DEVELOPMENT OF A GAME TO ENCOURAGE DATA SHARING IN SUPPLY CHAIN

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MSc Thesis

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Dedicated to

Mama, who picked me up the first time she saw me and has not put me down ever since

Baba, who loves to travel the world but when the ticket arrived, he gave it to me

Hamza, who can outwit and outsmart me but cannot outlove me

Zainab, who is 12 years younger than me in age but centuries older in wisdom

Hafsah, who knows no emotion but love

Dada, whom I would now call 24 hours a day, if only he could pick up

Executive Summary

As the supply chains became longer and included more players over a global level it became necessary to adapt the system to the requirements to facilitate this growth. Over time, the supply chain industry has undergone many transformations in technology and management. However, the current supply chain industry practices still involve many inefficiencies like inventory stock ups, late deliveries and increased operating costs, that in turn cause problems for supply chain firms. These inefficiencies can be decreased through a process of data sharing between the stakeholders in a supply chain. Currently, however, the industry does not follow the practices of sharing data due to a general reluctance of the key stakeholders to do so.

In order to tackle the problem of supply chain managers not being ready to share data, the thesis first identifies the root causes of the reluctance of supply chain managers towards sharing data. This reluctance of the supply chain managers is caused by many reasons. Firstly, they fear the misuse of their sensitive information. Information regarding one supply chain firm can be used by other firms in a way that undermines the original firm. The competitors can use this information to win the race over the original firm. There is not enough trust between supply chain firms and hence, they fear giving their information to each other. Lastly, the data sharing techniques would require investment in terms of infrastructure of data sharing technologies. The reluctance, caused by the aforementioned reasons, is a reason for the absence of data sharing in supply chains. By overcoming this reluctance and sharing data in a supply chain, efficiencies can be increased and optimal potentials can be achieved. Therefore, this reluctance is an obstacle that needs to be overcome.

After the issues are identified, a serious game is designed that is targeted for supply chain managers and decision makers in supply chain. The game demonstrates the effectiveness of data sharing and remedies the reluctance of supply chain managers by developing trust between players. It provides the evidence to support the claim that data sharing can be useful in overcoming the inefficiencies of a supply chain. The game is designed with the triadic game design approach. The reality of the supply chain, the meaning of that reality in context to the game and the actual gameplay are studied extensively, along with each player's role as a stakeholder in the game. Lastly, the game is evaluated in achieving its purpose by using suitable frameworks of evaluation from literature..

The game was designed using the triadic game design approach to ensure that the game is accurately linked to reality. It was played by experts from the field of supply chain and game design to evaluate whether or not the game was relevant to the problem, understandable and relatable to a real-life supply chain and attractive to the players. The game was played various times to analyze and understand the behavior of the players. Each game was played in two rounds, the first without data sharing and second with data sharing. The objective of the game was to have the most coins at the end of the game, which means ending with the most revenue by collecting the target set of cards. The purpose of playing the game twice with different rules was to observe the differences in the results of both the games. The better results in the data sharing round were then explained by a moderator to be an advantage of data sharing.

From the results of the playtests, it can be derived that in most trials when the players were playing without sharing information, they ended up with fewer coins than they had at the start. This is because they were unable to complete their set target in time. However, when the players were collaborating and playing with data sharing, each player had more coins than what they started with because the players completed their targets. The average of the scores in data sharing round was higher than the average in the round without data sharing. This proves that the efficiency of a supply chain is higher when the firms share data. In the second round, there was a distinction between information that can be shared and information that can be kept secret to show the managers that trade secrets are safe even while sharing data.

The playtests were also used for scenario discovery and different scenarios were identified in which a hostile player can cause damage to cooperating players. The results of the game played with this scenario showed that the hostile player was at a disadvantage and the cooperating players were able to outperform the hostile player. The game was evaluated with certain evaluation frameworks. The game was also linked with real life situations and the results proved that the game caters for these real-life scenarios in an efficient way. The answers to research questions were provided as conclusion to the report with recommendations for future works and final remarks.

Preface

We live in an age of information. The advent of new technologies in the field of communication like the internet and the world wide web has opened many novel possibilities for businesses across all industries (Berners-Lee, Hendler, & Lassila, 2001). This thesis aims to bring the industry of supply chain closer to the idea of sharing information. The topic of the thesis is to develop a serious game which will encourage data sharing in supply chain and logistics. Game design is another field that has seen recent growth and has been used for learning purposes. This thesis uses the learning capabilities of serious games to demonstrate how data sharing can help different stakeholders in a supply chain to achieve their goals quicker and minimize the risk of losses. No part of this thesis has been copied from anywhere. Due credit has been provided in the form of citations to works that have been quoted in this document.

Supply chain is an archaic field. With the industrial revolution and mass production of goods, the supply of raw materials became an important aspect of many businesses. The operations of logistics became more and more important because they guaranteed the availability of raw materials. More investment, financial as well as academic, started going into the field of logistics. Pretty soon, logistics became an operation equal in importance with finance and marketing. This led to the emergence of supply chain as a field of study and as a department in firms (Giunipero, Hooker, Joseph-Matthews, Yoon, & Brudvig, 2008). Supply chain is a change prone field and has gone multiple advancements since its conception. However, every industry has an inertia and change management can be a difficult task. Right now, despite the theoretical benefits of data sharing for supply chain, there have not been many instances of data sharing implementation because of the overall inertia of the supply chain industry in moving towards data sharing infrastructure. This thesis aims to nudge the supply chain industry towards data sharing by demonstrating how data sharing can be effective in supply chain operations.

The research for this thesis was done during the COVID-19 outbreak. Due to the unfortunate lockdown, almost all the communication between the committee and the author were done online. The game was designed, and the playtests were carried out through an online simulator of deck of cards. I would like to thank Dr. J.H.R. Ron Van Duin for his continued support throughout the duration of this research. Ron even made himself available during his vacation and answered my questions. I would also like to thank all the other members of my committee, Prof. Dr. Ir. L.A. Tavasszy, Dr. ing. V.E. (Victor) Scholten and Ir. A.J. (Linda) van Veen for

their support and constructive feedback in our meetings. Linda was kind enough to take out time for me while she was away from her duties at TU Delft.

I would like to show my gratitude to my parents, Mudaser Ijaz and Adeeba Mudaser, for giving me all the opportunities in my life and for making me the man I am today. I would like to thank all my teachers throughout my academic journey so far who taught me all that I know and all that I have known. I am also indebted to Hafsah Khizar Usmani and Bjorn Hoffman for proofreading my work at every stage, Meghna VS. for helping me throughout the course of this master's program and all my friends and well-wishers across the globe.

Table of Contents

List of Figures and Tables

1. Introduction

This chapter introduces the topic and the research problem along with research questions, contributions and societal relevance of the research. It also explains the structure of research followed over the course of this thesis and links the research to the learnings of the management of technology program.

A supply chain is a chain of firms that pass material forward until it reaches the customer (Mentzer et al., 2001). The supply chain of a firm is the chain of all the suppliers and distributors that the firm has to deal with in order to manufacture its product. As the nature of the products of these firms became more and more complex, the supply chain started to become longer and more vastly distributed (Mentzer et al., 2001). As the supply chain became longer and distributed, it became harder to keep track of individual links of the chain. Such vulnerabilities in the supply chain, have to be addressed to avoid the risk of disruption of the chain (Min, 2018). With the real time flow of information and a transparent decentralized control over transactions, blockchain seems to be a good fit for patching up the vulnerabilities in the modern supply chain (Kshetri, 2017). Although Kshetri presents the idea of the use of blockchain, the same objectives can be achieved through using any technique of data sharing. The use of technologies like RFID, GPS and IoT has enabled the industries to follow their shipments across continents while tracking quantities of the material, time taken for logistics and the quality of the product throughout the supply chain. This tracking has enabled firms to generate data which, if shared with other stakeholders of the supply chain, can create a harmony among these stakeholders and solve issues of traceability and transparency in the chain. According to theoretical research, data exchange seems to be a fitting solution to the vulnerabilities of supply chain, yet, very few firms have even begun to incorporate these principles into their supply chain.

The flow of information between parties in a supply chain is crucial for carrying out an effective and efficient transition of consignments (Stefansson, 2002). Overtime, many information sharing schemes have been proposed and tested within the field of supply chain management. These schemes include internet based data sharing (Mourtzis, 2010) and electronic supply chain design (K. C. Kim & Im, 2002) etc. These systems have put forward that supply chain can benefit from data sharing regardless of the mechanism of data sharing. Supply chain has

even tested the blockchain technology, which is a leading example of data sharing, to enable greater transparency and reliability, using IoT devices during logistical phases to track the materials at every stage of the supply chain (Kshetri, 2017). However, there might be an infrastructure cost and a large capital expense in developing a system around blockchain. The scope of this research is to create awareness on the idea of data sharing in supply chain and to point out the benefits associated with data sharing among stakeholders of a supply chain. This research will not be concerned with the technologies or systems used for the purpose of sharing data. It will be primarily concerned with highlighting the importance of data sharing in supply chain by designing a game that advocates the effectiveness of data sharing in supply chain.

The aim of this research is to develop a game that can be played by supply chain managers and decision makers in a supply chain and that contains the elements of supply chain and data sharing. By playing the game, the participant should learn that the activities within the game can be performed in an efficient and better way through sharing data. The efficacy of data sharing in a supply chain seems to be limited to the minds of academics and idealists. There is a need to propagate the message of data sharing from academia to practice. Research papers have proven the advantages of data sharing in supply chain, but the message has not been spread. One reason for this slow spread of the message could be the reliance of awareness on reading and researching. Executive level managers and decision makers might not learn too quickly through reading research papers. Research shows that learning by doing is a much faster and better method with high retention and greater spread (Felder & Brent, 2003). If, in a game, the supply chain managers and the decision makers actually apply data sharing to a given scenario which is analogous to their real-life environment, they will learn the message quicker and retain it for longer. If the game is fun and simple such that the participants find it interesting and eventful, they will be more willing to play the game and thus the message will be spread more and more.

