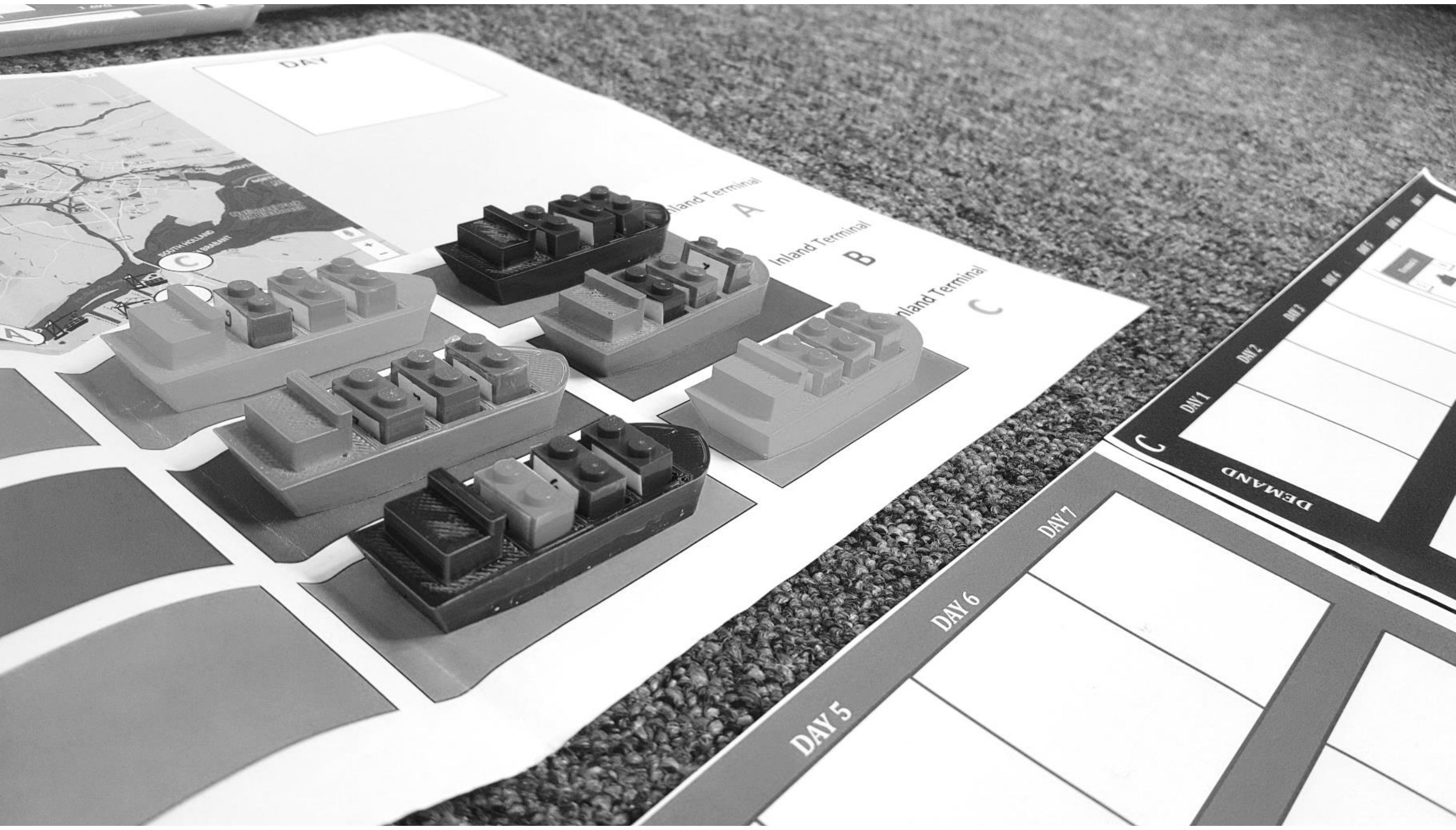
THESIS REPORT
TIL-5060 TIL Thesis

Perspectives on Collaboration Models in Intermodal Inland Waterway Transportation (IIWT):

Gaming simulation approach for terminal operator and barge operator



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Perspectives on Collaboration Models in Intermodal Inland Waterway Transportation (IIWT) – Simulation gaming approach for the inland terminal operator and barge operator

Master thesis submitted to Delft University of Technology

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By

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Delft, September 2018

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Executive Summary

Background

Intermodal Inland Waterways Transportation (IIWT) has a significant share in freight transportation in the Netherlands. It develops as the first alternative to reduce the dependency on the unimodal road transportation which get congested as the shipping demand keeps growing each year. The idea of Intermodal Inland Waterways Transportation (IIWT) is combining the road transport and Inland Waterway Transport (IWT) without a change of loading unit, where the inland waterway acts as the long-haul mode (Crainic, Perboli & Rosano, 2017). The utilization of the IWT is presumed to decrease the negative impact of road congestion such as emission and noise (Hanaoka & Regmi, 2011).

However, along with the growth on the use of Intermodal Inland Waterways Transportation (IIWT), several problems in the operation of this modality are discovered. The first identified problem is the high-frequent small call sizes which had generated the long duration of (un)loading in the container terminal, and it causes the barge congestion. Second, the insufficient capacity of the terminal had caused the barges to wait in queue before getting the handling service. The longer the waiting time generates longer rotation time of the barge, and this is undesirable for the barge operators since they normally try to make an efficient rotation schedule over the various terminals (Moonen et al., 2005).

In a further analysis, Caris et al. (2014) identify that collaboration models are potential to tackle these problems. From the perspective of Caris et al. (2014), the collaboration models in the form of *integration of operational planning systems* and *analysis of bundling networks* may increase the efficiency of the overall IIWT network and may lead to a higher performance due to possible time savings. The further study that relates the collaboration idea (*bundling network*) with the improvement of barge operators' performance level has been done by Ramaekers et al. (2017). However, it only focuses on the impact of horizontal collaboration on the cost attributes. The use of other relevance transport attributes to represent the more significant impact on performance level is assumed to be more convincing to the respective operators in IIWT to deploy the collaboration idea, not only for the barge operators but also the other relevant operators.

Considering the key actors in the operational system of Intermodal Inland Waterways Transportation (IIWT) who are directly affected by the collaboration model, this study then addresses only barge operators (BOs) and inland terminal operators (ITOs) as the focus. By taking into account its pros and cons as a research tool, Simulation Gaming has been chosen to execute

this task and properly designed to help the actors in decision-making. Therefore, this study aims to contribute to these gaps by focusing on the research question as follow.

How can the barge operators and terminal operators in Intermodal Inland Waterways Transportation (IIWT) understand the impact of collaboration on their performance levels with the help of simulation gaming?

Research Method

To answer this main research question, four steps have been taken. First, the type of collaboration models are identified. From the literature study, different types of collaboration between companies exist including the horizontal and vertical forms. Further analysis of these types of collaboration models will be carried out to check whether they are applicable in Intermodal Inland Waterways Transportation (IIWT). Along with the literature study, the analysis of collaboration models that already applied in the real IIWT market by the barge and inland terminal operators will also be identified.

Second, the identification of the relevant transportation attributes for Intermodal Inland Waterways Transportation (IIWT) is needed. These attributes are extensively studied in the transportation field, but not all of them are relevant for the case of IIWT since it covers the other modes such as road and railway system. Thus, a literature study is done in this study to choose the most suitable attributes to show the effect of collaboration models on the performance level of the actors. It is discovered that the relevant transportation attributes for Intermodal Inland Waterways Transportation (IIWT) include cost, transportation time, and reliability.

Third, the discussion in which way the transportation attributes should be appropriately represented in the game so the user can understand the background of the game. An exploratory study is done to decide the value of these transportation attributes due to the difficulty in obtaining the exact data. And lastly, a simulation game that incorporates the actors, system, and translation of collaboration's effect on performance level is built. The simulation game is designed based on Triadic Game Design (TGD) and developed through several gaming sessions and expert panel. Following the result of Simulation Gaming for the case study, the collaboration models that are suitable for each actor in their service condition are identified.

Game Design Process

During the design process, the game design is started with the conceptual design. The main target of the conceptual design is translating the real world to the gaming world by taking into account the scope of the involved actors and the transportation process. The conceptual design of the game takes a role as the blueprint which is then developed into the detail design. Three game versions as the result of the iteration process are included in the detail design.

The conceptual design is built based on the literature study which then revised iteratively according to the insights from the gaming session. The Game Version I and II are tested twice in the gaming session. These two versions do not satisfy the research objective due to the unclear representation of different impacts of each collaboration model on a performance level. Additionally, the sailing process of the barge in these two versions is not well enough on representing the real condition. In these versions, barges only can sail to one container terminal. Therefore, in the final version of the game (Game Version III), the characteristics of each collaboration model is explained more clearly. For the sailing process, two-time windows for barge to visit different containers terminal is used.

Gaming Sessions

The gaming session to try the simulation game is done by involving the master students of TU Delft and the expert panel (Synchromodality Community) which consists of Ph.D. students, lecturers, and researchers from different universities and organization, such as TU Delft, Erasmus Rotterdam University, Twente University, and DinaLog. At the end of a gaming session, the feedback from the players is collected and then used for the revision. The revision of *capacity*, *income & fine*, *time-period* and *disruption events* are learned from these gaming sessions.

Game Evaluation

After conducting the gaming sessions, the debriefing is done by directly collecting the feedback from the players also a questionnaire. This feedback collection has been done by a discussion where each player delivers their inputs to improve the simulation game. Meanwhile, in the online questionnaire, the questions about the views of the players on the connection between the reality in the game and real world. Following the debriefing process, the revisions of the game are conducted. The detail of the feedback session for improving the game version has been explained in Chapter 5, while the result of the questionnaire will be elaborated in this chapter.

According to the reality level from Kriz (2003), the debriefing is followed by the game evaluation. In the evaluation, how the game can facilitate the research objective is assessed. Since the game has been designed based on Triadic Game Design (TGD), the following discussion will present the assessment of game from three worlds: 1) Reality, 2) Meaning, and 3) Playability.

After the final gaming session, the game is evaluated from three perspectives based on the Triadic Game Design:

1) Reality: most of the elements of the game are based directly on the reality. Some of them are simplified but do not decrease the learning objective of the game.
2) Meaning: the game can clearly show the different effects from different collaborations to the performance level of barge operators (BOs) and inland terminal operators (ITOs). The

collaboration models do not always give the positive impacts, but also in some cases can generate a negative result if it is not managed well.

3) Playability: the rules of the game are found to be complex, however after the certain learning period, the players can follow the game completely and show the interest in gaining higher profits and reliability points.

To conclude, the designed simulation game has successfully answered the research question and achieved the research objective by showing a clear different impact of different collaboration models to the performance level of the involved operators. As an application, the target groups of this simulation game are the real barge operators and inland terminal operators, also student and researchers who are interested in freight transportation via in Intermodal Inland Waterway Transportation (IIWT).

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1
INTRODUCTION

1.1 Intermodal Inland Waterway Transportation (IIWT)

Congestion in the EU, which is experienced by road user each day, is often located in and around urban areas. It costs nearly EUR 100 billion, or 1 % of the EU's GDP, annually (European Comission, 2018). Aside from trips made from human traveling, the freight movement via the road network also contributes to this congestion. It tends to make the congestion worse due to the increasing demand of freight transportation demand with the total volume accounts for 10% higher in 2015 than 2010 in European countries (EEA, 2017). Intermodal Inland Waterway Transportation (IIWT) emerges as an option for delivering goods with less-dependency to road transportation. The main idea of IIWT is to also utilize an inland waterway network as part of the freight journey (Lin, Chiang, & Lin, 2014). It combines the road transport and Inland Waterway Transport (IWT) without a change of loading unit, where the inland waterway acts as the long-haul mode (Crainic, Perboli & Rosano, 2017). The utilization of the IWT is presumed to decrease the negative impact of road congestion such as emission and noise (Hanaoka & Regmi, 2011).

Despite the advantages of IIWT, the recent statistics according to European Commission (2013) show no real turn but a stable share of road transport of approximately 75% in the modal split in EU - 27 countries. One of the reasons that the road transport still grows strongly is the obligation to deliver the goods in time, which has become more and more difficult due to significant growth of freight demand is unequal with the growth of the transportation mode (van Elk, 2016). As the operation times for the barge handling at the inland terminals are often too long due to waiting times, has made the shipper have become more hesitant to switch to IIWT. This led the operators to choose the road transport more frequently to fulfill their shipping schedules and thus, left the market share of IIWT in the EU to be still insignificant.

Regardless of the low market share of IIWT in the EU in 2015 with only about 6.5% of total tonne-kilometers (Eurostat, 2018), the Netherlands is still one of the most potential countries with the highest share of IIWT in Europe (Santos, Limbourg, & Carreira, 2015). Also, as presented in **Figure 1.1**, Dutch freight transportation (including dry bulk, liquid bulk, and containers) via road transport still dominates with the modal split of 55.6% in 2015 versus 59.4% in 2010. There are, however, increasing share for rail (5.3% in 2015 versus 4.6% in 2010) and inland waterways

(39.1% in 2015 and 36% in 2010). These numbers portray the significant growth of IIWT within a 5-year period while intermodal rail slightly increases. Konings (2009) argues that this promising growth is related to the fact that well-developed IIWT is mostly centralized in Northwest European countries where the Rhein river lies upon, including the Netherlands. The highly accessible waterways network to the Port of Rotterdam also seems to support the shift of shipper's preference from road transportation.

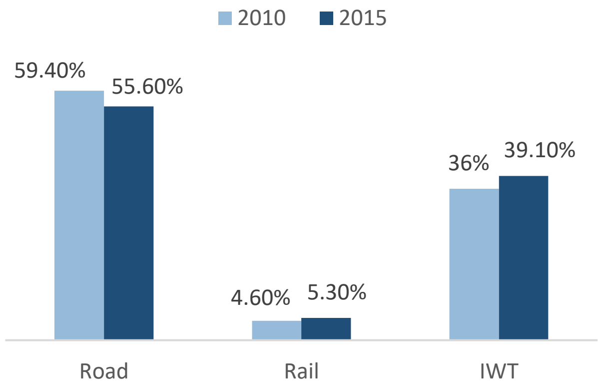

Figure 1.1 Change of modal split in Dutch freight transportation
(Source: Eurostat, 2018)

The Port of Rotterdam (PoR) as the largest seaport in the Netherlands with a container throughput of 13.7 million TEU in 2017 (Port of Rotterdam Authority, 2018) takes a role as the gateway to Europe. It has implemented the intermodality to cope with the increasing demand in European freight transport. Based on the Port of Rotterdam Authority (2017), the hinterland connection of PoR for container shipping is served via road (53%), inland waterway (36%), and rail (11%). The modal split of IIWT in PoR is targeted to be 45% in 2035. The recent modal split of IIWT in the Netherlands both for non-containers and containers commodity shows that IIWT which is considered less costly and environmentally friendly becomes the most competitive option for road transport in moving the container from and to PoR.

On top of that, the waiting time problem in IIWT that also happens in the Netherlands has led the involved operators to come up with another idea. They realize that the existence of numerous actors in IIWT has produced a complexity (Olvera et al., 2015). They compete with each other and hence, form a highly-competitive market. However, in general, these actors have a similar goal in gaining more preference from the shippers. To achieve this goal, one of the ideas is to let the involved actors work hand in hand which further will be called "collaboration."

1.2 Collaboration in Intermodal Inland Waterway Transportation

The government has put its concern on the idea of increasing the market share of IIWT. Several policies have been provided to promote the shift towards IIWT like tax, subsidies, and internalizing external costs (Caris, Limbourg, Macharis, van Lier & Cools, 2014). Aside from those, a different approach has been opted by the transportation operators to obtain more market share in freight transportation by implementing collaborative business in the form of mergers, acquisitions, and another type of collaborations (Saeedi et al., 2017a). The collaboration approach theoretically can generate benefits such as a lower operational cost, higher profit margin and more effective asset utilities (Sutherland, 2003; Mason, Lalwani, & Boughton, 2007; Saeedi et al., 2017a), as well as reduced risks (Stojanovic & Aas, 2015; Li et al.,2012).

As an option for the transportation operators, business collaboration in the transportation field itself can be classified into two types: vertical and horizontal collaboration (Saeed, 2013). Vertical collaboration is done by transportation operators from different submarkets, e.g., i) the ECT European Gateway Service which connects the Port of Rotterdam to the European hinterland by an extended network of barge, rail, and inland terminals; ii) collaboration strategy between truck company (pre- and end-haulage submarket) and rail company (main haul submarket). Meanwhile, the horizontal one is implemented by the operators from similar submarket, e.g., i) inland terminals in Noord Brabant cooperate to organize their cargo to Port of Rotterdam (Van Berkel Groep, n.d.); and ii) the less-than-truckload (LTL) carriers that operate together in cooperation (Liu et al., 2010; Wang and Kopfer, 2011).

Even though many benefits can be obtained from forming a collaboration, challenges also exist. In horizontal collaboration, Schulz & Blecken (2010) explain that the challenges when implementing a collaboration are related to a) how to establish mutual trust among the firms; and b) how to achieve a fair redistribution of both costs and profits among the partners. This argument is supported by Raue & Wieland (2015), Wallenburg & Raue (2011), and Adenso-Diaz, Lozano & Moreno (2014) who say that there is a high potential of conflicts between the involved actors due to the complexity of the collaboration. In the case of a vertical collaboration, due to its higher complexity by nature, these challenges are even highly likely to happen.

The transportation operators, therefore, should be aware of any chance of success and failure from the collaboration they will choose. Aid for decision making is needed to decide upon the partners, which collaboration models, and how the distribution of cost and profit is required.

1.3 Problem Definition from Collaboration in Intermodal Inland Waterway Transportation

Correlated to the benefits and challenges that are previously mentioned, transportation operators in IIWT, both barge and inland terminal operators, require a thorough consideration before forming a collaboration strategy, either horizontal or vertical, to achieve benefits and avoid failures. A study from Mesquita & Lazzarini (2008) states that the effect of forming these two collaboration types is relatively different. They argue that a horizontal collaboration can help the actors promote the collective sourcing of resources. Meanwhile, a vertical collaboration generates a lower ineffectiveness in overall production. However, associated with the argument from Mesquita & Lazzarini (2008), the operators do not only choose the collaboration models that satisfy their needs but also considering their available resources. Analogous to the collaboration scheme in IIWT, barge and inland terminal operators need to determine their intention and consider their resource first before forming either horizontal or vertical collaboration. Thus, a study that can help these operators developing their desired collaboration by giving the insight into how the collaboration scheme works in a specific environment is needed.

Unfortunately, research that studies the collaboration issue in IIWT market is still limited. There have been several research papers that present the competitiveness of IIWT compared to other modalities and unimodal transportation such as Wiegmans (2005); Konings, Bontekoning & Maat (2006); Caris et al. (2014); Wiegmans & Konings (2015); and Ramaekers, Verdonck, Caris, Meers & Macharis (2017). Among these studies, the collaboration idea between the actors of IIWT is only mentioned explicitly by Caris et al. (2014) and Ramaekers et al. (2017). In their paper, Caris et al. (2014) listed the research challenges to support the competitiveness of IIWT. They identify the *integration of operational planning systems* and *analysis of bundling networks* as those potential research topics to be pursued. They argued that these two forms of collaboration may increase the efficiency of the overall IIWT network and may lead to a higher performance due to possible time savings. The idea from the paper of Caris et al. (2014) is further implemented by Ramaekers et al. (2017) who build the business model for the collaboration between barge operators. However, they only focus on analyzing the bundling networks of barge operators (horizontal collaboration) in the form of *sharing capacity* without the inclusion of the possible vertical collaboration. As the conclusion from the literature, there are gaps that are potential to be studied further.

Research Gap 1	*Lack of explanation about the detailed impact of collaboration on the performance level*

Caris et al. (2014) assume that *integration of operational planning systems* (vertical collaboration) and *bundling networks* (horizontal collaboration) can give the positive impact to the performance level of the IIWT. However, the detailed impact of these collaborations on different involved actors in IIWT which at the same time include the possible negative side of these collaborations is not explained yet.

Research Gap 2	*Lack of the use of transport attributes for representing the impact of different collaboration on the performance level*

The further study that relates the collaboration idea (*bundling network*) with the improvement of barge operators' performance level has been done by Ramaekers et al. (2017). However, it only focuses on the impact of horizontal collaboration on the cost attributes. The use of other relevance transport attributes to represent the more significant impact on performance level is assumed to be more convincing to the respective operators in IIWT to deploy the collaboration idea, not only for the barge operators but also the other relevant operators.

Learning from these gaps, this proposed study, therefore, will explain the positive and negative impacts of different collaborations to the performance level of respective actors in IIWT. Both the potential horizontal and vertical collaborations will be elaborated. The performance level of operators will not be emphasized only by the cost attributes, but also by other relevant transport attributes for IIWT. By providing the clear difference between the impact from horizontal and vertical collaboration to the performance level, this study will give the involved actors the representation how these collaboration models work in the real market and help them to make the decision on forming the suitable collaboration.

By taking into account its pros and cons as a research tool, Simulation Gaming has been chosen to execute this task and properly designed to help the actors in decision-making (explained further in **Chapter 4**). Before the game designing, a literature study will be conducted to discover the involved operators of the system, the types of collaboration, the relevant transportation attributes to portray the performance of operators in IIWT, and how to differentiate the distinct collaboration models with regards to these attributes. Next, an empirical study will be done by taking a relatively small inland waterway network in the Netherlands as a representation of a market in IIWT. Several collaboration models are developed based on literature study as well as learning from the real market. Lastly, the operators can understand the effects of the represented collaboration models in the game and develop their own real collaboration based on the lessons learned from the case study.

1.4 Research Framework

Following the problem finding in **Section 1.3**, the research question that needs to be solved in this study is formulated in **Section 1.4.1**. It is followed by research goal (**Section 1.4.2**), research methods (**Section 1.4.3**), and research flow (**Section 1.4.4**).

1.4.1 Research Question

Based on the contextual background and scientific gap explained previously, the main research question for this study is:

How can the barge operators and inland terminal operators in IIWT understand the impact of collaboration on their performance levels with the help of simulation gaming?

To answer the main research question, the research sub-questions are derived from the research question as follow.

1. What are the collaboration models among the actors in IIWT?
   From the literature study, different types of collaboration between companies exist including the horizontal and vertical forms. Further analysis of these types of collaboration models will be carried out to check whether they are applicable in IIWT. Along with the literature study, the analysis of collaboration models that already applied in the real IIWT market by the barge and inland terminal operators will also be identified.
2. What are the relevant transportation attributes to represent the change of the performance level from the implementation of different collaboration models?
   The effect on the performance level is expected when an operator implements a collaboration model. To portray the change in the performance level of respective actors, the relevant transportation attributes are needed. These attributes are extensively studied in the transportation field, but not all of them are relevant for the case of IIWT since it covers the other modes such as road and railway system. Thus, a literature study is done in this study to choose the most suitable attributes to show the effect of collaboration models on the performance level of the actors.
3. How to translate the variation of the transportation attributes in Simulation Gaming as an impact of different collaborations?
   This includes the discussion in which way the transportation attributes should be appropriately represented in the game so the user can understand the background of the game. The value of these attributes is decided from the exploratory study since the exact data might be difficult to obtain.
4. From the simulation gaming, what the collaboration model in IIWT market that is suitable for each of the actors for their specific performance levels?
   Following the result of Simulation Gaming for the case study, this proposed study will identify the characteristic of collaboration models that are suitable for each actor in their service condition. From this identification, then the conclusion about the role of the conducted simulation game to help the actors find their own collaboration models will be explained.

1.4.2 Research Goal

The goal of this study is to give an understanding to the barge and inland terminal operators on how the collaboration between operators in the IIWT system can improve their performance levels. As different operator has different problems in their operational systems, they tend to have a different preference in choosing a suitable collaboration model. Therefore, this study wants to help the operators in developing their preferable collaboration models by learning from the case study presented in this study.

1.4.3 Research Methods

Suitable research methods are chosen to solve the problem that is depicted in the research questions. In this study, a combination of qualitative and quantitative approaches is implemented. The qualitative approach consists of a literature review and an expert panel. The game development as a research tool uses both qualitative and quantitative data to analyze the behavior of the players towards the alternative actions.

A. Literature Study

A literature study is adapted to gain the theoretical background on how the system of IIWT works and how the research tool (red. Simulation Gaming) should be developed to answer the research problem. The outcome of this approach will serve as a theoretical input in preparing the material for developing the collaboration models and the preliminary tool. The obtained information from this phase covers the actor analysis, the scope of the system, transport attributes, the possible types of collaboration, the parameters of Simulation Gaming, and the way to use Simulation Gaming for solving a transportation problem.

B. Simulation Gaming

With regards to the pros and cons, Simulation Gaming is chosen as the research tool to conduct this study. To build a simulation game, the theoretical background regarding the elements of the game that should be incorporated is found from the literature study that is previously conducted. The proposed Simulation Gaming will be designed based on an approach as proposed by Kortmann & Harteveld (2009). The approach is categorized as an agile development which facilitates the changing iteration in designing the game with regards to the feedback from the gaming try-outs. Recently, most of the Simulation Gaming designed for research purpose tend to use the agile development because it can tackle more complex and more uncertain projects. Harteveld (2011) presented this agile development as Triadic Game Design (TGD). Three components of TGD are Reality, Meaning, and Play, explained below.

1) **Reality**; this relates to the representation of the real world in games. The components of the game will be determined by the real conditions of a reference system which is in this study, the IIWT.
2) **Meaning**; this aspect relates to the purpose of the game.
3) **Play**; as a representation of a real world with specific meaning, games need to be attractive or engaging to the people by including the elements, like actors, rules, resources, challenges, and competition.

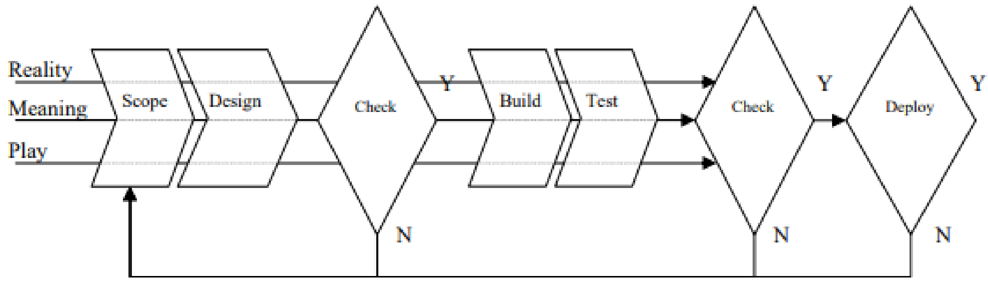

Figure 1.2 Triadic Game Design (Source: Kortmann & Harteveld, 2009).

