MODELING SHIPBUILDING INDUSTRIAL CLUSTER OF EAST JAVA'S COMPETITIVE ADVANTAGE USING SYSTEM DYNAMIC APPROACH

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Abstract: Huge potential of Indonesian maritime sectors should be a big momentum to leverage maritime base industry such as shipbuilding industry. Nowadays, shipbuilding industry in Indonesia, especially shipbuilding industrial cluster in East Java is not performing good, both in productivity even financial. Government has established development plan to wake up industry through several regulation and had stated that Indonesia to be world maritime center. This paper aims to modeling East Java's Shipbuilding cluster competitive advantage using system dynamics approach. The combination of data used are from both primary and secondary.

Keywords: *Industrial Cluster, Shipbuilding Cluster, Competitive Advantage, Causal loop diagram, System Dynamics.*

1. INTRODUCTION

Indonesia is one of the largest maritime and archipelago countries in the world with two third coverage area of water. The length of coastline Indonesia reached 80,000 km, with ± 17,500 islands. The huge number of island and distribution of the territory of Indonesia has been a major issue of development of the national. There are huge gap between regions in development and inter-island connectivity. One of the main of transportation modes can be used to create connectivity between islands is sea transportation (ship). One of strategies of acceleration and expansion of national economic development (MP3EI) is to strengthen inter-island connectivity, especially for outer islands. This connectivity only would be achieved if the sea transportation had significant role to connect the nation. So that, one of regional development framework in developing the inter-island connectivity is accelerating development of maritime-based economy by utilizing marine resources and services, this context refers to maritime and shipping industries.

One effort to improve maritime industry is to strengthen the shipping industry sectors. The development of the national shipbuilding industry became one of the key solutions Indonesia utilization of marine resources. Ships are crucial as the transport infrastructure and connectivity between islands. Ship as a means of transportation, mining, fishing, tourism, as well as the main tool of the defense system, is a commodity that is essential and vital that the ship can also be categorized as part of the structure of national development, and the shipping industry or shipyard is one of the strategic industries and an important future industry to be developed.

The Government's efforts to strengthen the maritime and shipping industry are indicated by ship procurement plans as listed in Table 1.1. It could be conclude that the amount of procurement plan is increasing every year with an investment of IDR 53.15 trillion. It can be used as the driving momentum to leverage the shipping industry in Indonesia, especially East Java's shipbuilding industrial cluster.

Table I The Government Plan about the Total Number of Ship Required in Indonesia

Year	Container				Cargo Ship Equivalent for 208 TEUs	
	15.000 DWT		40.000 DWT			
	1.000 TEUs		3.000 TEUs			
	Ship Amount	Billion (RP)	Ship Amount	Billion (RP)	Ship Amount	Billion (RP)
2015	10	2,500	0	0	8	1,280
2016	10	2,500	0	0	7	1,120
2017	9	2,250	12	5,400	4	640
2018	9	2,500	12	5,400	4	640
2019	8	2,000	13	5,850	3	480
TOTAL	46	11,750	37	16,650	26	4,160

*Development Investment Value for 24 Harbor : **RP 39,5 T**

*Ship Procurement Investment Value : **RP 53,15 T**

The huge domestic market potential of ship need the support from all elements of the State, especially the government to make regulation about the national shipping industry, to be able to compete and supply its demand independently.

The seriousness of the Indonesian Government to develop the shipbuilding industry is also showed by determining development targets in country's shipbuilding industry. The medium and long term targets are described in RPJMN 2014-2019. Some of the priority programs of development of the national shipbuilding industry such as:

1) Increased human resource capacity of national shipping industry
2) Development of ship components industry
3) Facilitation of the shipbuilding industry restructuring program
4) Development of Lamongan district as a special area Industrial Shipping

The Government has also established National Ship Design and Engineering Center (NASDEC) which serves as a testing institute for ship component in Surabaya and established shipbuilding industrial cluster in Surabaya, East Java in 2006 due to huge potential for shipping industry in East Java. In terms of facilities, there is one of the busiest harbor in Indonesia, Tanjung Perak. And in terms of human resources, East Java's shipbuilding industrial cluster. is supported by NASDEC in conducting joint research. East Java's shipbuilding industrial cluster formation is expected to be the role model for national shipbuilding industrial cluster. However, although it has been established, East Java's shipbuilding industrial cluster industrial elements have poor performances. This is showed by the financial performance of some members of them, and they could not fulfill the vessel demand in Indonesia.