This research will consider the case of a hypothetical company that trades perishable agri-food commodities. The company deals in exotic fruits and vegetables like pineapples. The game will focus on data sharing between different stakeholders of this fresh chain. The idea is to show how data sharing can help this hypothetical company in achieving its target in time and delivering the fruits to its customer quicker. The game will also focus on revenue and how data sharing results in a higher revenue for the whole chain with an increased revenue even in case of a delay in achieving the target.

1.1. Problem Description

The problem that this research aims to solve is that despite the features of data sharing being a suitable fit for the current models of supply chain, supply chain managers are still reluctant in sharing data and there has not been any large-scale integration of such technologies into supply chain. There is a gap between the research and practice such that research suggests that data sharing can have vital implications on supply chain, but managers seem to be reluctant on the use of these techniques in practice. Firms are hesitant to take this step despite theoretical support for data sharing (Francisco & Swanson, 2018). However, the use of data sharing techniques in supply chain has its own shortcomings, the strongest of which is infrastructural change management (Min, 2018).

Min also argues that despite the shortcomings, the advantages of data sharing technologies in supply chain still outweigh the shortcomings (Min, 2018). The shortcomings of blockchain related to large capital expenditure and infrastructure development can be overcome by using a different technological mechanism for data sharing. The advantages would be the same as blockchain with a highly reduced cost. However, there seems to be a lack of awareness in managers regarding the rewards of data sharing in a supply chain. The shortcomings seem to be overstated whereas the true advantages are consequently underplayed. Thus, it can be concluded that there is a need to create awareness among supply chain managers regarding the far fetching advantages of data exchange within supply chain. For this reason, there has to be a suitable medium of communication like a serious game or a simulation that can create awareness regarding data sharing in supply chains by addressing the hesitancy of supply chain managers.

Data sharing in supply chain has only been adopted or started to be adopted in big organizations leaving many small to medium sized firms out of the information sharing loop (Stefansson, 2002). A chain is only as strong as its weakest link. In a supply chain, if the large organizations are sharing information but that information is not reaching the small to medium sized firms, then whole chain is not efficiently using information sharing. If information is being shared by one party but not reaching the other parties or the party that is sharing information is not receiving any information in return, then the purpose of information sharing is defeated. Unfortunately, this is what is happening in practice in supply chains around the globe

(Stefansson, 2002). Despite having the theoretical suitability, many firms have not opted to share information. One reason for this might be the infrastructure and capital costs for putting the information sharing apparatus in place. However, one major reason is also the fact that many supply chain managers and decision makers are not aware of the overall benefits for sharing information. There are other problems of standardization around flow of information at both inter- and intra- organizational level (Themistocleous, Irani, & Love, 2003).

Thus, the problem at hand, is the absence of data sharing in real-life supply chains. On one hand, literature suggests that data sharing is good fit for supply chain but on the other hand, supply chain managers have their own concerns around the safety of the shared information and are reluctant to share information. There is a gap in our knowledge such that the reservations of supply chain managers are not taken into account while describing the advantages of data sharing. There is very little effort in academia to remedy the reservations pointed out by supply chain managers. This research will try to overcome this reluctance by demonstrating how data can be shared while solving the problems that cause the reluctance of managers. The reasons for the reluctance will be identified through literature review. The research will conclude in the development of a game that will advocate the use of data sharing in supply chain while catering for the reluctance of managers. The aim of the game will be that when supply chain managers play the game, they understand the importance of sharing information with their partners in the same chain. The game will ensure that the valid reservations of supply chain managers are addressed in the design of the game.

1.2. Research Questions and Objectives

The primary aim of this research project is to develop a game that highlights the advantages of data sharing. The research will be concerned with the field of data sharing and collaboration among supply chain firms primarily. The idea is that a game will be designed that will involve the mechanics of data sharing in a competitive environment and will be interesting to play. The target demographic for the game will be supply chain managers and decision makers within the field of supply chain. The first round of the game will be played without data sharing and then the second round with data sharing. The game design will facilitate sharing data and prove that data sharing is advantageous. Ideally, the game will be played multiple times in both configurations i.e. with and without data sharing. The result will prove that data sharing is

advantageous in increasing revenues and ensuring efficiency in the operations in the supply chain. The effectiveness of data sharing will be then argued using a maximin approach for the results (Pearman, 1977). The average revenues in a chain without data sharing and in a chain with data sharing will also be compared to prove that data sharing increases the total rewards of the suppliers in a supply chain. The steps mentioned above, are directly related to achieving the objectives of the game, which are described below:

The primary objective of the research is:

Demonstrate the effectiveness of sharing data among the stakeholders of a supply chain to create awareness among supply chain managers and provide a mechanism to overcome the reluctance of supply chain management

To achieve this primary objective, the following secondary objectives are also defined:

- To understand the root of reluctancy of managers while sharing data
- To create a serious game as a medium to communicate the benefits of data sharing in supply chain
- To ensure ease and attractiveness in the gameplay so that the game is diffused to the masses to create awareness regarding the role of data sharing in supply chain

Research objectives can only be obtained when the research follows an efficient structure and is guided by concise research questions. In order to achieve the objectives outlined before, my research will aim to answer the following research question:

Can a serious game be developed to highlight the advantages of data sharing in supply chain and help overcome the reluctance of supply chain managers toward sharing data?

This main research questions will help achieve the objectives if it is answered in a modular way. For this reason, following sub questions are defined that will help answer the above research question in a more streamlined way:

1. Why are managers reluctant in implementing a data sharing solution in their supply chain management?
2. What are the advantages of using serious gaming to spread awareness regarding the role of data sharing in supply chain?
3. What stakeholders have to be represented in the game and what will be their roles?
4. How can the gameplay be designed such that it's easy to play but attractive for new users at the same time within the context of fresh chains?
5. How will the game be evaluated to measure if the above goals are achieved? If not, how can the game be modified to achieve said results?

These research questions will be answered over the course of this research and throughout this report. The literature review section in chapter 2 of this report will help in answering sub question 1 and 2. The world of reality and world of play sections in chapter 3 will answer sub question 3 and 4 respectively. Finally, chapter 5 will provide the answer to sub question 5 by evaluating the game on commonly used standards.

1.3. Research Contributions and Societal Relevance

There is a gap between the perceived usefulness of data sharing in research and in practice. The theory seems to point that data sharing can solve many problems for supply chain and prove effective in doing so while supply chain managers are reluctant in sharing data and have reservations of their own (see literature review). The practice of the industry is nowhere near a data sharing ecosystem. There is a need to spread awareness regarding the role of data sharing in supply chain. A close look at the current ecosystem of the supply chain industry shows that some individual efforts are being done to employ RFID and IoT technologies (Kshetri, 2017). Both these technologies of RFID and IoT are very granular i.e. they provide data at a consignment level. An RFID tag can track the movement and placement of materials within a warehouse whereas IoT can link multiple devices together such that the movement of materials from a truck to a warehouse shelf or a warehouse shelf to a trolley be tracked. The use of such technologies proves that supply chain firms are willing to invest in technologies that make their life easier. The field of supply chain is also prone to changes and developments. It is a field that started off as being under the umbrella of logistics but today it is considered a field of its own. Supply chain has come a long way from only being able to supply materials to areas close

to the source to being able to move materials across the globe. Today, there are giant logistics firms that deal only with shipping and supplying materials.

The large extent of the supply chain industry means that there is also an inertia in the industry. A change can take a long time to diffuse from the top level to the bottom. An example of that can be that some suppliers in some parts of the world still use paper invoicing whereas the "norm" of the industry is to use electronic invoicing. This inconsistency creates problems for the whole chain (Taylor, 1994). Thus, it will benefit the whole chain if every firm in the chain is sharing data in a consistent standardized way. This research will highlight the benefits of data sharing for the whole chain. It will demonstrate the advantages of supply chain in a gaming environment such that players of the game can get the idea about the effects of data sharing in supply chains. By doing so, this research will help implement data sharing in supply chain and would make the practical reality of supply chain much more efficient and robust.

Disruptive technologies are usually slow to diffuse into society and managers have to play their part in encouraging the adoption of an innovation (Brown, 1992). This research aims to increase the adoption of data sharing technologies in supply chain. Over time, new innovations have greatly served the society at both business and consumer level. These innovations were slow to be adopted but once adopted, they saw a surge in usability and became a part of everyday routine of individuals, making their lives much easier (Brown, 1992). Data sharing technologies for supply chain can be a similar story. Through this research, the adoption of data sharing technologies will be encouraged such that it will make supply chain processes easier and more efficient. This will serve not only the supply chain managers but also the consumers who will get their products quickly and easily. Society, in general, can benefit from the implementation of data sharing in supply chains since redundant deliveries will be decreased. This will lead to a sustainable supply chain with less emissions due to the elimination of redundant transport activities.

1.4. Research Layout

This research will follow a systematic plan. Before starting the research for the thesis, the approval of the committee was to be obtained in regard to the research topic. The research idea was obtained after discussions with the supervisor on the initial topic. A proposal was

submitted to the committee that focused on using blockchain specifically for data sharing in supply chain and developing a game around that. However, the feedback of the committee highlighted that it will be best to proceed in line with data sharing in general without focusing on any single technology since that can introduce more complexities in game design. Once the proposal was approved, the research was formally started. The research for this thesis will go through the following modules:

1.4.1. Literature Review

The first major step in the research process will be a thorough literature review. This literature review will entail an analysis of contemporary literature in the fields of data sharing, supply chain and game design. Literature regarding data sharing, supply chain and the use of data sharing in supply chain will be studied. The aim of the literature review will be to point out advantages of sharing data in a supply chain. Based on these advantages, a game design would be formulated that would help reduce the reluctance of supply chain managers towards sharing data. Next, literature regarding game design will studied. The idea will be to derive examples from literature that tackle a similar problem of developing a game for a novel technology. This step will also provide answers to sub question 1 and 2.