TGD is designed by adapting the development of software engineering. As can be seen in **Figure 1.2**, TGD include iterations to accommodate the decision making in developing the game. For this study, an adaptation of TGD is used by implementing two-time checking process as iteration. The first checking process is done after designing the game, and the second checking is after the game is tested. The specific implementation of TGD for this study is presented in **Figure 1.3**.

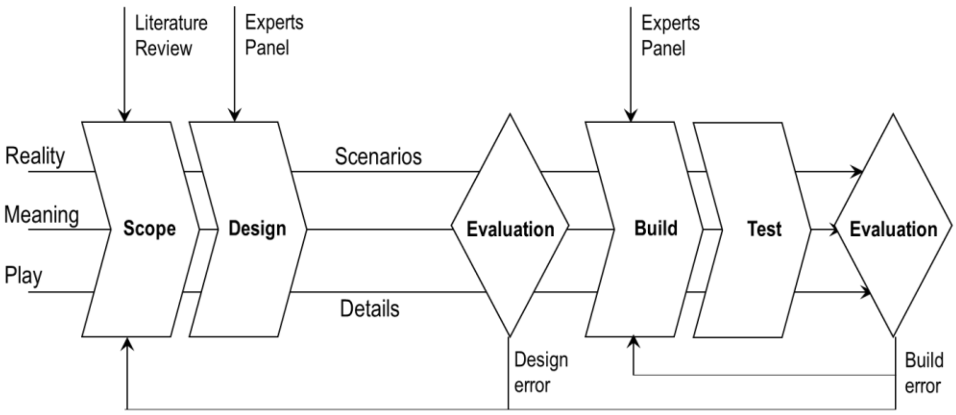

Figure 1.3 Implementation of Triadic Game Design for this study (Source: Adapted from Kortmann & Harteveld, 2009).

To accommodate the involved actors in experiencing different types of collaborations with the help of a game, collaboration models including *horizontal collaboration* and *vertical collaboration* among inland terminal operators (ITOs) and barge operators (BOs) are incorporated within the game.

C. Expert Panel

The expert panel will be arranged with the person who has expertise in freight logistics via inland waterway shipping. In this study, the expert panel involved is the Synchromodality Community which consists of Ph.D. students, lecturers, and researchers from different universities and organization, such as TU Delft, Erasmus Rotterdam University, Twente University, and DinaLog. Their researches are focusing on freight transportation development, ranging from the multimodal network modeling, supply chain efficiency, and the development of synchromodlity. During the expert panel, this involved community played the designed simulation game and gave their evaluations and feedbacks at the end of the game.

There are at least two main purposes from this expert panel. First and importantly, the expert panel will be used to check whether the system, which is applied in the Simulation Gaming, represents the real condition (validation). Second, the gathered feedbacks from this community is used for the development of the game.

1.4.4 Research Flow

In this chapter, the steps to conduct the research are shown. **Figure 1.4** presents the research flow. The research flow, in general, is divided into three phases. In the first phase, the main focus is on gaining the information of theoretical background from the literature study. Following the learning from the literature study, the simulation game starts to be built in the second phase. In the second phase, the simulation game is improved with regards to the feedback gained during the gaming session. And finally, the game is finalized in the third phase.

Next, **Figure 1.5** explains the data flow for each step of research and how it correlates with each other. Two forms of data are gathered during this study. The first type is the secondary data obtained from the literature study that includes the topic on Intermodal Inland Waterway Transportation and Simulation Gaming. Then, the primary data is gathered from the expert panel and during the feedback session after the gaming session. This primary data is mainly used for the detail improvement of the simulation game.

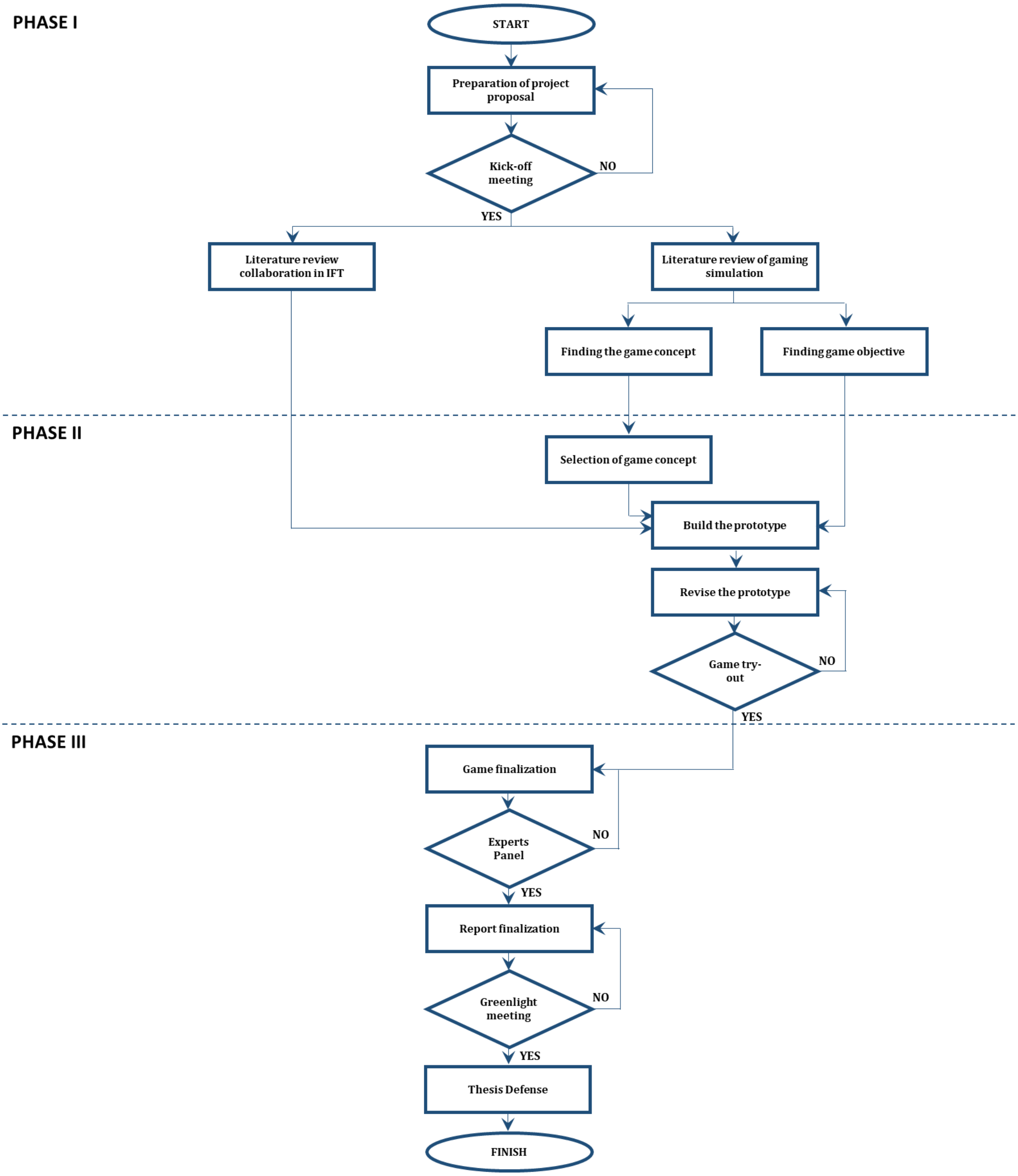

Figure 1.4 Research flow.

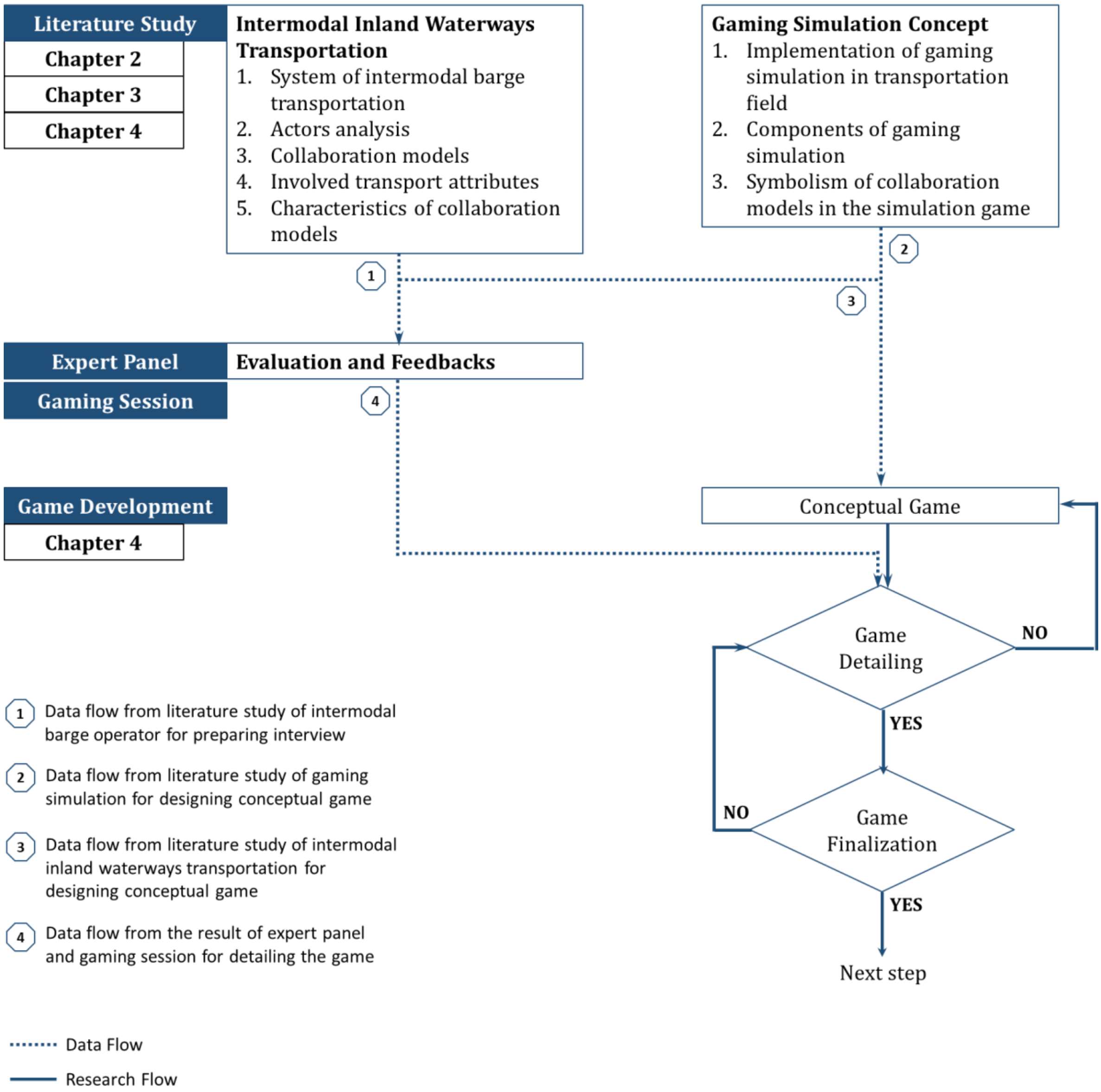

Figure 1.5 Data Flow

2

INTERMODAL INLAND WATERWAY TRANSPORTATION (IIWT) – PORT OF ROTTERDAM AND MOERDIJK NETWORK

2.1 Definition and Types of Intermodal Inland Waterway Transportation (IIWT)

Crainic & Bektas (2007) and Crainic & Kim (2007) define intermodal transportation as the transportation of people or freight from their origin to their destination by a sequence of at least two transportation modes. It starts from the initial shippers to the final consignee, and the transfer point between the different modes takes place in the intermodal terminal. Commission of the European Communities (2001) interpreted the intermodal transportation as the movement of goods in a single loading unit or vehicle that successively uses two or more modes of transport without handling the goods themselves in changing modes. The different modes referred to are including road, rail, inland waterway, sea, and air (Wiegmans & Konings, 2013). Therefore, this study combines the definition from Crainic & Bektas and Crainic & Kim, then adding the use of term *single loading unit* from Commission of the European Communities to form the definition of intermodal transportation as 'transportation of freight from its origin to its destination in a single loading unit or vehicle by a sequence of at least two transportation modes without handling the freight during the changing modes'.

The use of term *single loading unit* in this study reflects that the focus will be on containerized freight movement. Refer to the definition from UN/ECE, 2001 the use of container will be suitable as to keep the uniformity in transshipment process. Other than that, along with the rapid development of larger container ships, the demand for the container shipping from seaport to hinterland is also increasing and in accordance with the need of containerized intermodality.

Furthermore, based on the type of modality that is used in the system, there are three types of intermodal transportation which are land-based (railway-road transport), water-based (ocean-road transport, ocean-inland waterway, inland waterway-road transport, etc.), and air-based (airline-road transport) (Georgia Southern, 2011). The water-based intermodal transportation which utilizes of inland waterway transportation (IWT) as the main service in its chain which is then called as **Intermodal Inland Waterway Transportation** (IIWT). According to Wiegmans (2013) and Wiegmans & Konings (2013), IIWT itself can be distinguished into three types. The first one is typical intercontinental freight transportation which links inland terminals by IWT with pre- and end-haulage served by a truck as shown in **Figure 2.1a**. The second and third type of IIWT are actually for hinterland connection from seaports. If the initial goods are consolidated from several seaports, then it is considered as the second type (**Figure 2.1b**). Otherwise, it is classified as the third type (**Figure 2.1.c**).

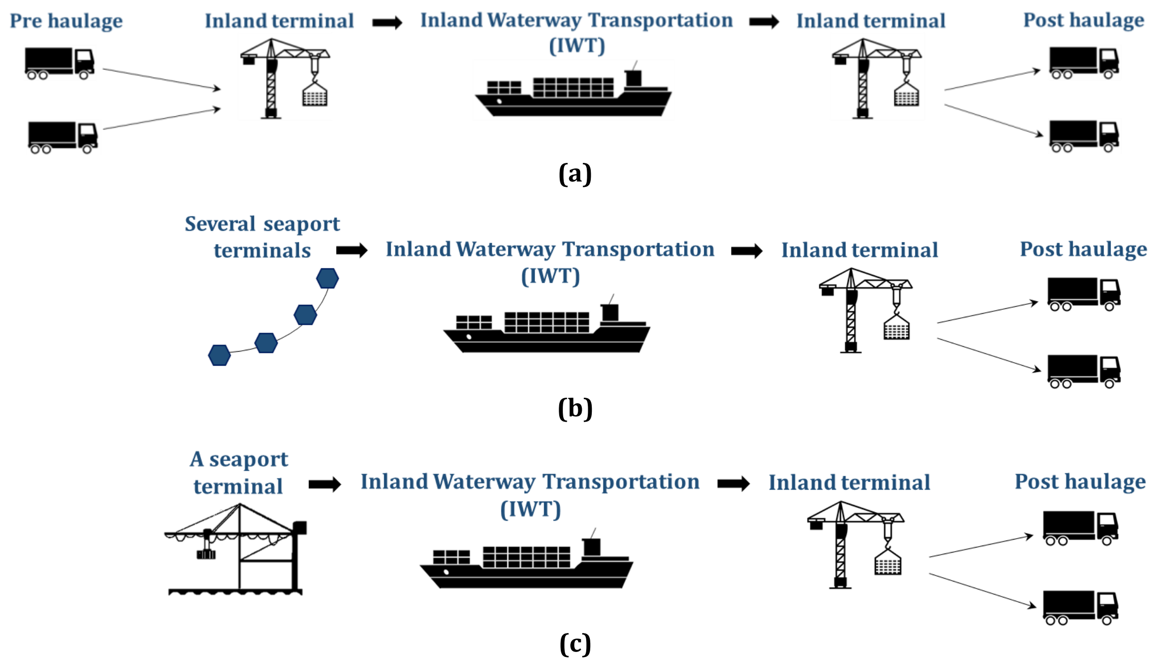

Figure 2.1 The different types of Intermodal Inland Waterways Transportation (IIWT): a) intercontinental connection, hinterland connection of b) consolidated seaports, and c) specific seaport.
(Source: Wiegmans, 2013; Wiegmans & Konings, 2013).

The intercontinental type only accounts for around 10% of the market, and 90% is led by the consolidated and specific seaport type. From the 90% share, the consolidated seaports type is the leading principle in IIWT. This happens since the volume of one container terminal in a seaport is usually too small to offer a point-to-point service between a seaport and inland container terminal (Wiegmans & Konings, 2013). However, regarding the availability of the data and the difficulty on tracking the proportion of the consolidated containers from several seaports, this study will focus on the hinterland connection between a specific seaport and an inland terminal which is the third type of the principles.

2.2 Geographical Development of Containerized Intermodal Inland Waterway Transportation (IIWT)

Even though its market share is quite low, IIWT plays an important role in the transport of goods in Europe (European Commission, 2018). Konings (2009) state that IIWT has become a well-developed mode specifically for transporting containerized goods in Northwest Europe in relatively short period compared to the other European regions. It is due to the location of The Rhine river as the most important European waterway which connects the Netherlands, Germany, Belgium up to Switzerland and France.

On the traditional Rhine, the volume of container transportation (in TEU) is fluctuating from 2010 until 2016, but overall, it has increased by 40% in 2016 compared to 2010 (**Figure 2.2**). The traffic of goods is mainly represented by trade between Belgium, Switzerland, Germany, France and the Netherlands, which accounted for more than 97% of freight transport on the Traditional Rhine in 2016. The only 3% of the freight transport on the Traditional Rhine is either heading to overseas destinations such as the United Kingdom or going through the Rhine-Main-Danube canal towards Danube countries. From the overall goods transported, the share of the container transport on the Traditional Rhine in 2016 was 16% (CCNR, 2017).

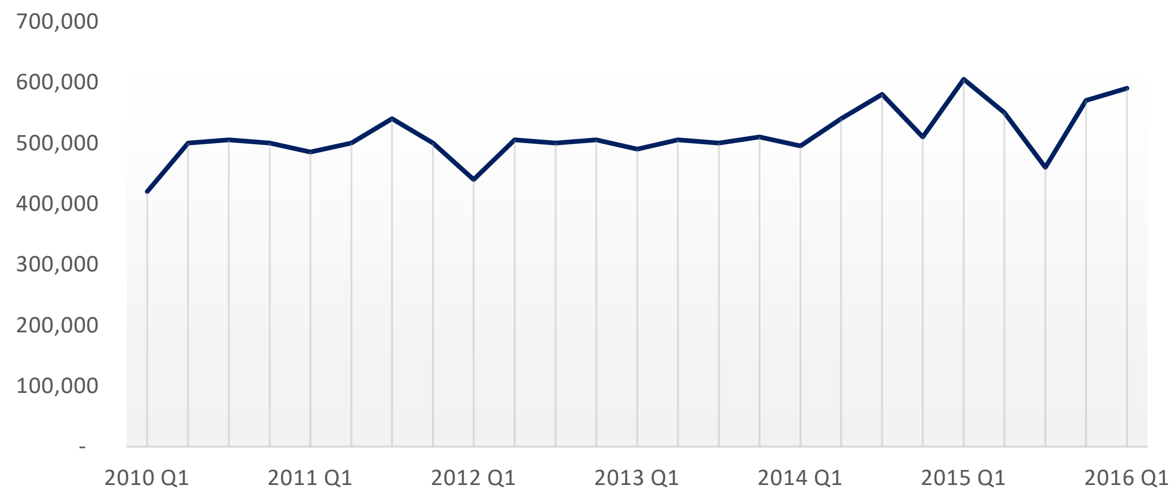

Figure 2.2 Volume of containers transported on the Traditional Rhine over 2010-2016 (volume in TEU) (Source: Destatis, CCNR Analysis, 2017)

The Netherlands, Belgium, Germany, and France have a consolidated performance higher than 99% share of European Union in transporting containers via inland waterways. From the 99% share, the distribution of performance is dominated by the Netherlands (45%) and Germany (40%) which can be seen in **Figure 2.3**. The infrastructures of Rhine area and good connections with the two major European seaports for container traffic, Rotterdam and Antwerp, partly explain dynamic container transport on inland waterways in the Rhine area (CCNR, 2017).

With the highest performance in containers transportation via inland waterway, the Netherlands has experienced the annual increase consistently since 2010. There was a major decrease in 2008 as the result of a slowdown in the world trade (CCNR, 2010), but other than that, the Netherlands successfully keeps the growth of containerized inland waterway transport roughly in 6% per year from 2010, and in 2016 the performance accounts 40% higher compared to 2010 (in TKM) which is presented in **Figure 2.4**.

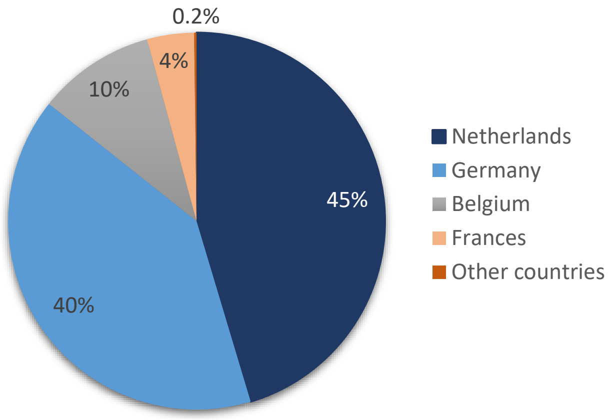

Figure 2.3 Distribution of container transport performance on inland waterways in 2016 in the European Union. (Source: Eurostat, 2017)

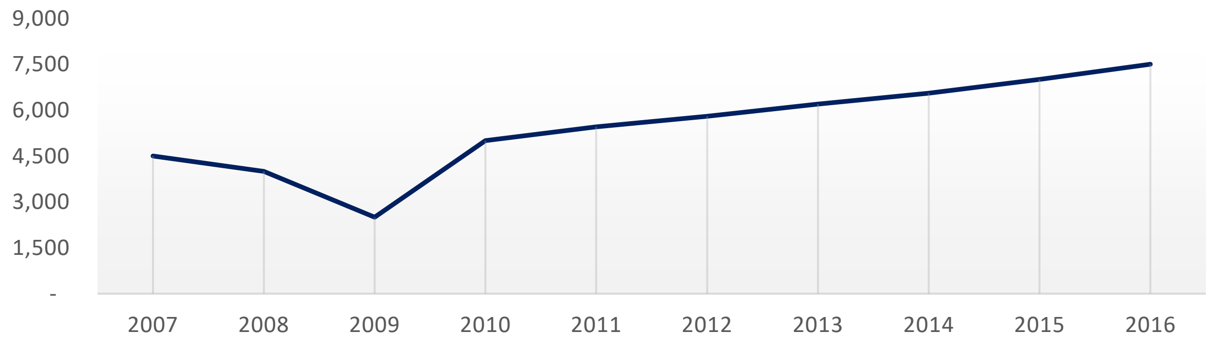

Figure 2.4 Container transport performance on inland waterways in the Netherlands (transport performance in million TKM).
(Source: Eurostat; CCNR, 2017)

The supporting reasons of the promising growth of IIWT in the Netherlands are not only the good network and infrastructure of The Rhine but also the good accessibility of the inland waterways from the Port of Rotterdam as its main seaports, which cause the inland waterways remains one of the most widely used modes of transport. Besides, several improvements have been made such as the introduction of fixed and regular sailing schedules and modern terminal facilities which seems to attract more shipper to use IIWT. It seems to keep growing since the technological development in the form of autonomous container barge which is fully electric will be introduced to the market this year with the hope to increase the performance of IIWT.

2.3 Actors and Roles in Containerized Inland Waterway Transportation (IIWT)

IIWT involves many actors who have different operational system whom, however, have a common objective to make IIWT be more reliable, less costly, and able to serve the demand effectively and efficiently. Crainic, Perboli, & Rosano (2017) differentiate these actors into two groups: 1) the advisory role and 2) the operational role. Actors in the operational role are the ones running the system in the daily environment. For the case of IIWT as hinterland connection of a specific seaport (third type), the actors who are considered in the operational role are seaport/ inland terminal operators, barge operators, and trucking companies. Shippers and consignees who are included in the advisory role also take an important part as the origin and the destination of the containers. The following **Figure 2.5** shows the sequence of the container's journey with the respective actors acting in the respective submarkets.

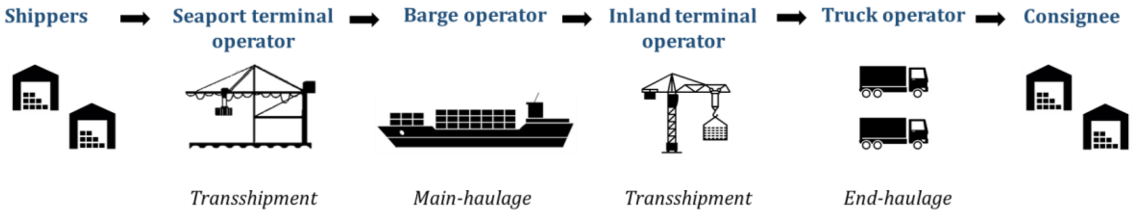

Figure 2.5 Involved actors in the IIWT for hinterland connection of a specific seaport (above sign) and their submarkets (bottom sign).
(Source: Adapted from Konings, 2009)

In short, the roles of the different actors in IIWT for hinterland connection from a specific seaport are explained as follow.

1) **Shipper or Consignee**: In the container shipping, the shipper or consignee is the most important player since they are the initial and endpoint of the container's journey. Shippers take a role as persons or companies who are usually suppliers or owners of the commodities. Shippers send the containers to the consignee by using preferred transportation modes. Although the smaller shippers tend to have a freight forwarder handle their shipments, larger shippers still exist having contracts directly with the terminal operator and barge operator (Van Rooy, 2010). Whereas, consignees are the party to whom the shipment is consigned. They are not always the buyer of the commodities, but most of the time they act as the intermediary between the shippers and the real customers.
2) **Seaport/ Inland Terminal Operators:** The role of the terminal operator is providing all terminal handling activities. These handling activities include the loading/unloading of ocean vessels and moving the containers from the stack to inland transport modes (truck, barge, and rail) and vice versa. Terminal operators can reside in a seaport or inland

terminal. The specific task for the inland terminal operator is handling the containers carried by barges via inland waterways and later move it to the trucks which transport the containers to the consignee (van Rooy, 2010).

3) **Barge Operator:** The barge operator provides the containers transportation via inland waterways. It uses relatively small vessels to transport containers from the container terminals in a seaport to the inland terminals. These companies do not always own barges themselves, but in some cases contracting barge companies, which do own barges and operate them (Douma, 2008).
4) **Trucking Companies**: For conveying the containers in the last leg of the journey, the truck companies play the role as the road hauler from the inland terminal yard to the consignee. In many countries, they have become professional service providers with whom the shipping line can outsource parts or all of its inland distribution operation (van Rooy, 2010). Trucking itself is considered the most frequently used transportation mode for container regardless of the shift to IIWT and rail is increasing. In intermodal transportation, it still takes the role as pre- and haulage operators.

