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Indonesian Port Cluster Simulation Game: Understanding Complex System Through Simulation Game

Metode Simulasi Permainan Klasterisasi Pelabuhan di Indonesia: Gambaran Sistem Kompleks Melalui Permainan Simulasi

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Abstract

Port Cluster is a collection of interdependent and involved companies in related activities in the same port area. Port clusters can be categorized as infrastructure. One of the characteristics of infrastructure is the number of parties involved in a problem, referred to as a Multi-Actor System. In a multi-actor system, policymaking becomes more complicated because it cannot be based on only one party's interests. Policymaking in this domain requires contemporary approaches where one of them is Simulation Gaming. This paper shows how Simulation Gaming can serve as an approach to comprehend the Indonesian Port Cluster, a multi-actor system.

Keywords: Simulation gaming, Port cluster, Maritime, Policy, Infrastructure, Multi-Actor System

Abstrak

Klaster pelabuhan adalah kumpulan perusahaan yang saling bergantung dan terlibat dalam aktivitas terkait di area pelabuhan yang sama. Klaster pelabuhan dapat dikategorikan sebagai infrastruktur. Salah satu ciri infrastruktur adalah banyaknya pihak yang terlibat dalam suatu masalah yang disebut Sistem Multi-Aktor. Dalam sistem multi-aktor, pembuatan kebijakan menjadi lebih rumit karena tidak dapat didasarkan pada kepentingan satu pihak saja. Pembuatan kebijakan pada domain ini membutuhkan pendekatan kekinian yang salah satunya adalah Simulasi Permainan. Makalah ini menunjukkan bagaimana Permainan Simulasi dapat berfungsi sebagai pendekatan untuk memahami Klaster Pelabuhan Indonesia, sebuah sistem multi-aktor.

Kata Kunci: permainan simulasi, klaster pelabuhan, maritim, kebijakan, infrastruktur, sistem multi-aktor

1. Introduction

The geographical position of Indonesia brings this country into the world shipping lane (Rodrigue, Comtois, & Slack, 2013). Automatically, Indonesia has become a market for the maritime industry in the world. Overseas companies have long made Indonesia as their market base. Indonesia can only benefit if it becomes host in its own country, and after that, markets its (maritime) products and services abroad. The conditions above lead us to a need for planning the maritime industry in Indonesia.

Industrial planning is a topic that has been discussed since the beginning of the 20th century. That is when the term Industrial Cluster emerged. Alfred Marshall in 1920 saw a tendency (in England) that factories tended to cluster in a particular area (cluster). In 1929, Hotelling saw a connection between technology (production) and the efficiency of transport costs (in the cluster) with increased revenues. The study of industrial clusters was split into two parts in the 1990s, namely when Krugman (1991)did his thesis on the Geography of the New Economy and when Porter (1998) issued a thesis on the competitive advantage of industries (Karlsson, 2008).

Cluster is a collection of companies in an area and interdependencies among others in producing similar products or services. In subsequent developments, the maritime industry also realized that there are benefits to be gained from agglomeration or at least adjacent locations within an area. This advantage is obtained through knowledge

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dissemination (knowledge spillover), the availability of sufficient experts/labor, and a supportive market (Wijnolst, 2006).

Maritime clusters have long been recognized in developed countries and have begun to be applied in developing countries (Benito, Berger, De La Forest, & Shum, 2003; Doloreux, 2017). The maritime cluster talks about significant industries in the maritime sector, such as shipyards, ship machining, and navigation tools. Studies in the maritime cluster are aggregate and generally qualitative (Pinto, Rita, & Combe, 2015; Viederyte, 2013).

On the other side of maritime industry studies, researchers in the field of Industrial Engineering and Regional Economics such as Peter de Langen, Theo Notteboom, and especially Elvira Haezendonck, introduced the term Port Cluster. Port Cluster is defined as a collection of companies that are interdependent and involved in related activities / in the same port area. It has a competitive advantage because it uses a relatively similar strategy and, as its output, competes with the environment outside the cluster (Haezendonck, 2001). The port-related activities are referred to as all activities related to ship and cargo arrival activities at the port, namely: cargo handling operations, logistics activities, manufacturing activities, and trading activities (de Langen, 2003).