1.4.2. Game Design

The next step will be the actual design of the game. This step will be divided into three sub modules which will run as serial tasks: model the reality, deduce the meaning and design the game. This will be an iterative process i.e. if things don't add up in the gameplay section, the focus will then be shifted back to the reality and meaning. Thus, this will also be a form of internal testing to keep all aspects in balance. First, the reality will be analyzed such that it can be represented in a gaming environment. In this step, stakeholders will be identified along with their roles. This will enable the creation of a model to give a realistic idea of what the gameplay should entail. Once the reality is studied, it will be important to start thinking about the meaning of the findings from reality. In the meaning section, the reality model will be converted into a gaming environment such that all stakeholders and their roles would be accurately represented. The last part of the design process will be designing the actual gameplay. In this section, the gameplay will be presented, and the game will take its final form. The rules of the game will

be defined and the roles of the players along with the required props will designed. This step will provide answers to sub question 3 and 4.

1.4.3. Play Tests

Once the game is designed, the next step will be to test the game through different play sessions. Playtesting is one of the most common methods to test functionalities of a game (Korhonen, 2010). Through play tests, researchers are able to gather feedback and judge the performance of the game. These tests generate additional feedback in terms of player response and reaction which can be used to judge the game experience. In this research, play tests are used to first check if the rules of the games are consistent such that the gameplay remains smooth and second, to judge the effectiveness of the game in delivering its intended message. If the players are immersed in the game and find it interesting that means that the design and rules of the game are effective in terms of in-game mechanisms. If the players are able to judge the message of the game themselves, that means that the game is effectively relaying its message and the gameplay corresponds correctly to the intended message. Playtests will be done with experts from the field of supply chain to check the relevance of the game to real-life supply chain processes and with game design experts to check the in-game mechanisms and the gameplay of the game.

1.4.4. Evaluation of the Game

Once the game design is completed and play tests are done, the next step will be to evaluate the game to check if the targeted objectives are achieved or not. The feedback from the playtests was incorporated in the game design. The final version of the game will be ready after the feedback has been incorporated. In addition to this, the game will also be played by student volunteers to better judge the gameplay and the general look-and-feel of the game. The objective of making the game easier to play will be judged by the reaction of the students. The two types of feedback combined i.e. feedback from experts of supply chain and game design and feedback from students regarding the gameplay will be used to judge the game and evaluate the objectives. The validity of serious games is very important and it is something that has to be kept in mind throughout the design process. (Peters, Vissers, & Heijne, 1998). Peters et. al. also mentions that the best way to check the validity is to play the game extensively and gather

feedback. Thus, after playtesting and feedback incorporation, the game will be evaluated by using frameworks from literature. This provided the answer to sub question 5.

1.5. Management of Technology Background

The research is linked to the management of technology program of the Technology Policy and Management faculty of the Delft University of Technology in many ways. Knowledge sharing is a complex phenomenon and is impacted by several factors (Newell, Robertson, Scarbrough, & Swan, 2009). A good part of the course, Leadership and Technology Management (MOT-1524) was concerned about managing knowledge and innovation. The course pointed out how knowledge was intended to be shared and how it was hampered by current industry practices. The concepts of implicit and explicit knowledge were also a part of the course. This research deals with sharing data between organizations that are a part of a supply chain. Because of the concepts learnt in this course, I was able to understand the complexity of problem of information withholding. I was also able to understand how trust plays a part in information sharing. Moreover, the course also touched upon structures of organizations and composition of team. It can be argued that organizations with a more hierarchical structure will have a lot of red tape to cut through before a part of information can be shared. Similarly, a supply chain whose suppliers are co-located in a small geographical area i.e. the same country might not find information sharing to be too critical. However, a supply chain whose stakeholders are dispersed over a vast geographical location would really benefit from data sharing. These were some factors that were learnt through the leadership and technology management course and really helped me in understanding the root of the problem with information sharing.

Data sharing can be done through many means. In the current age, the focus is on using digital technologies. Many of these technologies including RFID tags, IoT and blockchain are fairly new and innovative. The slow spread of the practice of data sharing is mainly due to reluctance of managers in adopting it but there is also a factor of technology diffusion. Many suppliers are yet unaware of the use of RFID tags and blockchain being used for data sharing purposes in supply chain. This is in-line with the concepts learned in Emerging Breakthrough Technologies (MOT 2421). A technologies diffusion follows an s-curve where the spread is slow at first, then starts to take off as more and more people start employing that technology and finally starts to slow down again since the new adopters decrease (Ortt, n.d.). The same

can be applied to the practice of using a technology since practice follows the adoption. Thus, data sharing in supply chain is still in early phases where its use is spreading at a slow rate. This research aims to increase the rate of spread of data sharing by developing a game that encourages data sharing by highlighting its advantages. The concepts learnt in the course of Emerging and Breakthrough technologies were helpful in making me understand the reasons of slow diffusion of data sharing and coming up with ideas on how to speed it up.

This research is aimed at developing a game. The concepts of game design were learnt in Integration Moment (MOT 1003). This course was a more of an end of year project activity, but it still imparted some important concepts. The concept of triadic game design was leant through integration moment. Triadic game design deals with dividing the process of game design into three sub processes of reality, meaning and play (Harteveld, 2011). The reality is about analyzing the reality and noting down key processes and stakeholders that play a role in the process which is to be mapped to a game. The meaning part is about extracting meaningful information from reality i.e. how a process will be represented? Which stake holder will play what role? This meaning is then used to design a game in the play section of triadic game design. The game development of this research will follow the principles of triadic game design.

2. Literature Review

This chapter is a literature study that looks at relevant research articles in the field of supply chain, supply chain management, data sharing in supply chain and serious game design.

In this section, literature pertaining to the field of supply chain, data sharing and serious gaming will be studied. The objective of the literature review will be to highlight the reasons for reluctance of managers and shed light on the advantages and disadvantages of serious games to merit the use of serious gaming in creating awareness for sharing data in supply chain management. Moreover, the sub questions 1 and 2 will also be answered through this literature review. The first part of the literature review will be about supply chain. A contemporary definition of supply chain and supply chain management will be presented. Then, the properties of a modern supply chain will be discussed which are relevant within the scope of data sharing and finally the current challenges faced by supply chain managers will be highlighted. Second part will deal with data sharing in a similar way. The definition and uses of data sharing will be sought from the literature. It will be investigated if sharing data is a solution to supply chain's problems. Finally, the last part will look at serious gaming and how serious gaming can be used for creating awareness regarding the use of data sharing in supply chain.

2.1. Supply Chain

The concept of supply chain is widely used in academics and in professional settings. The idea of supply chain seems to be clear in everyone's head. However, for this research, a concise yet accurate definition of supply chain and supply chain management shall be presented. This definition will help derive indicators of the performance of a supply chain and highlight issues with the current implementation of supply chain in coming sections. In the introduction section, it was mentioned that supply chain is the collection of all the suppliers and distributors that help a firm manufacture its product and then distribute it to retailers and consumers. This is the common definition that comes to most people's mind at first. However, this definition does not tell us anything about the properties of a supply chain and how it can be improved. A better definition of supply chain, as presented in literature is, a supply chain is an integrated process wherein a number of various business entities (i.e., suppliers, manufacturers, distributors, and

retailers) work together (Beamon, 1999). This new definition of supply chain introduces two new concepts that are conveniently left out in the everyday definition i.e. integration and working together. In another research. Beamon explains that all the links in a supply chain work together in an effort to: (Beamon, 1998)

(1) Acquire raw materials
(2) Convert these raw materials into specified final products
(3) Deliver these final products to retailers

Thus, the functions of the supply chain are to acquire raw materials, convert them to a final product and distribute those products. These functions can then help us understand the properties of a supply chain. One property is mentioned above, derived from Beamon (1998) definition i.e. all firms in a supply chain are integrated and work together towards a common goal. Let us consider some other definitions of supply chain in order to derive some more properties of supply chain. A supply chain is a set of firms that pass materials forward (La Londe & Masters, 1994). According to La Londe and Masters, a set of firms that pass materials forward such that every step takes the raw materials closer to a finished product can be thought of as a supply chain. Similarly, supply chain can also be defined as a network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer (Christopher, 1992). Christopher argues that the distinguishing factor along every step of a supply chain is that it adds value to the overall process of manufacturing the product. Christopher's definition includes a factor that is absent from La Londe's definition. La Londe does not talk about upstream or downstream or the addition of value. Instead, because La Londe's definition came later, he simply combines the idea of upstream and downstream as passing materials forward. Combining these two definitions, we can note another property of a supply chain i.e. every link in a supply chain adds value to the overall product by bringing the raw materials closer to a finished product.

Another important property of a supply chain is resilience. In physics and engineering, resilience is defined as the capability of a strained body to recover its size and shape after deformation caused especially by compressive stress (Merriam-Webster Dictionary, 2007). In supply chain, resilience can be defined as the unexpected deviations from the norm and their negative consequences (Svensson, 2002). Much like a strained body under pressure,

if a supply chain is faced by external forces, it will morph itself such that it can cope with the forces while delivering the value it intends to deliver. Once the external pressure is lifted, the supply chain returns to its original form or it evolves by growing into a new, more desirable state (Pires Ribeiro & Barbosa-Povoa, 2018). Thus, a supply chain has the property that is deals with disturbances with resilience and overcomes the disturbance by either adjusting or evolving. The property of resilience is an important property because it leads supply chain to evolve constantly in order to overcome hurdles. These evolutions pave way for modern technologies to be used within supply chain operations.