For IIWT as the hinterland connection of a specific seaport (third type), the journey starts from the shippers delivering the containers to the seaport which is mainly by deep-sea vessel. The containers then will be handled by terminal operators in the seaport. Without unloading process, these containers moved to the barge and delivered to inland terminals closest to the location of consignees by barge operator. Arriving in the inland terminal, the terminal operator will handle the container and stack them in the yard. Truck is mostly used to take the container from the yard and send it to the final destination. However, in this study, the involvement of truck companies is not included as it is quite difficult to trace and track the specific OD pair that served by them. Also, the role of shipper or consignee will not be studied further since this study wants to highlight the role of terminal operators and barge operators in forming the collaboration inside the IWWT system in order to adapt the changing market environment (see **Section 1.2**).

However, the presence of many involved actors in IIWT whose operational system are different but complement each other has generated problems. Van den Horst & De Langen (2008) identified three problems in the IIWT system, particularly in the Netherlands. The first identified problem is the high-frequent small call sizes which had generated the long duration of (un)loading in the container terminal, and it causes the barge congestion. Second, the insufficient capacity of the terminal had caused the barges to wait in queue before getting the handling service. The longer the waiting time generates longer rotation time of the barge, and this is undesirable for the barge operators since they normally try to make an efficient rotation schedule over the various terminals (Moonen et al., 2005). Next, the third problem is the limited exchange of cargo between barge operators. The possibility to exchange the cargo will allow the possibility for the barge operators to operate the larger vessels, have higher service frequencies, and fewer port calls. In recent time, this cargo exchange does not develop spontaneously, because many barge companies firmly wish to remain independent.

From three identified problems, only the first two problems involving both the barge operator and inland terminal operator would be incorporated in the Simulation Gaming. This decision is made according to the statement from Van den Horst & De Langen (2008) that the first two problems are the most important ones in the container barging market. Also, associated with the goal of this study to help the decision-making process for barge and inland terminal operator, only the first two problems are considered more suitable to include. These two identified problems will be incorporated in the scenarios of collaboration models (see **Chapter 3**) and further presented in the Simulation Gaming (see **Chapter 4**). The following **Table 2.1** shows the IIWT problems found by Van den Horst & De Langen.

Table 2.1 Identified problems related to container barging in IIWT (Van den Horst & De Langen, 2008)

PROBLEMS	INVOLVED ACTORS
Long stays of barges in the port because of too many calls and too small call sizes	Barge operator, seaport and inland terminal operator, forwarder
Insufficient terminal and quay planning with respect to sailing schedule	Barge operator, seaport, and inland terminal operator,
Limited exchange of cargo	Barge operator, forwarder

2.4 Case Study: Containerized Intermodal Inland Waterway Transportation (IIWT) between Port of Rotterdam and Moerdijk Inland Terminal

As explained previously, IIWT in the Netherlands is well-developed because of several reasons. With regards to the condition of Dutch IIWT, this study will take a small network of IIWT in the Netherlands to study how the system works between the involved actors regarding the collaboration problem.

The chosen network is the inland waterway connection between the Port of Rotterdam and Moerdijk Inland Terminal. Moerdijk is strategically situated halfway between the Port of Rotterdam and the Port of Antwerp (see **Figure 2.6**) which statistically has considerable container traffic with 2.000 ocean-going vessels and 13.000 inland waterway vessels use the transshipment and its storage facilities (Port of Moerdijk, 2018). This network doesn’t only serve the shipping lines from and to Rotterdam and Antwerp, but also towards several locations in the hinterland of the Netherlands and in the direction of Germany, Belgium, France, and Switzerland (CCT, 2018).

Figure 2.6 Location, actors and sailing routes for IIWT network between the Port of Rotterdam – Moerdijk Inland Terminal
(Source: Navigate Port of Rotterdam, 2018)

Based on Port of Rotterdam Authority (2018), in Moerdijk, there are three (3) inland terminal operators who provide container handling and three (3) container barge operators who offer the service in the sailing route from and to Port of Rotterdam and Moerdijk. The detailed characteristic of these key players in IIWT network Rotterdam – Moerdijk is explained as follow.

A. Inland Terminal Operator

a) Moerdijk Container Terminal (MCT)

MCT is formed from the collaboration between CCT from Moerdijk and the Rotterdam deep-sea terminal operator, ECT. It is a part of the hinterland network of ECT's subsidiary European Gateway Services and acts as an extended gate of the ECT terminals in Rotterdam. The hinterland connection via road, inland shipping, and rail are available from MCT location. Besides, MCT also provides service as an empty depot for many shipping companies, thus facilitating the exchange and repositioning of (empty) containers (MCT, 2018).

The transshipment of inland shipping containers takes place on the almost 700-meter long quay with two flexible mobile cranes. MCT handles approximately 350.000 containers annually (InlandLinks, 2018).

b) Combined Cargo Terminal (CCT)

Combined Cargo Terminals (CCT) is owned by Van Uden Group and has a 12-hectare terminal located in the Port of Moerdijk with a total quay length of 900 m (EuroRijn, n.d.). CCT is a combined shortsea terminal and inland terminal, a full-service seaport, and a trimodal hub. It (un)loads not only the containers from inland barges but also any kind of cargo: from bulk, breakbulk, to project cargo (CCT, 2018).

c) Steinweg Delta Marine Terminal

Steinweg Delta Marine Terminal (SDMT) was established in 2002 which handles a pure bulk and containers. It is becoming a modern equipped multipurpose terminal recently and has a total surface of 120.000 m^2 with a total quay length of 300 meters and a draft of 8,5 meters (C. Steinweg Group, n.d.). The throughput in this terminal is around 125.000 containers per year (InlandLinks, 2018).

B. Barge Operator

a) Danser Benelux

Danser is an independent company who acts as one of the largest inland shipping and rail operators in The Rhein. It is formed in 1982 and serves the multimodal transportation. Its annual container volume reaches 1.3 million TEU. Danser provides a scheduled sailing for the Rotterdam – Moerdijk route every day (Rotterdamtransport, 2018).

b) ECT European Gateway Service

As part of its European Gateway Service, ECT operates its own inland barges to ship the containers to MCT Moerdijk. ECT's barges sail to MCT six day in a week with only one day off. They carry containers from ECT Delta Terminal and Euromax Terminal at Rotterdam's Maasvlakte (ECT, 2018).

c) Dubbelman Container Transport (DCT)

Dubbelman Container Transport (DCT, 2013) is a part of Dubbelman Group. It focuses on the whole Rhine up to Basel/Birsfelden. Compared to Danser, on average DCT visits more terminals and as a result, the round trips of a single barge are longer. This condition also applied for the route Rotterdam – Moerdijk where DCT is the only operator who visits the Rotterdam city inland terminal during the journey (see **Figure 2.6**). Overall, DCT sails in this route four (4) times a week (Rotterdamtransport, 2018)

The following **Table 2.2** gives the information of comparison between the operators regarding its operational characteristics.

Table 2.2 Characteristic comparison of operators in IIWT Port of Rotterdam – Moerdijk

INLAND TERMINAL OPERATORS				BARGE OPERATORS	
The Operators	Annual handling	Commodities	Hinterland connection	The operators	Sailing schedule
1. Moerdijk Container Terminal (MCT)	350.000 containers	Container	Barge, truck, rail	1. Danser Benelux	7x per week
2. Combined Cargo Terminal (CCT)	No data	Bulk, breakbulk, project cargo, container	Barge, truck, rail	2. ECT European Gateway Service	6x per week
3. Steinweg Delta Marine Terminal (DTM)	125.000 containers	Bulk, breakbulk, container	Barge, truck, rail	3. Dubbelman Container Transport	4x per week

The inland waterway network between Port of Rotterdam and Moerdijk Inland Terminal is considered as one of the important corridors in the Netherlands that connects two largest container seaports in Europe, Port of Rotterdam and Port of Antwerp. With significant growth of container shipping between these two seaports, a better performance of involved operators in this corridor is required. The problem of barge congestion in this corridor has been reported by Waters (2018) and Knowler (2018). An interesting idea to introduce collaboration models as the option to solve this problem has been suggested by both port authorities. Considering this condition, this study adopts this case to analyze the impact of the collaboration on the performance level of the involved operators. If the real operators in this corridor can utilize this study, there is a possibility that the problems faced in this corridor can be solved.

3
LITERATURE STUDY – COLLABORATION MODELS IN CONTAINERIZED INTERMODAL INLAND WATERWAYS TRANSPORTATION (IIWT)

3.1 Definition and Classification of Collaboration Models

A term alliance, strategic alliance, partnership, cooperation, and collaboration are first intended in a business field which is in several studies have a broad variety of definitions (Tuimala & Lukka, 1999). The definition that can be adopted in any research field is presented by Vyas, Shelburn, & Rogers (1995) who describe the collaboration as an agreement between two or more partners on sharing the knowledge or resources which could give advantages to all parties involved. Spekman et al. (1998) also add that the involved actors in the collaboration have at least three characteristics: a) each has goals that are both compatible and directly related to the partner's strategic intent; b) each has the commitment of, and access to, the resources of its partners; and c) each represents an opportunity for organizational learning. The simpler adoption of these definitions is applied on transportation-related study by Wiegmans (2013) who use the term “cooperation” instead of “collaboration” as “working together on the same end” where a mutual trust and a high stage of commitment must be included during the formation (Serrano-Hernandez, Juan, Faulin, & Perez-Bernabeu, 2017). The term “collaboration” will be consistently used throughout this study and further elaborated.

Due to a limited number of studies that particularly discussed the classification of collaboration in the transportation field, this study also refers to research which provides the discussion of this topic in general and finds the relevant adoption for the case of IIWT. The first classification of collaboration is based on the involved organizational level inside the operators who collaborate. It generates the collaboration in strategic, tactical, and operational level. According to Serrano-Hernandez, Juan, Faulin & Perez-Bernabeu (2017), the decisions in strategic level are carried out for a long time period and involve the whole company. For tactical level, the decisions are focused on the mid-term, and they typically require a high level of synchronization among the departments of a firm while the collaboration in operational level only works on the short-term period with the main aim is to increase the load factors, thus avoiding lack of efficiency in transport activities.

The next classification is regarding the range of integration level between the partners involved. A study from Weick (1982) introduces two types of collaboration between "any A" and "any B" which varies in integration level from loose to tight. From its structure, the loose collaboration is usually related to informal agreement where it includes activities that are spontaneous and unplanned. Meanwhile, as the opposite, the tight collaboration is associated with a formal agreement that its activities are consciously planned (Beekun & Glick, 2001).

Then in the last classification, collaboration is interpreted based on the submarket where the operators offer their services (Mason, Lalwani, & Boughton, 2007). This differentiates the collaboration into horizontal and vertical forms (Wiegmans et al., 2007; Alvares-SanJaime et al., 2013a; Alvares-SanJaime et al. 2013b; Caris et al., 2014; and Guo et al., 2016) and as it is already explained in **Chapter 1**, the scope of horizontal collaboration includes the operators who provide a transportation service in the same level of market while the vertical form is in the different level of market.

Overall, the detail classifications of collaboration models are shown in the following **Table 3.1.**

Table 3.1 Classification of collaboration models

COLLABORATION PERSPECTIVES	COLLABORATION MODELS	ARTICLES
Organizational level	Strategic Tactical Operational	Pomponi et al. (2013) Serrano-Hernandez, Juan, Faulin & Perez-Bernabeu (2017)
Integration level	Loose Tight	Weick (1982) Beekun & Glick (2001)
Submarket	Vertical Horizontal	Wiegmans et al. (2007) Alvares-SanJaime et al. (2013a) & Alvares-SanJaime et al. (2013b) Caris et al. (2014) Guo et al. (2016)

On top of that, due to the purpose of this study to highlight the change of operational performance level of the operators caused by the formed collaboration, the organizational classification will not be included in the analysis, and all the collaboration models are assumed to stand in an operational framework. This decision also supports the exclusion of integration level-related collaboration models since Beekun & Glick, 2001 state that this classification in their definition is more to the strategic level of companies. To conclude, by focusing on the operation performance of operators, this study will derive the collaboration only based on the submarket classification which are horizontal and vertical forms.

3.2 Relevant Transportation Attributes in Representing the Performance Level of Operators Related to Different Collaboration Models

The implementation of different collaboration models in IIWT shown in **Section 3.1** can potentially change the performance level of the operators (Mason et al., 2007). Each involved operator has the possibility to experience different effects from each collaboration model. Moreover, related to the aim of collaboration to obtain a higher market share in hinterland transportation by making a more effective and efficient transportation system, the performance level of operators here is presented by the transportation attributes. By definition, transportation attributes are parameters that show the overall utility offered by a trip and represent the qualities of the trip, including practical, objective factors such as journey time, reliability, and price, and more subjective variables, such as comfort and pleasantness of the staffs (Parkhurst, Enoch, Ison, & Meyers, 2006). The shippers will choose the operators based on the performance level which in this case is shown by the transportation attributes. If the collaboration models can generate a positive change on the attributes, then they logically influence the preference of the shippers as well.

Van Klink & Van den Berg (1998); Barthel & Woxenius (2004) consider transport cost as the most important attribute. Meanwhile, Ballou (2004) argued that the transport time is also essential to be added. In 2007, Wiegmans, Hekkert, & Langstraat list several transport attributes of rail industry from previous studies by Nooteboom, 1989; Rogers, 1995; Bergquist & Abeysekera, 1996; Konings, 1996; Kreutzberger 1997; Konings & Kreutzberger, 2001; Tidd et al., 2001; Chan & Wu, 2002; and Wiegmans (2005). Only a part of these listed attributes that actually can be adapted to this study since not all of these attributes can portray the operators other than rail. Furthermore, Marcucci, Danielis, & Zotti (2004); Danielis & Marcucci (2007), Guo et al. (2016), and Chang & Thai (2017) introduce several transport attributes for studying the shipper's behavior that is not considered before. **Table 3.2** below shows the list of transport attributes that are presumed to be relevant to the case of IIWT. However, it might be difficult to cover all of these, but at least the most significant ones will be analyzed and translated into a Simulation Gaming.

Table 3.2 List of transport attributes from previous studies

ARTICLES	TRANSPORT ATTRIBUTES			
	Cost	Travel Time	Reliability	Others
1. Klink van, & den Berg van(1998)	√	-	-	-
2. Konings (2003)	√	√	√	Frequencies
3. Barthel & Woxenius (2004)	√	-	-	-
4. Ballou (2004)	√	√	-	-

ARTICLES	TRANSPORT ATTRIBUTES			
	Cost	Travel Time	Reliability	Others
5. Zotti & Danielis, (2004)	√	√	√	Loss and damage Frequency Flexibility
6. Danielis & Marcucci (2007)	√	√	√	Loss and damage
7. Wiegmans et al. (2007)	√	-	√	Efficiency Flexibility Safety Speed Size Area savings Automation Catchment area
8. Guo et al. (2016)	Fuel cost Environmental cost	Delays	-	Safety Service quality Congestion
9. Chang & Thai (2017)	√	√	-	Distance CO2 emission Customer service Shipper-forwarder relationship

All the listed transport attributes might be less relevant for IIWT since they are also used for other modalities such as road and railways. A study by Konings (2003) has further explained the relevant transport attributes for IIWT. He divided the attributes based on the perspective of shippers and operators as presented in **Figure 3.1**.

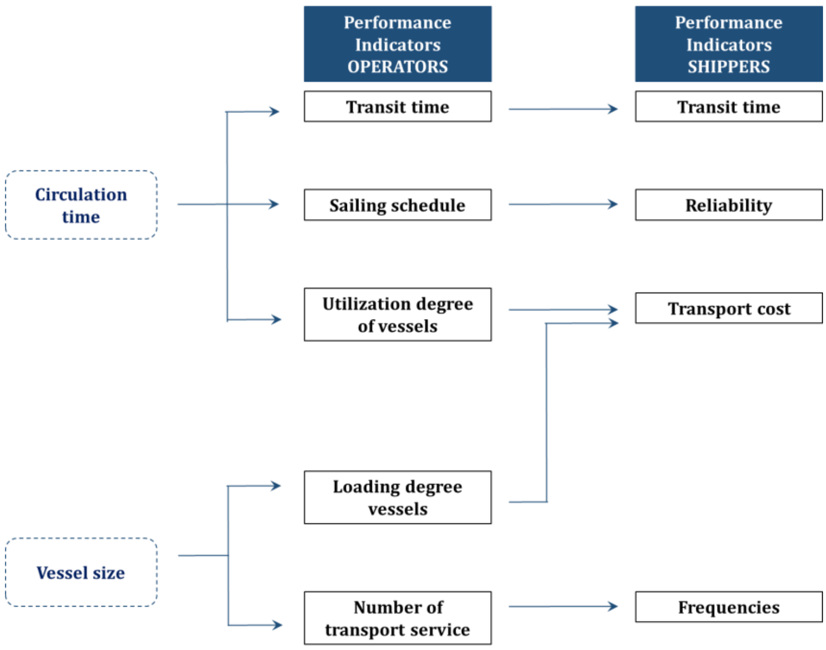

Figure 3.1 Transport attributes as performance indicators in Intermodal Inland Waterways Transportation (IIWT) (Source: Adapted from Konings, 2003)

In **Figure 3.1**, Konings (2003) argues that the transport attributes that are considered necessary by the shippers in perceiving the performance of the operators are transportation time, reliability, transport cost, and frequencies. These four attributes are then interpreted to be used in portraying the collaboration models as follows.

3.2.1 Transport time

This attribute is derived from the circulation time, which based on Konings (2003) includes the sailing time, terminal waiting time, and terminal handling time. In an ideal condition, the transit time experienced by the operators is the total of waiting time and handling time in a terminal. Since in this study two operators are involved, then the transport time is defined as the total of sailing time, waiting time, handling time, and delivery time.

3.2.2 Reliability

In a simple way, reliability is achieved by the constant sailing schedule (Konings, 2003). However, as all barge operators are assumed to have the similar pattern of shipping schedule, this study will add another indicator to define reliability which is a percentage of successful shipment. The successful shipment here is the number of containers sent on time compared to the received demand container.

3.2.3 Transport Cost

Wiegmans & Konings (2013) calculated the transport cost of IIWT by grouping the cost parameter as a fixed cost and variable cost. They explained that the fixed cost is time-related cost and means that the number of business hours as the key factors to assign the fixed costs to the cost price of the service. Meanwhile, variable cost consists of distance-related cost. This classification is presented in **Table 3.3**.

Table 3.3 Assignment of transport cost (Wiegmans & Konings, 2013)

VARIABLE COST	FIXED COST
Distance-related	Time-related
Variable cost/ km: kilometer cost coefficient	Fixed cost/ hours: hour cost coefficient

Moreover, as can be seen in **Figure 3.2**, the transport cost is derived from the utilization and loading degree of the barge operators. The higher the loading degree means, the more profitable it is for the barge operator (see **Figure 3.2**). In another word, it also means that the empty slot in sailing will cause disadvantage and to capture this condition, the transport cost in this study will include the penalty for an empty slot. Furthermore, if we talk about an empty slot, it is also related to the capacity of the operator. Then it can be concluded that transport cost in this study will consider distance-related cost, time-related cost, and penalty cost related to the empty slot.

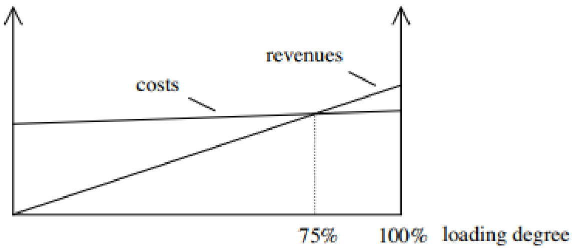

Figure 3.2 The relation of loading degree to cost and revenue of barge operator (Source: Konings, 2003)

3.2.4 Frequency

Each barge operator owns a different number of the vessel which influences the frequency that they can provide. Since this study will take into account a specific case which has an assumption that the barge operator has the same sailing frequency for the chosen Origin-Destination route, this attribute, thus, is not included for the analysis.

To conclude, there are three attributes that will be analyzed further in this study by taking into consideration the previous research which are **cost, transport time, and reliability**.

3.3 Designated Collaboration Models in Containerized Intermodal Inland Waterway Transportation (IIWT) between Port of Rotterdam and Moerdijk Inland Terminal

In the case study of IIWT Rotterdam-Moerdijk, six operators are involved including three barge operators (BO) and three inland terminal operators (ITO). In this study, all of these operators are assumed to have the equal possibility in forming submarket-related. As an adaptation of the result from the literature study explained in **Section 3.1,** three combinations of collaboration models are generated and can be seen in **Table 3.4.**

Table 3.4 Collaboration models for the case study

COLLABORATION CLASSIFICATION	INVOLVED ACTORS	COLLABORATION MODELS
Horizontal	Barge Operators	HBO
	Inland Terminal Operators	HTO
Vertical	Barge and Inland Terminal Operators	V

Based on the submarket classification, three types of collaboration models are generated for the study case. In the horizontal framework, two different collaborations are present, between the barge operators (HBO) and between the inland terminal operator (HTO). Another collaboration model is the vertical form where barge operators (ITOs) decide to collaborate with the inland terminal operators (ITOs).

Moreover, following the finding in the type of collaborations applied to the case study, the utilization of transportation attributes to show the different effect of these collaboration models is required. Cost, transport time, and reality are incorporated into the collaboration models by deriving them into the operational condition of the operators. **Table 3.5** below shows the parameters related to each transport attributes which are used to evaluate the performance level of the involved operators.

Table 3.5 Derivation of transport attributes of IIWT for this study

TRANSPORT ATTRIBUTES	COMPONENTS
COST	Fixed cost (distance dependence) Variable cost (time dependence) Fine (empty slot)
TRANSPORT TIME	Sailing time Waiting time in Inland Terminal Handling time Delivery time
RELIABILITY	Successful delivery Late delivery

As one of the goals of this study is giving the operators the understandable representation of collaboration models, the different effects of each collaboration must be captured clearly. In submarket-related, Mason et al. (2007) discuss that through vertical collaboration the operators involved will gain a cost reduction and improve their performance levels. Meanwhile, by forming a horizontal collaboration, the operators can obtain the better assets utilization assets and hence further can reduce the costs. In the study case, improving the performance levels means increasing the successful container delivery on time. Thus, the vertical collaboration will be portrayed as more effective in reducing the transport time of containers compared to the horizontal form. Besides, as horizontal collaboration more related to asset utilization, it will emphasize the reducing cost from slot optimization both for barge and inland terminal operators. As a result of the learning process based on these studies, the following **Table 3.6** presents the designated collaboration models which are incorporated into the game.

Table 3.6 The designated collaboration models to implement in simulation gaming

<table>
<tr><th>ACTORS</th><th>PARTNERS</th><th>COLLABORATION MODELS</th><th colspan="2">EXPLANATION</th></tr>
<tr><td rowspan="3">BARGE OPERATOR</td><td rowspan="2">BARGE OPERATOR</td><td rowspan="2">Horizontal (HBO)</td><td colspan="2">Consolidated capacity planning</td></tr>
<tr><td>PROS

For provider:
(+) asset utilization
(+) revenue

For renter:
(+) additional shipping capacity
(-) expenditure for fine on the empty slot</td><td>CONS

For renter:
(+) expenditure for empty slot utilization</td></tr>
<tr><td>INLAND TERMINAL OPERATOR</td><td rowspan="2">Vertical (V)</td><td colspan="2">One destination demand</td></tr>
<tr><td></td><td>BARGE OPERATOR</td><td>PROS</td><td>CONS</td></tr>
</table>

ACTORS	PARTNERS	COLLABORATION MODELS	EXPLANATION	
			(++) on time delivery (+++) availability of handling slot (++) revenue from stable container shipping demand (--) expenditure for fine on late delivery	(+++) expenditure for collaboration agreement (--) flexibility on changing the partner
INLAND TERMINAL OPERATOR	INLAND TERMINAL OPERATOR	Horizontal (HTO)	Sharing new yard	
			PROS	**CONS**
			(++) additional handling capacity (--) expenditure for fine on late delivery	(++) expenditure for collaboration agreement (-) flexibility on changing the partner

(-) **Level of reduction**

(+) **Level of increase**

Learning from Caris et al. (2014), in this study, a *horizontal collaboration* between barge operators (BOs) is designed in the form of consolidated capacity planning. Barge operator (BO) who has an empty slot can share its capacity to the other barge operators (BOs) in need whose destination is the same. By deploying this approach, the barge utilization will increase while the environmental cost for the empty slot can be reduced. This environmental cost in the simulation game is represented by a fine. However, for the barge operator (BO) in need of more slot, they have to spend higher expenditure to rent.

The *horizontal collaboration* between the inland terminal operators (ITOs) is designed as sharing a new yard where they can gain an additional handling capacity. This form has been adopted from practical evidence in the market where the several inland terminal operators (ITOs) in Moerdijk Inland Terminal have applied this collaboration model. The additional handling capacity of the inland terminal operators (ITOs) will help them to serve more barge operators (BOs) which then generate the higher income. As this collaboration model is normally formed for a longer period compared to the sharing capacity of the barge operators, the involved inland terminal operators require to spend more investment in forming an agreement with the partner. Also, a bit different from the collaboration between barge operators (BOs), the inland terminal operators (ITOs) have less flexibility to change a partner due to its longer period.

Lastly, for the *vertical collaboration* between barge operators (BOs) and inland terminal operators (ITOs), the barge operators (BOs) will only sail to one inland terminal. This form of collaboration is adopted from the assumption that the *integration of operational planning* that is suggested by Caris et al. (2014) is done specifically only by two operators. With this operational system, the barge operators (BOs) get a guaranteed handling capacity where the inland terminal operators (ITOs) will prioritize them in their handling process which can raise the successful delivery of containers. In this collaboration model, the barge operators (BOs) can match their sailing schedules with the availability of handling capacity of inland terminal operators (ITOs) who still receive the shipment from other barge operators. However, this collaboration model is not easy to form due to the high investment that should be spent by both operators and enough reliability level to ensure the partner that their performances together can generate more efficient process. Moreover, the negative side of this collaboration model is once the partners are chosen, there is a high difficulty to change them. It is because this collaboration is designed to apply for a very long period.

4
DEVELOPMENT OF RESEARCH TOOL

Two different methods are used in this study to accomplish the research goal including literature study and simulation gaming. A literature study is required to provide extensive learning material before translating the study case into a gaming simulation. As the main tool to analyze the problem in Intermodal Inland Waterway Transportation (IIWT), a simulation gaming requires a clear problem definition and theoretical background to represent the real condition appropriately. These needs can be answered by conducting a systematical literature study which is used by the author to discover related information from previous studies. Furthermore, a questionnaire is prepared to collect the idea from the game participants. It is a part of de-briefing step included in the game designing which will be explained in more detail in the following sections.

