

Key performance indicators (KPIs) on Vannamei shrimp supply chain performance (a preliminary research)

D Widyaningrum

Department of Industrial Engineering, Muhammadiyah Gresik University, Gresik, Indonesia

dzakiyah@umg.ac.id

Abstract. Higher competition makes the company should be able to fulfill consumer needs quickly, precisely and low cost. It can achieve by designing good supply chain. To know supply chain's success, we must measure its performance with proper KPIs (Key Performance Indicators). But, to get proper KPIs is not easy because of each supply chain has unique characteristics, one of them is vannamei shrimp supply chain. Vannamei shrimp is perishable products, seasonal in production, and highly dependence on nature. This preliminary work will propose a set of proper KPIs by considering its uniqueness to measuring its performance. This work done by mapping vannamei shrimp supply chain network first, then determines the KPIs from six literatures. The stakeholders mostly consist of small and medium enterprises (SMEs). We get 34 KPIs from this study, which are 31 KPIs can be use in general supply chain and three special KPIs which only use for vannamei shrimp supply chain. Furthermore, this research will be done to complete the KPIs by considering stakeholders suggestions, weighting the KPIs by AHP and develop vannamei shrimp supply chain performance measurement system (PMS). The PMS will be used to measure vannamei shrimp supply chain and compared with another PMS.

1. Introduction

Indonesia is the second largest producer of aquaculture fish [1]. According to [2], the aquaculture fish production reaches almost 2.5 million tons since 2015, its increase almost three times over the last ten years. The fish supply will rely on aqua culture because the supply of marine fish is reduced due to over fishing [3] so the aquaculture fish production must be increased in line with the demand in fish consumption.

Aquaculture fish in Indonesia is dominated by shrimp, i.e. prawns and vannamei [3]. Vannamei shrimp more desirable than prawns. It makes the production in Indonesia is growing rapidly. In 2013, vannamei shrimp production is 390.278 ton, and increased to 411.729 ton in 2014 [3].

But in the other side, as the second largest shrimp producer after China [1], in numbers, Indonesia is only 50% of China. If the vannamei shrimp is not properly considered, then Indonesia will be more left behind than China, and the worst thing is Indonesia's position may go down.

The current competition is a global competition. Its competition is not only between company, but also between supply chain networks. Companies are required to meet consumer demand accurately, quickly and cheaply [4]. To get success in globally market we must build the right supply chain network [5, 6]. It should be designing appropriately [7] because it is most crucial planning problems in supply chain management [8]. To assess the success of supply chain can be done by measuring its



performance with the proper instrument [9]. To get the right performance measurement results, we must use proper tool in accordance with the supply chain characteristics [10].

There are several studies to establish instrument on supply chain (examples are [11, 12]). Besides, we can use SCOR (Supply Chain Operation Reference) to establish supply chain KPIs based on its process, i.e. Plan, Source, Make, Deliver and Return. Balanced Scorecard (BSC) also can be used for measuring supply chain performance [13]. Another method is DEMATEL (Decision Making Trial and Evaluation Laboratory) [14] and combine DEMATEL and AHP (Analytical Hierarchy Process) [15]. Dynamics system model used for choosing KPIs which are influence on performance measurement significantly [10].

Those studies did not consider supply chain characteristic, whereas every supply chain has unique characteristic and should be measure using proper indicators based on its characteristics. Example is vannamei shrimp supply chain. There was no supply chain performance measurement tool in accordance with the characteristics of vannamei shrimp.

Vannamei shrimp is perishable product. It makes vannamei shrimp has special handling. Vannamei shrimp also high dependence on climate and season, high dependence on nature, especially for aquaculture vannamei shrimp. This condition makes gap on production quantity. Sometimes high in production, but sometimes low in production. Such unique characteristics should be considered, when designing performance measurement system, one of which is indicator determination.