2.2. Supply Chain Management

As supply chain as became more and more involved in the manufacturing process and success of organizations, more focus was diverted towards managing the supply chain. Academics started studying new organizational structures that were deployed by successful manufacturing companies. One such study was carried out by Jay Forrester which highlighted factors that can spearhead the advance of management in industrial success (Forrester, 1958). Forrester ran simulations to describe factors that play a vital role in the success of a company. He concluded that for success in the future, the organizational authority will have to be decentralized and more decision-making power will go into policy making than the day to day operations. Forrester was calling out for decentralization of power in every aspect of the company which called for the distribution and logistics to have their own management structure.

Much like the Forrester study, a literature review was done on the supply chain management literature which studies paper from the 1980s to provide a commutative definition of supply chain (Giunipero et al., 2008). Giunipero et al. studied literature from the past decades to highlight the progress in the field of supply chain management. Their research was focused on several research papers from different journals with the goal of identifying gaps in supply chain management research and opening avenues to fill those gaps. Following the steps of Giunipero et. al, a definition of supply chain management will be presented by consulting prominent papers from the field.

The earliest notion of collaboration between suppliers and distributors was presented as early as 1961. It was realized that the flow of information, materials and manpower between organizations played a key role in the success of a business (Forrester, 1961). Although the

words supply chain or supply chain management were not used by Forrester, he did, however, present an idea of a chain which consists of different organizations and passes on materials and information. An important point to note is that Forrester argued that a successful business will not only move materials around but also information (Forrester, 1961). Thus, inherently, the idea of information sharing is present in supply chain management.

The term supply chain management was coined by Oliver and Webber in 1982. They defined supply chain management as the process of planning, implementing and controlling the operations of the supply chain with the purpose to satisfy customer requirements as efficiently as possible (Oliver & Webber, 1982). Oliver and Webber further argued that supply chain management spans all activities from the point of origin to point to consumption. This definition is particularly helpful for green chains. In order to provide the customer with the origin of the product, it is important that the management itself is efficiently tracking the product from origin to consumption. A supply chain management implementation that only comes in at a certain point of the supply chain (and not from the point of origin) will itself be oblivious to the origin of the product and will not be able to prove its provenance. In cases where external logistics carriers are used, the only way to truly track the origin of the product will be through sharing information. If the supply chain management of a fruit's exporter is buying their products from a distributor (and not the actual farmer), then the distributor must share the information about the origins of the product with the fruit's exporter reliably. Thus, by sharing information, the supply chain management of a small fruit's exporter can also track their product from origin to consumption without having the actual machinery for the entire chain.

The next milestone research in the field of supply chain management was done in 1998. Lambert et. al. not only provided a thorough definition of supply chain but also pointed out key process that make up the supply chain. In essence, supply chain management can be seen as a collection of two management components i.e. physical and tactical and managerial and behavioral (Lambert, Cooper, & Pagh, 1998). Physical and tactical components are tangible components like organizational structure, planning and workflows. Management is usually on top of this group of activities. The managerial and behavioral component, one that is often ignored by management includes the power structure of company, risk analysis, effort and reward mechanisms etc. An effective supply chain management is the one that manages both these components effectively. Data sharing can be seen as an amalgam of both these

components. A company would need to have tactical processes to ensure effective data sharing but at the same time, the behavior of the managers will have to be cooperative with a decentralized power structure to support data sharing activities.

Finally, the look at previous supply chain management literature takes us to a widely accepted definition of supply chain management which was put forth by Mentzer et. al in 2001. Many other supply chain management definitions have been put forward after this, but none offers a concrete addition to Mentzer's definition and so we can conclude with this definition. Mentzer introduced the concept of supply chain orientation. The idea of viewing the coordination of a supply chain from an overall system perspective, with each of the tactical activities of distribution flows seen within a broader strategic context is more accurately called a Supply Chain Orientation (Mentzer et al., 2001). Mentzer calls supply chain management the implementation of the supply chain orientation across different companies within a supply chain. If all companies within a supply chain are striving towards a common goal i.e., they have the same supply chain orientation, the management of the supply chain will be the most effective form of supply chain management. Mentzer does not go deep into how supply chain orientation can be achieved. In our case, information sharing can be a huge enabler for supply chain orientation and thus effective supply chain management. If different companies within a supply chain are sharing information effectively, they have a better chance of aligning their orientation. Similarly, in a data sharing scenario, the management will have more data to base their decisions and improve decision making through predictions and analysis.

2.3. Issues in Supply Chain Management

In the previous parts of this literature review, we have seen how the definition of supply chain has evolved over time and how new concepts and components have been introduced. Despite being a prominent and archaic field of study, supply chain still faces challenges in its deployment and performance. Recent literature regarding modern deployments of supply chain and the problems faced by supply chain managers will be reviewed here to identify primary challenges in supply chain.

Supply chain operations involve all departments within an organization. An important aspect of supply chain management is communications between various departments of an organisation like marketing or production. Thus, as more and more entities started joining the

chain, the integration of supply chain became more and more complex (Bala, 2014). Bala studied the supply chain status quo in India, with the increased demand from all around the world for products being manufactured in India. Bala highlighted some major issues and challenges in supply chain. Two relevant issues were supply chain integration and the flow of information in a supply chain. Different partners in a supply chain are reluctant in sharing information because of the idea that other parties might earn a higher incentive using shared information (Bala, 2014). Moreover, there are certain data points in the information that might be sensitive like cost price per unit or capital expenses for the product. Thus, the first issue in supply chain management is limited information sharing due to the reluctance of managers for the fear of misuse of their information and unproportionate rewards for others.

The field of supply chain has grown constantly due to which the term 'supply chain' has risen to prominence in the last few decades (Mentzer et al., 2001). More and more researches are being done within the field of supply chain. This growth has seen the technologies that are used within supply chain to evolve with time. The field of supply chain is plagued with uncertainty. This uncertainty stems from the interaction of multiple suppliers, distributors and warehouses within the manufacturing processes of a single product (Davis, 1993). Technological advances are vital for supply chain managers in order to overcome the uncertainty and streamline the delivery of materials.

To overcome this uncertainty, a supply chain has to be integrated. An integrated supply chain is one that synchronises the requirements of the customer with the flow of material from suppliers in order to effect a balance (Stevens, 1989). The idea of supply chain as mentioned by Stevens is the core of Bala's research. The requirements of the customer are known by the marketing department whereas the flow of materials is controlled by suppliers or procurement departments of the suppliers. Thus, even in its most basic form, supply chain integration can only be achieved if these different departments are somehow communicating. In other words, the marketing departments of all the suppliers share the customer requirements, production departments share the manufacturing predictions and the procurement shares the incoming materials. Supply chain integration is virtually impossible without information sharing.

If we delve more into fresh chains literature, which is the main topic of this thesis, we find similar trends. In 1994, a case study was done on the problems of food supply chains. Some problems found by this study were around food production, food shrinkage, warehousing and

retailing (Taylor, 1994). However, the first problem cited by this study was the use of outdated technologies. The study was done in context of Russia and the technologies were pointed out in comparison with rest of Europe. However, in a fresh chain, if a part of the chain in Russia is using outdated technologies, the effect will be directly visible on the product wherever it is shipped. If one part of the chain is not communicating effectively, the whole chain will be affected negatively. Thus, difference in technological standards have to be mitigated since the chain is only as strong as its weakest link. Another case study observing the logistics of fresh salads concluded that uncertainties in supply chain are increased due to differences of operations between different parts of the chain (Vorst, Beulens, Wit, & Beek, 1998). Vorst et al. also identified main sources of uncertainty in supply chain. One such source is the lack of data available for managers to base their decisions.

Thus far, we have looked at literature concerning supply chain and supply chain management. An overarching definition of supply chain has been presented along with its properties. The concept of supply chain management has been reiterated along with the issues faced by supply chain managers in moving towards effective supply chain management. The foremost issues identified in supply chain management are given below:

- Lack of information regarding activities of different departments and firms within a supply chain
- Differences in processes and operations in different part of the world
- Lack of data to make effective decisions regarding supply chains

In the coming sections, the use of technology will be presented as a viable solution for solving these issues and then the use of serious gaming for spreading awareness regarding the use of information sharing in supply chain will be argued through literature.

2.4. Data Sharing in Supply Chain

It is evident from the discussion above, that supply chain integration is one of the most key factors in the success of a supply chain. An intuitive way to achieve integration will be through sharing knowledge or data. If one firm is aware of the delays in their predecessor's production, it can then adjust its own forecasts and communicate the delays to its successor firm. Thus, the whole chain remains aware of the recent developments and adjusts its forecasts based on the data. Ultimately, the manufacturing firm can update its customers and distributors regarding

the delay in delivery and shipments. Thus, information sharing serves as an essential enabler of supply chain integration (Lotfi, Mukhtar, Sahran, & Zadeh, 2013). Lotfi et. al. researched the effectiveness of information sharing in supply chain. The concluded that information sharing is effective in creating supply chain integration. Some intermediary advantages of information sharing in supply chain are inventory reduction, inventory management and increased visibility. In fact, Lotfi et. al. finished the article by saying that just to survive in today's global economy, data sharing might be inevitable for supply chain managers.

Literature points to two dimensions towards information sharing in supply chains – connectivity and willingness (Fawcett, Osterhaus, Magnan, Brau, & Mccarter, 2007). Connectivity is the conventional dimension of information sharing. It is concerned with how much information is being shared and what is the mode of sharing information. However, the dimension that most firms lack is willingness. Even if the best mode of information sharing connectivity is present, the project will not be successful unless people are willing to share information. Huge investments in technology can be negated by an unwillingness to share needed information (Fawcett et al., 2007). The dimension of willingness links directly to the reluctance of managers in sharing information. Higher willingness means less reluctance and vice versa. So, if we were to investigate the reasons for low willingness of managers in sharing information, we will have the reasons for reluctance. Some reasons for reluctance were mentioned before, which were the fear of misuse of sensitive information and disproportionate rewards for others. Fawcett mentions another reason for low willingness (reluctance). Managers are reluctant to share information in fear of conceding power to their competitors. Information is power. Thus, by sharing information, firms often times feel that they are giving power to other firms. These firms can later use this information against the original firm or to gain a competitive advantage over the firm. However, it is also hypothesized that willingness is directly related to performance of a supply chain firm. If the firm itself does better as a result of sharing information, it will be more willing to share information in the future.

