	1.143.411.983,00
Retailers of Central Market	8.248.873.487,00	8.248.873.487,00
Retailers	4.205.006.422,00	4.205.006.422,00
SMEs	9.058.524.002,00	9.058.524.002,00
Cold storage industry	-	10.233.203.644,00
Total	72.615.608.004,00	92.640.961.705,00

6. CONCLUSIONS

This paper has analyzed the configuration structure of Indonesian downstream commodity fish in SMEs level. The description of the parties involved in the process of cultivation of commodity fish to the distribution process of both fish and processed products into the hands of the end consumer. The suppliers of this supply chain are suppliers of seed, suppliers of drugs, fertilizer suppliers, feed suppliers. Focal actors of this supply chain are the farmers. Wholesalers are fish collectors. Retailer is the retailers in the central market, small retailers, and enterprises which process the milkfish into processed food. The end consumers are people who consume milkfish either fresh and processed fish. Variables influencing the profit of structure in downstream supply chain of milkfish were obtained by field observation, interviews, and secondary data.

According to the simulation results, the profit of existing condition of downstream milkfish' supply chain in 4 periods of simulation will be slightly increase. However, the profits of farmers have been decreasing for the next few periods. Therefore, policy recommendation is needed to prevent the predictive condition. The proposed recommendation is to add new cold storage industry to stabilize the price and extend the lifetime of product. The result of proposed scenario was shown the increase of total profit of farmers and the supply chain in the same time.

However, more study is needed to design the detailed concept of cold storage industry and analyze its feasibility. The future study of alternatives scenarios need to be conducted to develop the most effective and robust configuration in downstream supply chain of fish.

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