When viewed from the type of industry, a port cluster can be categorized as infrastructure (Mayer & Veeneman, 2003). One of the characteristics of infrastructure is the number of parties involved in a problem, referred to as a Multi-Actor System. That character carries the following consequences: decision making becomes more complicated because it cannot be based on the interests of only one party (De Bruijn, Heuvelhof, & Veld, 2002; de Bruijn & ten Heuvelhof, 2008). Policymaking in this realm requires contemporary approaches where one of them is Simulation Gaming (Bekebrede, 2010; van Daalen, Schaffernicht, & Mayer, 2014).

The authors' approach in analyzing a multi-actor system is by dividing it into several levels of the system. In this context, the Indonesian Port Cluster is analyzed from several levels (sub-systems): the micro (A.O. Moeis & Goputra, 2015; Moeis et al., 2018), meso (Moeis, Zagloel, Hidayatno, Komarudin, & Guo, 2017), and macro levels (Moeis et al., 2020). Simulation Gaming is used as an integrative method to analyze these sub-systems comprehensively (as a *gestalt*).

2. Methodology

Port Clusters

Several studies have discussed clusters as a central topic. One of the most substantial works and arguments regarding port clusters was from (Haezendonck, 2001). The port clusters concept has also been applied in practice 1) The Port of Rotterdam and Port of Antwerp were discussed by de Langen (2003), and 2) De Langen & Haezendonck (2012) analyzed Copenhagen-Malmö as one port cluster.

Moreover, de Langen (2004) argued that a seaport is a cluster. The cluster comprises a vast number of companies related to the arrival of ships and goods at the port. The majority of added value and employment are not generated in primary port activities (i.e., cargo handling) but in related activities such as logistics, manufacturing, and trading that are concentrated in ports. Furthermore, Jacobs, Ducruet, & De Langen (2010) asserted that a port cluster is an agglomeration in terms of the public sector, private sector, and business unit which when connected with port, business agglomeration that occurs is formed from every company related to loading and unloading activities at the port such as cargo handling, manufacturing, logistics, transportation, and the port (itself) as an intermediary for trade activities. This business agglomeration then also adds value to the area around the port, including industrial estates located in the same area as the port and directly connected to the port. The agglomeration of this business unit then also adds value to the area around the port (i.e., hinterland), including the industrial area located in the same port area and connected directly to the port (Figure 1).

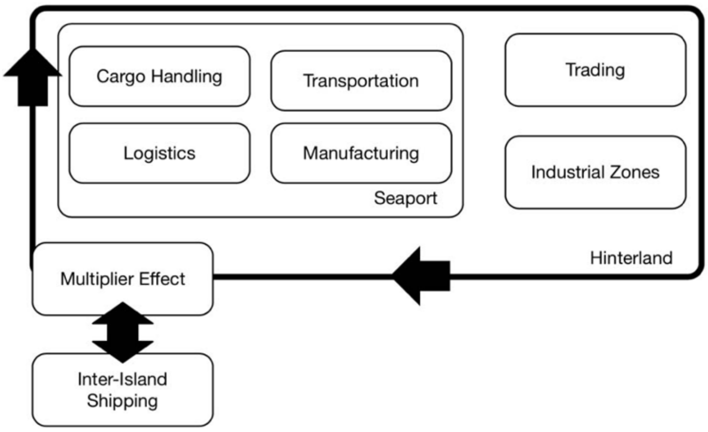

Figure 1. Ports Cluster Concept (adapted from de Langen & Haezendonck, 2012)

Complexity and Dynamics of Infrastructure

Miller & Lessard (2000) identified several signs of large engineering projects (mostly infrastructure projects). One of these signs is negotiated innovation, which means most of the projects required negotiations to achieve client needs and involve networks of integrated actors. Moreover, Mayer & Veeneman (2003) described that relationships between actors in infrastructure value chains had changed significantly. The liberalization and privatization of infrastructure firms extend the complexity of the infrastructure industry and increase social pressures, globalization, and sustainability topic.

