Perishable Product Supply Chain Modeling with Quality Considering

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Abstract. In perishable product supply chain, time is very sensitive to product quality. The delivery delay can cause product value is decreased even zero. So, maximized value is become important performance indicator. To maintain perishable product's quality is needed technological effort that can decrease the rate of deteriorating. Its consequences are cost increasing that subjected to customer's purchasing power.

The earlier researches about perishable product focus on time or cost as performance indicator. The relationship between those performance indicators and quality was lack. This research tried to fill the gap through the proof of relationship between quality, cost (price), and delivery. Specifically, this research would answer the question: Did the usage of supply chain technologies influence supply chain performance?

By using simulation method, it can be concluded that the use of supply chain technologies influenced directly to decay and activity time, it means it can reduce activity time because of the changes of transportation modes or it can extend decay time using packaging or storing technologies. Meanwhile, the use of supply chain technologies also lead to cost increasing, so it can be seen the interaction among quality, cost, and time that were new finding in this research.

Keywords: delivery, perishable product, price, quality, supply chain, technology.

1. Introduction

In perishable product supply chain time is very crucial, because delivery delay to customer lead to product economic value is decreased even zero. Because its characteristic was perished, so to maintain perishable product's quality is needed technological effort to keep the rate of products deteriorating. The technological efforts are especially in products storing and transportation.

Besides packaging that must be designed in order to keep products quality, in other hand transportation time is also must be as fast as possible in order that products delivery to customer are still within tolerable limit usage, it means products still have economic value. In this case the choices of transportation mode become the thing that cannot be avoided anymore in order that products are on time delivery. The better and faster transportation modes that are used the bigger costs that have to be spent.

Based on the description above it can be seen that there is the strong relationship among quality, time, and cost in handling of perishable products. There is a trade off among the three of variables. To maximize the quality of perishable products, delivery time must be as fast as possible with packaging techniques that can maintain products freshness. Its consequences are the spending of cost become high. This leads to the decreasing of profit earned by each supply chain party. From the explanation above, so the research question is: Is the increasing of selling price due to the usage of supply chain technologies to maintain products quality proportionate with the increasing of the spending of cost? Or in other word: Can profit increase due to the usage of supply chain technologies to maintain products quality?

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2. Conceptual Model

2.1. Fish Supply Chain

In this research fish supply chain was explored as an example of perishable product while demonstrating the interaction among quality, cost, and delivery using simulation modelling in fish supply chain. Here is fish supply chain that will be discussed further.

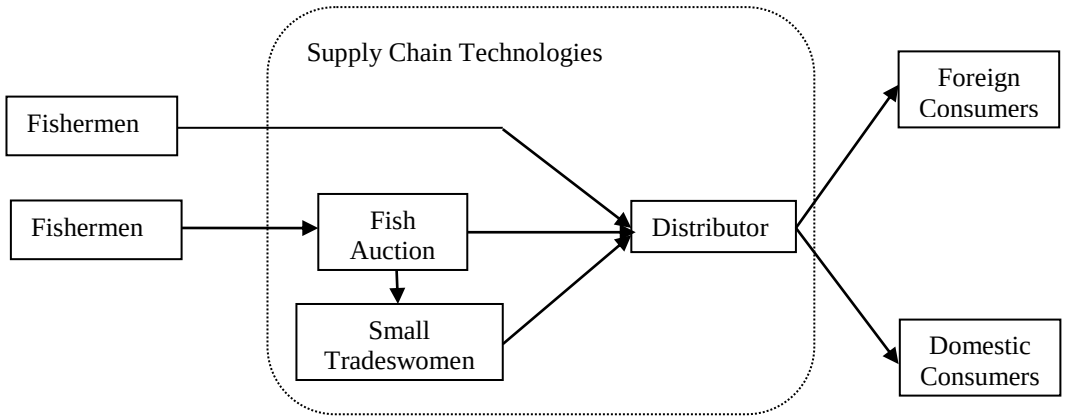

Fig. 1: Fish Supply Chain.

Supply Chain Technologies are transportation modes and packaging that are used to distribute raw fish from fishermen to foreign and domestic consumers, so that technologies in fishermen are not considered.

Fish are perishable products, it means the rate of fish freshness determines the value of fish, so dead fish have no economic value. Consequently, fish need serious handling since they captured from the sea until consumers. The phenomenon of fish quality decreasing empirically from time to time, after it was tested, it will form an exponential graph that can be approximated by equation: Quality = Initial Quality x $e^{-t/T}$; t: activity time; T: decay time.

From the equation above it can be seen that fish quality in fishermen can different with fish quality in fish auction, small tradeswomen, distributor, and also consumers because there are transportation process among party and storing process in each supply chain party.

2.2. Conceptual Model

The usage of supply chain technologies is expected can maintain fish supply chain through two ways, namely: (1) to enlarge decay time, it means fish decay time is made longer through storing technologies and or packaging; and (2) to accelerate activity time, that is to replace transportation modes into better capacity and speed.

The usage of technologies to maintain fish quality will cause additional cost become larger, directly it can affect supply chain total cost. The total cost is also affected by activity time, because there are cost components that are depended on the long of activity time. The longer activity time the bigger total cost. Total cost will also affect unit cost together with the number of existing fish in each supply chain party. The larger the number of fish that are handled the smaller unit cost and the longest time activity.

Furthermore the better fish quality the better price. Selling price per unit together with unit cost will affect profit margin or profit potent in each supply chain party. The larger unit cost the smaller profit margin or profit potent in each supply chain party, otherwise the larger selling price the larger profit margin or profit potent in each supply chain party.