This study aims to develop vannamei shrimp supply chain performance measurement system (instrument) based on its characteristics. Designing the proper instrument can be done by determining its KPIs first. The biggest aquaculture fish producer in Indonesia is East Java, i.e. Banyuwangi and Gresik [2]. Because Banyuwangi is far, so this study held in Gresik.

By using this KPIs, it is expected that the performance of aquaculture fish supply chain can be measured properly. Then, it can be known KPIs or things that need to be prioritized for improvement. With the improvement of the supply chain according to the priority, it is expected supply chain will be built better and can meet the needs of aquaculture fish consumers. In long-term use, hopefully it can make Indonesia is the largest aquaculture fish producer in the world and big on its export number.

2. Literature review

One of key elements in effective supply chain management is performance measurement [16]. The purpose of performance measurement is to evaluate and to determine the best strategy to improve the supply chain [4]. To make performance measurement system, we must determine its KPIs first.

There are some previous studies, either determining the KPIs alone or creating a model or framework of performance measurement. Current models are Balanced Scorecard (BSC), hybrid (DEMATEL - Decision Making Trial and Evaluation Laboratory and AHP – Analytical Hierarchy Process), dynamics system model, and Supply Chain Operation Reference (SCOR).

BSC measures supply chain performance by involving four perspectives. They are financial perspective, customer perspective, business process perspective and learning and growth perspective. It is balance because this framework involves financial and non-financial aspects [17]. BSC used by approximately 59% researchers [13]. But, BSC still has shortages, they are difficult to use and need many data.

Another researcher using DEMATEL [14] or combinations between DEMATEL and AHP methods [15]. Relationship between KPIs is described in this research using DEMATEL. While AHP is used to integrate the indicator of the entire supply chain. This is mathematical model, so it needs more understanding.

Research for the development of KPIs has also been done with dynamic systems [10]. System dynamic used to describe the relationship between the KPIs. But, if we want to use this model we must know and define the relationship between KPIs well.

SCOR was developed in 1996 by the Supply Chain Council. This framework is hierarchical with KPIs (Key Performance Indicators) on each level [18], SCOR measures performance based on process-oriented of the supply chain, i.e. Plan, Source, Make, Deliver and Return. This framework

involves the process from start to finish, so it does not provide specific results, but by building models based on supply chain processes, it is expected to cover all processes in the supply chain from upstream to downstream without any process being missed. It needs additional tool to measure its KPIs [13]. SCOR combining business process reengineering (BPR), performance measurement, and logistics management to establish the supply chain performance measurement framework [19].

Previously built models, including SCOR, have not considered the characteristics of the vannamei shrimp supply chain. To apply the supply chain performance measurement model should be adjusted to the characteristics of the supply chain. Vannamei shrimp characteristic is different from other supply chain. So far, no one has done research on supply chain performance with special characteristics such as vannamei shrimp [4] have developed a framework for measuring the performance of sea fishery supply chain. Sea fishery and vannamei shrimp have similar characteristics. They are having differences, such as the season in the vannamei shrimp influenced by rainy and dry season, while the sea fishery is influenced by wind, and storm. In addition, vannamei shrimp are cultivated, so can be more controlled whereas sea fishery is not. The location of the two were different, shrimp vannamei in the pond while the sea fish in the ocean. Therefore, this study will be based on sea fishery supply chain performance measurement research [4].

Framework is built based on [9] framework and SCOR framework. The KPIs in [4] study is collected from several literatures and stakeholders. Metric set is done by researchers based on agriculture food supply chain framework [9], and verified by stakeholders (especially Department of Marine and Fisheries). Each indicator tested by the validity and reliability. The framework is already used to measure its supply chain in Sadeng. Gunung Kidul, Yogyakarta.

3. Methodology

This preliminary study focuses on determine KPIs on vannamei shrimp supply chain. This study conducted by several steps. First step is mapping the vannamei shrimp supply chain network to know its stakeholders and business processes. The vannamei shrimp supply chain to be mapped is located in Cerme, Gresik, East Java. Second step is collecting KPIs from literatures. This study use sea fishery supply chain performance measurement system [4] as a primary literature because of its similarity. Another literature also used in this research [5, 6, 14, 16, 19]. KPIs from literatures then sorted. The unsuitable KPIs are eliminated. Then, if there are similar KPIs with different name, they will be merged or combined.