Infrastructure provides a means for developing and maintaining prosperity for a nation. Countries must mitigate those arising complexities. Engineers and industrialists must gain knowledge and skills on how to manage the uncertainties and ambiguities in infrastructure projects. Mayer & Veeneman (2003) demonstrated a significant interest in understanding the institutional and organizational complexities and dynamics of infrastructure. They also stated that the complexity of infrastructure seems to be regulatory and organizational rather than technological. Whether we agree with that statement, it is evident that the variables, as mentioned earlier, contributed to the dynamics of infrastructures. Innovative things can always be created, but human interaction (and willingness) is required to adopt them.

Simulation Gaming in Infrastructure

Simulation Games have often been used as learning media in infrastructure and policy. Examples of Simulation Games in infrastructure development are *Simport V2* (Bekebrede & Mayer, 2006) and Maritime Spatial Planning (MSP) Challenge (Mayer, Zhou, Keijser, & Abspoel, 2014). Those games require thorough planning, and there are many uncertainties and risks, such as delays, demand uncertainty, and coordination issues.

One method to understand the complexity of an infrastructure system is to become a system of thinkers. Sweeney and Meadows (2001) mention that system thinkers should consider the whole picture and change their perspective repeatedly. Therefore, the system must be modeled (mentally or otherwise) dynamically or comprehensively, by focusing on feedback, nonlinear development, and system behavior in the short- and long-term. Because technical factors and sociopolitical actors cause complexity, those factors and actors must be included in the model or simulation. This inclusion of elements and actors caused Bekebrede et al. (2006) to argue that simulation games are the most appropriate method for understanding complex systems. Simulation games may be the only decision support method that can incorporate players and social interactions, social and physical rules, mental and computer models, and individual and collective goals.

Thus, the games can mimic the system in the real world in a highly controlled environment. Games help ascertain a problem and integrate different perspectives and disciplines. By exchanging roles, players can adapt and learn to understand different views, try systems from different angles, and learn from these differences (Geurts, Duke, & Vermeulen, 2007)

Duke (1974) divided the simulation game design into three phases: design, construction, and use (construction refers to the development of the game). In the design phase, the most critical steps are generating the conceptual map, defining the game objective, and defining the game message. Each stage is elaborated in the following description.

Generating the Conceptual Map

The conceptual map is the most critical part of the simulation game's design and addresses the system a simulation game wants to represent. Lots of time and resources should be put into this phase because it determines the success of a simulation game. Generating a conceptual map means the game designers must analyze the real system a simulation game wants to mimic.

Duke (1974) did not specify a specific method to model the system. Today, we have many tools to draw models of systems. This phase can be performed by conducting a Systems Analysis (Thissen & Walker, 2013). The main output of this process is a System Diagram (figure 2), and other outputs are Causal and Actors Analysis. Each actor's roles should be defined as well as their degree of power (regarding how they can use the ability to change or influence the system). A System Diagram helps the designer draw the elements in the system and their structure.

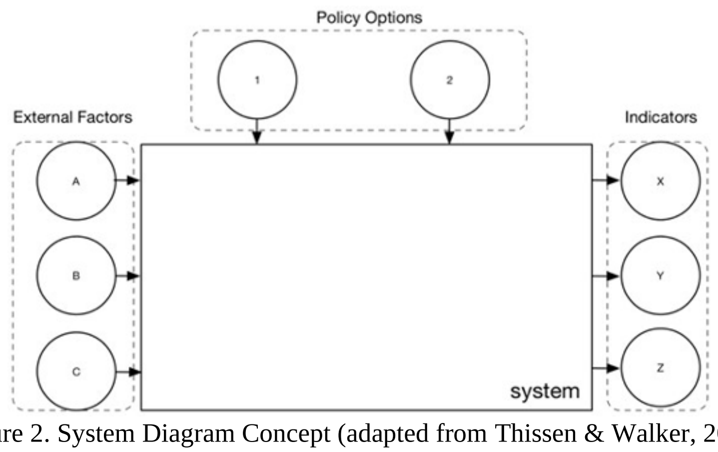

Figure 2. System Diagram Concept (adapted from Thissen & Walker, 2013)