How the literature study is arranged is presented in **Section 4.1**. Then it will be followed by the detail explanation of the reasons why simulation gaming is the most suitable research method for this study in **Section 4.2**. And in **Section 4.3** as the last section, the details of how to conduct a simulation gaming will be elaborated.

4.1 Arrangement of Literature Study

The necessity of the literature study for academic purposes has been explained clearly by Hart (1999). According to Bruce (2001), there are purposes for the literature study in a thesis: a) it acts as a source for students on their particular subject matter, b) it stands as a testament to the student's rigorous research dedication, c) it helps in finding the future research (including the thesis itself), and it introduces the student to scholarly tradition and etiquette. Finding the scientific reports, papers, and articles as the sources for conducting a literature study is done by a repository search. For this study, the sites of ScienceDirect and Google Scholar are used to track down the topics required. While other sources are also used such as a governmental report, dissertation, thesis, and information from an official site. To conduct a well-structured literature study, this study makes a segmentation of the topics into two major discussions. First, it is related to Intermodal Inland Waterway Transportation. Within the IIWT topic, the literature is segmented based on the required sub-topics, for instance, the definition and recent development of IIWT, submarket, and actors, etc. Second, the literature is grouped in Simulation Gaming topic and segmented as well. By using this segmentation, each related category of knowledge can be analyzed thoroughly which in the end can provide a sturdy background for the whole literature study. Also, the segmentation is arranged systematically to lessen the time spent on the process of repository search. **Table 4.1** shows the segmentation of the literature study that has been done in this study.

Table 4.1 Segmentation of literature study

TOPIC	SEGMENTATION	CATEGORIES
Intermodal Inland Waterway Transportation	IIWT recent development	Geography Actors Commodities
	Submarkets	Shipper Barge operator Inland terminal
	Collaboration models	Organizational Level Integration Level Submarket
	Transport attributes	Stated preference Statistical analysis
Simulation Gaming	Transportation-related Simulation Gaming	Related to IIWT Non-related to IIWT
	Designing Simulation Gaming	Triadic Game Design

The segmentation of the literature study is arranged as shown in **Table 4.1** with the objective to cover the two main topics of knowledge. First is about the system where this study lies upon, and second, the method to analyze the problem in the system.

In the topic related to IIWT, this study intends to start the literature study by scoping the problem. It is done by learning from the recent development of IIWT's real market. It is followed by a study concerning the detail components required for the analysis using simulation gaming, including the existing submarkets in IIWT, the collaboration models as one of the solutions for the problem in IIWT, and how to use the transport attributes to present the effect of the collaboration. For the segmentation of topic related to simulation gaming, it starts by learning from the previous studies about the utilization of simulation gaming as a research method. Different research field has different detail on using simulation gaming, and a clear differentiation between transportation-related and no transportation-related is required. The theoretical background that explains the detail steps in designing the game is presented as the last segmentation.

4.2 Comparison of Potential Research Tools in Operational Research

The collaboration models which are presented in **Chapter 3**, are assumed to affect the performance level of operators in IIWT. This study aims to provide the involved actors the understanding of these effects and further can help them in deciding to develop their collaboration models. Bradley, Hax, & Magnanti (1977) characterize the use of models in providing guidelines to decision makers for conducting effective decisions within the current knowledge, or in finding further information if current knowledge is insufficient to reach a proper decision as *operational research*. This study is considered as part of operational research due to its objective that related to the decision making of transportation operator to increase their performance levels. To be more specific, the performance level in this study is described only in the operational scope. Therefore, the research tools that are suitable for the operational research at some point is potential as well to be used in this study.

Bradley et al. (1977) added that the operational research has three essences. First is the *model-building approach*. Models are built to portray the situation in the real world, should be simple to understand, and easy to use. Along with this simplification, models have to keep representing the complete and realistic condition of the decision environment. Substantial elements which characterize the real problem within the system must be incorporated on the model as well. Second is the *model-design effort*. This essence is related to the aim of the models in increasing the understanding of decision-makers about the consequences of their actions. Models are expected to show effectively the effect of any considered relationship that might be present and explicitly evaluate the consequences. And the last essence is the *complexity of the decision* under the study. The knowledge or information needed by the decision makers should be well-provided by the models. Thus the decision makers can decide to take the actions required.

Based on the degree of realism for the representation of the real operational problem, Bradley et al. (1977) categorized the tools for the operational research into four types: 1) operational exercise; 2) simulation gaming; 3) simulation and 4) analytical model. However, Hsu (1989) and Feinstein et al., (2002) consider the simulation gaming along with computer simulation and role-playing as part of the simulation. Also, a hybrid between simulation and analytical model emerges as explained in papers by Byrne & Bakir (1999); Byrne & Hossain (2005), and Ko et al., (2006). It covers not only the combination between computer simulation and analytical model but also between simulation gaming and analytical model. This study incorporates the ideas from these previous papers and classifies the potential research tools into 1) operational exercise; 2) simulation; 3) analytical development; and 4) hybrid method. These are shown more clearly in **Figure 4.1**.

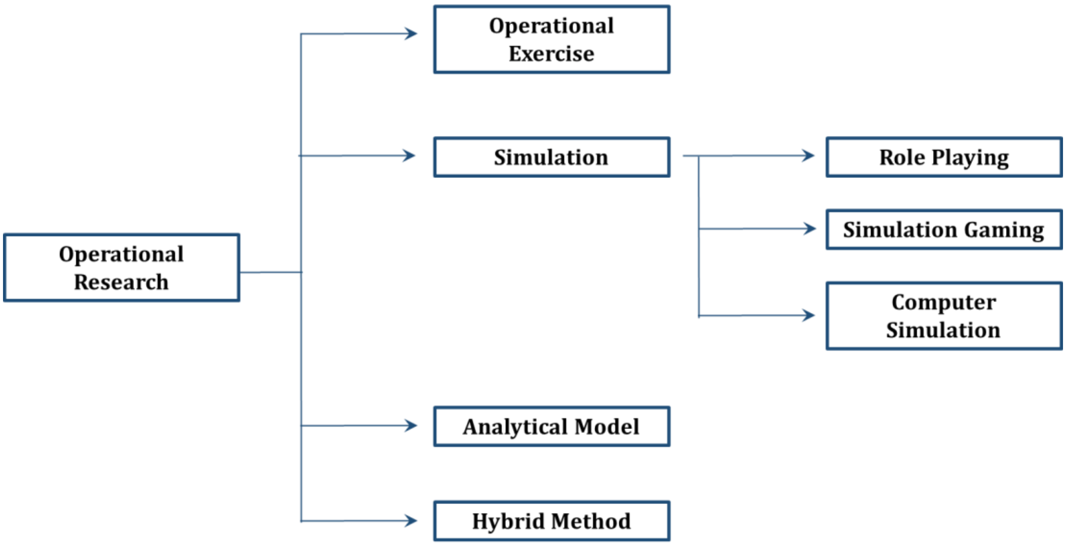

Figure 4.1 Derivation of potential research tools in Operational Research topics (Source: Adapted from Bradley et al., 1977; Hsu, 1989; and Feinstein et al., 2002).

However, from the derivation shown in **Figure 4.1**, the role playing will not be discussed further as it is considered not suitable for this study. Curtis (2000) argued that this method can be used only for solving the problem related to the internal communication of a company, which is not applied to this study.

4.2.1 Explanation of Operational Exercise as Research Tool

In the classification from Bradley et al. (1997), the first research tool implements the experiments directly to the real environment where the decision is taking place. The example of its implementation is when the barge operators would like to determine the combination of vessel size that they own for shipping the containers that can satisfy the demand and profitable for the operators. If these operators were to conduct an operational exercise to support the decision, they would try different quantities of several combinations of vessel size directly in the operational market. After several trials, they would begin to develop the understanding of the relationship between the vessel size combination and the revenue gained from it, which would give them insight into finding the appropriate combination. The result of the trial is usually further analyzed properly with statistical and optimization methods.

From the perspective of Bradley et al. (1977), the operational exercises can provide the highest degree of realism because the simplifications are hardly introduced. However, this tool is exceedingly expensive, quite impossible, and exhausting to analyze all pre-defined alternatives of condition to the real environment. It is mostly used in the old period where the simplification of the operational condition is not well developed yet. The implementation of this research tool is slowly left by the actors due to its economic inefficiency and high complexity.

4.2.2 Explanation of Simulation as Research Tool

A. Simulation Gaming

Lukosch, Bekebrede, Kurapati, & Lukosch (2018) have developed the definition of simulation gaming based on study from Mayer (2009) and describe it as "experimental, rule-based, interactive environments, where players learn by taking actions and by experiencing their effects through feedback mechanisms that are deliberately built into and around the game". The complexity of multiple actors involved who have different values means and resources can be well-represented in the simulation gaming either in a physical simulation or virtual reality (Bekebrede, 2010; Klabbers, 2006). Moreover, the human interactions that influence the decision environment are allowed to take part actively in the game. These interactions usually provide the realization of their activities (Bradley et al., 1977). If the previous example is analyzed using simulation gaming, the operational condition of vessel operators would be represented in such a way, by using symbology, scenario, cycle sequence, roles, rules, etc. to keep the game as close as possible to the reality (Duke, 1980).

Furthermore, as stated by Bradley et al. (1977), the degree of realism in this research tool is less than the operational exercise since the performance test is conducted in an abstract environment, but the human interactions in the real process are retained. Also, the processing cost for implementing each pre-defined conditions will be reduced, and it can increase the speed of performance measurement of each condition.

B. Computer Simulation

Quite similar to simulation gaming, the characteristics of a particular environment are replicated through the use of mathematics or simple objective representation Feinstein et al., (2002). However, all human decision-makers are removed. To evaluate the performance in different conditions, the decision makers supplied the pre-defined conditions externally to the models (Bradley et al., 1997). If the previous example is done by simulation, then the form of computer program, where a pre-arranged logical arithmetic operations are performed in a sequence, would be built to gain the profit associated with each pre-defined conditions without the external inputs from the decision-makers. The program is kept running until it is decided that it has reached a proper representation and understanding of the problem.

A highlight of this tool, as well as operational exercises and gaming, is that the models are inductive and empirical which are used to evaluate the performance only for identified pre-defined conditions of decision-maker (Bradley et a., 2007).

4.2.3 Explanation of Analytical Model as Research Tool

Choi (2016) describes the analytical model as a theoretical construct expressed in mathematics, which is usually a simplified framework (compared to the real-world scenario), to demonstrate the complex processes. This tool represents the real problem completely in mathematical terms, by using objective to maximize or either minimize and constraints that characterize the conditions under each type of decision. The optimal solution would result from the computation, which can satisfy all the constraints and generates the best possible value of the objective function (Bradley et al. 2007).

Bradley et al. (2007) add that analytical models compared to the other research tools are considered as the least expensive and easiest model to develop. However, the level of simplification in this model is the highest than the previous research tools. To decide which research tool is the best for a specific case, there should be a consideration related to the aim of the study, either to involve more on human-decision or not at all.

4.2.4 Explanation of Hybrid Method as Research Tool

Hybrid simulation-analytic modeling is defined as ‘‘building independent analytic and simulation models of the total system, developing their solution procedures, and using their solution procedures together for problem solving in which hybrid modeling occurs through using the solution procedures together’’ by either sequential or iterative use of the solution procedures (Shanthikumar & Sargent, 1983). Suyabatmaz, Altekin, & Sahin (2014) stated that the hybrid simulation-analytical modeling is a suitable framework that can incorporate the uncertainties to the mathematical representation in the analytical model. The application of this hybrid model between the analytical model and simulation gaming is done by Rivera (2018). He designed the anticipatory freight scheduling in mathematical equations then incorporate them to a simulation gaming to give a more interactive representation of trade-offs between parameter involved to the participants.

In conclusion, the different characteristic of these four research tools can be seen in the following **Table 4.2**.

Table 4.2 Characteristic of potential research tools to analyze the operational research

RESEARCH TOOLS	PROS	CONS
1. Operational Exercises	*Bradley et al. (2007)* 1) Operate directly in the real environment. 2) Has the highest degree of realism.	*Bradley et al. (2007)* 1) Highly expensive to implement. 2) Quite exhausting in analyzing the various pre-defined conditions.
2. Simulation		

RESEARCH TOOLS	PROS	CONS
2.1 Simulation Gaming	*Bekebrede (2010); Bradley et al. (2007); Klabbers (2006)* 1) Simplify the real environment but represents it as close as possible. 2) Easy to understand. 3) Facilitate the involvement of human interaction with the system. 4) Different values, means, and resources from the real environment can be well-represented	*Harteveld (2011); Bradley et al. (2007)* 1) The involvement of the human decision might generate complexity. 2) Only useful for assessing the conditions that are pre-defined beforehand but neglect the conditions that develop during the system is running. 3) Requirements to present the model in such a fun way is quite challenging.
2.2 Computer Simulation	*Bradley et al. (2007); Feinstein et al., (2002)* 1) Simplify the real environment similar to the gaming. 2) The complexity of human interaction does not exist. 3) Pre-defined conditions are put externally to the system.	*Bradley et al. (2007); Feinstein et al., (2002)* 1) Does not facilitate the involvement of human interaction to the system 2) Only useful for assessing the conditions that are pre-defined beforehand but neglect the conditions that develop during the system is running.
3. Analytical Model	*Choi (2016); Bradley et al. (2007)* 1) The model can compute the optimal condition of each problem related to operational research. 2) Least expensive. 3) Easier to develop.	*Choi (2016); Bradley et al. (2007)* 1) Heavy of mathematical equations that might be difficult to understand 2) No involvement of human interaction at all.
4. Hybrid Model	*Suyabatmaz, Altekin, & Sahin (2014); Shanthikumar & Sargent, (1983)* 1) Considered as an advanced method to study the operational research topic. 2) Can incorporate the uncertainties from human decision into a computer simulation, through the use of simulation gaming.	*Suyabatmaz, Altekin, & Sahin (2014); Shanthikumar & Sargent, (1983)* 1) Still not widely used. 2) Time-consuming since it combines two processes of research method.

From these four potential research tools, simulation gaming is considered as the suitable one for this study for several reasons. First, since this study aims to analyze the interaction between the operators (decision makers) within the collaboration models in IIWT, the research tool should facilitate the human interaction in the model. Second, as we know that for an operational system, there are two separated complexity: system and process complexity (van Riel, Post, Langeveld, Herder, & Clemens, 2017). System complexity is related to the interactions between physical infrastructure and the environment. Meanwhile, process complexity refers to the many interactions between the involved actors and their interest. The collaboration models in IIWT includes both these complexities in its system. Van Riel et al. (2017) argued that only gaming simulation that can incorporate both types of complexity by presenting the model that simplifies the real environment and facilitates any kind of human interaction during the game. Thus, from the perspective of complexity representation, gaming simulation still fit for this study. However, the hybrid model can also be implemented, but due to limited time in conducting this study, incorporation of an analytical model to the simulation gaming will be as an option for future development.

4.3 Conducting a Simulation Gaming for Intermodal Inland Waterway Transportation (IIWT)

Before implementing a simulation gaming to this study, reflection on how far this tool has been used in the transportation field can be found in **Section 4.3.1**. This section is then followed by the explanation of detail elements required for designing the game based on Triadic Game Design (TGD) in **Section 4.3.2**.

4.3.1 Previous Implementation of Simulation Gaming in Transportation Field

The application of simulation gaming in transportation problems is not new and has been reviewed by Raghotama & Meijer (2014). They argue that simulation gaming is suitable for transportation analysis because it can accommodate the questions regarding individual decision making, the interaction of individuals, and the behavior of organizations across institutional levels. Furthermore, according to Raghotama & Meijer, simulation gaming in transportation domain is distinguished into three categories. The majority of the simulation gaming is for business purpose, with the goal being building and managing transportation networks and companies of different modes. The second category is game for realistic simulation, commonly flight or driving simulation. The third one is city building games in virtual environments. This study, hence, falls into the first category. Some research has conducted the first type of simulation gaming, including studies by Lardinois (1989); Reckien & Eisenack (2010); Watcharasukarn, Krumdieck, Green, & Dantas (2011); Meijer, Mayer, van Luipen, & Weitenberg (2012); Kurapati, Lukosch, Verbraeck, & Brazier (2015); Kurapati, Kourounioti, Lukosch, Tavaszzy, Verbraeck, & van Veen (2017); and Kurapati, Kourounioti, Lukosch, Tavasszy, & Verbraeck (2018).

The game built by Lardinois in 1989 focuses on passenger transportation by representing the competitive multi-company in intercity passenger-transportation. Meijer et al. (2012) and Kurapati et al. (2017) focus on the operational condition of the rail industry with the case studies in the Dutch railway company, ProRail. Important to be noted, the games that are designed by Meijer et al. (2012) and Kurapati et al. (2017) represent only one type of transportation mode.

Meanwhile, the simulation gaming that adopted the utilization of different transportation modes, both intermodality, and synchromodality, are provided by Kurapati et al. (2015) and Kurapati et al. (2018) respectively. In the first study, the paper presented a simulation gaming to test several scenarios that can affect the resilience level of a container terminal. The latter one, the game is used to check the sustainability level of the synchromodality corridor and how the involved stakeholders react to this concept. Other simulation gaming designs are Reckien & Eisenack (2010) and Watcharasukarn et al. (2011). They make a virtual transportation environment with the pre-defined condition. They put their main objective to measure the behavior, the preference, and interdependencies between roles in their pre-defined virtual environments.

4.3.2 Game Designing with Triadic Game Design

A structural theory on how designing the game is based on two approaches presented by Duke & Geurts (2004) and Harteveld (2011). The significant difference between these approaches lies on how the steps should be taken during the game designing. Duke & Geurts (2004) state that to design a game, there are five sequential phases: 1) Setting the stage for the project; 2) Clarifying the problem; 3) Designing the game; 4) Developing the game; 5) Deployment. In this approach, it is assumed that the designers cannot do two steps at the same time because the earlier steps should be done first before moving on to the next steps. Harteveld (2011) argues that several complex problems are quite difficult to be entirely known upfront as well as the changes in the system. He proposed that in designing a game, an iterative approach is more suitable which then is called Triadic Game Design (TGD) where it suggests to progressively develop a game based on a cyclic process of prototyping, testing, and evaluating the results. This study implements this approach to be able in capturing the complexity of Intermodal Inland Waterway Transportation and have agility on the changes of the system.

In TGD, three important elements are involved which are "Reality", "Meaning", and "Play". The idea of this approach is designing the concurrently by taking into account all these three worlds (Harteveld, 2011). Each of the worlds has several *criteria, aspects, people*, and *disciplines* which cannot be thought of separately (see **Figure 4.2 (left)**). The need for concurrent design also follows logically from the idea that games are systems (Fullerton et al. 2008; Salen and Zimmerman 2004). Harteveld (2011) also presents that the interdependency between these three elements shows that all of them are equally important and therefore, will be incorporated in designing the game for the case study. However, in the following section, only the criteria of each world are explained which then will be used to evaluate the simulation game in **Chapter 6.**

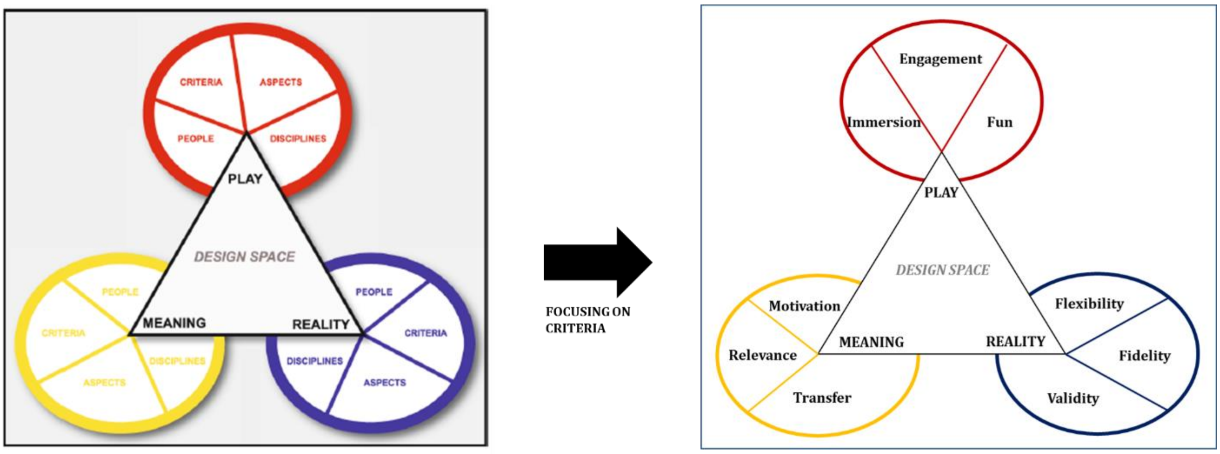

Figure 4.2 (left) The design space of Triadic Game Design, (right) the elements of "criteria" for each designing world. (Source: Harteveld, 2011)

A. Reality

A simulation game should relate to a real world in some way (Harteveld, 2011). The correlation between a game and reality suggests that a game is a representation (or parts) of reality (Peters et al. 1998) and can be called as a *model of reality*. Three components of reality should be taken into account: 1) the involved actors; 2) the system, and 3) the relationships. The importance of the first and the second components are apparent but might be not for the third one. Harteveld (2011) explained that by drawing the relationship between *who or what to involve*, can retrieve the real-world situation. It helps to illustrate the systematic overview of reality into the game properly. In TGD, criteria for evaluating the "reality" aspect are "flexibility," "fidelity," and "validity."

1) Flexibility

It is understandable that during the initial design, the designers of a game might not be able to include and consider everything in the system of the real world at the same time. The system can be established over time while the outdated version of the game can be updated. The real world is also very dynamic. Thus, the game should be able to be changed for future developments or extra features (Harteveld, 2011).

2) Fidelity

This criterion is defined as the degree of realism that presented by the game (Harteveld, 2011). According to Hays & Singer (1989), the degree of realism can be measured in two dimensions: a) the physical characteristics, for example visual, spatial, kinesthetic, etc.; and b) the functional characteristics, for example the informational, stimulus, and response options of the training situation (Feinstein & Cannon 2001).

3) Validity

Harteveld (2011) based on Raser (1969) defines validity as "the extent that investigation of that model provides the same outcomes as would investigation in the reference system." It means if we put input in the game, it will be processed as close as possible to the way it will be processed in the real world. Validity is closely related to fidelity, but fidelity highlights more about the similarity in the look and feel of the game (Harteveld, 2011).

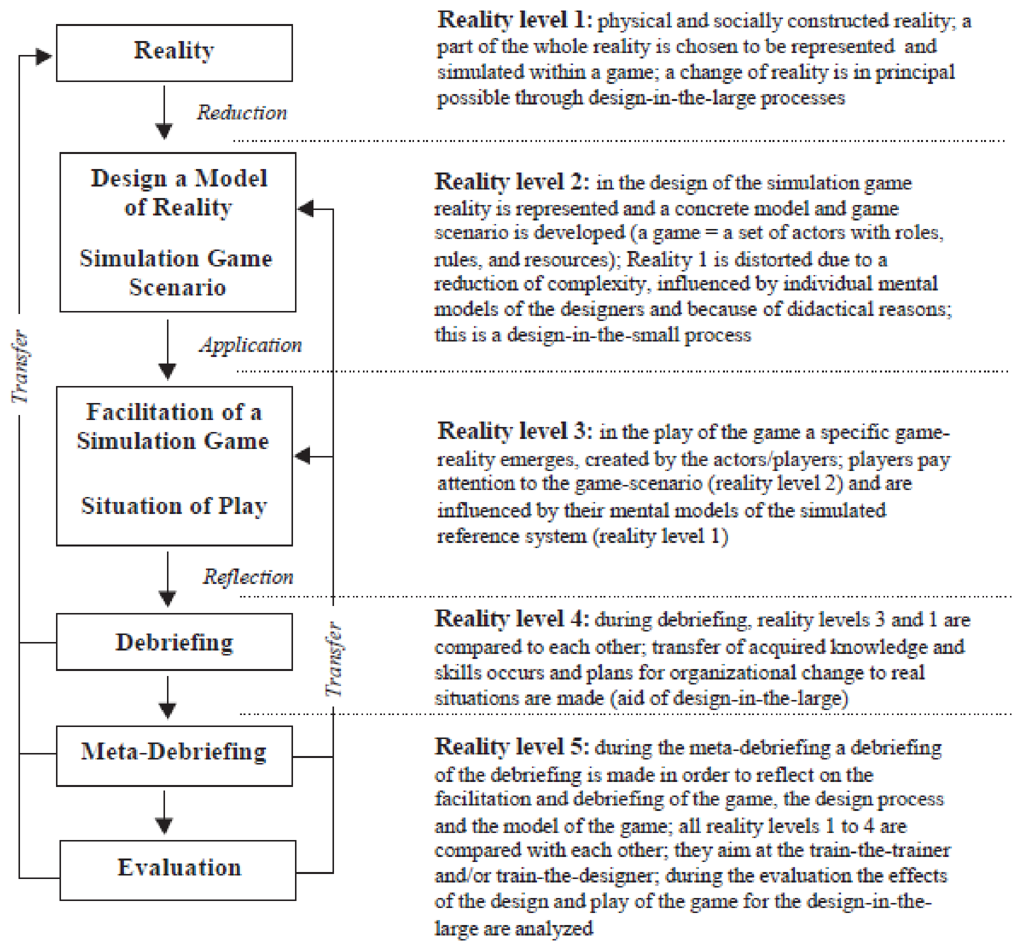

Figure 4.3 Linking the reality to the simulation gaming (Source: Kriz, 2003).

Moreover, a study by Kriz (2003) explains how to translate the reality into the simulation gaming which is shown in **Figure 4.3**. This study will only incorporate these five reality levels to create a game (Reality Level 3) that can portray the reality (Reality Level 1) as close as possible. Debriefing will be done by arranging a discussion after the game session. Furthermore, the evaluation of the game is conducted by giving the game participants an online questionnaire in which the result is discussed in **Section 6.1** and can be seen in more detail in **Appendix D**.

B. Meaning

The second element of TGD is the meaning of the game. Each game is designed by the problem owners with a particular purpose. This problem owners want to use the game as a medium to transfer the value to the players. Harteveld (2011) added that a plan of actions should be planned to ensure that the purpose is appropriately incorporated into the game. These planned actions are called a strategy which creates a unique mechanism in the game. There are three criteria to evaluate the meaning of the game as explained by Harteveld (2011):

1) Motivation

It is related to the willingness of the players spending their time and energy to involve in the game. In the end, the game should encourage the players not only to play the game as it is but also to be enthusiastic in learning the topic offered by the game.

