Analysis of supply chain management in ABC poultry using system dynamics approach

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Abstract. This study discusses supply chain management to produce broilers in ABC Poultry using System Dynamics approach. Small poultry farm in Indonesia must make a decision to sustain itself in the midst of needs to increase its capacity and facing issue with dependency to day-old chick producers. The purpose of this study is to analyse the supply chain management to increase profitability of the poultry in between two options of decision, buying the day-old chicks from third-party supplier or doing vertical integration to produce its own day-old chicks. This study found that doing vertical integration is the best option for the poultry because it can increase the profitability of the poultry and reduce the sensitivity of day-old chick price to the poultry.

1. Introduction
Poultry sector is one of an important sector in Indonesia’s food industries. Poultry is one of the cheapest protein source, and it is consumed by majority of Indonesian people that has low income. Poultry farming in Indonesia is dominated by broiler farm. Broiler meat is 66% of the national meat consumption. Broiler farming industry in Indonesia is dominated by multinational corporation about 80% of the market. These multinational corporations have technology, resource, and skilled workers. The Indonesian Commission for the Supervision of Business Competition (KPPU) in 2016 suspected that 12 companies had involved in chicken cartel practices in day-old chick prices. Individual broiler farmers face the problems to acquire day-old chick supply with competitive prices and to produce more broiler in their farm.

This study discusses the impact of supply chain management decision in individual poultry farm in Indonesia using system dynamics in 5, 10 and 15 years. The study use ABC Poultry Farm in Bogor to be the case study material. There are four scenarios available to choose for the ABC poultry to increase its profitability:
1. Buy day-old chicks from 3rd party suppliers and increase their farm capacity to rear more chicken with traditional type of farm (Opened-house)
2. Buy day-old chicks from 3rd party suppliers and increase their farm capacity to rear more chicken with modern-type of farm (closed-house)
3. Do vertical integration to produce its day-old chicks and increase their farm capacity without any probability to buy day-old chicks from 3rd party suppliers.
4. Do vertical integration to produce its day-old chicks and increase their farm capacity with probability to buy day-old chicks from 3rd party supplier if it is necessary.
These scenarios were simulated and calculated using system dynamics approach with Powersim application and the references of this paper is primary data of the ABC Poultry and secondary data from previous studies. The simulation was made based on several assumptions.

2. Literature Review

2.1. Supply Chain Management
Supply chain is the business link that need to fulfill customer request of particular goods or services [1]. Supply chain needs to be managed to maximize value of goods or services (supply chain surplus) and the success of managing supply chain depends on decisions-making related to flow of information, product and cash.

2.2. Vertical Integration
Vertical integration is one of supply chain management strategy that can be implemented by an organization to enhance ability to replace third party supplier (backward integration) or third party distributor (forward integration) in supply chain. The advantages of vertical integration:
1) Decreasing transaction cost.
2) Increasing in certainty of supplies.
3) Increasing coordination. [2]

2.3. System Dynamics
System Dynamics is a method to enhance learning in complex system that was developed by Jay W Forrester [3]. System Dynamics, formerly known as Industrial Dynamics, finds the feedback and the characteristic of the feedback that is generated by industrial activity or agent activity in the system. The decision that is taken by one agent in the system will affect positively or negatively to other agent on the system.

Causal Loop Diagram is a one of tools in System Dynamics that is usually used to learn about the system and to picture the feedback in the system. Stock and Flow Diagram is another tool that is used to learn about the feedback effect in numbers and mathematical model.
3. Research Methodology

This study was made to help decision-making in ABC Poultry Farm. This study used interviews and observation to collect primary data in ABC’s farm that located in Bogor, West Java. The secondary data was using the farm historical report in two periods of producing. All of the data have been collected for six months.