Defining Game Objective

In this phase, the game designers should clearly define the goals of the Simulation Game. The objectives should convey the Simulation Games' purposes. Duke (1974) indicated that simulation games have four intentions: dialog, project, extraction, and motivation. Simulation Games are used to establish a "dialog" to increase communication within a group about a complex topic. Simulation Games also "project" information in an educational or training context. Thirdly, Simulation Games can be useful to "extract" opinions from a group regarding the addressed system. Lastly, Simulation Games can serve as a "motivational" tool.

Defining the Game Message

Setting the game message means defining a multidimensional, simultaneous, complex, and interactive situation (Duke, 1974). The game's message is one of the challenges game designers must face in designing a simulation game. Often, because of the ambiguous nature of the game, game designers fail to define a clear game message.

Other Frameworks for Developing Simulation Games

Also, in the same school, Geurts, Duke, & Vermeulen (2007) offer another framework for developing Simulation Games. The framework has five main stages: goal setting, problem clarification (which will be discussed in the game, one of the outputs: System Diagram), game design, game development/construction, and usage (trials, subsequent iterations).

A different framework is offered by Harteveld (2011) with the Triadic Game Design approach, which tries to find common ground between Reality (the original system/reality), Meaning (the message to be conveyed in the game), and Play (the element of discussion, feedback, and entertainment in games). Mayer et al., (2014) then complements the above approach with more appropriate game evaluation methods.

3. Results and Discussions

Game Design on Systems and Actors Analysis

Thissen & Walker (2013) explained the importance of analyzing complex problems from a system scale and examining the actors' interdependency. The port system comprises two main actors when conducting economic activities: Port Authority has the authority over the ports and the companies related to events in the harbor (de Langen 2004). From the perspective of a cluster, Notteboom (2005) added that the government as a stakeholder plays an essential role in forming and controlling a cluster. Therefore, three main actors are in a port cluster: governments, private companies, and port managers. In Indonesia's case, the government is divided into two parts: the central government and the regional government.

This game attempts to map the integration between the actors involved in the cluster by first mapping the system and the decision variables of each actor involved in the systems. Next, the assertion regarding the phenomenon of decentralization and how it can affect the coordination between actors and the decision-making that might occur is also described. Thus, the players, especially the government as policymakers, know the form of coordination and policy-making priorities concerning infrastructure development (when and to what level it should be developed) and the multiplier effect produced on the economy (in this case, gross domestic product (GDP)). Those causalities can be seen in Figure 3.