Literature shows some data sharing means that have been tested for supply chain. An early form of data sharing in supply chain is a system called electronic supply chain design. e-SCD is a supply chain design which integrates and coordinates suppliers, manufacturers, logistic channels, and customers using information technology (IT) (K. C. Kim & Im, 2002). Basically, e-SCD can be seen as a basic IT based information sharing system that allows the suppliers to communicate with each other regarding the state of the materials in transit. This could be, for

example, synonymous with one supplier calling the next supplier once he had sent the materials on their way. With the advent of the internet, communication became faster. Supply chain was incorporated with this new technology of the internet to allow suppliers to use the internet to communicate (Mourtzis, 2010). Although, the internet was a big step up from the preceding technologies, there was still room for improvement with all the new technological advancements in communication systems.

Various modes of information sharing have also been tested for supply chain. One of the latest modes to be proposed through research was blockchain. In his article, Kshetri points out cases where blockchain has been used in parts of a supply chain to deliver exceptional results (Kshetri, 2017). In his research, Kshetri concludes with the example of the E. coli outbreak at a restaurant and its damaging effects on the food supply chain. This is even more relevant today, in the wake of the 2020 COVID-19 (Coronavirus) outbreak. Through blockchain's innovation of shared ledger and audible transactions, it will be much easier to pinpoint transactions from possible risk areas and to handle shipments from those transactions with care. However, with such technologies like blockchain, a huge investment cost or capital expenses is associated. Managers are again reluctant in moving towards such technologies due to the increased costs and the risk of limited delivery (Kshetri, 2017).

Similarly, other approaches have also been found in literature that facilitate data sharing. Among these the semantic web approach (Huang & Lin, 2010), RFID data sharing (Thiesse & Condea, 2009) and blockchain (Ge, Brewster, Spek, Smeenk, & Top, 2017) stand out. Ge Lan et. al. conducted a pilot study to observe the effects of blockchain on agriculture and food supply chains. Their proof of concept demonstrator showed how blockchain can be used to ensure that different parties share the same layer of information on the validity and provenance of certificates that is tamper-proof (Ge et al., 2017). Despite being successful in its demonstration, the proof-of-concept showed issues of scalability and limited complexity. However, the proof of concept did establish the effectiveness of blockchain in agriculture chains and offered valuable lessons for the industry. In the scope of this thesis, data sharing is looked at as a process without commenting or comparing the underlying technologies. Thus, all of the aforementioned technologies provide arguments in favor of data sharing in a supply chain.

2.5. Serious Gaming

The second sub question for this research is why serious gaming will be effective in spreading awareness regarding sharing data in supply chain. For answering this question, we will look at research articles that employ serious gaming for a similar objective. A major use of serious gaming is documented to be in learning. Serious gaming has been employed for educational purposes at different levels. One key advantage of serious gaming in teaching is long term retention of the message. the game lets you experience things in a fun way, and this aspect may make the difference in the long-term retention ("it is so fun it is impossible to forget") (Mortara, Catalano, Fiucci, & Derntl, 2013). Instead of writing a message in a notebook or trying to cram it in memory, a person plays a game that explains that message through a series of fun events which are controlled by the person. Because the events are fun and different, they will stay in the person's mind for a long time and will remind them of the message imparted by those fun events. In our case, we can conduct a series of seminars where supply chain experts can argue the advantages of sharing data in supply chains. This will be not be as effective as designing a game. The game will help managers remember the message by associating it with a series of fun events rather than a lengthy slide share session.

In design, there is an idea of design-in-the-small and design-in-the-large. Design-in-the-small (DIS) is the idea of limited world where unnecessary principles can be taken out and only the minimalistic view of the necessary principles is used. Klabbers (2003) argued that while designing a game, a person should take the DIS approach such that the players and other in-game actors might be aware of the important principles that govern the game (Klabbers, 2003). Thus, from a design perspective, gaming gives you the ability to define a minimalistic view of the real world in which everything is known to actors, giving one more control over the outcomes. This can be particularly useful in our case of designing a game for data sharing. If the actors within the game are familiar of the rules and are in control of the outcomes, they will feel more connected to the result. In real life, if the supply chain does well due to shared information a low-ranking supply chain manager might not be able to relate to the success. However, when he plays the game, he can see his efforts being converted to success first-hand.

Building on the concept of design in small, Duke argues that games can be applied as a prologue to the actual activity. Games are usually employed in a predecision context by top administrative personnel in an effort to communicate more effectively with one another about

the problem at hand (Duke, 1980). In the context of data sharing implementation in supply chain, a game would be helpful since it will portray both the problem at hand and its solution more elegantly. Moreover, gaming can also help create a better culture in an organization and deal with an organizational change in a better way (Willy C. Kriz, 2003). Thus, the reluctance of managers towards the change of implementing data sharing infrastructure in supply chain can be overcome by creating a game that lists all the necessary steps required for the change and provides an ideal scenario for the execution of those steps.

Finally, it is also important to look at the method of game design and not just its advantages. An approach towards game design has to be identified that will guide the entire game development process during the course of the research. There are many different approaches to game design. One of the most prevalent approaches is triadic game design. Triadic game design philosophy outlines three major elements in the design of every game i.e. reality, meaning and play (Harteveld, 2011). The reality element represents the game's model of reality and how reality will be presented in the game. The meaning element is concerned with the values associated with the game. The play element is concerned with the gameplay and the virtual game space where events take place. There have been many analysis on the triadic game design approach (Lukosch, Bekebrede, Kurapati, & Lukosch, 2018). The triadic game design approach still remains more broadly applicable to game design research. This research will follow the triadic game design, and the three different elements of the game will be mapped out to their corresponding counterparts.

2.6. Reflections on Literature

The objective of this literature review was to answer research questions related to reluctance of managers in sharing data and the effectiveness of serious gaming in creating awareness regarding the role of data sharing in supply chain. The literature review has provided some key insights into the academic world of supply chain. It can be seen that in literature, there are clear models or approaches of data sharing in supply chain management. Moreover, the research also highlights how these models can be highly effective if implemented in a supply chain. However, we don't see much examples of such implementations in the industry in practice. Hence, there is a gap in contemporary research such that the research is not taking into account the industry's inertia to employ data sharing. In practice, managers are wary of the capital expenditure, time investment and change management associated with implementing a data

sharing solution. Although, researchers are aware of these barriers, but they seem to underplay or ignore them while highlighting the advantages of data sharing. This research aims to bridge this gap by highlighting the advantages of sharing data while keeping the limiting factors associated with data sharing in mind. The game that will be developed through this research will have a mechanism for representing costs. Data sharing will only be considered effective if its advantages outweigh the costs.

3. Game Design Methodology

This chapter explains the design methodology used in the development of the game for this research. It consists of three main parts which are world of reality, world of meaning and world of play. World of reality looks at the real-life supply chain processes and stakeholders. World of meaning derives meaningful processes and stakeholders from the world of reality that will be represented in the game. World of play presents the actual gameplay and rules of the game.

In this section, the design of the game will be presented, and different steps of the game design process will be explained in detail. Game design is a complex process, especially for designing a game based on a complex reality. In order to ensure the proper design of an effective game, the choice of the design process is very important. It has already been discussed that when designing a game that is an abstraction of a real-world process, extra attention has to be paid towards studying the reality. The success of the game design will depend on the accuracy of the representation of reality i.e. the right stakeholders and right processes are represented in the game. One of the earliest game design process was a 9-step process that listed the critical activities of a game design into a systematic step by step process (Duke, 1980). These steps are generic and are followed in almost every game design process. Essentially, Duke provides a checklist of activities that have to be performed while designing games. However, these activities are too specific and can be generalized into categories that can then be performed as sub processes of the game design. One such game design approach is the triadic game design (Harteveld, 2011). As stated in the literature review section, triadic game design process is a broad category process that can be applied to any game design. It incorporates the possibility of a complex reality and caters for studying the stakeholders and processes of the reality. It does not provide a specific step by step approach but rather a modular research approach that can be applied broadly. Some other game design methodologies include the VAP (Values at Play) method (Flanagan & Nissenbaum, 2007). The VAP method is specific to cases where value sensitive games are to be designed. Thus, in line with the discussion above and the findings from the literature review section, the triadic game design method is used to design the game for this research.

Triadic game design is an approach that divides the game design process into three distinct sub processes or worlds. These sub processes are world of reality, world of meaning and the world of play (Harteveld, 2011). Each sub-process takes the game closer to completion. World of reality is about studying the reality and analysing the different processes in light of the problem statement. In the world of reality, one can identify the relevant stakeholders and how they play a part in the complete process as well as the problem. The world of meaning is about extracting meaning from reality. After studying the reality, identifying the stakeholders and defining the problem, the next step is to extract meanings from the findings. More specifically, what is the purpose of the game? How will the steps in the game translate into reality? The world of meaning acts as a bridge between the reality and the game. The final section is the world of play which is purely related to designing the game. The reality that has been studied and the meaning that has been derived from that reality will combine directly to dictate the design of the gameplay. The rules of the game will be formulated in light of the result of findings from reality and their meaning. The design process of the game for this research is as following:

3.1. World of Reality

The first step of the triadic game design approach is to understand the reality of the current supply chain implementation. The idea is to develop a game that encourages data sharing in supply chain and so supply chain processes in the real world have to be understood accurately. This is why the literature review had sections pertaining to supply chain management and data sharing practices in supply chain management. We know from the literature review that supply chain management is a dynamic field that has been around for a long time and it has evolved over time to overcome challenges. Similarly, it is also concluded that despite the theoretical advantages of using data sharing in supply chain, data sharing is not implemented in supply chain management. If designed properly, a game can be an effective way to demonstrate the advantages of data sharing in supply chain management. The literature review section provides arguments for these conclusions.