Improvement for East Java's shipbuilding industrial cluster development is indispensable for the competitiveness of the shipbuilding industry in East Java, So, it can support the government objectives in the development of maritime sector. Synergy is important, because shipbuilding require big and varied resources. As an example, large resources-required production stage of vessels is ship design process. With the synergy between elements, i.e. between the core industry and Support Institution, the production stages would be able to run efficiently and accurately, because the ship design process has been carried out by NASDEC.

This research focuses on modeling competitiveness of East Java's shipbuilding industrial cluster based on 4 main parameters. Hopefully, these models would be formulated could increase competitiveness of companies in East Java's shipbuilding industrial cluster and ship demand can be fulfilled by national companies.

2. LITERATURE STUDY

2.1 Shipbuilding Industry Structure

An analysis of the shipbuilding industry in Indonesia was done to understand its nature. The following characteristics of the industry were identified:

1. Shipbuilding industry requires huge investments in capital, equipment, labor and technology.
2. There are some major barriers in the shipbuilding industry. Huge capital investments, high taxes of import ship component, requirement of skilled-labor, and flexibility in operations.
3. The bargaining power of buyers is quite high. This is happening because there are only few buyers. These buyers base their decisions on price, delivery time, quality, and government policy. Buyers are knowledgeable and sensitive to price and delivery time.
4. The main suppliers of this industry are steel manufacturers, main/supporting machine and part manufacturers. Most of The steel manufacturing companies are from Indonesia, but most of machine and other components are obtained from import. Therefore, price of the materials depend on the exchange rate and import taxes.

2.2 Shipbuilding Competitiveness

Concept of Competitiveness is expressed by some people in many different ways. Specific competitiveness applied to shipbuilding industry has been defined as The ability to win and execute shipbuilding orders in open competition and stay in business[2]. The former definition illustrates three objectives which represents shipbuilding competitiveness. The first objective is the ability to attract shipbuilding orders. In ordering standardized ships, the buyer is primarily concerned with price[2].

Competitiveness is often evaluated by comparing newbuilding contract price denoted in common currency[2]. The ability to execute shipbuilding orders refers to the ability to design and produce ships based on current physical facilities and manpower capacity. Ship quality and delivery time are the most frequently used indicators, but data on ship quality are difficult to obtain, however, differences in ship quality and delivery time are likely to be converted into monetary terms and reflected in contract prices[2]. A ship owner may be willing to pay a premium for fast delivery, and a shipyard may offer a lower contract price if its ships are relatively lower in quality than its competitors. The shifting of world shipbuilding centers implies that shipbuilding costs are crucial factor in remaining competitive. Shipyard with cost advantage will have greater profit margins when bargaining with buyers and be more likely to maintain profitability in the long run[2].

Cao Jianhai (2000) thinks that competitiveness is the ability of enterprises to occupying market and winning long term profits by using special resource of enterprises include: human resources, production capability, R&D capability, marketing skills and network and core technology.

The enterprises competitiveness shall be explained as : the ability of enterprises using effective means to produce at low cost and sell well the products which can meet consumer demands, thus the market share of the enterprises enlarged continuously and greatest profit won[9].

Krajewski & Ritzman (2002) defined that competitive advantage can measured by production cost, reliability as a supplier, which represented by delivery time, flexibility which represented by innovative ability, and product or service quality.

From a few concepts of competitive advantage explained above, this paper adopt a competitiveness theory. Therefore, shipbuilding industrial cluster competitiveness model in this paper have 4 key variables : production cost, ship delivery time, ship quality and innovative ability. And the main goal is sustainable marketshare.

2.3 Industrial Cluster Concept

The basic theoretical of cluster concept was proposed by Porter (1990) in "The Competitive Advantage of Nations", through a model called The Diamond of Advantages. This model depicts that competitiveness is determined by the area of cooperation between business units and industrial located in a region. Industrial cluster is a geographic cooperative group that include suppliers, peripheral industries, consumers, governments and supporting institutions such as universities.