4. Results and discussion

4.1. Vannamei shrimp supply chain network

There are two types of supply chain network (figure 1), namely traditional and intensive. Intensive supply chain networks are medium and large scales networks, while traditional networks are small and medium scale.

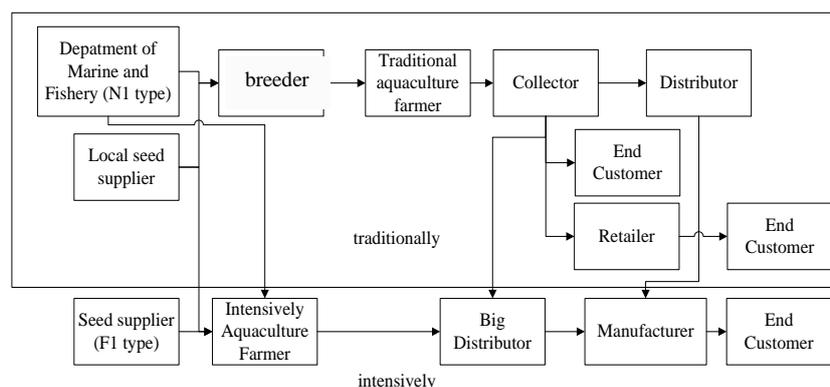


Figure 1. Vannamei shrimp supply chain network.

Intensive vannamei shrimp supply chain produce high quality vannamei shrimp. Its seeds are high quality product from outside Gresik. Intensively aquaculture farmer breeds the seeds in intensive aquaculture with high level of control. They try to control many dangerous factors so that they will get high quality product. It farmers have big distributors as their customers. This big distributor will supply vannamei shrimp to manufacturers. If intensive is cultivated with high control, then traditional is cultivated in open ponds with less control.

The upstream of traditional vannamei shrimp supply chain are local breeders and Fisheries and Marines Department. Then seed nurseries, aquaculture farmers, collectors, distributors, end customers, and manufacturer. The samples are seed nursery, aquaculture farmers, small distributor, big distributor, and end customers.

Fisheries and Marine Department is a provider of N1 (the best vannamei shrimp seed) vannamei shrimp seed. There are also local seed come from Tuban and surroundings in East Java. Both seeds are very small. It will usually die, if it directly cultivated by aquaculture farmers. It needs treatment by breeder. Breeder will take care of the seeds for 7 – 12 days. The treatment is intended to give time to the vannamei shrimp seeds to adapt from sea water to fresh water. During the treatment, the water in the seed pool that was originally the sea water was reduced the salt level slowly to become fresh water. The best time treatment duration 12 days. But the seeds can be removed within 7 days, if there is an urgent request from farmers.

Farmers are vannamei shrimp producers. Farmers buy seeds from breeder. Seeds are not directly spread to pond, but quarantined first for one until two nights. It aims to minimize the risk of vannamei shrimp death. Quarantine is done by placing a net on the edge of the pond and then the seeds are inserted in the net.

The vannamei shrimp treatment does not cost a lot. For example, vannamei shrimp does not need to be fed, the vannamei shrimp will eat plankton in the pond. However, it takes patience in shrimp vannamei farming. For example, once or twice a week, pond should be checked. Pond checking is done by diving to ensure the condition of the shrimp, because the die shrimp will drown. If the diseased and dead shrimp are left unchecked, it will infect the other shrimp and may result in crop failure or non-optimal production. Another way that can be done to minimize the risk is to cultivate other fishes in the same pond, so they can eat the dead shrimp.