2) Relevance

A relevant game means that it accomplishes its purpose. Harteveld (2011) argues that it is necessary to check the pertinence, connection, and the applicability of the game to its original purpose while measuring the relevance level of the game.

3) Transfer

The principle of "transfer" is the learning process of individuals in one environment and then apply what they got from there to another environment which are sharing similar characteristics. This means that an ideal transfer is one where the input (what is learned in the learning environment) is more or the less the same as the output (what is applied in the other environment) (Harteveld, 2011).

C. Play

The last element of TGD is Play. Designing the game should consider the experience of the players towards the game. A game might be able to represent the real world (Reality) and fulfill its purposes (Meaning) but unfortunately is not interesting enough or comfortable enough to be played by the players. The main idea of this element involves the point of view of the players as one of the inputs of game design. Harteveld (2011) shows that this element consists of three criteria: a) engagement; b) immersion; and c) fun.

1) Engagement

In TGD, the engagement means the connection between the players and the game. A human being is a curious nature who, at most of the time, play a game because it intrigues them. An interesting game can generate the willingness and commitment from the players to keep playing the game even though they do not like the subject matter behind the game

(Harteveld, 2011). A theory related to the engagement level of participants in general topics is presented by Csikszentmihalyi's (1991) and called the theory of flow. It describes that when people engage in an activity, they can get into a steady "flow" where they will keep engaged in the activity. To reach and stay in such a condition, Csikszentmihalyi (1991) states that:

"..optimal experience requires a balance between the challenge perceived in a given situation and the skills a person brings to it. To remain in flow, one must increase the complexity of the activity by developing new skills and taking on new challenges. Flow forces people to stretch themselves, to always take on another challenge, to improve on their abilities." (p. 30)

Figure 4.4 shows the illustration of Csikszentmihalyi's theory of flow.

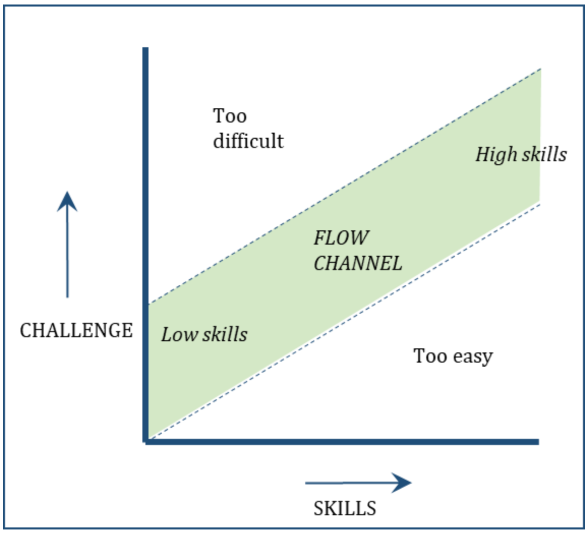

Figure 4.4 The theory of flow
(Source: Adapted from Csikszentmihalyi, 1991).

2) Immersion

The effect of this criteria will make sense of timelessness to the players during the gaming session (Harteveld, 2011). Different studies defined this element differently, but in TGD, it lies on the idea of (Witmer & Singer, 1998). They describe it as the state where the players believe that the fictional environment of the game surrounding them is real. To differentiate immersion from engagement, Harteveld (2011) stated that when players play the game and start getting involved, it is called engagement. Meanwhile, if the players start to dive into the game and their senses start to involve to the other world which is represented in the game, it is called immersion.

3) Fun

Lazzaro (2008) consider fun as an emotion. It is a response, a reaction to something and in this context, this something concerns the playing of a game. Not all researchers think that "fun" element is significantly important for the simulation gaming regarding its serious purposes. However, Harteveld (2011) in his TGD thought that fun is related to the other two elements of "Play." The players can experience the engagement and immersion throughout the whole gaming session, while fun experiences might only be found on a particular occasion such as defeating the competitors, etc.

As a conclusion of this section, the theoretical explanation of Triadic Game Design as shown previously will be implemented for designing the game for the case study in **Chapter 5** and further will be used to evaluate the game in **Chapter 6**.

5
GAME DESIGN PROCESS

In this chapter, the process of designing the game and the arrangement of a gaming session are presented. As previously explained, the game is designed based on Triadic Game Design (TGD) which incorporates the iteration phase. For this study, the result of the iteration process is shown by three game versions. The development of each game version is detailly explained in **Section 5.1**. Each game version is created with regards to the feedback from the gaming session which is discussed in **Section 5.2**. The structure of how the gaming sessions are conducted also can be found in **Section 5.2**.

5.1 Game Design

During the design process, the game design is started with the conceptual design. The main target of the conceptual design is translating the real world to the gaming world by taking into account the scope of the involved actors and the transportation process. The conceptual design of the game takes a role as the blueprint which is then developed into the detail design. Three game versions as mentioned earlier are included in the detail design. The elements of conceptual design and detail design are discussed in more detail in **Section 5.1.1** and **5.1.2** respectively.

5.1.1 Conceptual Design

A. Objectives of the Game

In this study, as mentioned in **Section 3.3**, the game should show the difference between potential collaboration models with regards to transport attributes. These applied collaboration models will act as examples for the actors, give them the insight on how they perceive the different collaboration models, and in the end help them to form their preferable collaboration model that is suitable for their operational conditions.

In **Chapter 4**, it has been explained that three aspects of gaming simulation are included: Reality, Meaning, and Playability which are adopted for this study as follow.

a) The Reality

The game should represent the system of Intermodal Inland Waterway Transportation, which is discussed in **Chapter 3**. It is important that the game flow simulates the daily operational activities of each role along with the problems they experience in real life. The sequence in the game might be accelerated compared to the reality to provide the players a chance to understand the real long-term problems in shorter time-period during the game.

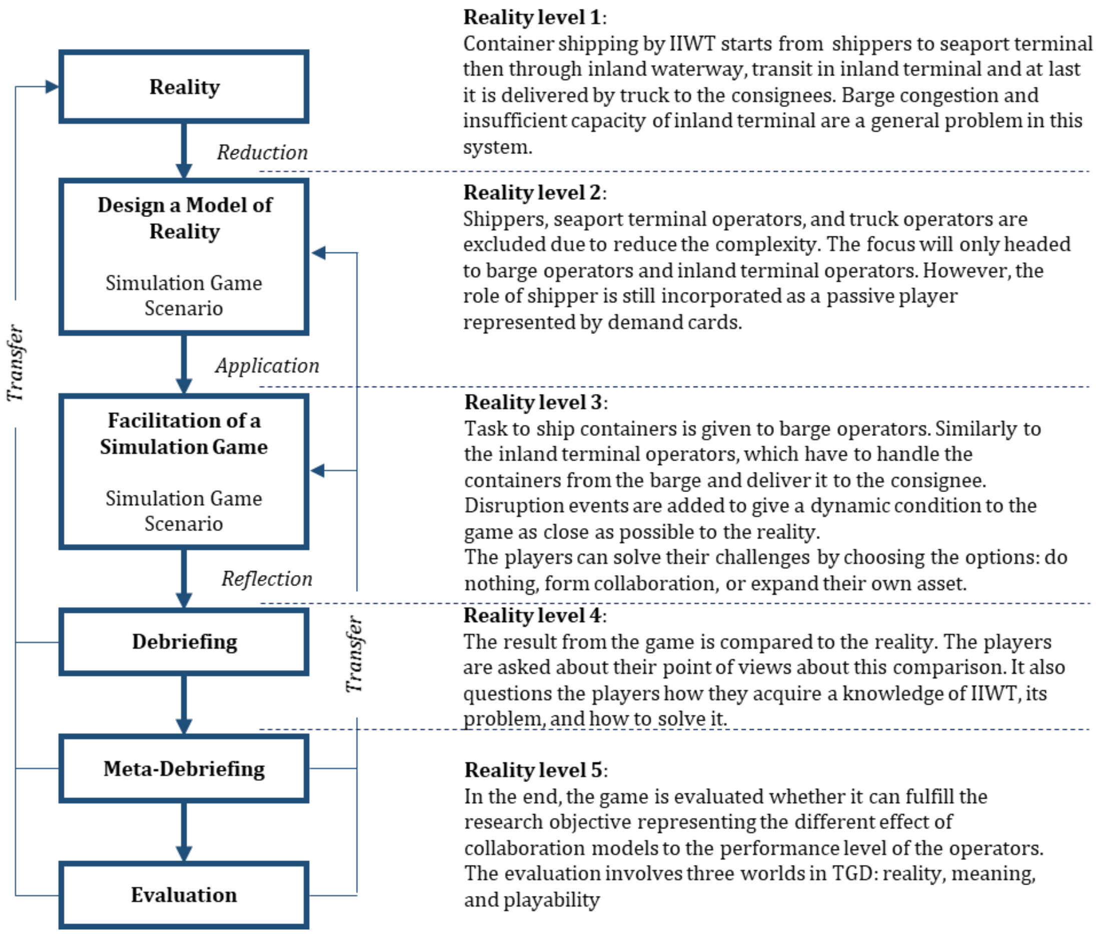

Figure 5.1 The application of reality level by Kriz (2003) for this study.

Based on the reality level from Kriz (2003), this study applies the reality translation as shown in **Figure 5.1**. From **Reality Level 1** to **Reality Level 2**, a reduction of actors is made with the exclusion of seaport terminal operators and truck operators. Meanwhile, the role of the shippers is incorporated as a passive player. From **Reality Level 2** to **Reality Level 3**, the shipment task is assigned for barge operators (BOs) along with the handling task for the inland terminal operators (ITOs). Different decisions will be found on **Reality Level 3** as it strongly depends on the performance level of the operators. Three options for each operator are available including do nothing, expand their own asset, and form collaboration. The result from **Reality Level 3** is then reflected **Reality Level 4** during the debriefing process. On this reality level, the players can express their perspectives regarding what happened in the **Reality Level 3** and connect it to the **Reality Level 1**. And the last one, on **Reality Level 5,** the game designer analyzes and evaluates how the **Reality Level 1, 2, 3,** and **4** are connected to each other.

b) The Meaning

In this game, the meaning is to show the effect of implementing different collaboration models on the operational performances. The players should understand the advantages and disadvantages of forming different collaboration models. This is shown by the improvement level of the operational performance by the implementation of horizontal and vertical collaborations. The game, therefore, includes the existing problems that are caused by no collaboration condition, portrays the effects on different players, and shows the positive and negative effects of collaborating with other players in the different submarket.

c) The Playability

Concurrently, the game is designed to be fun and interesting for the players. Along with the given task, the players receive the disruption events to increase the challenge level. The inclusion of these events is assumed to make a closer representation of the real world which can provide a more interesting experience to the players.

B. The Roles

Barge operators (BOs) are considered as the most crucial actor in the operational role of IIWT system because they are the ones who provide the shipping service by utilizing the inland waterway network. Their daily activities are receiving the shipping demands from the shippers and must send it to the destined location in the required schedule. Meanwhile, the other included actor is the inland terminal operators (ITOs). They have a task to handle the container after the barge arrives, put it in the container yard, and arrange the delivery schedule to the consignee by truck. The trucking company, however, is chosen to be not included in the game with the assumption that their presences are not compulsory at the core of IIWT system.

The sender (shipper) and the receiver (consignee) of the container are actors who own important role in the IIWT system as the generator of shipping demands. Their preferences of transport operators directly influence the market condition of IIWT. However, they are not directly involved in the transportation process and is designed as a passive player with pre-defined shipping demand. Also, other parties such as port official, bank, and government official are played passively by the game master without an active decision because they do not have a direct influence on the operational system of IIWT.

To conclude, from the involved actors in IIWT presented in **Figure 2.5**, only two actors are included in the game with the consideration of the level of complexity. These two actors are barge operators (BOs) and inland terminal operators (ITOs). The following

Figure 5.2 how the simulation gaming for this study incorporates the involved actors of IIWT.

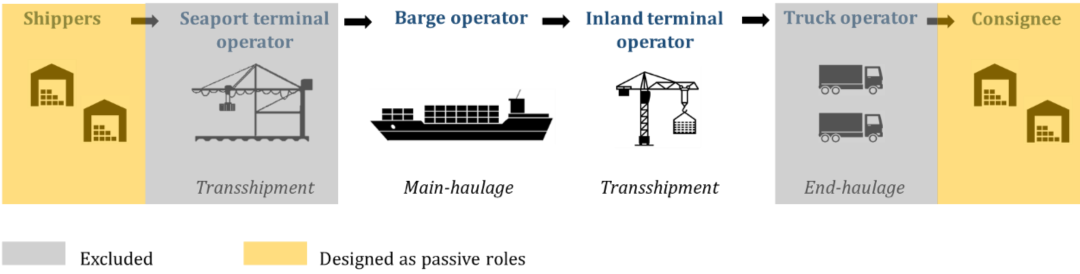

Figure 5.2 The involved actors of IIWT which are incorporated as roles in the simulation gaming.

The barge operators (BOs) and inland terminal operators (ITOs) are considered the key actors in the operational system of the third type Intermodal Inland Waterways Transportation (see **Figure 2.1**). The seaport operator and truck operator are neglected in this study to reduce the sequential steps for the container shipping without reducing the learning objective of collaboration. These actors are possible to be involved in the future for the extended version of the game. Meanwhile, the shippers and consignees are designed as the passive roles because during the operational system, their active involvements are not significantly required. Giving them a passive role also helps in reducing the complexity of the game.

C. The Flow of the Game

As close as possible to the reality, this game will start with the demand of freight shipping. The shipper is replaced by the demand cards which are varied in volume (TEUs) and a deadline of delivery time (days). These demands are received by barge operators who then ship it to the inland terminal. Time to sail from the location of barge operators which is in this case study is Port of Rotterdam, to the inland terminals in Moerdijk is assumed approximately one day. The inland terminal handles the containers from the barge with regards to their capacities. Each barge operator and inland terminal operator is assumed to have similar capacities but through the days in the game, they can manage their capacities by choosing the option to collaborate or expand their own assets. The flow of the conceptual design of the game can be seen in **Figure 5.3**.

In the conceptual design as presented in **Figure 5.3**, there are two decision points (shown by decision symbol). The first decision point is designed for the barge operator (BO), and the second one is for the inland terminal operator (ITO). These decision points are crucial since it will generate a successful or late/ failed delivery. During the development of the game versions, these decisions points are added adopt the real condition. Each game version is explained further in the following sections.

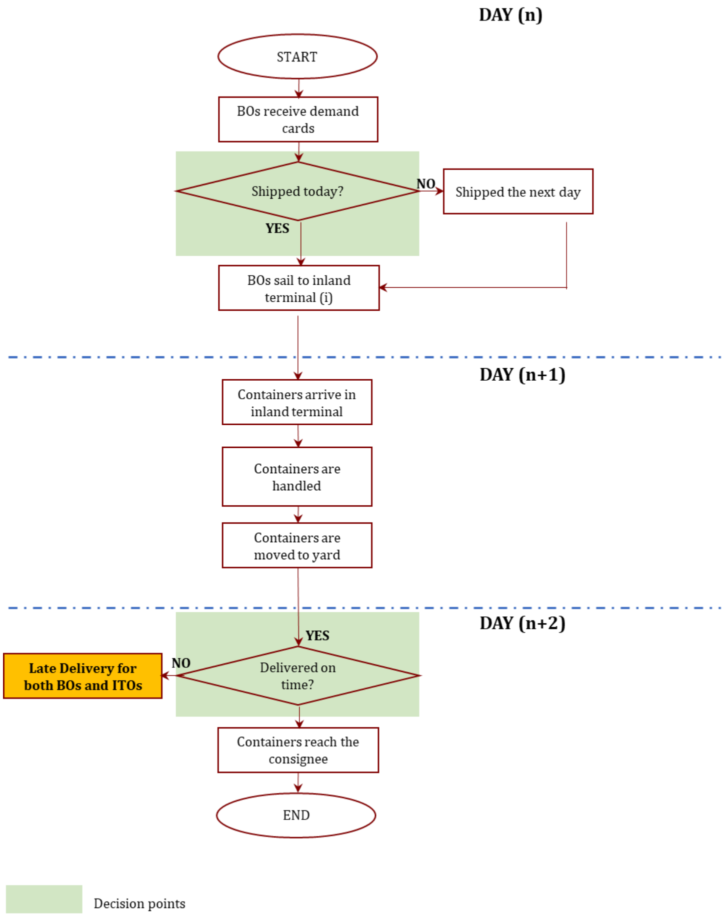

Figure 5.3 The flow of Conceptual Design of the game.

5.1.2 Detail Design

From the conceptual design, the game is incorporated with the collaboration models as explained in **Section 3.3**. The difference between the game versions is based on the feedback from the gaming session, input from the supervisors, also the further literature study. In the following section, the detail of each game version is explained including the description, players, game structure, learning effect, and the flow.

A. Game Version I (V.01)

a) Description

In the first version of the game, the focus is to ensure the depiction of the real system of IIWT in the game. This is to increase the credibility level of the game from the perspective of the expert panel who act as the evaluator. The main task for the players is to ship the containers to the destined location. The shipping demand (in TEUs) is represented by a demand card that is kept by the barge operators (BOs) and the containers shipped to the terminal are portrayed by *legos*. Each lego represents *5 TEUs*.

As mentioned in **Chapter 3**, three transport attributes are incorporated in this game. The cost attribute is included by the use of income and fine. The capacity attribute is represented exactly the same as the reality both for barge's capacity and inland terminal handling's capacity. Meanwhile, for the reliability, the use of positive and negative point is implemented. By the end of the game, the financial condition (represented by money) and reliability (represented by total point) will decide who is the winner between barge operators (BOs) and between inland terminal operators (ITOs).

b) Players

There are five players for 2 roles: 3 players as barge operators (BOs) and 2 players as inland terminal operators (ITOs). Each of these players has their own task which is discussed as follows.

Barge Operators. Barge operator (BO) has 3 barges and operates on a fixed schedule which is every day in a week. The trip from the seaport (Port of Rotterdam) to the inland terminal (Moerdijk Inland Terminal) takes 1 operational day. Each barge has capacity *15 TEUs*. Every day, barge operators will receive 3 demand cards with the different destined terminal, number of containers, and deadlines. They must ship the containers by taking into consideration this deadline also their carrying capacity. When they arrive in the inland terminal, the inland terminal operator (ITO) will handle the barge based on First In First Out (FIFO) queuing system.

Inland Terminal Operators. Inland terminal operator (ITO) has a handling capacity of *100 TEUs/ day*. This handling capacity is assumed to be the same with the yard capacity to simplify the calculation. After the barge arrives in the inland terminal, the inland terminal operator (ITO) will require the barge to be arranged in a queue. Inland terminal operators handle with FIFO system and then decide which containers must be handled first. The handling means moving the containers from the barge to the container yard. It takes one day more to deliver the container to the consignee from the container yard.

c) Game Structure

The game is designed in the daily scheme, starts from Day 1 and ends on Day 14. The players get shipping demand in TEUs and have to ship it within the required deadline. In this version, 6 scenarios of collaboration models are included:

1) Two *horizontal collaborations* between barge operator (BO) and barge operator (BO), ranging on *partnership* and *joint venture*.
2) Two *horizontal collaborations* between inland terminal operator (ITO) and inland terminal operator (ITO), ranging on *partnership* and *joint venture*.
3) Two *vertical collaborations* between inland terminal operator (ITO) and barge operator (BO), ranging on *partnership* and *joint venture*.

Two rounds are implemented in this version. On the first round (Day 1 – Day 7) no collaboration is allowed, while on the second round (Day 8 – Day 14), 6 type collaboration models are available as options for the operators.

d) Learning Effect

The point reward is introduced in this version. Every successful delivery of containers to the consignee will give the barge operators (BOs) and inland terminal operators (ITOs) positive point. The negative point will be given if the delivery exceeds the deadline. Meanwhile, money/balance system is also incorporated in this version. Every shipment and handling will give the income while the empty slot of the barge operators (BOs) will require them to pay fine. As a driving force for the operator in forming a collaboration, each collaboration that is chosen by the operator will add positive reputation point.

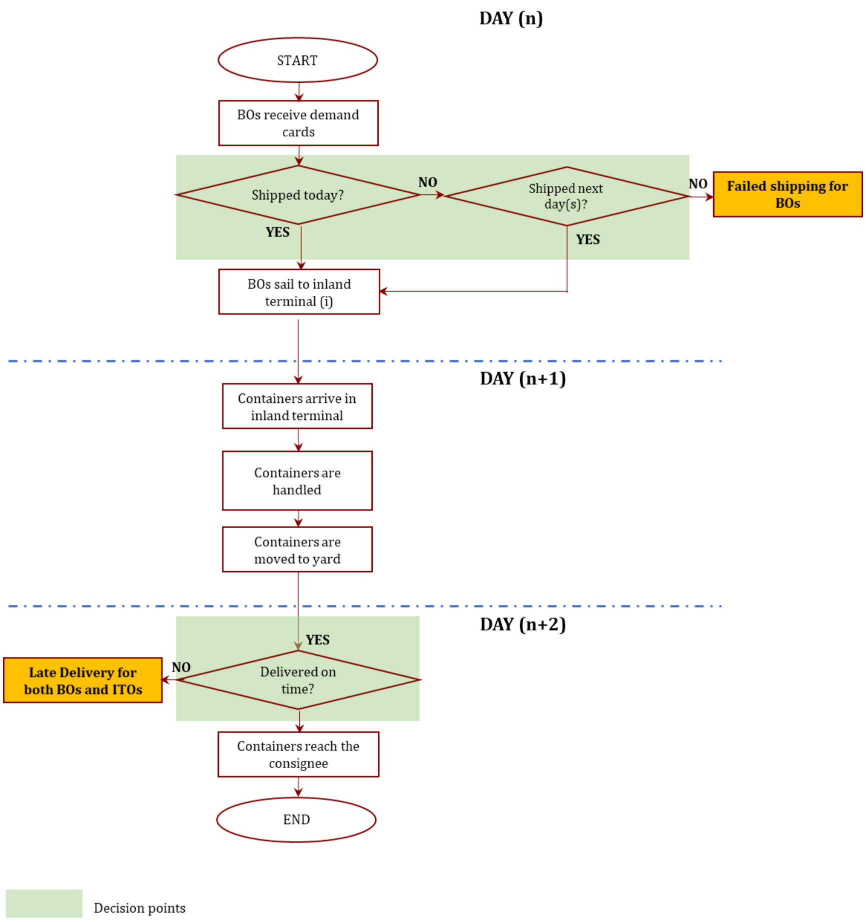

Figure 5.4 The flow of Game Version I.

e) Flow of The Game

The significant development of V.01 from the conceptual design is the rules of failed shipping and late delivery. If the barge operators (BOs) cannot ship the container and keep it until the deadline day, they will be charged with a negative point for failed shipping. The steps in this game version can be seen in **Figure 5.4.**

B. Game Version II

a) Description

After the validation of the game is assessed in the first version, the second version is used to emphasize the introduction of different collaboration models to the players. The author as the game designer elaborates the different effect of each collaboration model by conducting a more comprehensive literature study. The demand cards and *legos* are still used to portray the containers demand, but in this version, a lego represents *10 TEUs*.

b) Players

Two roles are still used in this version with adding one more inland terminal operator (ITO) due to the result of literature study for the case study in which three container terminals exist in Port of Moerdijk. In the Version I, the capacity of the barge is *15 TEUs/ barge*. Since a lego now represents 10 TEUs, the barge's capacity becomes *30 TEUs/ barge*. Also, as an adaptation to the feedback from the gaming session of Version I, the handling capacity of the inland terminal is too high which causes the need to collaborate rarely happened. With regards to this feedback, in Version 2 the handling capacity of inland terminal is reduced into *50 TEUs/ day*.

c) Game Structure

In this version, the game duration is only 9 days. The basic shipment flow happens on Day 1 – Day 3. Then the collaboration models and disruptions emerge from Day 4 until Day 9. The collaboration models introduced to the players only consist of three (3) models:

1) Two *horizontal collaborations* between barge operators (BOs) and between inland terminal operators (ITOs).
2) One *vertical collaboration* between inland terminal operator (ITO) and barge operator (BO)

d) Learning Effect

In this version, the disruption cards start to be used. These cards are given to each player on Day 4, 5, and 6. The disruption cards act as the driving force for the players to take actions, so their late delivery can be reduced. Point and balance-scheme are still used to represent the financial condition and the reliability of the players. In Version, I, the late/ failed delivery is punished only by a negative point. However, in this version, for the late delivery, the operators are not only punished by negative point but also fine (EUR/ TEU).

e) Flow of The Game

The difference between this version with the V.01 is that the inland terminal operators are given a chance to decide whether to handle the container or not. It depends on the deadline when the containers must be delivered. Logically, if the barge operators (BOs) that they cannot fulfill the deadline, they will use a truck instead of barge. In this game, the use of truck is not included. Instead, the barge with potential late containers is possible to be rejected by the inland terminal operators (ITOs). **Figure 5.5** below shows the flow of the Game Version II.

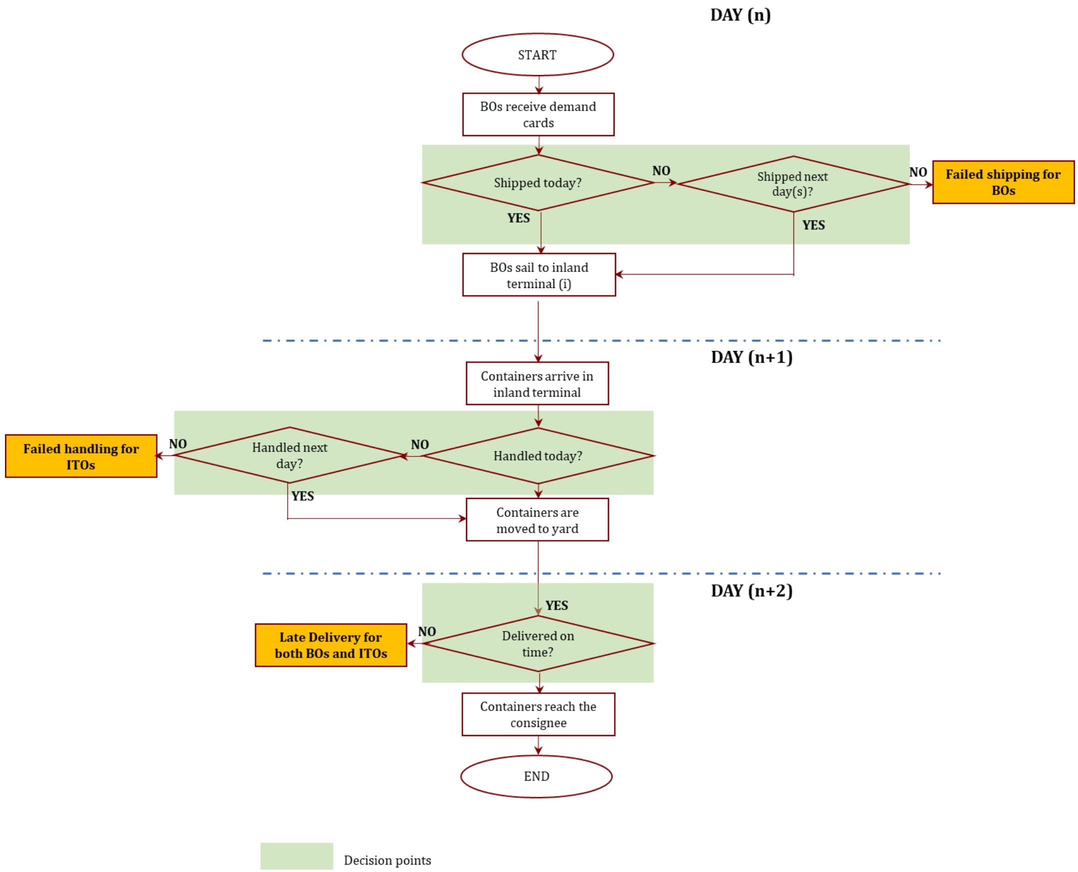

Figure 5.5 The flow of Game Version II.