Industrial cluster is a production network of companies that are interdependent to each other (including specialized suppliers), producer of knowledge (universities, researchers institutions), intermediaries (broker, consultants), and customers that related to one another in an increase value-added chain[7].

Hill and Brennan (2000) define an cluster as a system that causes component firms and institutes to generate higher unit earnings and more efficient operations owing to innovations stimulated by intense competition and cooperation within clusters.

Cluster are a form of virtual enterprise, and furthermore, some components of clusters can serve several industries and be members of several clusters; therefore the field of industrial cluster is generally larger than that of industry, and it can seize the connect point among factories and industries, complement, spillover effect of technology, technological competence, information, marketing and demands of customer. The conditions of industrial cluster formation include human resource quality, technological knowledge, capital, infrastructure and foundation of technique[12].

2.4 System Dynamics Methodology

System dynamics is a methodology, a concept and a tool. System dynamics was developed by Jay W. Forrester et al. system dynamic is also referred as industrial dynamics and is increasingly applied widely in the social sciences.

System dynamics approach was made feasible by advance information feedback control system design and analysis, modeling of decision making processes, simulation techniques and techniques for electronic data processing[7].

System dynamics is a methodology to figure out a complex problem. This methodology stressed on policies and how the policies determine behavioral problems that can be modeled using system dynamics. When mathematical study cannot be applied to solve a complex economical problems, system dynamics can be a solution to these problems[4].

System dynamics approach begin with understanding the system of forces that created and continues to sustain a problem. A formal model then developed as soon as relevant data are gathered from a variety of sources. This model initially uses in the format of a set logical diagrams showing cause-and-effect relationships. A visual model is then translated in to a mathematical model. This model is criticized and revised, in an iterative process that continues as long as it is useful.

3. SYSTEM DESIGN DEVELOPMENT

3.1 System Description

The depiction of the system aims to understand the mechanisms involved in the system. It is intended to recognize the relationship between the need statement and the problem statement in order to solve existing problems. In this study, the depiction of the system used is Input-output Diagram and Causal Loop Diagram. The system being modeled is shipbuilding industrial cluster which located in East Java, Indonesia.

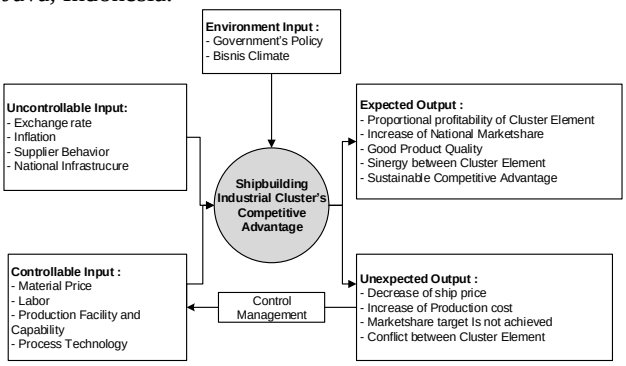

Figure I. Input-Output Diagram

The input elements are obtained from analysis about shipbuilding industry in Indonesia above.

Output

The output of the system consists of desirable and undesirable output. Undesirable output is unavoidable and is usually a negative impact on system performance. The expected output are proportional profitability of cluster element, increase of national marketshare, good product quality, synergy between cluster element, and sustainable competitive advantage. The unexpected output are decrease of ship price, increase of production cost, market share target is not achieved, and conflict between cluster element.

Input

Input from the system also categorized into two, namely controllable and uncontrollable inputs. In addition, there are also environmental inputs. In the

diagram above, the environmental inputs are government policies and business climate. Government policies can be import taxes policy, and others. The controllable inputs are price of raw materials, labor (categorized as wage and labor skills), facilities and production technology, and production capacity. The uncontrollable inputs are exchange rate, inflation, supplier behavior, and national infrastructure.

Control

Undesirable output have to serve as a feedback through control management to turn inputs into expected outputs and anticipate undesirable output.

3.2 Conceptual Framework

This paper adopted a qualitative method because this approach is best suited to understanding a complex socio-economic phenomena. Figure 2 shows a conceptual framework for modeling competitiveness of East Java's shipbuilding industrial cluster. The model divided into four flows: cost of goods sold, ship quality, innovative ability and ship delivery.