After data were collected, then Causal Loop Diagram was made based on the collected data. The Causal Loop Diagram helped to find the main loops and the secondary loops in the system. Next step, Stock and Flow Diagram was made based on the Causal Loop Diagram and the collected data. After the Stock and Flow Diagram was made, The SFD was verified using Barlas’s steps of model validation. Then, the simulation was done and the simulation record was analysed [4]. The analysis result was used to choose the best scenario and explain the constraint.

4. Result

The ABC Poultry focuses on rearing of broiler chicken. This study is focused on a farm that located on Gadog, Bogor with 6,500 chickens for one farm capacity. Figure 3 showed the supply chain of The ABC Poultry that consists of day-old chick suppliers, feed suppliers, slaughterhouses, distributors and market. The ABC Poultry orders day-old chicks from suppliers once the farm is empty and the ABC Poultry orders feed every two weeks. The slaughterhouses buy adult chicken directly from the farm and chicken that has been slaughtered are brought to the market by distributors.
The Simplified Causal Loop Diagram, shown on Figure 4, made based on interview with the owner of The ABC Poultry, observation, literature review and Integrated Supply Chain Model for Sustainable Poultry Production in Bangladesh: A System Dynamics Approach by Shamsuddoha in 2014 [5]. The CLD consists of 1 reinforcing loop, shown by indicator “R”, and 7 balancing loops, shown by indicator “B”.

The Stock and Flow Diagram made based on historical data and the CLD. The SFD shows the system of production chain in ABC Poultry. The cash on hand generator in this model is chicken for sale inventory and the costs of this system consist of feed total cost, day-old chick cost, Farm build cost and maintenance cost. The stock and flow diagram simulated in 5, 10 and 15 years and using weeks as a timestep.

The Stock and Flow Diagram of 1st and 2nd Scenarios, shown on Figure 5, was made based on a real condition on a farm. This SFD model used a traditional farm type (Opened-house) with each farm capacity equals to 6,500 chickens and 20,000 chickens with a build cost equals to Rp 150,000,000/farm. In these scenarios, ABC Poultry bought day-old chicks from third party suppliers with a price equals to Rp 6,000/chick.

The Stock and Flow Diagram of 3rd Scenario, shown on Figure 6, was modified from the model of 1st scenario. This SFD model used a modern farm type (Closed-house) with each farm capacity equals to 20,000 chicken with a build cost equals to Rp 2,500,000,000/farm, in this scenario, ABC Poultry also bought day-old chicks from third party suppliers with a price equals to Rp 6,000/chick.

The Stock and Flow Diagram of 4th Scenario, shown on Figure 7, was modified from the model of 2nd scenario. This SFD model also used modern farm type (Closed-house) with farm capacity and build cost same as the 2nd scenario model. In this scenario, ABC Poultry could produce and sell its own day-old chicks with a price equals to Rp 5,000/chick, but couldn’t buy day-old chicks from third party suppliers.

Input for each variable of the Stock and Flow Diagram:
1) Farm Capacity: 6,500 chickens (Scenario 1), 20,000 chickens (Scenarios 2, 3 and 4)
2) Initial Cash: Rp 1,000,000,000.
3) Day-Old-Chick Price: Rp 6,000/chick
4) Chicken Price: Rp 18,500/kg
5) Food Price: Rp 7,100/kg
6) Building Cost: Rp150,000,000/farm (Scenario 1), Rp2,500,000,000/farm (Scenarios 2, 3 and 4)
7) Farm Depreciation: 10%
Figure 5. The Stock and Flow Diagram of ABC Poultry for 1st and 2nd Scenarios

Figure 6. The Stock and Flow Diagram of ABC Poultry for 3rd Scenario
Figure 7. The Stock and Flow Diagram of ABC Poultry for 4th Scenario

The result of all scenarios in 5 years is shown on Table 1. The NPV result was calculated with rate of 4.75% (Bank Indonesia 7 days Repo Rate). The result showed that the 4th scenario generates highest NPV of cash on hand in the amount of Rp 26,036,541,756 with production capacity equal to 160,000 chickens in one cycle of production. Followed by 3rd Scenario with cash on hand in amount of Rp 19,360,590,397 and 100,000 chickens for production capacity. The least preferable scenario is 1st Scenario with cash on hand equals to Rp 262,937,439 and production capacity equals to 24,000 chickens.