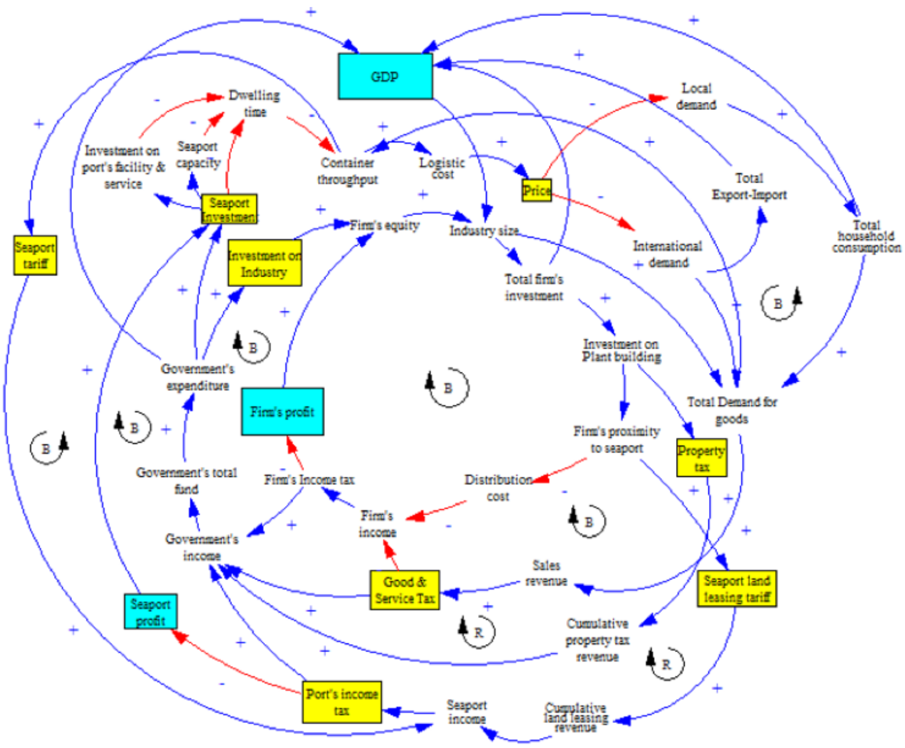

Figure 3. Causal Analysis of Indonesian Port Cluster

Relationship with the Real World

Kwakkel, Walker, & Marchau (2010) suggested further research to examine the causality so that the game can represent conditions in the real world. The specifications of the data validated for causality based on the input required by players in the game are as follows 1) Consumption data or demand in each region was used as a case study in the game; 2) Data on each port's busyness was considered from historical data cargo throughput and vessel call number; 3) Port specifications and seaport tariff bases; 4) Comparison of the investment costs for infrastructure development and production plants; 5) Comparison of the port capacity and industrial area; and 6) Comparison of the potential in each region used as a case study.

The ports (and its adjacent industrial areas) used as a case study are the ports that have a significant contribution to container movement in Indonesia and are included in the Indonesian National Master Plan: Tanjung Priok, Tanjung Perak, Belawan, Kuala Tanjung, Pontianak, Kariangau, Makassar, and Bitung (Figure 3). The liner networks that linked those ports are based on a previous study in Indonesian liner shipping network design (Moeis et al., 2017).

The number of players is determined by the name of activities or work that each role must perform. There are four leading roles: central government, local government, port management, and industry.

Game Development

Game Development is an iterative and creative stage where aesthetics is a factor. In this research, game development is divided into two main stages: the development stage of the main game and the development stage of the game supporters.

The main game development stage comprises two substages. The first is the substage of initial infrastructure development, which focuses on designing a simple flow process of goods from producers to buyers. The second is the substage for incorporating elements of policy, natural resource potential, and risk into the game's central infrastructure. The Game Board design can be seen in Figure 4. Additionally, the development stage of the game supporters was the process of developing the game during the initial briefing of the game and the final debriefing of the game.