3.1.1. Problems in the World of Reality

As pointed out in the introduction chapter, this research will work around a hypothetical fruit trader company. Fruits are agricultural products that are perishable with time because if not kept in the right environment, fruits can go bad and get spoiled after a while. The biggest

concern of this fruit trader would be to quickly get the fruits from its suppliers so that they are fresh when they reach the customer. Moreover, the traceability of the origin of the fruits will also be important to check if these exotic fruits are actually coming from the right locations and have been shipped and handled carefully and hygienically. Moreover, these fruit traders, like any other businesses, also want to get the highest possible revenue from their operations. With this case in mind, we can define the problem in the reality of supply chain processes of our target group to be that they need their supplies (fruits in this case) as soon as possible from their suppliers while also being able to trace the origins of these fruits and ensuring a high revenue. Thus, in order to convince this fruit trader to share data with its suppliers, the trader would have to be shown that sharing data between stakeholders in a supply chain can shorten the time in which supplies are acquired, increase the traceability of a supply and also increase the revenue of the firm.

Moreover, in the literature review section, a more generic analysis was done on the reasons for reluctance of supply chain managers towards sharing data. The analysis was not focussed on any particular type of supply chain or any particular field within supply chain management. It looked at reluctance to share data in supply chain industry in general. From that analysis, many factors have been identified which highlight why supply chain managers are reluctant in sharing data with other firms in a supply chain. The main reasons for reluctance are the misuse of shared information, the fear of other people getting better rewards by using the shared information and the safeguarding of trade secrets.

The problem that this research is that data sharing is not implemented in supply chain management. In the literature review, we looked at reasons of why data sharing is not implemented. The major reason, as concluded from literature review, was the reluctance of managers in sharing data. So, in order to implement data sharing in supply chain management, we will not just have to demonstrate its effectiveness but also have to tackle the reluctance of supply chain managers. The reluctance of supply chain managers can be alleviated by showing them mechanisms within the data sharing scenario that safeguard their trade secrets and stop the misuse of information. The effectiveness of data sharing can be demonstrated by solving the operational problems that are faced in the supply chain industry. While studying the reality of supply chain processes in the world of reality, it was seen that fresh chains, which is the focus of this research, face issues of latency and traceability. If data sharing can decrease the time of delivery of products and introduce the ability to trace the origin of materials, it will be

able to prove its effectiveness. Thus, from the world of reality, we can see that the game would have to cover two important aspects:

a) The ability to hide trade secrets and stop misuse of information
b) The ability to obtain materials faster and trace their origins

3.1.2. Identifying Relevant Supply Chain Processes

In the world of reality, the real-life supply chain processes are studied and from these real-life processes, relevant processes are derived. A process will be relevant to the game if it is part of the problem that the game is trying to solve and if it involves an aspect that can be improved through data sharing. Supply chain is an archaic field that has grown to vast extents because of developments over the years. We saw in the literature review that supply chain is a series of firms that pass materials forward (Mentzer et al., 2001). However, the process of passing materials forward consists of several sub processes itself. Now a days, supply chain and logistics are concerned with not just the passing of materials but also the inventory management, warehousing and demand management for the materials (Douglas M). However, not all of these processes are relevant to this research. This research will look at supply chain based on the definition provided by Mentzer et. al. i.e. only the process of passing materials around will be represented in the game. The sub processes associated with passing materials such as ordering materials, receiving materials and selling materials to other will be represented in the game. Based on the fresh chain processes, the game will represent the processes in the following scenario:

Taking the example of the hypothetical fruit trader from the introduction, say this trader imports pineapples to the Netherlands. It can also be assumed that the pineapples are imported from a farm in Brazil. Let's assume that this is the only importer of pineapples in the Netherlands and he sells the pineapple to wholesalers in the Netherlands. Since, the weather of Netherlands does not support the growth of pineapples, this fruits trader is the only source of pineapples for the Dutch market. The trader places an order to the farm based on the orders placed by the wholesaler. All three firms of the trader act as suppliers. The farm supplies pineapple to the trader, the trader supplies pineapples to the wholesaler and the wholesaler supplies them to its customers. However, the trader is not able to see the production levels at the farm until he places an order at the farm and nor is he able to predict the demand of pineapples himself until the wholesaler places an order of pineapples with the trader. There can be instance when the

trader accepts an order from the wholesaler but when he places an order at the farm, he is told that the production is low, and his order will be delayed. Thus, due to no information being shared, these suppliers face issues of delays and failed orders.

3.1.3. Identifying Stakeholders

So far, in the world of reality, the problems in real-life supply chain management and the relevant processes from real-life that the game will represent have been identified. Another important aspect of the world of reality is to identify the stakeholders that will be represented in the game.

In their book, Stakeholders and the supply chain (2008) Walker et. al. lay out actions of different supply chain stakeholders. Walker et. al. argued that the downstream supply chain is a very key stakeholder in supply chain management but is often neglected while discussing supply chain processes (Walker, Bourne, & Rowlinson, 2008). Intuitively, this makes sense since the delivery to the customer is the actual reason why a product is manufactured and facilitating that delivery is one of the key activities in a supply chain. Moreover, within our definition of supply chain, downstream activities also add value to the product by discovering delivery networks and identifying popular point of sales. However, in terms of activities i.e. stockpiling, moving and delivering, the downstream supply chain does not differ with the upstream chain to any considerable extent. For the purposes of the game, there is no difference between the upstream and downstream chain.

One common way while analysing a system or designing a simulation is to simplify the system. An example is such that while analysing the role of RFID tags in accurately recording the inventory levels, a complex supply chain process can be minimized and represented by just one retailer and two suppliers (Ligang et al., 2016). Ligang et. al. explores the effectiveness of RFID tags used for inventory through stochastic analysis and comes up with best use cases for RFID tags. Ligang et. al. was able to generalize their findings for larger systems as based on their analysis of the minimalistic system. Based on the findings of this study, the stakeholders that will be represented in the game for this research are described below:

Going back to the processes explained in the last section where a fruit trader in the Netherlands orders pineapples from a farm in Brazil and supplies it to wholesalers in the Netherlands, it can

be seen that all three entities in this example i.e. the farm, the trader and the wholesaler have a similar situation. Each of them has a supplier from whom they order pineapples and a customer to whom they sell the pineapples. Thus, the important relationship is that of obtaining materials from one party and selling them to the next. For this reason, players in the game will represent suppliers who will have the ability to obtain materials and pass them on. Within supply chain management, the action of obtaining supplies is performed by procurement managers whereas the action of selling materials is performed by the sales managers. Thus, players in the game of this research would act as procurement and sales managers while obtaining materials from other players or passing materials to other players.

3.1.4. Relationships between Stakeholders

Having identified the important stakeholders that have to be portrayed in the game and that play an important role in the reality of supply chains, it is important to see how these stakeholders interact with each other. In business management, different stakeholders can have different relationships. Sometimes, a different relationship can be viewed between the same stakeholders in different times. A good example is what is happening right now (2020). The markets are closing a recession and organisations are operating in survival mode i.e. prioritizing their own interest over any partners or friendly organizations (Stevis-Gridneff & Ewing, 2020). Normally, business relationships follow a trend of competition. This competition can be fierce in case the parties that are direct competitors. Even in the case of organisations that are not competitors, the cooperation is lose and mostly based on what each partner gets in return. French and Granrose (1995) looked further into business relationships. The three main types of relationship in a business setting are as follows (French & Granrose, 1995):

1. Exploitation

   One party uses the other for its own selfish objectives without considering the outcome for the other party
2. Reciprocity

   Two parties use each other in such a way that is beneficial for both the parties. This defines a more ‘tit-for-tat” relationship
3. Mutuality

   The two parties treat each other not just as means to reach their own goal but as respectable entities and treat the other’s objectives as equal to their own

Building on this further; it can be seen that trust is one of the most important underlying factor that determines the type of relationship that is going to be displayed between two parties (Walker et al., 2008). In his research that focussed on shared service centres in e-government in the Netherlands, Marijn Jaansen pointed out that managing the expectations of fellow stakeholders is a critical factor in stakeholder relationships (Janssen, 2005). His paper concluded that stakeholder expectations changes throughout the duration of the project and stakeholders ranked different on scales of power, influence and urgency. This is quite analogous to supply chain management where different stakeholders will have different attributes and it can be expected that managing expectations might be the biggest concern in a shared data process in a supply chain. Thus, the game will also be concerned about how data sharing can facilitate operations for each of these types of relationships.

3.1.5. Target Audience of the Game

It is also important to note that other than the stakeholders that take a part in supply chain processes, there are also some stakeholders that make decisions that affect the working of the supply chain. These are the people who decide how the internal working of their organisation is going to handle the supply chain. For example, an organisation that is a supplier of fresh fruits, will only use GPS tracking or temperature recording technologies when the higher management of this organisation will decide in favour of such technologies. Thus, if a game has to be developed that aims to make supply chain managers aware of the advantages of data sharing and that aims to implement data sharing in supply chain, then it is important that the game is also targeted to be played by supply chain managers and decision makers in a supply chain. In light of this, the game in this research will represent procurement managers and sales managers as entities in the game but the game itself will be targeted to be played by decision makers of a supplier firm so that they learn about the advantages of data sharing and facilitate the decision of sharing data in real life.

In the world of reality, the real-life scenario of supply chain was studied. The problems faced by supply chain management of fresh chains in real life were pointed out. It was decided the game would have to solve these problems through data sharing in order to prove the effectiveness of data sharing. The representation of stakeholders in the game was also analysed

and it was decided that players will perform the action of obtaining materials and passing them on and thus they will act as procurement managers and sales managers. The different types of relationships between stakeholders in a supply chain were defined. The target audience of the game was defined to be the decision makers in supply chain management.