3. Model Formulation

There are four sub models namely: (1) fish supply sub model; (2) fish quality and distribution sub model; (3) time and cost in each supply chain party sub model; and (4) price, cost, and profit potent in each supply chain party sub model.

Data that are needed to support simulation process consist of: (1) numeric data: the number of sales, maximum fish price, each activity time, and costs; (2) written data: any references that are used in modeling such as secondary data, research journals, and books that related theme with the research; (3) mental model is rule that is underlying model structure creating. Meanwhile, data collection techniques are: interview (numeric data and mental model); observation (fish distribution process from fishermen to consumers); and documentation study (secondary data and research report).

4. Result and Discussion

Based on model validation result using Root Mean Square Person Error (RMSPE) can be seen that all variables have small values of RMSPE, bias proportion, and variance proportion, and large value of covariance. It means actual values have the same cycle with simulation results, and the model can be said valid because it has small rate of error.

Further analysis is based on simulation method after developing eight scenarios that can be seen as follow:

- Scenario 1: to replace initial transportation mode to alternative 1 transportation mode in a part of supply chain party (fishermen, fish auction, and small tradeswomen).
- Scenario 2: to replace initial transportation mode to alternative 1 transportation mode in a part of supply chain party (distributor).
- Scenario 3: to replace initial transportation mode to alternative 1 transportation mode in all part of supply chain party.
- Scenario 4: to replace initial transportation mode to alternative 2 transportation mode in a part of supply chain party (fishermen, fish auction, and small tradeswomen).
- Scenario 5: to replace initial transportation mode to alternative 2 transportation mode in a part of supply chain party (distributor).
- Scenario 6: to replace initial transportation mode to alternative 2 transportation mode in all part of supply chain party.
- Scenario 7: scenario 3 plus to replace packaging that is used in distribution process from distributor to consumers.
- Scenario 8: scenario 6 plus to replace packaging that is used in distribution process from distributor to consumers.

The alternative 1 and alternative 2 transportation method that are used in each supply chain party can be seen in Table 1.

Table 1 Transportation Modes that in Each Supply Chain Party

Distribution Among Party	Initial Transportation Mode	Replacement Transportation Mode
Fishermen to Fish Auction	Manual	Alternative 1: Four wheel cart
		Alternative 2: Two wheel cart
Fish Auction to Small Tradeswomen	Pedi cab	Alternative 1: Pick up van
		Alternative 2: Cart motorcycle
Fish Auction to Distributor	Pedi cab	Alternative 1: Pick up van
		Alternative 2: Cart motorcycle
Small Tradeswomen to Distributor	Pedi cab	Alternative 1: Box van
		Alternative 2: Truck
Distributor to Domestic Consumers	Pick up van	Alternative 1: Box van
		Alternative 2: Truck
Distributor to Foreign Consumers	Regular plain	Alternative 1: Commercial plain
		Alternative 2: Special plain

The simulation results showed that fish quality in each supply chain party is different. The implementation of scenario 2 and 5 didn't change fish quality value in fishermen, fish auction, and small tradeswomen. It means fish quality value is fixed as initial condition (without the replacement of transportation mode and packaging). This condition showed that fishermen, fish auction, and small tradeswomen have the characteristic that is quality is not sensitive to the replacement of alternative 2 transportation mode in a part of supply chain party (fishermen, fish auction, and small tradeswomen) and also the replacement of alternative 2 transportation mode in a part of supply chain party (distributor). It means the replacement of alternative 2 transportation mode in each supply chain party didn't cause fish quality better, so the usage of alternative 2 transportation mode is not suggested to implement.

Based on the simulation results, it can be seen that the implementation of scenario 2, 7, and 8 showed negative difference between price and cost. It means cost spent for the implementation of three scenarios was over selling price, so the implementation of those is not suggested. This is applied for distribution to domestic and foreign consumers.

The influence of transportation modes and packaging replacement to quality, cost, and profit that have been described above showed totally condition in supply chain. This has not showed the behaviors happened in each supply chain party due to the replacement of transportation modes and packaging. The replacement of supply chain party transportation mode means that supply chain parties are burdened to replace transportation mode used hoping can reduce transportation time and maintain fish quality. The increasing of cost in fishermen, fish auction, and small tradeswomen due to transportation mode replacement was not significant. The most cost increasing was happened in distributor for scenario 2, 7, and 8 implementation. The cost increasing was caused by the replacement of transportation mode in distributor from pick up van to box van or truck, from regular plain to commercial or specific plain, and the replacement of dry packaging to wet packaging or specific packaging with coverage material. The increasing of profit almost cannot be seen in each supply chain party, even tent to loss if distributor besides replace transportation mode also replaces packaging. This can be seen in scenario 7 and 8 implementation.

Simulation method used above is Powersim Constructor 2.5. To convince the simulation results, other simulation methods are used Powersim Studio and Spread Sheet Excel. The simulation results show both relatively the same conclusion.

5. Closing

The model resulted in this research showed the interaction among quality, cost, and time in perishable product supply chain. More specifically model resulted showed the influence of supply chain technologies utilization that consist of transportation mode and packaging to the performance of perishable product supply chain, that cover quality, cost, and profit in each supply chain party. Supply chain modeling that has been done was a little linked supply chain performance with quality. Meanwhile in this research quality was a prime performance measure in perishable product supply chain, so it was necessary to create model structure that linked quality with supply chain technologies as a trigger to maintain products in order to be in expected quality.

The use of supply chain technologies influenced directly to decay and activity time, it means it can reduce activity time because of the changes of transportation modes or it can extend decay time using packaging or storing technologies. Meanwhile, the use of supply chain technologies also lead to cost increasing, so it can be seen the interaction among quality, cost, and time that were new finding in this research.

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