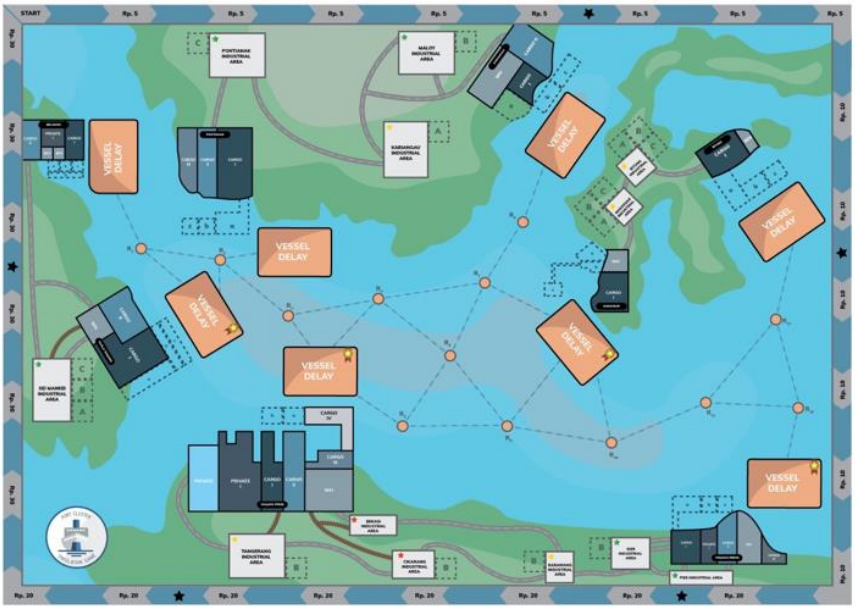

Figure 4. Game Board Design

The briefing session (Figure 5) briefly describes the port cluster theory, its development, and the types of policies that can be taken in the port cluster. Next, the briefing session explains the game guide through game manuals and case studies, summarized in the form of presentations made by the facilitator before the game starts. Additionally, case studies are made in hardcopy so that participants can read and learn during the game. In the debriefing phase, participants are expected to be able to evaluate and reflect on the results of the game they just played. At this stage, the facilitator first recapitulates the game's final results from the Excel spreadsheet and then attempts to discuss the learning points obtained from the game. Furthermore, in this stage, the facilitator conducts a discussion session to evaluate the strategies taken by the players during the game with the results obtained.

Figure 5. Briefing Session during a Game Session

The game comprises two phases; the first phase is to observe players' behavior when each receives an individual goal in the form of profit. In this first phase, players learn strategies to increase the income of each role. The second phase is when the player acts as a team with the same objective: the highest GDP. At this stage, players learn the multiplier effect and the form of coordination required to achieve optimal GDP.

Discussions

Adopting the framework proposed by Mayer et al. (2014), players' behaviors and strategies are categorized into the Integration of Game Output and Integration of the Game Process. Furthermore, the description of these categories is as follows 1) Integration of game output a) Regional-based vs. National-based: game strategy refers to the output for a particular region or nationally (GDP); b) Economy-based vs. Environment-based: game strategy refers to economic parameters with or without considering aspects of natural resources; c) Short-term vs. Long-term: the game strategy recognizes or does not find the benefits generated from current investments; and d) Interest-based vs. Evidence-based: game strategy is created only from experience, knowledge, and interest in certain aspects or from facts and information provided. While 2) Integration of the game process are a) Centralized vs. Networked: game strategy provides a centralized or diffused process; b) Out of control vs. Well-managed: game strategies and negotiation processes that occur in the game are out of control or can be appropriately managed; and c) Individual vs. Cooperative: game strategy only refers to individual interests with or without cooperation.

Referring to Kriz and Hense (as cited in Kuijpers, 2009), the approach taken in the game evaluation is divided into two parts: the first part is to evaluate the simulation game as a product, and the second part is the effect given to the change process. The first point is the verification process carried out by the game designer to determine whether the game has been designed according to the specifications of its needs. Moreover, the second point is a validation performed through the game participants' assessment to determine whether the game's objectives have been achieved.

The game participants received a questionnaire comprising four parts. The first part aims to evaluate learning points, in general, and contains multiple-choice questions about the port cluster theory. The second part aims to assess advanced learning points, including items that illustrate how the game helps players make decisions (interventions) and whether game participants can consider the system more comprehensively. The third part aims to evaluate the game's strategy by grouping game participants' behavior into several categories to examine differences in approach and behavior in the first and second phases (of the main game) for each role. The final part aims to evaluate the game as a whole regarding whether it has met the design requirements. After conducting the playtest to 32 players, the findings are as follow.