A causal loop diagram for each flows then established. Analysis of the causal loop diagrams helped to identify the influential factors of East Java's shipbuilding industrial cluster.

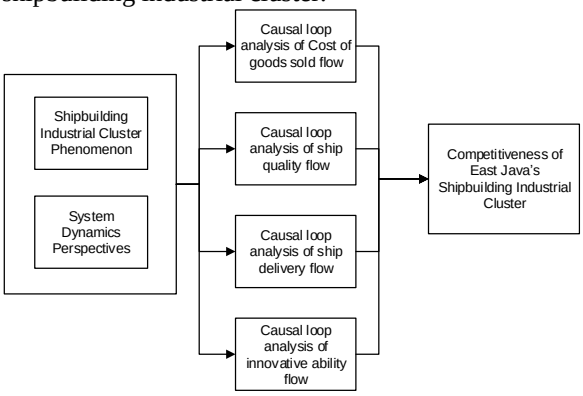

Figure 2. Conceptual Framework

4. RESULTS AND DISCUSSION

4.1 Causal Loop Diagram

Causal loop diagram is used to show the main variables in the system. Causal loop diagram also can show cause and effect relationship between variables. The relationship will depicts with arrow symbol. Arrow with positive symbol indicate a proportional relationship, and adding the value of these variables will cause value added to the variable influenced. Otherwise, arrow with negative symbol indicates an inverse relationship, and adding the value to the variable will cause a reduction to the value of the variables influenced. Causal loop diagram of Shipbuilding Industrial Cluster ini East Java, Indonesia showed in Figure 3 below.

The main goal of the model is sustainable marketshare, which has 4 key variables: cost of goods sold, ship quality, innovative ability and ship delivery time. Cost of goods sold consists of labor cost, material cost, manufacturing overhead cost and other costs (such as certification cost). One of Retained earning component is net profit, which obtained from revenue minus by cost of goods sold. The more efficient operation, then cost of goods sold will follow to decrease.

Retained earning play a big role for investment fund of the cluster. The investment divided by: facility investment and research and development investment. Facility investment can influence production capacity. If the production capacity is increase, delay time for production and delivery can be decreased. Also, the shipbuilding cluster can handle more orders and increasing sales.

Research and development investment affect the innovative ability. Innovative ability is related to knowledge sources. The abundant knowledge sources can make an advance technological level as a result. The advance technological level can reduce cost and benefits for the competitiveness.

Ship quality is influenced by engineering design support. R&D institutions such as universities play significant roles in providing ship design which can affecting on reducing ship design time and manufacturing overhead cost for ship design.

CONCLUSIONS

This study presents a number of conclusions, based on the causal loop diagram of East Java's shipbuilding industrial cluster competitiveness:

1. Shipbuilding industrial cluster's competitiveness is measured by 4 main parameters; ship delivery time, ship quality, innovative ability and production cost.
2. Ship delivery time associate with production capacity, facility investment, ship design time, material delivery time and production rate. Production capacity is influenced by facility utilization and increase asset.
3. Retained earning for investment fund is associate with profit. Profit is obtained from deviation between revenue and production cost. Profit can be increased by either reducing costs or increasing revenue. Cost of goods sold consists of labor cost, material cost, manufacturing overhead cost and other costs. To increase revenue, the industry can either increase sales amount or raise prices. Increasing sales amount can influence the total needs of production facility and labor, therefore it can increase overhead cost and labor cost.
4. Research and development investment affect the innovative ability. Innovative ability is related to knowledge sources. The abundant knowledge sources can make an advance technological level