3.2. World of Meaning

After studying the world of reality, the triadic game design dictates working in the world of meaning to derive meaning from the world of reality that is relevant to the game design. As described in the previous sections, the purpose of the game development is to instigate the advantages of sharing data in a supply chain among supply chain managers. In the world of reality, we defined the objectives of the game to demonstrate effectiveness of data sharing by solving the problems faced by the fresh chain industry and to tackle the reluctance of managers by providing a way to hide trade secrets. Moreover, the key supply chain processes were identified in the world of reality and in the world of meaning, these processes will be interpreted to fit a gaming environment. Similarly, the role of stakeholders will also be defined:

3.2.1. Interpretation of Supply Chain Processes in the game

In the world of reality, the real-life supply chain process was described. The case was presented of a farm, trader and wholesaler to highlight the process of obtaining materials and passing them on. It was decided that the game will replicate this process. The key stakeholders were identified to be the procurement managers and sales managers. Therefore, within the game the players must be able to act as procurement and sales managers to perform the actions of obtaining materials and then passing them on. The game will have to represent materials and then give the players the ability to obtain new materials and pass on the materials in their hands to other people. There will also be a product which will be made when players obtain certain materials. Thus, in the game a supply chain will be replicated by players obtaining materials and passing these materials on. Players will be able to sell products which will only be made when they have certain materials in their hands. Players will be able to earn revenue by selling their products. They will also have to pay an operational cost while obtaining materials.

3.2.2. Interpretation of Advantages of Data Sharing

The analysis from world of reality and the findings from literature state that there is reluctance in supply chain management to share data. This can be interpreted as supply chain managers lacking the motivation to share information. Supply chain managers have to be motivated in such a way that they see an advantage in sharing data and in playing the game. (Maslow, 1954). This means that data sharing must be able to solve the problems faced by supply chain managers in real-life in the current implementation of data sharing. In the world of reality, the problems faced by fresh chains in real life were pointed out. These problems were time constraints and traceability of fruits obtained from other suppliers. Thus, the game will have to ensure a mechanism through which, while sharing data, players are able to trace the origins of their materials and make their products quicker. All the players in the game must be able to notice the advantages of data sharing. The game will have to create an environment of harmony such as a win-win situation for all the players in the game. It will not suffice to show the managers that data sharing improves their revenue. Rather, a harmonized added value of data sharing will have to be presented i.e. the average revenue of the supply chain with data sharing should be higher than the average without data sharing.

3.2.3. Interpretation of Reluctance

In the world of meaning, so far, it has been described how the game will replicate a supply chain and how it will demonstrate the effectiveness of data sharing to motivate the players to share data in real life. Intrinsic motivation works better than extrinsic motivation in business activities (Malone, 1981). Intrinsically, the supply chain management is reluctant to share information because of the fear of disproportionate rewards, fear of misuse of information and protecting their trade secrets. The supply chain managers will not be willing to share data unless the game finds a remedy to the reasons of their reluctance. For this reason, the game will also have to ensure that players have the ability to hide important information while sharing other necessary information, stop the misuse of information and have a better division of rewards. A higher average of revenue would mean that data sharing creates a better distribution of rewards in the chain. In addition to this, the game must be able to stop the misuse of information i.e. if one player is misusing information, other players should be able to know it and stop this player from misusing the information

3.2.4. Learning from the Game

In a supply chain (or networked) environment, players learn constantly through their interactions with other players and the outcome of their previous moves (De Bruijn & Ten Heuvelhof, 2018). Hence, it can be seen that in a supply chain environment, knowledge is a product of networks and social factors (Harteveld, 2011). De Bruijn et. al. and Harteveld both point to a similar conclusion that is a network of data sharing, knowledge is derived from interactions as well as the regular sources. A supplier will not only depend on the knowledge shared by their partner but over time, they will learn from interactions with their partners and adjust their position accordingly. The game developed for this thesis will also have to find a way of enabling networked learning and providing a way for the players to learn and adjust their moves based on the moves of other players. Naturally, this is manifested in many competitive games and should not be too hard of a point to replicate. Therefore, to ensure the supply chain managers can relate to the game, the game must represent the data sharing process as it occurs in reality. A closer link to reality is very important if the aim is to make the players learn (Lave & Wenger, 1991). Therefore, the operations of the game should be such that it motivates the managers in playing the game and the game should have meaningful interactions so that the players can learn from each other during the game. The gameplay must be designed in such a way that the purpose of the game is not overshadowed by supporting activities (Reiss, 2012). In other words, the game should be simple and must also have a proper message that the players find relatable.

3.2.5. Context of the Game

An important outcome of the meaning derivation is deriving the context of the game. The context involves justifying the gameplay, identifying props to be used for the game and conjuring the physical space needed to play the game. The target demographics of the game are supply chain managers and the decision makers in supplier firms which deal with receiving materials and passing them forward to their customers. As supply chain managers, it is expected that the managers will be aware of the activities of their partners in supply chain. As such, they will be familiar with problems in the supply chain and how it affects their ability to serve their own customers. From the discussion above, we can identify the following concepts that will have to be a part of the game:

- Obtaining materials from other players
- Passing materials to other players
- Collecting materials to manufacture a product
- Concept of revenue
- Operational cost
- Time
- Traceability of materials
- Sharing information with other players

The game focusses on data sharing on an operational level in a supply chain, not at a strategic level, so the actual processes of how materials are delivered and moved around falls outside of the scope of the game i.e. the game will not simulate the last mile delivery or shipping process. The goal of the game is to make the players aware of the advantages of sharing data in a supply chain, the value of data sharing and its influence on supply chain as a whole. The supply chain managers play the game and share data while they are playing. The gameplay should involve a mechanism through which players can see the difference made by sharing data. For this reason, the game will be played in two rounds. In one round, the game will be played without sharing data. In the next round, it will be played while sharing data among the same players. The results (lowest score and average score) of the two rounds will be compared. The time duration, cost spent, and the score will also be compared across the two rounds. The game should be playable without any elaborate setting and should not take too long so that the interest of the players is maintained.

In the world of meaning, the conclusions from the world of reality were used to design the purpose and context of the game. The underlying mechanism of the game is to motivate players to share information. Since, the game environment is an abstraction of reality, the players will also be motivated to share information in real-life based on their learnings from the game. For this reason, the game will be played in two rounds, first round without data sharing and the second round with data sharing. The lowest score and average score across the two rounds will then be compared to argue the effectiveness of data sharing. The game can be played anywhere and requires only a deck of card and writing material for the moderator.

3.3. World of Play

According to the triadic game design approach, after studying the reality and deriving its meaning, the research enters the world of play. In the world of play, the game objectives and rules can be formulated such that the game starts to get a final shape.

3.3.1. Game Play

The game designed for this research is played with a deck of cards and fictional coins to simulate currency for revenue. The game uses a customized deck of cards (see appendix B). Because the research focusses on fresh chains and green logistics, the cards represent fruits. Each card has a name and picture of a fruit on it. There are 52 cards in total with 13 different fruits. There are four cards with the same fruit. The objective of the game is to have the most revenue at the end of the game. Each player will start with a revenue of 10 coins. Players will have to pay coins for different operations throughout the game, but coins can also be collected by collecting four cards with the same fruit. In the beginning of the game, players will select a "target" fruit. The players will get the most points if they collect four of their target fruits. When 4 cards of a fruit that is not the target of a player are collected, the players get one coin from the bank. This serves as a side revenue stream. However, when a player collects four cards of their target fruit, they get 8 coins, 2 for each card. After collecting their targets, the player cannot collect any further cards but only pass cards around based on the turns of other players. Being a card game, the game can be played anywhere.

3.3.2. Rules of the Game

The game will be governed by a set of rules. The game will be played across two rounds. In the first round, players will not be allowed to share information with each other. The only information available to players, in this round, will be based on the cards that they have in their hands and the moves of other players. The second round will be played with information sharing. Players will announce their targets to other players and will be allowed to share information regarding each other's targets. The game rules for turns and moves for each round are given below:

Round 1: Without Data Sharing

To decide the order of the turns, each player rolls the dice, and the player with the highest roll goes first. The sequence of the turn goes clockwise from the starting player. The mediator then deals the cards and each player receives 5 cards. The rest of the deck is scattered in the middle. The players then look at their cards and decide a "target". This would be the fruit they would aim to collect all four cards of. The players are required to select a target out of the five cards in their hands. A player cannot have "pineapple" as their target if they don't have the pineapple card in their hand. Most likely the players would select a target they have the most cards of, but if they don't have more than one card of any fruit, they can pick any fruit as their target. The players will tell their targets to the moderator, but they will not share their targets with other players.

The players then start the game, with each player having ten coins. The players pay one coin at the start of every turn. The player that goes first can ask any player for any fruit. This fruit may or may not be the target fruit, but it must be a fruit which the player already has in their hand. If the player who is asked for the fruit, has that fruit, he or she must give that fruit to the player who asked. In case the player who is asked has multiple cards of that fruit, they are obliged to give all those cards. This is called a "successful fishing" for the player who asked. The player who gave the card(s) must pick up the same number of card(s) from the deck. If the player does not have the card, he or she says, "Go Fish!" and the player who asked for the card picks up one card from the deck. If the card drawn from the deck is the same fruit as the one asked for, it is still considered as successful fishing. The player shows the card to prove that it is the same fruit and continues his or her turn by asking any player for any card again. If the card drawn is not the same fruit, it is then considered as "unsuccessful fishing". The turn ends after an unsuccessful fishing and the next player in the sequence start their turn after paying one coin.

If the player was successful in fishing, he or she goes again. The player can ask the same player for a different card, or a different player for the same card, or a different player for a different card. This player's turn continues till an unsuccessful fishing occurs, i.e. the player asked does not have the card which was asked for and the player then goes fishing from the deck. If a player collects all the four cards of a fruit after successful fishing, he or she must place them on the table and take another turn.