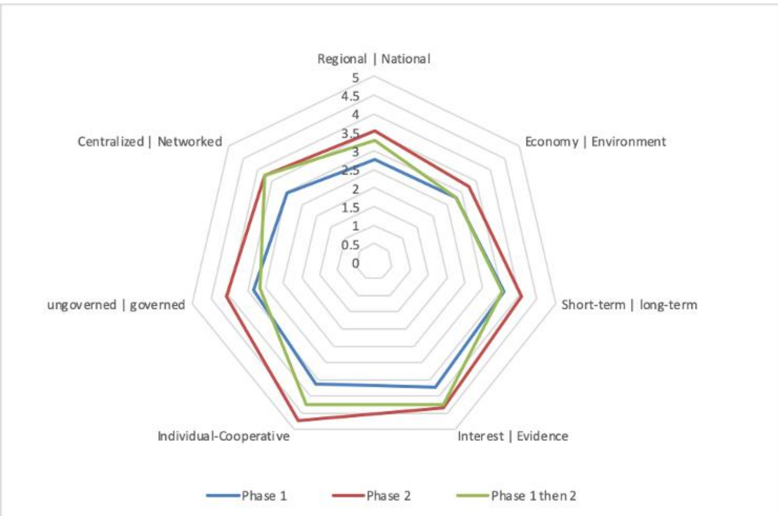

Figure 6. Results from Two (and combined) Phases of the Game

In the first phase of the game, all the players have not thought about equalizing development so that it is not centralized in one particular area. Private sectors tend to want to be in the regions profitable for their business such as, near the ports, areas with the highest demand, or areas with the closest distribution access. Regional and central governments tend to think of strategies on how to increase profits through taxes. Often, the local government cooperates with the port management and the industry for mutual benefit, while the central government tends to act one-sidedly. In planning, the central government plans to make accurate decisions based on the information it receives with little involvement in intuition or experience (observed at higher evidence points). The private sector uses more logical thinking and knowledge in making decisions. In this phase, all the players have not thought of a long-term strategy and focused on obtaining profits quickly.

Unlike the first phase, in the second phase, players have received a collective goal to win from other teams. There are differences in the characteristics between teams that have already passed the first phase, and teams that directly play in the second phase. Teams that directly play in the second phase are more oriented toward national goals than regional goals. The cooperation side is even more reliable because the central government acts as a controller and stabilizer in the game. In this phase, development tends to spread more to form a network, where not only the central government, local governments, and private sectors contribute to equalizing growth by specializing commodities for the industry. The private sector is observed to tend to build many factories because the type of planning is long-term, not just about the present. Furthermore, the government created policies that could support the economy by providing incentives for development in the eastern region, investment to develop certain commodities, and assistance in logistics costs for several types of products. The regional government also focused on strengthening commodity centers by referring to each region's potential and providing tax relief for industry players. Those results are shown in Figure 6.

4. Conclusion

This paper discusses a Simulation Game as an active learning media regarding infrastructure development in a ports cluster. The game also provides differences in behavior and approaches in the strategic planning of players in the first phase and second phase, whereas, in the first phase, players tend to be individualistic and conduct short-term planning to obtain profits quickly. Development centers on one point, and the slow economy is characterized by little investment and lower GDP. In the second phase, the approach is based on clusters where industries and ports join in a cluster that spread across regions. The Simulation Game can help players understand the concept and complexity of port cluster development and possible policies taken in the port cluster and understand the variables that affect economic activity in a port cluster and the resulting multiplier effect.

What can be learned from this game is the need to clearly define the collective (negotiated) objectives of the Indonesian Port Cluster System. Without that, the development of Port Clusters in Indonesia will run partially without a form of cooperation that can increase the quality and output of the system. Such a systemic / *gestalt* view needs to be reduced to a Network-based Ports Cluster System concept. With the network concept, the potential that exists in each region can be developed and can strengthen the overall system output (in this case: national output/ GDP).The shipping company's role in this game is not raised more because of the simplification of the shape of the game. In a more dynamic form (Mayer et al., 2012), namely computer-based Simulation Games, this role can be raised.

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