C. Game Version III (V.03)

a) Description

The main difference of this version to Version II is the use of two time-windows for barge to visit the inland terminal. All the components of the Game Version II are adopted. However, in this version, the barge can visit maximum two inland terminals. A day is divided into two time-windows, first in the morning (06.00 AM -12.00 AM), and second in the afternoon (12.00 AM – 18.00 PM). The inland terminal's capacity is unchanged (50 TEUs/ day) which can be distributed as needed between the two time-windows.

As the number of players has been adjusted to the real condition in Version II, there is no addition or reduction on it.

b) Game Structure

In this version, the game duration is changed to 10 days. The basic shipment flow happens on Day 1 – Day 3. Then the collaboration models are applied on Day 4, 6, and 8. Meanwhile, the disruptions emerge on Day 5, 7, and 9. The collaboration models introduced to the players are still similar with the Version II which highlight the difference between *horizontal* and *vertical collaboration*.

c) Learning effect

The same with the Version II, there is no change regarding the rule of income, fine, positive and negative point.

d) Flow of The Game

The difference between this version with the Version II is that there are two (2) time-windows for the barge operator to visit the inland terminals. It also means that the inland terminal operators have two time-windows to handle the containers. **Figure 5.6** below shows the flow of the Game Version III.

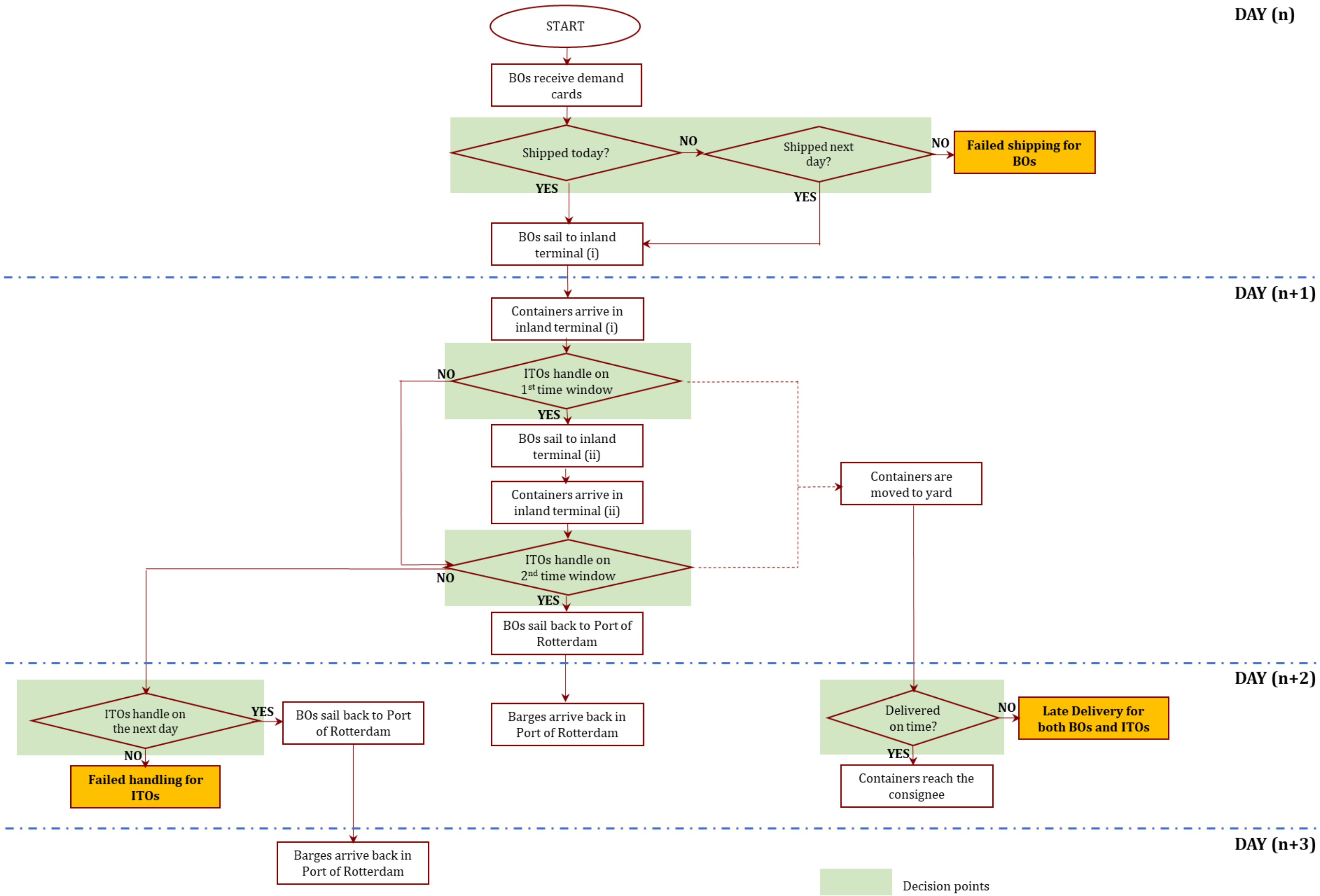

Figure 5.6 The flow of Game Version III.

5.1.3 Conclusion of Designing the Game

From the detail explanation of each game version in the previous section, **Table 5.1** below concludes the changes to game elements during the development process. This table is provided to help the reader following the designing process and understand clearly why the change in each game is needed.

Table 5.1 The recapitulation of game version development.

UNITS	VERSION I	VERSION II	VERSION III
CAPACITY	Barge 15 TEUs/ barge Terminal handling 100 TEUs/ day	Barge 30 TEUs/barge Terminal handling 50 TEUs/ day	The same as V.02 The same as V.02
INCOME AND FINE	Income from shipment and handling Fine for empty slot and late delivery	The same as V.01 Fine for an empty slot, late, and failed delivery	The same as V.01 The same as V.02
POINTS	Positive point for on-time delivery Negative point for late/ failed delivery	The same as V.01 The same as V.01	The same as V.01 The same as V.01
FLOW	One time-windows for handling	The same as V.01	Two time-windows for handling
TIME PERIOD	14 days in gaming world	9 days in gaming world	10 days in gaming world
COLLABORATION MODELS	6 types	3 types	3 types
DISRUPTION EVENTS	Not incorporated	Incorporated	The same as V.02
SHIPPING DEMAND	Constantly 3 demand cards per day	For the operator who forms a *vertical collaboration*, they got 4 demand cards per day Otherwise, the operator got constantly 3 demand cards per day	For every two days, each operator got one additional demand cards

Units revised in V.02

Units revised in V.03

The revision of *capacity*, *income & fine*, *time-period* and *disruption events* are learned from the gaming session which is further explained in **Section 5.2**. Meanwhile, the incorporated collaboration models are changed with the aim to be more focus in comparing the horizontal and vertical collaboration. This has helped the participants to understand more clearly about the difference between each collaboration model due to the clearer distinction of the effect comes out from these collaboration models.

5.2 Gaming Session

Game Version I and II have been played twice by the participants, while the last version played once. The detail arrangement of the gaming session can be seen in the following **Table 5.2**.

Table 5.2 Recapitulation of an arranged gaming session.

GAME VERSION	GAMING SESSION	PARTICIPANTS	LOCATION AND TIME
Version I	Session 1	Supervisors Ph.D. students	TPM Building 12 May 2018
	Session 2	Ph.D. students from Synchromodality Community	Erasmus University 13 June 2018
Version II	Session 1	MSc students with non-transportation related background	TU Delft Library 28 June 2018
	Session 2	MSc students with transportation and non-transportation related background	Molenstraat 33, Delft 29 June 2018
Version III	Session 1	MSc students with transportation and non-transportation related background	TU Delft Library 28 August 2018

5.2.1 The Result of Game Version I

Two sessions are arranged to try the Game Version I and II, while the Game Version III is played once. The result of Gaming Session 1 and 2 for the Game Version I are presented together as follow.

A. Flow

In both gaming session, the collaboration model that is implemented by the barge operators (BOs) is only *horizontal collaboration.* The players consider this collaboration model is the easiest to form and does not require high investment. Also, with handling capacity 100 TEUs/ day has made the inland terminal operators (ITOs) stay in the comfort zone, and the under-capacitated circumstances are not found in this trial. The implementation of the *horizontal collaboration* itself can help the barge operators (BOs) in reducing their expenditures in paying the empty slot and increase their balance from offering the empty slot to the other barge operator (BO).

B. Insight from the session

1) The flow of container shipping in the game is representative compared to the real world (validation).
2) However, the collaboration models introduced in the game is still considered as unclear because the players still not sure about the difference in advantages and disadvantages from each collaboration models.

3) The driving force that gives pressure to the players to take action (either expand their capacity or forming collaboration) is still ineffective.
4) The share of demand cards with regards to the destined terminal is less fair.
5) There is no reward for the operator who has good performance. The reward, for instance, can be in the form of additional demand card which will generate more income.
6) The punishment of failed delivery should be similar with late delivery which is by getting the fine and negative point.
7) In this version, only *horizontal collaboration* is implemented by the operators due to the unclear explanation about the characteristic of *vertical collaboration*. Moreover, the system in the simulation game does not give pressure to the player to try the *vertical collaboration* which is considered as more complicated than the *horizontal collaboration*.

5.2.2 The Result of Game Version II

A. Gaming Session 1

a) Flow

In the first gaming session, *vertical collaboration* is formed by Barge Operator C and Inland Terminal Operator A. The decision of this collaboration is generated from the competition insting of Barge Operator C to be more profitable than the other Barge Operators. Barge Operator C bought another barge to expand its capacity before asking Inland Terminal Operator A to form *vertical collaboration*. Meanwhile, Inland Terminal Operator A is considered as the busy container terminal with the highest handling demand compared to the other terminal. It also expands its handling capacity before accepting *vertical collaboration* offer from Barge Operator C. The events happen during the Game Session II can be seen in **Table 5.3** and **Table 5.4.**

Table 5.3 The circumstances that are experienced by Barge Operators during the Gaming Session 1

PLAYERS	CONDITIONS
Barge Operator A	1) It buys a new barge for expansion. 2) It only applies the *horizontal collaboration* to solve the late delivery. 3) The strategy that is used is to accumulate the containers with longer time-window and ship it later. 4) After receiving one additional demand card in Day 6, the delivery performance drops into minus.
Barge Operator B	1) It only applies the *horizontal collaboration* to solve the late delivery. 2) The strategy is to ship the containers as soon as possible after the demand is received. However, the demand received is pretty fluctuating during Day 2 until Day 5. 3) After receiving one additional demand card in Day 6, the delivery performance drops into minus.
Barge Operator C	1) It buys a new barge for expansion. 2) It applies the *horizontal collaboration* and *vertical collaboration* to solve the late delivery. 3) The strategy is to ship the containers as soon as possible after the demand is received. It is supported by the less fluctuated demand received during Day 2 until Day 5. 4) After receiving one additional demand card in Day 6, the delivery performance also drops but still higher than Barge Operator A and B. It can be interpreted that Barge

	Operator C with its *vertical collaboration* to Inland Terminal Operator C gives a bit robustness towards the higher shipping demand.

Table 5.4 The circumstances that are experienced by Inland Terminal Operators during the Gaming Session 1

PLAYERS	CONDITIONS
Inland Terminal Operator A	1) It expands its handling capacity. 2) It applies *vertical collaboration* with Barge Operator C. 3) The demand for container handling is quite stable each day.
Inland Terminal Operator B	1) No collaboration model is applied. 2) The daily demand is not as many as Inland Terminal Operator A. 3) Even after additional demand cards in Day 6 for Barge Operators, it seems the handling demand of Inland Terminal Operator B does not significantly increase.
Inland Terminal Operator C	1) No collaboration model is applied. 2) The daily demand is not equally spread in each day. 3) After additional demand cards in Day 6 for Barge Operators, the delivery performance collapses.

b) Insight from the session

1) The introduction of extra demand cards can be done in an earlier day, instead of Day 6, so the players can be pushed to form the collaboration earlier.
2) It will be better if to form a *vertical collaboration*; the requirement is not only payment but also minimum points.
3) The normal cards will be good to be added to disruption cards.
4) The definition of failed delivery is still unclear. It must be defined clearer so both Barge Operators and Inland Terminal Operators can decide whether to leave it failing or keep shipping the containers but late.
5) Give the Inland Terminal Operators an option to reject the containers which arrive from BOs that are apparent to be late.
6) The duration of the game should be a bit longer to see the effect of *vertical collaboration*.

B. Gaming Session 2

a) Flow

In the second gaming session, three *horizontal collaborations* are formed between all Inland Terminal Operators. The decisions are made because the Inland Terminal Operators (ITOs) think that by having more yard capacity and sharing it with other Inland Terminal Operators (ITOs) will be beneficial in increasing the successful delivery. For Barge Operators (BOs), they only apply *horizontal collaboration*. The events happen during the Game Session II can be seen in **Table 5.5** and **Table 5.6.**

Table 5.5 The circumstances that are experienced by Barge Operators during the Gaming Session 2

PLAYERS	CONDITIONS
Barge Operator A	1) It only applies the *horizontal collaboration* to solve the late delivery. 2) The strategy that is used is utilized all the barges in one day and wait until the day after tomorrow to ship again. 3) In Day 6, the accumulated late containers just delivered.

PLAYERS	CONDITIONS
Barge Operator B	1) It only applies the *horizontal collaboration* to solve the late delivery. 2) The demand spreads equally during the days, but the shipping performance keeps dropping because the player is not sure to take any action. 3) In Day 6, the accumulated late and failed containers just delivered.
Barge Operator C	1) It only applies the *horizontal collaboration* to solve the late delivery. 2) The shipping demand does not spread equally during the days. 3) Keep shipping the barge as required, and the capacity seems still enough without any further collaboration.

Table 5.6 The circumstances that are experienced by Inland Terminal Operators during the Gaming Session 2

PLAYERS	CONDITIONS
Inland Terminal Operator A	1) It forms a *horizontal collaboration*. 2) The handling demand is quite high compared to the other terminal. 3) After forming the *collaboration*, Inland Terminal Operator A can handle all the containers arrive.
Inland Terminal Operator B	1) It forms *horizontal collaboration*. 2) The handling demand is the least compared to the other terminal. 3) With additional handling capacity from the *collaboration*, the accumulated late containers from Barge Operators still can be handled.
Inland Terminal Operator C	1) It forms *horizontal collaboration*. 2) With additional handling capacity from the *collaboration*, the accumulated late containers from Barge Operators still can be handled.

b) Insights from the session

1) The definition of failed delivery is still unclear since it can be caused by the delay from the barge operators (BOs) or from the inland terminal operators (ITOs).
2) The different effect between forming *horizontal collaboration* and *vertical collaboration* for the inland terminal operators (ITOs) is still unclear. Due to this condition, the players are hesitant to implement the *vertical collaboration* though they already had a suitable barge operator (BO) as a partner.
3) In reality, actually, a barge can visit several container terminals in one inland terminal area. This real condition should be considered.

5.2.3 The Result of Game Version III

A. Flow

During the game session only two types of collaboration models used by the players. The barge operators (BOs) first apply the *horizontal collaboration* to cope with the increasing demand in every two days. Some of them also expand their new asset by buying the new barge. Quite similar with barge operators (BOs), two inland terminal operators (ITOs) also expand their handling capacity. However, the decision of these inland terminal operators (ITOs) due to their plan to arrange a *vertical collaboration* with their preferable barge operators (BOs). Start from Day 4; two *vertical collaborations* are formed between Inland Terminal Operator A and Barge Operator

A, also between Inland Terminal Operator B and Barge Operator B. Two days later, in Day 6, Inland Terminal Operator C and Barge Operator C also form a *vertical collaboration*. The detail circumstances from this gaming session are shown in **Table 5.7** and **Table 5.8**.

Table 5.7 The circumstances that are experienced by Barge Operators during the Gaming Session for Game Version III

PLAYERS	CONDITIONS
Barge Operator A	1) It expands its asset by buying a new barge. 2) Along with the increasing demand every two days, it considers forming a collaboration. 3) After learning the difference between each collaboration model, it chooses to form *vertical collaboration*. 4) Within the first three days of the game, Barge Operator A has a good performance. 5) It asks the Inland Terminal Operator A to form the *vertical collaboration*. Barge Operator A thinks that the Inland Terminal Operator A has a good performance equal to its own. 6) At the end of the game, these collaborative operators become the winners in their own submarket. 7) Despite its *vertical collaboration*, sometimes it also applies *horizontal collaboration* as its barge's capacity is not enough.
Barge Operator B	1) It expands its asset by buying a new barge. 2) Along with the increasing demand every two days, it considers forming a collaboration. 3) After learning the difference between each collaboration model, it chooses to form *vertical collaboration*. 4) Within the first three days of the game, Barge Operator B has a medium performance. 5) It asks the Inland Terminal Operator B to form the *vertical collaboration*. Barge Operator A thinks that the Inland Terminal Operator A has a good performance to compete with the collaborative Inland Terminal Operator A and Barge Operator A. 6) The problem of Barge Operator B is the scheduling strategy. It ships the already late containers first than prioritizes the on-time ones. 7) Barge Operator B does not discuss its scheduling with its partner, Inland Terminal Operator B. 8) At the end of the game, these collaborative operators gain the lowest balance and point. 9) Despite its *vertical collaboration*, sometimes it also applies *horizontal collaboration* as its barge's capacity is not enough.
Barge Operator C	1) At first, Barge Operator C has the least performance level through high failed shipping and late delivery. 2) It expands its asset by buying a new barge which sometimes, it offers the empty slot to the other barge operators (BOs). It helps Barge Operator C to gain more balance and form a *vertical collaboration* with Inland Terminal Operator C. 3) Through the game, these collaborative operators do not receive shipping demand as many as Inland Terminal Operator A and Barge Operator A. However, the scheduling strategy that involves the two operators has helped them to grow together and reach the second place at the end. 4) Despite its *vertical collaboration*, sometimes it also applies *horizontal collaboration* as its barge's capacity is not enough.

Table 5.8 The circumstances that are experienced by Inland Terminal Operators during the Gaming Session for Game Version III

PLAYERS	CONDITIONS
Inland Terminal Operator A	1) It has the highest demand for handling within the first three days. 2) As a preventive action towards late delivery, it expands its handling capacity to 100 TEUs/ day 3) It receives a *vertical collaboration* offer from Barge Operator A who also has a high performance in shipping the containers. 4) At the end of the game, these collaborative operators become the winners in their own submarket.

PLAYERS	CONDITIONS
Inland Terminal Operator B	1) It has a medium performance for handling within the first three days. 2) However, its demand grows from Day 3, and it expands its handling capacity to be ready in forming a collaboration. 3) Barge Operator B asks to form a *vertical collaboration* in order to compete with the collaborative Inland Terminal Operator A and Barge Operator A. 4) During the collaboration, Inland Terminal Operator B is not involved in schedule planning of Barge Operator B which as a result, generates a high number of late deliveries. 5) At the end of the game, these collaborative operators gain the lowest balance and point.
Inland Terminal Operator C	1) It has the lowest demand for handling within the first three days. However, its performance level is very good with no late deliveries. 2) On Day 6, it finally gains enough balance and points to form a *vertical collaboration* with Barge Operator C. 3) Through the collaboration, Inland Terminal Operator C is involved in deciding the scheduling strategy of Barge Operator C. 4) At the end of the game, these collaborative operators gain the second place in balance and point.

b) Insights from the session

1) The definition of failed delivery is clearer than the Version II. In a further development, maybe the difference punishment can be applied for the late delivery in one day, two days, and three days.
2) The explanation of different effect from each collaboration model is clearer than the Version II. The players can understand it better and see which one is more suitable for them.
3) The price of buying a new barge and added yard's handling better to be increased, so the players are really forced to choose collaboration.

5.2.4 Conclusion of Gaming Session

From all the gaming session, insights from the players and the observation of the gaming flow become the input on the revision process of the game. As can be seen in the previous sections, the flow of the game is shown in detail events. These detail events are categorized into main category of revision which is presented in the following **Figure 5.6.**

The main categories in the game include the actors, elements, and process. For the *actors*, it derives into the asset of each involved operators. Second, in the *elements* category, the cards, rewards, and punishment are discussed. Cards subcategory consists of the frequency and operationalization of demand cards, disruption cards, collaboration models. *Rewards and punishments* category covers the insights for the value of money and points for each success and failure scheme. The last category is a process where the sequential processing phases from the start of the game until it ends are examined.

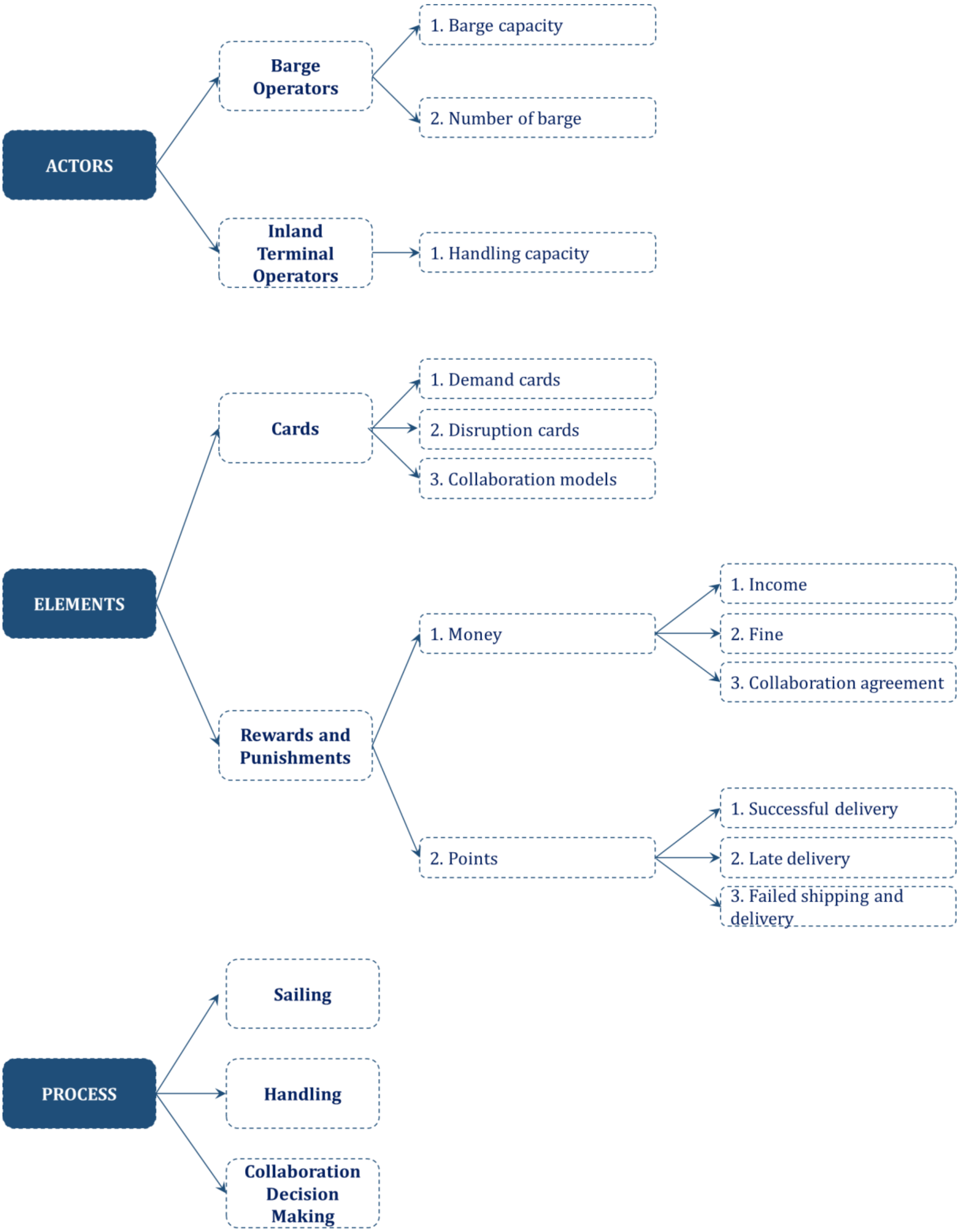

Figure 5.7 Categorization of detailed insights from the gaming session

By applying the categorization as shown in **Figure 5.7**, the development of game versions is presented in the following **Table 5.9.** In the following table, it also presents how the insight from each session is solved in the next version of the game.