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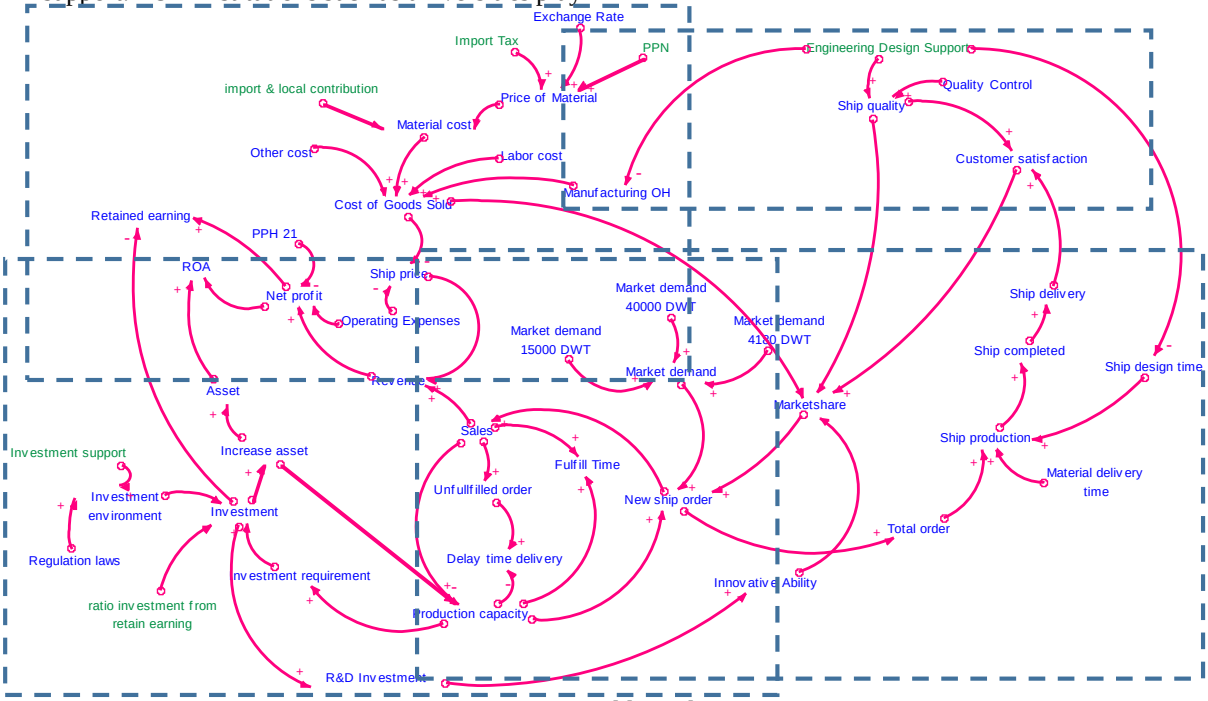

Figure 3. Causal loop diagram

REFERENCES

[1] Krajewski, L. J., & Ritzman, L. P. (2002). *Operation Management Strategy Analysis Sixth Edition.* New Jersey: Prentice Hall.

[2] Jiang et al. (2013). The International Competitiveness of China's Shipbuilding Industry. *International Journal of Transportation Research, 60*, 39-48.

[3] Porter, Michael (1990). Toward a new conception of the environment-competitiveness relationship. *The journal of economic perspectives*, 97-118.

[4] Coyle, R. (1979). *System Dynamics Modelling, A Practical Approach.* United Kingdom: Chapman & Hall.

[5] Lin, C.-H., Tung, C.-M., & Huang, C.-T. (2006). Elucidating The Industrial Cluster Effect from a System Dynamic Perspective. *Journal of Technovation*, 473-482.

[6] Sterman, J. (2000). *Business Dynamics : System Thinking and Modelling for a Complex World.* Boston: Mc.Graw-Hill.

[7] Forrester, J.W. (1961). *Industrial Dynamics*, Mass : Productivity Press, Cambridge.

[8] Jianhai, Chao. (2000). *Overcompetition.* Beijing : China Renmin University Press.

[9] Qingfang, Jiang. (2001). *Mathematic Theory Analysis of Enterprises Competitiveness.* Journal of Management of Science Research Vol 22(4) : 56-64.

[10] Roeland, T. J., & Hertog, P. (1999). Cluster Analysis and cluster based-policy making : The state of the art. *Boosting Innovative : The cluster approach*, 413-427.

[11] Hill, E.W., & Brennan, J.F. (2000). A methodology for identifying the drivers of industrial cluster : the foundation of regional competitive advantage. *Economic Development Quarterly 14*, 65-96.

[12] Carrie, A. S. (2000). From integrated enterprises to regional clusters: the changing basis of competition. *Computers in industry 42*, 289-298.