Another problem is weather. The best time for vannamei shrimp farming is when the rainy season because vannamei shrimp live in the cold waters. However, if the rainy season, the water in the pond will be high and flood or overflow. This can make crop failure, because the vannamei shrimp will be lost in the flood. Meanwhile, if the dry season arrives, the water will recede, so that the hot sun will reach the bottom of the pond. The water temperature gets too hot for the vannamei shrimp. The heat can be slightly reduced by sowing inorganic urea fertilizers, but if it too much will cause pH levels become acidic and vannamei shrimp may die. Typically, pond farmers will avoid vannamei shrimp farming in the dry season, so the pond will be used for other fish cultivation.

The best time to harvest vannamei shrimp is three months for a high selling price. Vannamei shrimp are harvested by netting, not by emptying the water, so that shrimp that are not ready to be harvested can be released again.

Once harvested, the shrimp will be sold to collectors. Shrimp collected from pond farmers, will be sent to distributor, then distributor will distribute it to the consumer (big class consumers/companies). While household consumers or stalls and traders in the market usually buy shrimp from collector.

Stakeholders in this study are small and medium enterprises from vannamei shrimp supply chain network. Object of this research is supply chain of small and medium enterprises or traditional on vannamei shrimp supply chain in Gresik, East Java, Indonesia (figure 1 grey area).

4.2. Collecting KPIs from literatures

We got 48 KPIs from six literatures. Table 1 shows the list of KPIs. There are unsuitable KPIs to be used in vannamei shrimp supply chain, also similar KPIs in different name. So the KPIs would be sorted. List of sorted KPIs shown in table 2.

Table 1. List of KPIs from literatures.

No	KPIs	Author(s)					
		D. Widyaningrum and N.A. Masrurroh	Lee, Tzong-Ru, Shiu Yi Siang, P. Sivakumar	R. Tarasewicz	F. Uysal	I. B. Bukhori, K. H. Widodo, D. Ismoyowati	M. A. Wibowo, M. N. Sholeha
1	Total Cost	√	√		√	√	√
2	Asset Turn	√					
3	Profit	√					
4	Inventory Levels	√					√
5	Return on Investment (ROI)	√					
6	Cash-to-cash Cycle	√		√			√
7	Delivery Flexibility	√				√	
8	Customer satisfaction	√					√
9	Productivity value-added/ innovations	√			√		
10	Volume flexibility	√					
11	Product Lateness	√					
12	Fill rate	√					
13	Lead time	√				√	√
14	Appearance	√					
15	Shelf life	√					
16	Salubrity	√					
17	Energy use	√			√		
18	The Number of Employee	√			√		
19	Computerized system	√			√		
20	Equipment	√					
21	Ice availability	√					
22	Cold storage	√					
23	Training	√			√		
24	Organization	√					
25	Accuracy season forecast	√					
26	Price stability	√					
27	total sales				√		
28	Turnover rate of Employee				√		
29	forecast accuracy					√	
30	Customer complaints					√	
31	Delivery Cycle Time		√			√	
32	Perfect order fulfilment		√			√	√
33	Product cycle time					√	
34	Production flexibility					√	√
35	Delivery order fulfilment					√	
36	Transportation cost		√			√	
37	Supply chain management cost		√				√
38	Inventory days of supply		√				
39	Quality						√
40	Customer Satisfaction						√
41	Cost						√
42	Environmental cost						√
43	Business waste						√
44	order fulfilment cycle time		√				
45	Source cycle time		√				
46	make cycle time		√				
47	Dock	√					
48	Fish Auction	√					

Table 2. List of sorted KPIs.