Table 5.9 Recapitulation of game revision based on the insight from gaming session

GAME VERSION	GAMING SESSION	PARTICIPANTS	INSIGHT FROM GAMING SESSION	REVISION OF GAME VERSION
Version I	Session 1	Supervisors Ph.D. students	**ELEMENTS** 1) Unclear different effect between collaboration models 2) The driving force to form a collaboration is not strong enough 3) The distribution of demand cards is not fair enough 4) Punishment of the late and failed delivery is not strong enough	
	Session 2	Ph.D. students from Synchromodality Community		
Version II	Session 1	MSc students with non-transportation related background	**ELEMENTS** 1) There should be an increase in the demand cards 2) Normal cards should be added in disruption events **PROCESS** 3) Decision point for the inland terminal operators (ITOs) is required	**ELEMENTS** 1) Collaboration models more focused on *horizontal* and *vertical collaboration* 2) The randomization of demand cards is reduced 3) The punishment for failed delivery is not only a negative point but also fine. **ACTORS & ELEMENTS** 1) To increase the driving force, there are a) reduction of handling capacity for inland terminal and b) introduction of disruption events
	Session 2	MSc students with transportation-related background	**ELEMENTS** 1) Still unclear different effect between collaboration models **PROCESS** 2) A barge should be able to visit more than one container terminal	
Version III	Session 1	MSc students with transportation and non-transportation related background	**ELEMENTS** 1) The different effect of each collaboration model is clear 2) The distinction between the late delivery and failed delivery is much clearer **PROCESS** 2) The option of expanding the own asset should be limited by increasing the price of buying a new barge or adding the handling capacity	**ELEMENTS** 1) The number of demand cards received by barge operators (BOs) increases in each two days 2) Normal card has been included in the disruption events 3) Collaboration models have been modified, and now the difference between them is much clearer **PROCESS** 4) Inland terminal operators (ITOs) now can decide whether to accept or receive the containers from the barge 5) A barge now can visit maximum two container terminals in a day by the use of two time-windows

Category revised in V.02 (yellow)

Category revised in V.03 (orange)

6
GAME EVALUATION

In this chapter, the evaluation of the game is presented. Game Version III is considered the final design for this study. After conducting the gaming sessions, the debriefing is done by directly collecting the feedback from the players also a questionnaire. This feedback collection has been done by a discussion where each player delivers their inputs to improve the simulation game. Meanwhile, in the online questionnaire, the questions about the views of the players on the connection between the reality in the game and real world. Following the debriefing process, the revisions of the game are conducted. The detail of the feedback session for improving the game version has been explained in **Chapter 5**, while the result of the questionnaire will be elaborated in this chapter.

According to the reality level from Kriz (2003), the debriefing is followed by the game evaluation. In the evaluation, how the game can facilitate the research objective is assessed. Since the game has been designed based on Triadic Game Design (TGD), the following discussion will present the assessment of game from three worlds: 1) Reality, 2) Meaning, and 3) Playability.

6.1 Reality

In **Section 5.1.1**, the discussion is given how the reality is translated to the model of the reality, and the elements of the reality which must be included in the game are presented. In this section the reversed work is described: the designed game is evaluated on how the game reflects the reality.

In the designed game, there are only two roles, one role from the reality is played passively by means of the demand cards. The rest of the roles in the Intermodal Inland Waterway Transportation (IIWT) is not included in the game. Money is included in the game to represent the transportation attribute “cost.” The tariff for incomes and fines are chosen randomly and adapted from the feedback during the gaming sessions. In the following section, the criteria of the real world are evaluated.

6.1.1 Flexibility

During the development process, the game is designed starts from the conceptual design where only the basic elements of the system are included. Given the feedback from the gaming session, three versions of the game are conducted. These versions show the flexibility of the game to be improved to achieve the research objective. This improvement can still be made if there is an updated system in the reality of Intermodal Inland Waterways Transportation (IIWT) as long as it is still related to the learning objective of the game.

6.1.2 Fidelity

The degree of realism for this criterion can be seen from the physical form of the elements of the game. The representation of the containers and barges in this game are made as close as possible to the reality by using legos and 3D printed barges. There is a map where the players can see the waterway network between Port of Rotterdam and Moerdijk Inland Terminal that also shows the queuing location of the barge before getting handled in the destined inland terminal. The containers, barge, and waterway network are well resemblance by these elements as shown in the following **Figure 6.1, Figure 6.2,** and **Figure 6.3**.

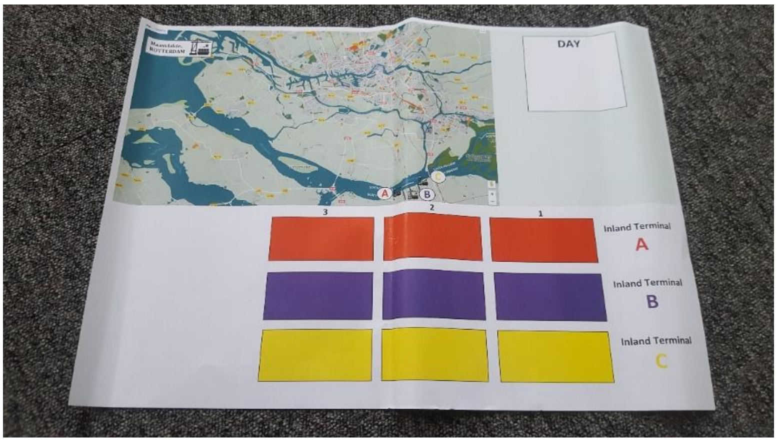

Figure 6.1 The map of the inland waterway between Port of Rotterdam and Moerdijk Inland Terminal

Figure 6.2 3D-printed barges

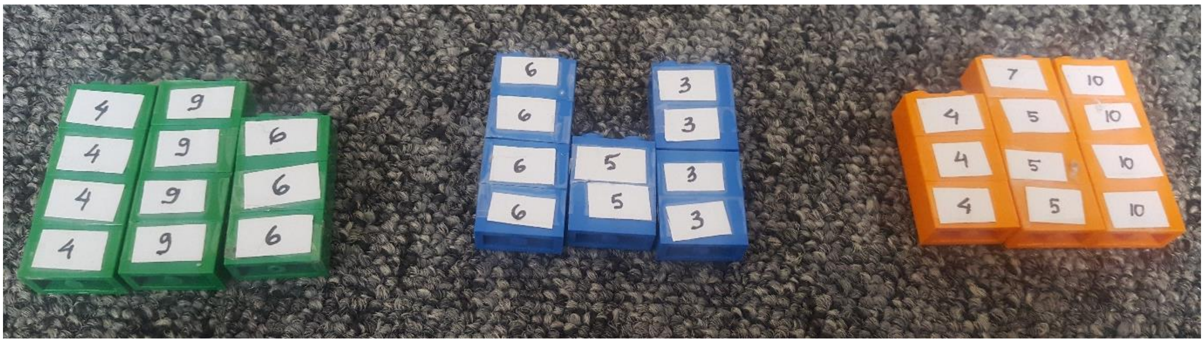

Figure 6.3 Legos as containers

6.1.3 Validity

The validity of the game is assessed by the use of literature study and expert panel. The validity level is more related to the processing system in the game compared to the real world. The shipment of containers is portrayed similarly with the real condition starting from the shipping demand from the shippers. These containers then shipped by the barge operators (BOs) using barges via inland waterways to the destined inland terminal. Before getting handled, these barges are designed to queue in front of the inland terminals. Lastly, the containers are handled by inland terminal operators (ITOs) to their stocking yard and delivered to the consignee. This process is also added by several elements to add the validity level as follow.

A. Collaboration Models

The collaboration models are represented by the collaboration cards which can be applied only on Day 5, 7, and 9. The decision to choose the collaboration models is limited to these three days to reduce the confusion of the players when the collaboration can be made. In reality, this case does not actually exist. Collaboration models can be deployed every time as long as the involved actors are ready.

B. Disruption Events

The use of disruption events is to increase the driving force to the operators for forming the collaboration. Disruption cards are given on Day 4, 6, and 8 or a day before the collaboration cards are available. There is a difference between disruption cards received by the inland terminal operators (ITOs) and the cards received by the barge operators (BOs). Three disruption cards are designed for the inland terminal operators (ITOs), including “bad weather,” “maintenance,” and “normal cards.” Meanwhile, for the barge operators (BOs), five disruption cards are used, including “bad weather,” “maintenance,” “water level rise,” “fire,” and “normal cards.” The representation of these cards can be seen in **Figure 6.4** below.

C. Time Windows

In the last version of the game, two time-windows are incorporated. The first time-window is 06.00 AM – 12.00 AM, and the second one is 12.00 AM – 18.00 PM. These time-windows are used to facilitate the barge operators (BOs) on visiting more than one inland terminal in one day. This condition normally happens in reality.

6.1.4 Conclusion About the Reality of the Game

To sum up, the game is based on reality. At the same time, many elements of the reality are simplified and modified to reduce the complexity of the reality and to balance between three dimensions of the game: Playability, Meaning, and Reality.

6.2 Meaning

The learning objective of the game is to show the effect of each different collaboration models to the performance level of the inland terminal operators (ITOs) and barge operators (BOs). During the days where the collaboration models are still locked, the performance level of the operators tends to generate more late delivery along with the increasing demand. After the collaboration models are unlocked, slowly the operators can cope with their shipping demand. Moreover, the type of collaboration models taken by the operators is quite tricky since it can be suitable/ unsuitable for their operational cases. In the meaning world, the evaluation is done for the criteria *motivation* and *relevance*. The criterion *transfer* is not assessed due to no further analysis of the behavior of the player after learning the objective of the game after the gaming session is finished.

6.2.1 Motivation

The gaming session is last for around three hours. Despite this long period spent by the players, during the last two gaming session they stayed enthusiastic. The players who have played it before are still encouraged to learn the difference between collaboration models as they want to use it for gaining more profit. Meanwhile, the new players tend to slowly build their interest through the competition they faced during the game.

6.2.2 Relevance

Based on the questionnaire to the players (**Appendix C**), they seem to be able to differente the incorporated collaboration models and choose it as they need. Also, they can relate what happens in the gaming world to the reality as most of the players expressed that they can understand the problem on the real Intermodal Inland Waterway Transportation (IIWT) both related to barge congestion and handling's capacity insufficiency.

6.2.3 Conclusion About the Meaning of the Game

To sum up, the game shows the different effect of each collaboration models to the performance level of the operators. It also gives an understanding that there is a chance that a collaborative decision can result in success or failure. This game can represent that the operator's decision is an important aspect of improving their performance levels.

6.3 Play

In the world of play, the main objective is to design the game as interesting as possible. Different approaches are possible to be used to achieve this objective. In this game, the elements designed to increase the level of playability is the physical money, points, and disruption cards. The players seem to like the game that can give them a built-up challenge which requires them a higher skill in choosing a strategy. As mentioned in **Section 4.3.2**, the criteria of the world of play consist of engagement, immersion, and fun which are explained as follow.

6.3.1 Engagement

The players of the final version of the game show a high engagement level both for the persons with transportation background or not. From the start of the game, during the introduction, the players have shown curiosity about the topic by asking several critical questions to the game master about the game operationalization. During the gaming session, the players keep engaged for around three hours and develop their skills in coping with the challenges they experience in their daily operation. Adopting the Theory of Flow from of Csikszentmihalyi (1991), **Figure 6.4** shows the flow in this game.

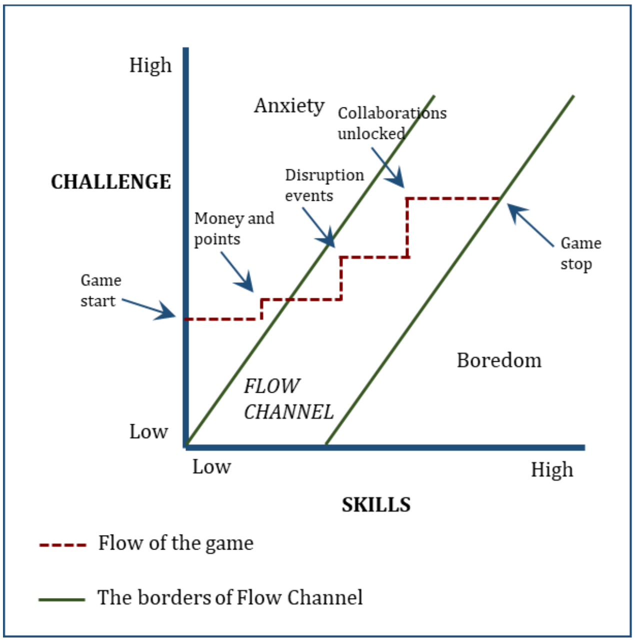

Figure 6.4 The balance between challenge and skill in the final version of the game
(Source: adapted from of Csikszentmihalyi (1991))

From the graph, it can be seen that the challenges are generated from the events of competition to gain more money and positive points, the disruption events, and the option to collaborate. During each event, the players experience a learning process that gradually raises their skills. However, each event does not generate an equal challenge to the players. It is assumed that disruption events and collaboration models have the similar challenging sense, but the rewards in form of money and points are not as high as those. It happens due to the condition where the players relatively easy to gain more money every day, as well as for the points. Meanwhile, the disruption events are varied in level of difficulty, and the collaboration models have requirements on points and financial condition which require more decision skill.

6.3.2 Immersion

The simple way to assess this criterion is observing the communication between players during the game. From the observation, the players most of the time observe the other players who are potential to be their partners in collaboration. Then during the collaboration, they are sharing strategy and compete with the other players like they are in the real market. A simple example is sometimes a barge operator (BO) reminds another barge operator (BO) when they forget that their barge is still on the sail and cannot be used. From the perspective of the game master, this behavior illustrates the sense of competition as if they are immersed in the gaming world.

6.3.3 Fun

Learned from the questionnaire, the players seem to like the game and think that the game is fun. Along with the challenges they face, they strive to survive it and become a winner. Most of the time, in the final session of the game the players look so eager on collecting the money and points to become a winner. Meanwhile, the player with the lowest points and money show distress as if they experience an almost real bankruptcy. Given the disruption cards, the players also found it very interesting, and at some point, they try hard to avoid the highest level of disruption.

A. Conclusion About the Playability of the Game

From the result of the questionnaire, the players think that the game is not only playable but also interesting to play. Even though some players do not understand the whole problem of the Intermodal Inland Waterway Transportation (IIWT), but all of them said that they experience the flow of the game where they recalled as quite fun (**Appendix C**).

7
CONCLUDING CHAPTER

In this chapter the discussion about the conclusion, recommendation, limitation and future research are described. In **Section 7.1** the conclusion is derived into the answer of the sub research question and main research question. Then in **Section 7.2**, the recommendation from the learning process during this study is presented. Lastly, the limitation and suggestion for future research can be found in **Section 7.3.**

7.1 Conclusions

7.1.1 Answering the Sub Research Questions

This thesis is started with the explanation of the importance of Intermodal Inland Waterways Transportation (IIWT) as an alternative to reduce the dependency of freight transportation to the unimodal road transportation. In the Netherlands, IIWT has gained the second highest share in the freight transportation market which indicates that it is the main alternative of road transportation compared to rail. To cope with the increasing shipping demand of container, the operators in Intermodal Inland Waterway Transportation (IIWT) desire to improve their performance level. One of the options to achieve the improvement is forming a collaboration. One of the options to achieve the improvement is forming a collaboration. According to Caris et al. (2014) and Ramaekers et al. (2017), the collaboration, both in horizontal and vertical forms, is assumed to generate a higher performance level of IIWT by cost and time savings.

However, given the fact that collaboration does not always generate an improvement for the respective operators, there is a risk that the collaboration might cause a decrease in performance level. The way the collaborations affect the performance level of the operators in IIWT has not been clearly understood which cause them to be hesitant to deploy this idea. To introduce the way these collaborations work, several research tools are possible to implement. However, with the aim to facilitate the operators to experience the impact of collaboration to their daily operation directly, simulation gaming is considered as the most suitable research tool due to its nature which accommodates a direct human interaction to the simplified system. Given this condition, this research began with an objective on helping the operators in Intermodal Inland Waterway Transportation (IITWT) understanding the effect of different collaboration models to their performance level. Drawing upon this concern, a research question focused on the use of simulation gaming to achieve the objective is written as follows.

How can the barge operators and terminal operators in IIWT understand the impact of collaboration on their performance levels with the help of simulation gaming?

To answer this research question, four sub-questions are used. The answer to these questions will be briefly discussed below.

SQ 1: What are the collaboration models among the actors in IIWT?

Several classifications of collaborations are presented in previous studies. There are organizational level-related, integration level-related, and submarket-related classifications. In this study, due to the concern to show the operators the impact of collaboration on their operational performances, only submarket-related collaborations are involved in this study. The submarket-related collaboration consists of horizontal and vertical collaborations. As this study focuses only on two actors in IIWT which are barge operators (BOs) and inland terminal operators (ITOs) whom their roles are in the core of the system of Intermodal Inland Waterway Transportation (IIWT), there are three forms of collaboration incorporated in this study. In the horizontal forms, the barge operator (BO) can collaborate with the other barge operators, as well as between inland terminal operators (ITOs). The third collaboration model is the vertical collaboration formed between barge operator (BO) and inland terminal operator (ITO).

SQ 2: What are the relevant transportation attributes to represent the change of the performance level from the implementation of different collaboration models?

Previous studies have discussed the transportation attributes to represents the performance level of transportation mode. Three transport attributes are listed in most of these studies. First, *transportation cost* which is mentioned in papers by Van Klink & Van den Berg (1998); Barthel & Woxenius (2004). Second, *transportation* time is considered important by Konings (2003), Ballou (2004), Zotti & Danielis (2004), Danielis & Marcucci (2007), and Chang & Thai (2017). Last, *reliability* has been highlighted by Konings (2003), Zotti & Danielis (2004), and Danielis & Marcucci (2007). Among these papers, this study refers mostly to the idea from Konings (2003) as it discusses the transportation specifically related to the Intermodal Inland Waterway Transportation (IIWT). Even though Konings (2003) includes frequency as another transportation attributes for Intermodal Inland Waterway Transportation (IIWT), this study will neglect this attribute since this study analyzes the case study that has already fix a frequency per week. Therefore, only cost, transportation time, and reliability are incorporated for this study to represent the performance level of operators in Intermodal Inland Waterway Transportation (IIWT).

SQ 3: How to translate the variation of the transportation attributes in Simulation Gaming as an impact of different collaborations?

Two main problems in Intermodal Inland Waterway Transportation (IIWT) are included in this study: 1) longs stays of barges in the port because of too many calls and too small call sizes and 2) insufficient terminal and quay planning. These problems as explained by Konings (2003) are related to transportation attributes which then can be varied according to the different performance level. Adopting the study of Konings (2003) and taken into account these problems resulted from the use of three transportation attributes: 1) cost, 2) transportation time, and 3) reliability. These transportation attributes are used further in simulation gaming to differentiate the effect of each collaboration model to the performance level of the operators.

In this study, the collaboration models incorporated in the game includes the *horizontal* and *vertical collaborations*. Mason, Lalwani, & Boughton (2007) have differentiated the effect from these two collaborations to the transport optimization. As an adaptation from the study of Mason et al. (2007), this study highlights that the effect of the *horizontal collaboration* will relate to asset utilization. Meanwhile the *vertical collaboration* is relevant with the aim to reduce the cost and improve the performance level. These collaboration models are then offered to the involved operators, inland terminal operators (ITOs) and barge operators (BOs).

These theoretical impacts then translate into the simulation game as follow:

a) To implement *horizontal collaboration* between barge operators (BOs), the consolidated capacity planning is done. Barge operator (BO) who has an empty slot can share its capacity to the other barge operators whose destination are the same. The effect of this approach is the increase of the barge utilization and reduce the environmental cost for the empty slot. This environmental cost in the simulation game is represented by a fine. Along with these positive impacts, the negative side is experienced by the renter of the slot, where they have to pay the fee for using the capacity of other barge operators (BOs).
b) In the *horizontal collaboration* between the inland terminal operators (ITOs), they share a new yard where they can gain an additional handling capacity. From this additional handling capacity, they can serve more barge operators (BOs)which then help them to gain more income. However, this collaboration model requires the inland terminal operators (ITOs) to spend more investment in forming an agreement with the partner. Also, a bit different from the collaboration between barge operators (BOs), the inland

terminal operators (ITOs) have less flexibility to change a partner since this kind of collaboration model normally applies for a longer period.

c) Lastly, for the *vertical collaboration* between barge operators (BOs) and inland terminal operators (ITOs), the barge operators (BOs) will only sail to one inland terminal. With this operational system, there is a guarantee for the barge operators (BOs) that their container will be handled because the inland terminal operators (ITOs) will prioritize them in their handling process which can raise the successful delivery of the container. By this collaboration model, barge operators (BOs) can match their sailing schedules with the availability of handling capacity of inland terminal operators (ITOs) who still receive the shipment from other barge operators. Aside from these benefits, this collaboration model is not easy to form. Several requirements are needed such as high investment cost for arranging the agreement and enough reliability level to ensure the partner that their performances together can generate a more efficient process. Moreover, the negative side of this collaboration model is once the partner is chosen, there is a high difficulty to change them. It is because this collaboration is designed to apply for a very long period.

SQ 4: From the simulation gaming, what the collaboration model in IIWT market that is suitable for each of the actors for their specific performance levels?

From the gaming sessions that have been conducted, different behavior of the barge operators (BOs) and inland terminal operators (ITOs) are discovered.

First, from the perspective of the barge operators (BOs), in the early phase of the game, they prefer to use the *horizontal collaboration* due to the need to minimize the empty slot which causes them fine. In this phase, they need to build a reputation and increase their balances, so they will be eligible to form the *vertical collaboration.* However, they are not always interested in forming the *vertical collaboration* because in a particular case, they choose to expand their assets by buying a new barge. The condition where there is no inland terminal operator (ITO) interested in forming a *vertical collaboration* also influences the strategy of the barge operators (BOs).

According to Rindfleisch (2000), managing horizontal collaboration is quite difficult. It is because the partners in horizontal collaboration are actually competitors, they tend to be less trusting on each other. Rindfleisch argues that involved operators may be engaged temporarily which is fit in condition during the game. The barge operators (BOs) only use the *horizontal collaboration* mostly in the early phase of the game and when their balance is not enough to buy a new barge.

Second, from the perspective of the inland terminal operators (ITOs), their first choice is mostly expanding their own handling capacity. The design of the game where there is no fine related to asset utilization has caused them to be less interested in forming *horizontal collaboration*. During the development of the game, due to the unclear different effect between *horizontal collaboration* formed by inland terminal operators (ITOs) and *vertical collaboration* formed by the inland terminal operator (ITO) and barge operator (BO), has caused the inland terminal operators (ITOs) to prefer the *horizontal collaboration*. It is assumed that they do not want to take a high risk by forming a *vertical collaboration* that lasts until the end of the game.

Distinct condition happened during the last gaming session. Since the different effect of the previously mentioned collaboration for the inland terminal operators (ITOs) is clearer in the last game version, the inland terminal operators (ITOs) show the high interest in forming *vertical collaboration*. It again agrees with the statement of Rindfleisch (2000) where the level of trust between the involved operators in *vertical collaboration* is higher than in *horizontal collaboration* and due to competitive instinct owned by the operators in the same submarket.

Furthermore, a behavior pattern can be traced from the gaming session where the operators, both inland terminal operators (ITOs) and barge operators (BOs) will prioritize to expand their own asset first then consider on arranging the collaboration. This behavior is easier to be found in inland terminal operators (ITOs) since they are not pressured by the fine related to asset utilities. They also have a right whether to receive or reject the containers according to the deadline of the containers. With this condition, they can reduce their expenditure from late delivery. Compared to the inland terminal operators (ITOs), barge operators (BOs) has a higher pressure regarding the fine for failed shipping where their containers are rejected by the inland terminal operators (ITOs). Thus, before they have enough balance, they have no option than forming a *horizontal collaboration*.

7.1.2 Answering the Main Research Questions

In the initial phase of this study, it has been assumed that a simulation game can be used to carry the explanation of the effect of collaboration to the performance level of operators in Intermodal Inland Waterway Transportation (IIWT). To verify this assumption, the literature study has been conducted on the topic of Intermodal Inland Waterway Transportation (IIWT) and Simulation Gaming.

From the literature study, the involved actors are identified. Barge operators (BOs) and inland terminal operators (ITOs) are taken as the focus in this study with the consideration that they have the significant role in the operational system of Intermodal Inland Waterway Transportation (IIWT). From this inclusion, this study then identifies the problems experienced by these respective operators related to their performance levels including *the congestion of small size barge's calls and* the *insufficient handling capacity of the inland terminal*. Barge operators (BOs) and inland terminal operators (ITOs) intend to solve these problems to raise their performance levels which overall may increase the efficiency of the operational system of Intermodal Inland Waterway Transportation (IIWT).

These discovered problems are then represented in the simulation game where the players can understand that these problems in such a way are required to solve if they want to cope with the increasing shipping demand of containers. In the game, barge operators (BOs) and inland terminal operators (ITOs) are given an active role as they are the key actors in Intermodal Inland Waterway Transportation (IIWT). Meanwhile, the shippers and institutional roles (bank and government) are included as passive roles by the game master since their presents are not directly related with the operational system but still important. The game is designed in a daily operational system where the barge operators (BOs) receive the shipping demands, and the inland terminal operators (ITOs) are required to handle the containers sent by the barge operators (BOs).

In the final version of the game, after giving the players experience on daily operational system of Intermodal Inland Waterway Transportation (IIWT) without any possible collaboration during Day 1 – Day 3, the different disruption events are introduced in Day 4, 6, 8 to emphasize the possibility of further degradation of the performance level related to the environmental conditions. After that, the players will get to know the different collaboration models along with its benefits and risks in Day 5, 7, 9 wherein the end of these days they can make a decision whether to collaborate, expand their own assets, or even do nothing.

To test this simulation game, the gaming session is conducted. The gaming session is started with the introduction of the topic of Intermodal Inland Waterway Transportation (IIWT) to the players by the game master. After giving the introduction, the game master will explain the sequential steps of the game, controlling the game execution, and leading the discussion of the result of the game. The role of game master is significantly important to ensure the connection of the game experience with the reality. The gaming sessions are done with students, both with transportation background and not, supervisors, and an expert panel consisting of researchers and lecturers who focus on the topic of freight transportation.

During the gaming session, each of the players is evaluated by using performance measures (in the form of money and points), game master's observation, and questionnaire. From the observation of the game master, during the early phase of the game where no collaborations are allowed, the barge operators (BOs) and inland terminal (ITOs) are struggling to avoid the late and failed deliveries. Their performance levels are slowly decreasing along with the increase of late delivery due to the rise of shipping demands but no improvement in their operational systems. After the collaboration models are introduced and implemented by the players, several players experience a better performance level and gain more money and positive points. However, some players also face a decreasing performance level because of the wrong decision on choosing a partner to collaborate. Moreover, along with the process of a gaming session, the players start to be able to differentiate the use of each collaboration models with regards to their operational conditions. This result of observation is in accordance to the questionnaire result which shows that most of the players can grape the problem in the system of Intermodal Inland Waterway Transportation (IIWT) and understand the use of the game in portraying the difference of collaboration models.

After the final gaming session, the game is evaluated from three perspectives based on the Triadic Game Design:

1) Reality: most of the elements of the game are based directly on reality. Some of them are simplified but do not decrease the learning objective of the game.
2) Meaning: the game can clearly show the different effects from different collaborations to the performance level of barge operators (BOs) and inland terminal operators (ITOs). The collaboration models do not always give the positive impacts, but also in some cases can generate a negative result if it is not managed well.
3) Playability: the rules of the game are found to be complex, however after the certain learning period, the players can follow the game completely and show the interest in gaining higher profits and reliability points.

To conclude, the designed simulation game has successfully answered the research question and achieved the research objective by showing a clear different impact of different collaboration models to the performance level of the involved operators. As an application, the target groups of this simulation game are the real barge operators and inland terminal operators, also student and researchers who are interested in freight transportation via in Intermodal Inland Waterway Transportation (IIWT).