Table 1. The Simulation Result (5 years)

| Scenario   | NPV (Normal Condition) (Rp)     | Production Capacity (year 5th) (chicken) |
|------------|---------------------------------|----------------------------------------|
| 1st Scenario | 262,937,439                      | 24,000                                 |
| 2nd Scenario | 1,005,656,132                    | 160,000                                |
| 3rd Scenario | 19,360,590,397                   | 100,000                                |
| 4th Scenario | 26,036,541,756                   | 160,000                                |

The result of all scenarios in 10 years is shown on Table 2. The NPV result was calculated with rate of 4.75% (Bank Indonesia 7 days Repo Rate). The result showed that the 4th scenario generates highest NPV of cash on hand in the amount of Rp 55,903,825,170 with production capacity equal to 240,000 chickens in one cycle of production. Followed by 3rd Scenario with cash on hand in amount of Rp 31,436,846,956 and 120,000 chickens for production capacity. The least preferable scenario is 1st Scenario with cash on hand equals to Rp 1,939,664,849 and production capacity equals to 40,000 chicken.
Table 2. The Simulation Result (10 years)

| Scenario | NPV (Normal Condition) (Rp) | Production Capacity (year 10th) (chicken) |
|----------|-----------------------------|------------------------------------------|
| 1st Scenario | 1,939,664,849 | 40,000 |
| 2nd Scenario | 6,596,184,815 | 240,000 |
| 3rd Scenario | 31,436,846,956 | 120,000 |
| 4th Scenario | 55,903,825,170 | 240,000 |

The result of all scenarios in 15 years is shown on Table 3. The NPV result was calculated with rate of 4.75% (Bank Indonesia 7 days Repo Rate). The result showed that the 4th scenario generates highest NPV of cash on hand in the amount of Rp 89,629,854,208 with production capacity equals to 300,000 chicken in one cycle of production. Followed by 3rd Scenario with cash on hand in amount of Rp 44,554,368,851 and 120,000 chickens for production capacity. The least preferable scenario is 1st Scenario with cash on hand equals to Rp 4,946,468,051 and production capacity equals to 50,000 chickens.

Table 3. The Simulation Result (15 years)

| Scenario | NPV (Normal Condition) (Rp) | Production Capacity (year 15th) (chicken) |
|----------|-----------------------------|------------------------------------------|
| 1st Scenario | 4,946,468,051 | 50,000 |
| 2nd Scenario | 17,311,688,979 | 300,000 |
| 3rd Scenario | 44,554,368,851 | 120,000 |
| 4th Scenario | 89,629,854,208 | 300,000 |

5. Conclusion

The simulation result of this study showed that the most preferable scenario to choose by poultry is 4th scenario. The 4th scenario in 5 years generates NPV of cash on hands equal to Rp 26,036,541,756, in 10 years equals to Rp 55,903,825,170 and in 15 years equals to Rp 89,629,854,208. The most accurate result of simulation is the five-year simulation, because the longer period of simulation has lesser accuracy.

The model of this study showed that the best decision to the ABC Poultry is the 4th Scenario or do the vertical integration with buying from 3rd party supplier and using closed-house farm type. This 4th scenario generates highest cash on hand and decrease the cost of day-old-chick transaction. The second of the best decision is the 3rd scenario that is vertical integration without buying from third party supplier.

The implications of choose the 4th scenario are:
1) The poultry needs to provide initial cash on hand in the amount of Rp 1,000,000,000 to afford operational expenses.
2) The poultry needs to administer the permits to produce and sell its own day-old-chick.
3) The poultry needs to provide available land lots to build ten farms and provide Rp 2,500,000,000 to build farm each year.
4) The poultry needs to provide vehicles to transporting day-old-chick.

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