No	KPIs	Author(s)					
		D. Widyaningrum and N.A. Masrurroh	Lee, Tzong-Ru, Shiu Yi Siang, P. Sivakumar	R. Tarasewicz	F. Uysal	I. B. Bukhori, K. H. Widodo, D. Ismoyowati	M. A. Wibowo, M. N. Sholeha
1	Asset Turn	√					
2	Profit (Total Sales - Total Cost)	√	√		√	√	√
3	Inventory Levels	√					√
4	Return on Investment (ROI)	√					
5	Cash-to-cash Cycle	√		√			√
6	Delivery Flexibility	√				√	
7	Customer satisfaction/ complaints	√				√	√
8	Productivity value-added/ innovations	√			√		
9	Volume flexibility	√					
10	Product Lateness	√					
11	Fill rate	√					
12	Lead time	√				√	√
13	Energy use	√			√		
14	The Number of Employee	√			√		
15	Equipment	√					
16	Ice availability	√					
17	Cold storage	√					
18	Training	√			√		
19	Organization	√					
20	Season forecast Accuracy	√					
21	Price stability	√					
22	Turnover rate of Employee				√		
23	forecast accuracy					√	
24	Delivery Cycle Time		√			√	
25	Perfect order fulfilment		√			√	√
26	Product cycle time					√	
27	Production flexibility					√	√
28	Delivery order fulfilment					√	
29	Inventory days of supply		√				
30	Quality	√					√
31	Business waste						√
32	order fulfilment cycle time		√				
33	Source cycle time		√				
34	make cycle time		√				

After being shorted, the number of KPIs is only 34 items. Three KPIs are eliminated, they are dock, fish auction, and computerized system. Dock is not suitable for vannamei shrimp supply chain. Dock is used for marine fishery products or offshore ponds, while vannamei shrimp is aquaculture product. Vannamei shrimp does not need fish auction because it sold directly to distributors without auction process. Computerized system is also eliminated because object of this research is small and medium vannamei shrimp enterprises, where they have not yet used a computer system. If this KPI persists, its performance score is bad and will affect the overall performance result.

Sorting process is also done by combines similar KPIs. KPI related to cost (cost, environmental cost, supply chain management cost, and transportation cost), merged to be total cost. Then, total sales and total cost joined with profit. They are used to count profit (no. 2 on table 2). Customer satisfaction and customer complaints are combined (no. 7 on table 2). Users can choose which one is easier to use.

Productivity value-added is similar with innovations, so it can be merged. Appearance, shelf life and salubrity are metric to show quality.

There are three special KPIs from 34 KPIs. They are ice availability, cold storage, and season forecast accuracy. Ice availability and cold storage are used for preserve vannamei shrimp. Vannamei shrimp is perishable product which needs special material handling (kept in frozen state to keep its shelf life from expired quickly). While season forecast accuracy is needed to maintain best time to spread the seeds.

5. Conclusions

This is a preliminary research. From this research, there are 34 KPIs suitable for small and medium enterprise vannamei shrimp supply chain collected from six literatures. Some of 31 items are general KPIs that can be used in general supply chain. They are Asset Turn, Profit (Total Sales - Total Cost), Inventory Levels, Return on Investment (ROI), Cash-to-cash Cycle, Delivery Flexibility, Customer satisfaction/ complaints, Productivity value-added/ innovations, Volume flexibility, Product Lateness, Fill rate, Lead time, Energy use, The Number of Employee, Equipment, Training, Organization, Price stability, Turnover rate of Employee, forecast accuracy, Delivery Cycle Time, Perfect order fulfilment, Product cycle time, Production flexibility, Delivery order fulfilment, Inventory days of supply, Quality, Business waste, order fulfilment cycle time, Source cycle time, make cycle time. Another three KPIs are special used on vannamei shrimp supply chain. They are ice availability, cold storage, and season forecast accuracy. In further research, more in-depth research can be done to determine the KPIs on the vannamei shrimp supply chain and establish a performance measurement system. First step is giving explanation at each KPIs including how to measure it. Then, stakeholders are asked to propose KPIs by interview method and questionnaire. AHP will be used for weighting the KPIs. The results of the measurement of supply chain performance with the lowest score and the highest weight is the priority to be improved. It would be better if those KPIs are tested to measure vannamei shrimp supply chain. Then compared it with other measuring instruments. For long-term research, it can be done for general aquaculture supply chain not just vannamei shrimp.