7.2 Recommendations

Collaboration models as an option for improving the performance level have not been the first choice for the operators in Intermodal Inland Waterway Transportation (IIWT). In reality, they tend to expand their own assets or even do nothing to cope with the barge congestion issue. Moreover, the antitrust policy also limits the development of collaboration to keep the market stay competitive.

Based on an article written by Sarkissian (2018), the antitrust policy focuses on the limitation of *vertical collaboration*. The implementation of *vertical collaboration* is limited due to its effects on the market structure which then affect the consumer's welfare from controlling the price (Mazzeo

& McDevitt, 2014; Saeedi et al., 2017). If it reflects the result of simulation gaming, it can be understood that the operators naturally prefer to form *vertical collaboration* than *horizontal collaboration* due to their nature to be less trusting to their competitors.

However, also learned from the simulation gaming, the *vertical collaboration* potentially harms the relatively small companies with low financial. The barge operators (BOs) and inland terminal operators (ITOs) naturally prefer the partner who has equal performance level with their own. Hence, the operators whom performance level is low will be left out from the collaboration. Since the *vertical collaboration* is normally designed for a very long period, this can limit the chance of the left-out operators to improve their performance levels and become eligible to form collaboration in the future.

Quite different from the *vertical collaboration*, a *horizontal collaboration* does not generate significant harm for the low-performance operators since the duration of this collaboration model is very short. The left-out operators will be able to keep competing in the market by improving their performances. Moreover, a study by Riordan, 2005 also suggests that *vertical collaboration* may cause a monopoly that gives power to specific collaborative operators to control the price in the market. This is why the antitrust policy emphasizes the limitation of this collaboration model to be applied.

Given the negative side of *vertical collaboration*, this study recommends two types of consideration for the involved operators:

1) Learning from the suggestion from Caris et al. (2014) and the result of the simulation game, the form of *horizontal collaboration* by sharing barge capacity between barge operators (BOs) is considered a better option for barge operators (BOs) to improve their performance levels. To solve the trust issue, it is better for the barge operators (BOs) to clearly understand the positive impacts of this collaboration in reducing the barge congestion. Moreover, the business model on this sharing capacity has been discussed by Ramaekers et al. (2017) which is also quite useful if the barge operators (BOs) want to get the detailed insight of how this collaboration should be done.
2) Also learned from Caris et al. (2014), instead of forming vertical collaboration only between two players, it is better if this collaboration is formed by all the players together. Caris et al. (2014) named it as *integration operational planning* where the barge operators (BOs) can match their shipping schedule with the inland terminal operators. Recently, this idea refers to the concept of *synchromodality*. In another word, a platform that can facilitate all the barge operators (BOs) to access the information about the availability of handling capacity from all the inland terminal operators (ITOs) is suggested. By the

implementation of this idea, it is assumed that the negative side of *vertical collaboration* related to monopolistic theory can be diminished while its benefits are still obtained.

7.3 Limitations and Future Research

1) This study has a limited scope, in which only includes inland terminal operators (ITOs) and barge operators (BOs). As explained in **Chapter 2**, there are seaport terminal operators, truck operators, and shippers/ consignees who operate in the system of Intermodal Inland Waterway Transportation (IIWT). These operators are potential to be incorporated into the game to increase the validity level of the game if the extended version is needed where the collaborations also involve them.

2) The author in this study takes both roles as the participating researcher and the game designer. In some way, the objectivity of the game designer while evaluating the game tends to less critical. It also generates a high-dependency of the operationalization of the game to the game designer.

3) The number of gaming session might affect the result of the analysis since different players are possible to have different decision during the game. The least number of participants also should be considered in order to fulfill the resulting validity.

4) The distinction between collaboration models in this study is derived from the literature study. To validate them, only the expert panel is used by asking them to play the game. However, it might be better to conduct an interview with the related players in the industry to obtain more insight into how they view the impact of *horizontal* and *vertical collaboration* on their performance levels.

5) Moreover, a quantitative approach also can be implemented along with the qualitative one in this study. How the different collaboration affects the performance level can be traced by comparing the shipping demand and the successful delivery which in this study is only partially implemented.

6) Also, the last recommendation concerns the game itself. The designed game is a board game. However the idea of having all the players at the same table is quite uneasy. Not all players are able to spend their two till three hours of playing the game. Instead, it is interesting to investigate the effect of the similar game but implemented on the computer, as it has the potential to simulate real everyday activities of the operators, sitting behind screens. But, due to the need on providing the direct interaction between the players, it is better if the computer-based game is designed in a form of *online group game* where the interaction is still accommodated.

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A APPENDIX: THE STRUCTURE OF THE GAME

DAY 1

BARGE OPERATOR SHIPS THE CONTAINERS

1. Only BOs play.
2. Throw the dice, the highest as the first player.
3. Take the demand cards, prepare your LEGOs.
4. BOs ship LEGOs, put the cards in the SHIPPED box, the rest stay in the DEMAND box.
5. BOs place the barges in the maps in queue.

DAY 2 and DAY 3

INLAND TERMINAL OPERATOR HANDLES THE CONTAINERS

1. ITOs round for FIRST TIME WINDOW (06.00 AM – 12.00 AM).
2. ITOs receive the barges based on queue in *first time window*, choose which containers are HANDLED first and which wait for the *second time window.*
3. Empty barges back to Maasvlakte.

4. ITOs round for SECOND TIME WINDOW (12.00 AM – 18.00 PM).
5. ITOs handle the rest of the containers from *first time window*.
6. ITOs receive the barges based on queue in *second time window*,
7. Empty barges back in Maasvlakte.
8. Non-empty barges wait for handling the next day.

BARGE OPERATOR SHIPS THE CONTAINERS

1 Throw the dice, the highest as the first player.
2. Take the demand cards, prepare your LEGOs.
3. BOs ship LEGOs, put the cards in the SHIPPED box, the rest stay in the DEMAND box.
4. BOs place the barges in the maps in queue.

By the end of the day, BOs and ITOs report their demand, successful shipping, and successful delivery

DAY 4, 6, and 8

COLLABORATIONS DAY

A) INLAND TERMINAL OPERATOR HANDLES THE CONTAINERS

1. **Introduction and implementation of all collaborations for ITO.**
2. ITOs round for FIRST TIME WINDOW (06.00 AM – 12.00 AM).
3. ITOs receive the barges based on queue in *first time window*, choose which containers are HANDLED first and which wait for the *second time window.*
4. Empty barges back to Maasvlakte.

5. ITOs round for SECOND TIME WINDOW (12.00 AM – 18.00 PM).
6. ITOs handle the rest of the containers from *first time window*.
7. ITOs receive the barges based on queue in *second time window*,
8. Empty barges back in Maasvlakte.
9. Non-empty barges wait for handling the next day.

B) BARGE OPERATOR SHIPS THE CONTAINERS

1. **Introduction and implementation of all collaborations for BO.**
2. Throw the dice, the highest as the first player.
3. Take the demand cards, prepare your LEGOs.
4. BOs ship LEGOs, put the cards in the SHIPPED box, the rest stay in the DEMAND box.
5. BOs place the barges in the maps in queue.

By the end of the day, BOs and ITOs report their demand, successful shipping, and successful delivery

DAY 5, 7, 9

DISRUPTIONS DAY

A) INLAND TERMINAL OPERATOR HANDLES THE CONTAINERS

1. **Introduction and implementation of all disruptions for ITO.**
2. ITOs round for FIRST TIME WINDOW (06.00 AM – 12.00 AM).
3. ITOs receive the barges based on queue in *first time window*, choose which containers are HANDLED first and which wait for the *second time window.*
4. Empty barges back to Maasvlakte.

5. ITOs round for SECOND TIME WINDOW (12.00 AM – 18.00 PM).
6. ITOs handle the rest of the containers from *first time window*.
7. ITOs receive the barges based on queue in *second time window*,
8. Empty barges back in Maasvlakte.
9. Non-empty barges wait for handling the next day.

B) BARGE OPERATOR SHIPS THE CONTAINERS

1. **Introduction and implementation of all disruptions for BO.**
2. Throw the dice, the highest as the first player.
3. Take the demand cards, prepare your LEGOs.
4. BOs ship LEGOs, put the cards in the SHIPPED box, the rest stay in the DEMAND box.
5. BOs place the barges in the maps in queue.

By the end of the day, BOs and ITOs report their demand, successful shipping, and successful delivery

B APPENDIX: DOCUMENTATION OF GAMING SESSION

A. Session for Game Version I

Figure 1 Gaming session with Synchromodality Community at Erasmus University of Rotterdam

B. Session for Game Version II

Figure 2 Gaming session with MSc students with transportation and non-transportation related background

Figure 3 Gaming session with MSc students with non-transportation related background

C. Session for Game Version III

Figure 4 Gaming session with MSc students with transportation and non-transportation related background (*vertical collaboration 1*)

Figure 5 Gaming session with MSc students with transportation and non-transportation related background (*vertical collaboration 2*)

Figure 6 Gaming session with MSc students with transportation and non-transportation related background (*vertical collaboration 3*)

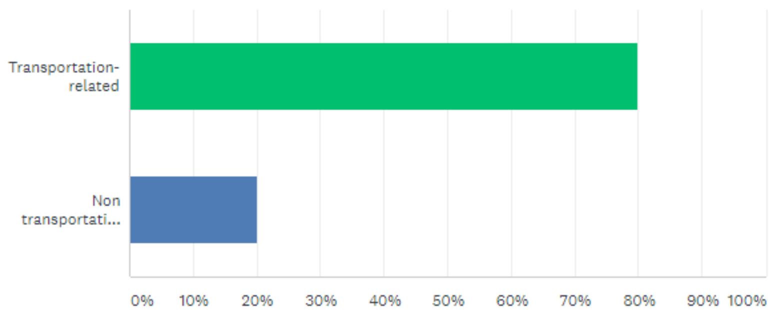
C APPENDIX: EVALUATION QUESTIONNAIRE

Q1

Customize Export

What is your academic background?

Answered: 5 Skipped: 0



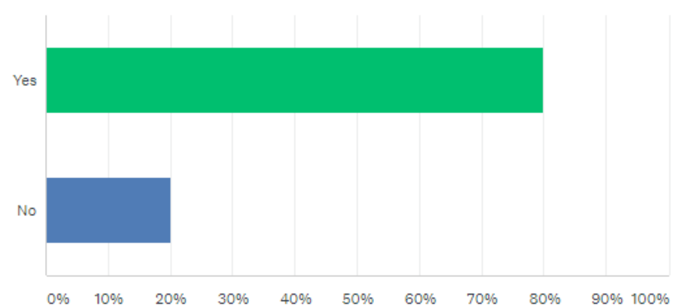
ANSWER CHOICES	RESPONSES	
Transportation-related	80.00%	4
Non transportation-related	20.00%	1
TOTAL		5

Q2

Customize Export

Have you ever heard/ learned about Intermodal Inland Waterway Transportation (IIWT) before this gaming session?

Answered: 5 Skipped: 0



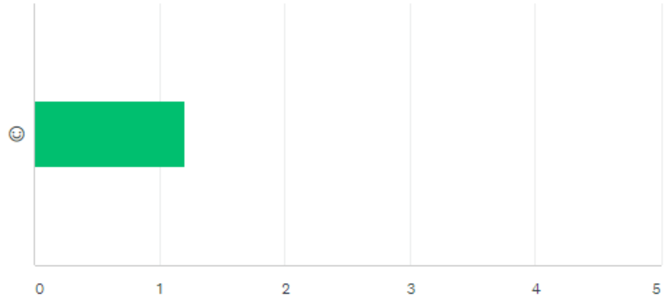
ANSWER CHOICES	RESPONSES	
Yes	80.00%	4
No	20.00%	1
TOTAL		5

Q3

Customize Export

Does this game represent the reality of IIWT appropiately?

Answered: 5 Skipped: 0



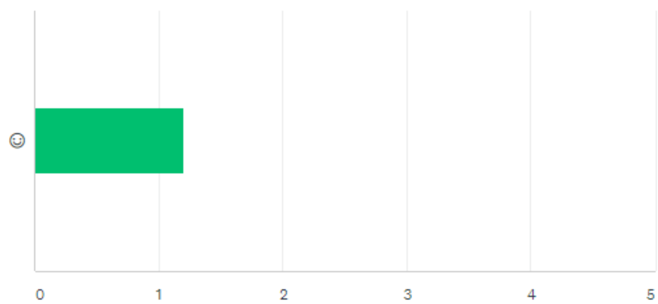
	YES, IT DOES	NOT SURE	NO, IT DOESN'T	TOTAL	WEIGHTED AVERAGE
☺	80.00% 4	20.00% 1	0.00% 0	5	1.20

Q4

Customize Export

Does this game provide a clear knowledge about IIWT?

Answered: 5 Skipped: 0



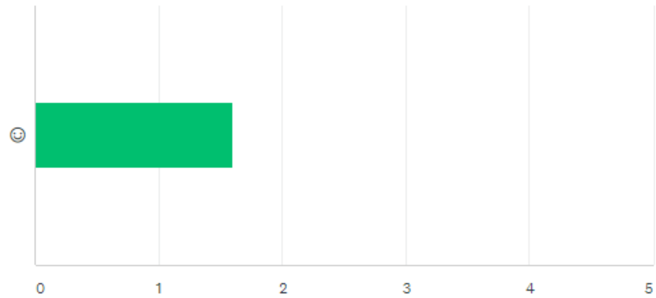
	YES, IT DOES	NOT SURE	NO, IT DOESN'T	TOTAL	WEIGHTED AVERAGE
☺	80.00% 4	20.00% 1	0.00% 0	5	1.20

Q5

Customize Export

Can you understand clearly the problems in IIWT system from this game?

Answered: 5 Skipped: 0



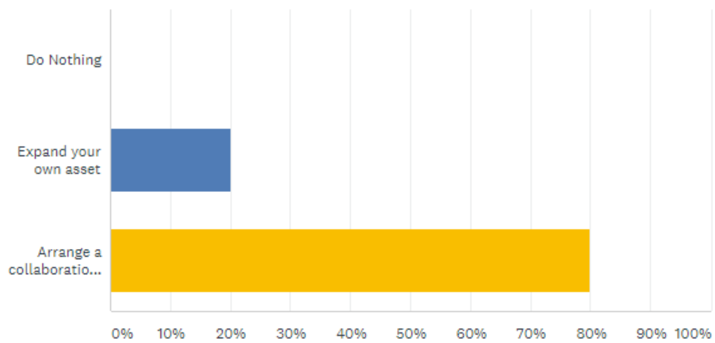
	YES, IT IS CRYSTAL CLEAR	YES, BUT I CAN ONLY UNDERSTAND PARTIALLY	NEUTRAL	NO, THE PROBLEM IS STILL UNCLEAR	TOTAL	WEIGHTED AVERAGE
☺	40.00% 2	60.00% 3	0.00% 0	0.00% 0	5	1.60

Q6

Customize Export

What will you do in real life as a Barge Operator to get a better operational performance based on your learning from this game?

Answered: 5 Skipped: 0



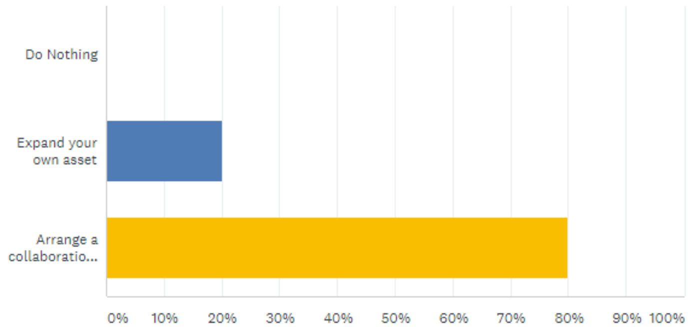
ANSWER CHOICES	RESPONSES	
Do Nothing	0.00%	0
Expand your own asset	20.00%	1
Arrange a collaboration with other company/ companies	80.00%	4
TOTAL		5

Q7

Customize Export

If your answer is YES in Q6, what will you do in real life as an Inland Terminal Operator to get a better operational performance based on your learning from this game??

Answered: 5 Skipped: 0



ANSWER CHOICES	RESPONSES	
Do Nothing	0.00%	0
Expand your own asset	20.00%	1
Arrange a collaboration with other company/ companies	80.00%	4
TOTAL		5

Q8

Export

Which collaboration model will you choose as a Barge Operator? Why?

Answered: 5 Skipped: 0

ANSWER CHOICES		RESPONSES	
None of them	Responses	0.00%	0
Horizontal collaboration	Responses	80.00%	4
Vertical collaboration	Responses	20.00%	1

Q9

Export

Which collaboration model will you choose as an Inland Terminal Operator? Why?

Answered: 5 Skipped: 0

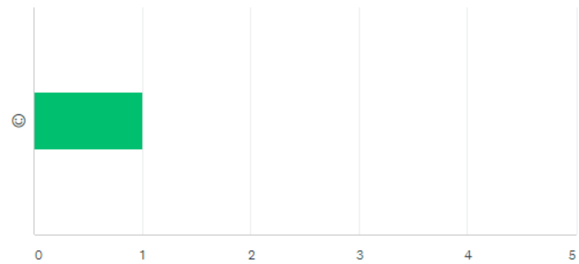
ANSWER CHOICES		RESPONSES	
None of them	Responses	0.00%	0
Horizontal collaboration	Responses	40.00%	2
Vertical collaboration	Responses	80.00%	4

Q10

Customize Export

At last, Is this game fun to be played?

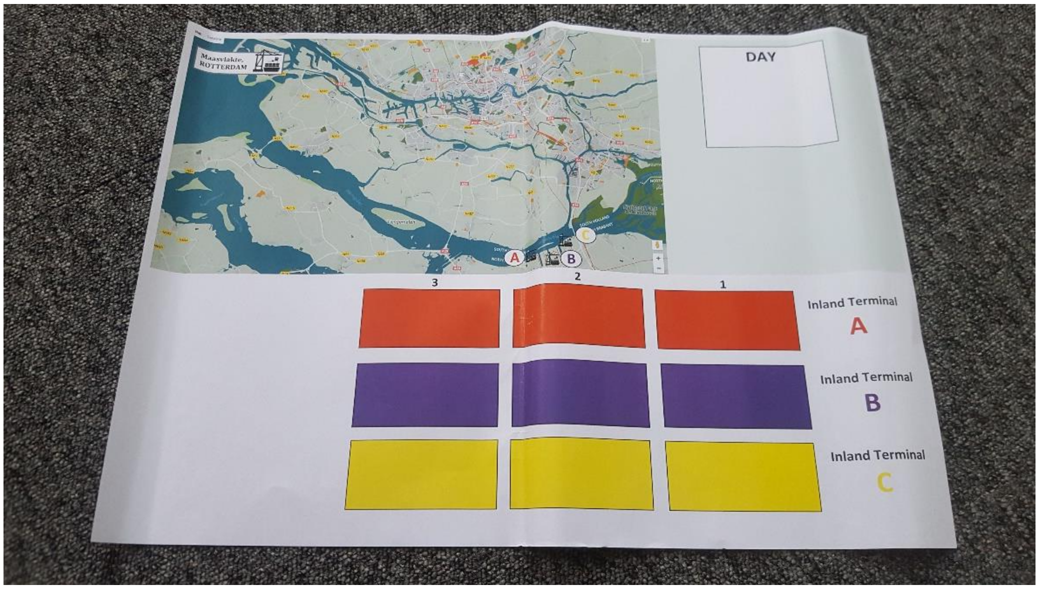
Answered: 5 Skipped: 0



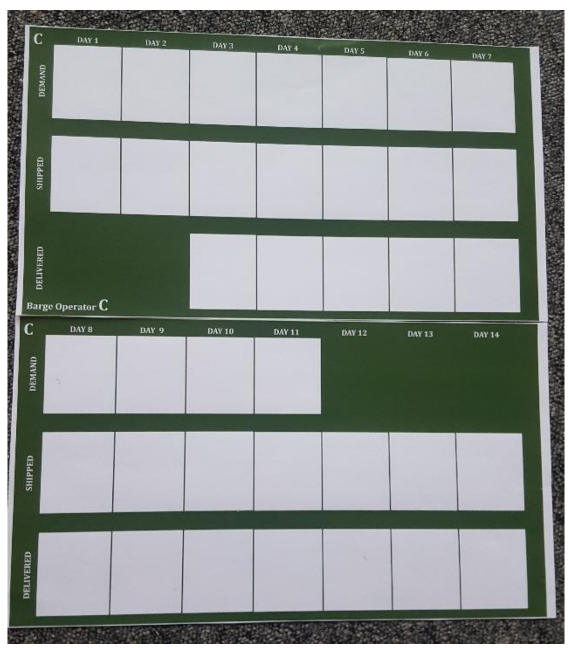
	YES, IT IS	NOT SURE	NO, IT IS NOT	TOTAL	WEIGHTED AVERAGE
☺	100.00% 5	0.00% 0	0.00% 0	5	1.00

D APPENDIX: ELEMENTS OF THE GAME

A. Maps

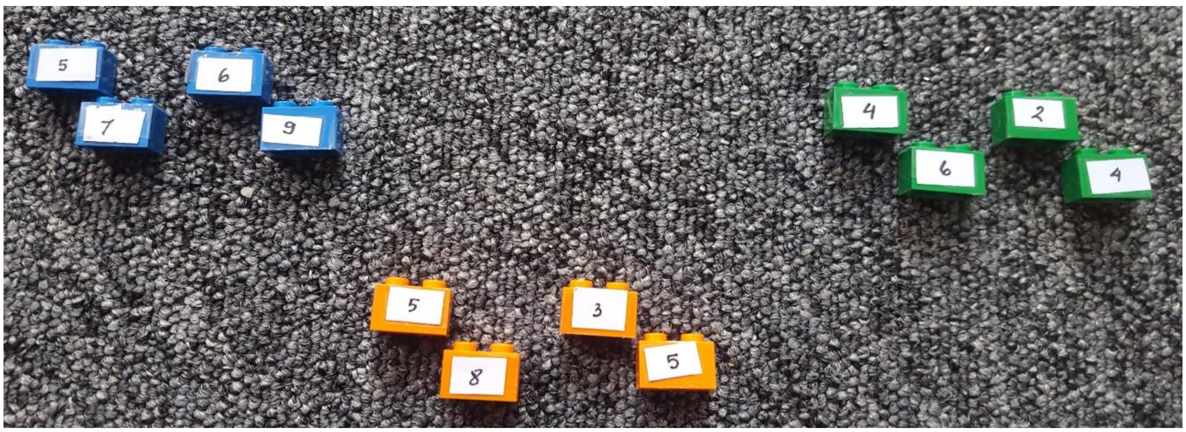


B. Flow Chart

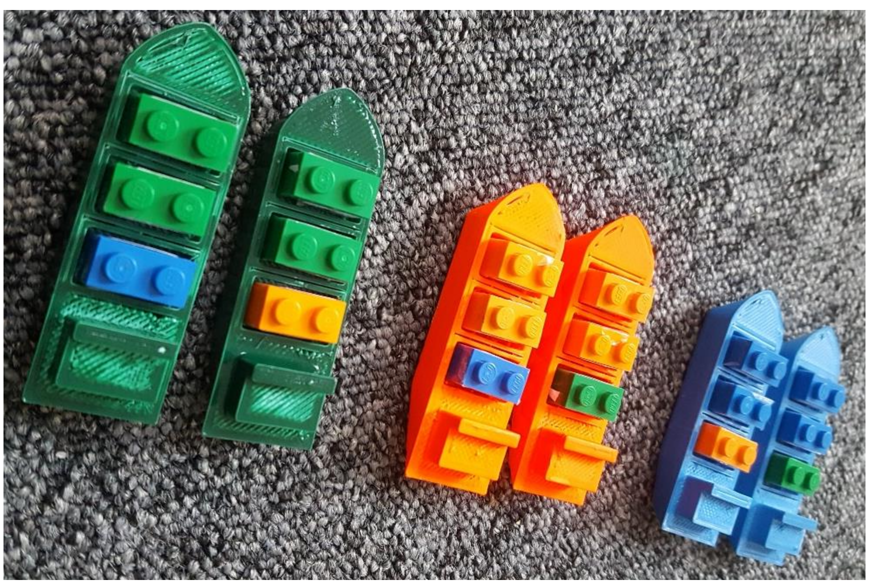


C. Demand Cards

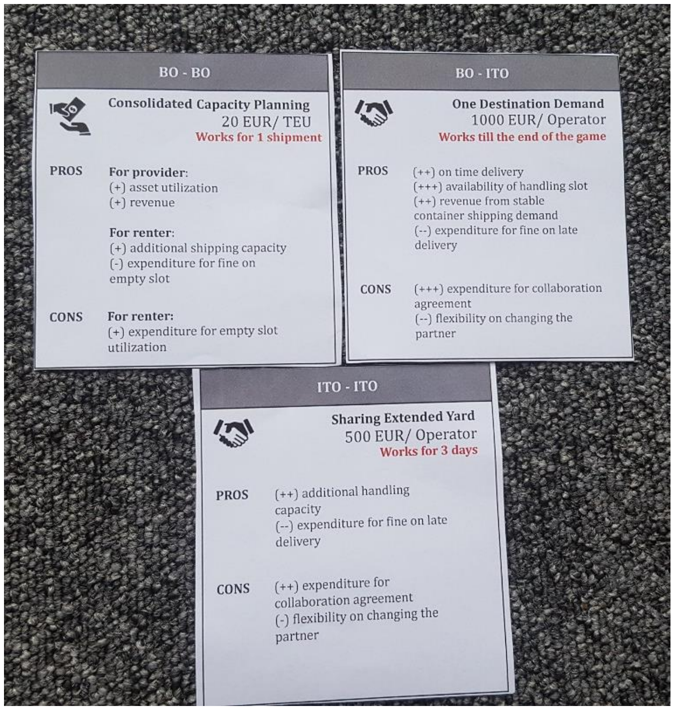
D. Containers



E. Barges



F. Collaboration Cards



G. Disruption Cards

H. Expansion Cards

I. Payment and Points

RULE FOR PAYMENT AND POINTS

YOU RECEIVED MONEY!

DEMAND SHIPPED
300 EUR/ 10 TEUs

DEMAND HANDLED
300 EUR/ TEUs

YOU HAVE TO PAY!

EMPTY SLOT
200 EUR/ 10 TEUs

LATE AND FAILED DELIVERY
300 EUR/ 10 TEUs*

* Applied both to involved BO and ITO

YOU GET PLUS!

SUCCESSFUL DELIVERY
+200/ 10 TEUs

YOU GET MINUS!

LATE DELIVERY
-100/ 10 TEUs

FAILED SHIPPING
-500/ 10 TEUs