References

- [1] Shrimpnews 2015 *The World Estimated Farmed Shrimp Production in 2013 and 2014* [Online]. Available: shrimpnews.com/FreeReportsFolder/NewsReportFolder/WorldProductionIn2013And2014.html [Accessed 11 June 2017].
- [2] Badan Pusat Statistik 2016 *Statistik Indonesia 2016* [Online] [Accessed 11 June 2017].
- [3] Ministry of Marine Affairs and Fisheries Republic of Indonesia 2015 Ministry of Marine Affairs and Fisheries Republic of Indonesia [Online]. Available: <http://www.djpb.kkp.go.id>. [Accessed 11 June 2017]
- [4] Widyaningrum D and Masruroh N A 2012 Development of the Sea Fishery Supply Chain Performance Measurement System: A Case Study *International Journal of Supply Chain Management (IJSCM)* vol 1 No 3 pp 20-32
- [5] Tarasewicz R 2016 Integrated approach to supply chain performance measurement – results of the study on Polish market *Transportation Research Procedia* vol 14 pp 1433–42
- [6] Wibowo M A and Sholeh M N 2015 The Analysis of Supply Chain Performance Measurement at Construction Project *Procedia Engineering* vol 125 pp 25–31
- [7] Butzera S, Schötzb S, Petroschkea M and Steinhilper R 2017 Development of a Performance Measurement System for International Reverse Supply Chains *Procedia CIRP* 61 pp 251–6
- [8] Chopra S and Meindl P 2007 *Supply Chain Management Strategy, Planning and Operation, 3rd ed.* (Upper Saddle River: NJ) pp 38-59
- [9] Aramyan L H, Lansink A G J M O, Vorst J G A J and Kooten O 2007 Performance Measurement in Agri-food Supply Chain: A Case Study *Supply Chain Manangement: An International Journal* vol 12 no 4 pp 304-15
- [10] Jamil C M and Mohamed R 2011 Performance Measurement System (PMS) In Small Medium

- Enterprises (SMEs): A Practical Modified Framework *World Journal of Social Sciences* Vol 1 No 3 pp 200-12
- [11] Fauske H, Kollberg M, Dreyer H C and Bolseth S 2006 Criteria for Supply Chain Performance Measurement Systems *14th International Annual EurOMA conference* Ankara, Turkey
- [12] Cai J, Liu X, Xiao Z and Liu J 2009 Improving Supply Chain Performance Management: A Systematic Approach to Analyzing Iterative KPI Accomplishment *Decision Support Systems* Vol 46 No 2 pp 512 –21
- [13] Neely 2005 The Evolution of Performance Measurement Research: Developments in the Last Decade and a Research Agenda for the Next *International Journal of Operations & Production Management* Vol 25 No 12 pp 1264-77
- [14] Uysal F 2012 An integrated model for sustainable performance measurement in supply chain *Procedia - Social and Behavioral Sciences* vol 62 pp 689-94
- [15] Najmi and Makui A 2010 Providing Hierarchical Approach for Measuring Supply Chain Performance Using AHP and DEMATEL Methodologies *International Journal of Industrial Engineering Computations* Vol 1 No 2 pp 199-212
- [16] Lee, Tzong-Ru, Shiu Yi-Siang and Sivakumar P 2012 The Application SCOR in Manufacturing: Two Cases in Taiwan *Procedia Engineering* vol 38 pp 2548-63
- [17] Kurien G P and Qureshi M N 2011 Study of Performance Measurement Practices in Supply Chain Management *International Journal of Business, Management and Social Sciences* Vol 2 No 4 pp 19-34
- [18] Delipinar G E and Kocaoglu B 2016 Using SCOR model to gain competitive advantage: A Literature Review *Procedia - Social and Behavioral Sciences* vol 229 pp 398-406
- [19] Bukhori B, Widodo K H and Ismoyowati D Ev2aluation of Poultry Supply Chain Performance in XYZ Slaughtering House Yogyakarta using SCOR and AHP Method *Agriculture and Agricultural Science Procedia* vol 3 pp 221-5