If the player completes the four cards of a fruit after he or she picks it up from the deck, he or she must place them on the table but does not take another turn. For collecting four cards of random fruit, the player earns 1 point but for collecting four cards of the target fruit, the player earns 8 points. Once a player collects all the cards of the target fruit, he or she cannot collect any other set. Every time it is their turn, they only pick up a card and then it is the next player's turn. The other players can still ask such player for cards. The game ends when all the players have collected their targets or when all the fruits have been collected.

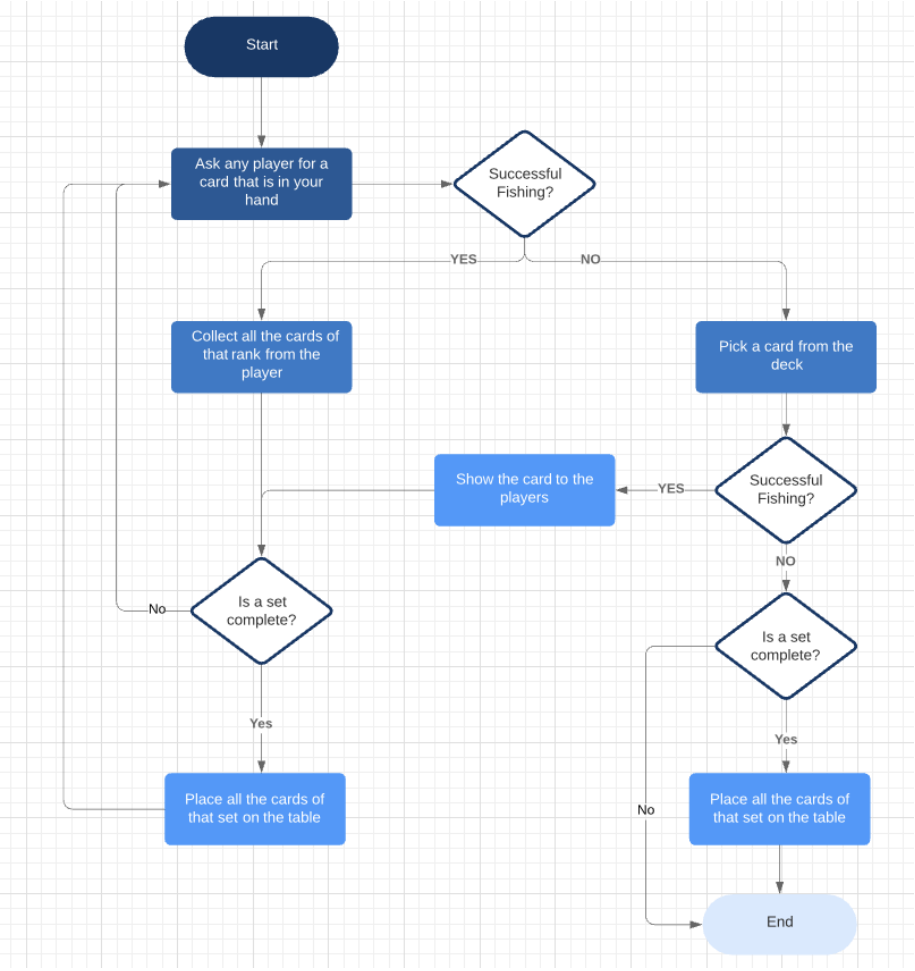

Figure 1: Flowchart explaining a turn mechanism in round 1

Round 2: With Data Sharing

The general rules of the games stay the same in the second round. However, the players are allowed to share information in this round. To decide the order of the turns, each player rolls the dice, and the player with the highest roll goes first. The sequence of the turn goes clockwise

from the starting player. The mediator then deals the cards and each player receives 5 cards. The rest of the deck is scattered in the middle. The players then look at their cards and decide a “target”. This would be the fruit they would like to collect all four cards of. The players are required to select a target out of the five cards in their hands. A player cannot have “pineapple” as their target if they don’t have the pineapple card in their hand. Most likely the players would select a target they have the most cards of, but if they don’t have more than one card of any fruit, they can pick any fruit as their target. The players will tell their targets to the moderator. The moderator will then announce the target of each player to the whole group such that each player knows the targets of other players.

The players then start the game, with each player having ten coins. At the start of their turns each time, players are allowed to share information about other player’s targets. The player who is performing his turn will point to another player and tell him that he has the target fruit of the other player given that he actually has the target fruit. If a player shares information regarding the targets of other players, he will not have to pay a coin for his turn. Otherwise, like round 1, players will pay one coin at the start of their turns. The player that goes first can ask any player for any fruit. This fruit may or may not be the target fruit, but it must be a fruit which they already have in their hand. If the player who is asked for the fruit, has that fruit, he or she must give that fruit to the player who asked. In case the player who is asked has multiple cards of that fruit, they are obliged to give all those cards. This is called a “successful fishing”. The player who gave the card(s) must pick up the same number of card(s) from the deck. If the player does not have the card, he or she says, “Go Fish!” and the player who asked for the card picks up one card from the deck. If the card drawn from the deck is the same fruit as the one asked for, it is still considered as successful fishing. The player shows the card to prove that it is the same fruit and continues his or her turn by asking any player for any card again. If the card drawn is not the same fruit, it is then considered as “unsuccessful fishing”. The turn ends after an unsuccessful fishing and the next player in the sequence start their turn after paying one coin.

If the player was successful in fishing, he or she goes again. The player can ask the same player for a different card, or a different player for the same card, or a different player for a different card. This player’s turn continues till an unsuccessful fishing occurs, i.e. the player asked does not have the card which was asked for and the player then goes fishing from the deck. If a player collects all the four cards of a fruit after successful fishing, he or she must place them

on the table and take another turn. An addition to this round is that, if a player asks another player for their target fruit, the asking player will have to pay extra cost of 2 coins and his target will also be changed to the target of the other player that he just collected. The player who loses his target in such a scenario will get the chance to select a new target.

If a player collects all the four cards of a fruit after successful fishing, he or she must place them on the table and take another turn. If the player completes the four cards of a fruit after he or she picks it up from the deck, he or she must place them on the table but does not take another turn. For collecting four cards of random fruit, the player earns 1 point but for collecting four cards of the target fruit, the player earns 8 points. Once a player collects all the cards of the target fruit, he or she cannot collect any other set. Before putting the set of his target fruit down, the moderator will check if the player has a target fruit of any other player about which they have not shared information. Before completing their target set, the players must ensure that they don't have the target of another player whose information they haven't shared with the player. In case there is such a fruit in this player's hand whose information the player was hiding, the player in question will get a penalty of 2 coins. Every time it is their turn, they only pick up a card and then it is the next player's turn. The other players can still ask such player for cards. This player is still allowed to share information at the start of his turn. In such a case, when the player has completed his target set, he will get one extra coin for sharing information if he gets it. The game ends when all the players have collected their targets or when all the fruits have been collected.

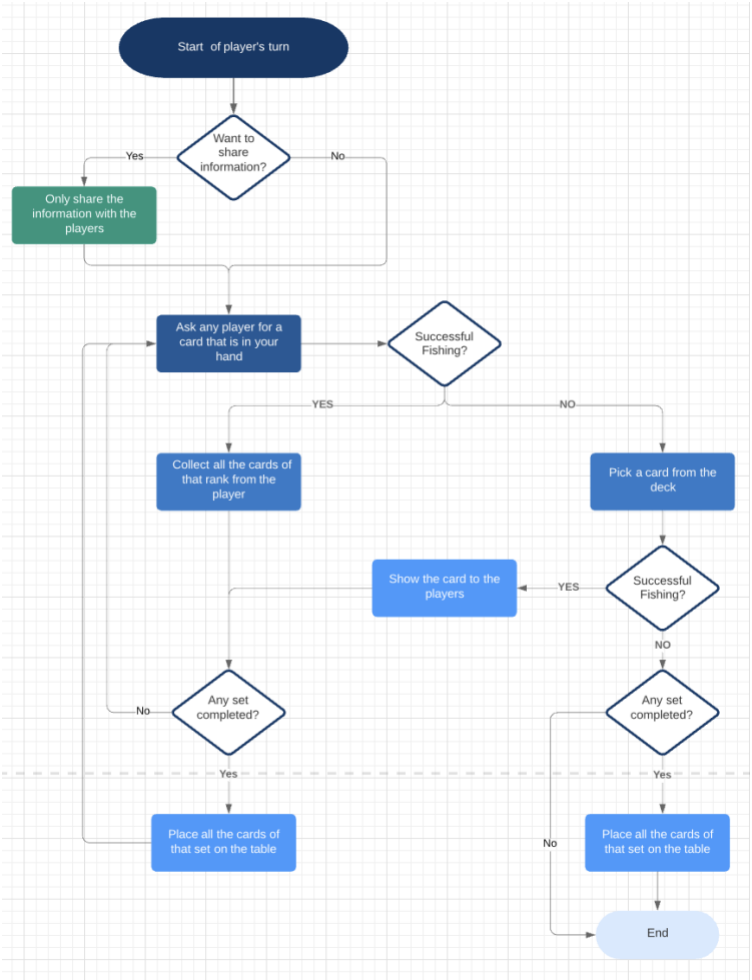

Figure 2: Flowchart explaining a turn mechanism in round 2

3.3.3. Multiple players with same targets

The current design of the game allows players to choose their targets freely. While choosing their targets, the players have no information available to them other than the cards in their hands. It is probable that multiple players can pick the same fruit as their target. The game caters for such a situation and the procedural rules of the game change if this situation occurs. In the first round, when no information is being shared, this is played out normally. Players play the game with their natural strategy and aim to collect their target fruits. In most cases, the players don't find out that they had same targets until the end of the game. Acquiring the target fruits depends on the strategy of the players and their attention to the transactions in the game. It is possible that one of them will get the target while the other player would lose it, but it is also possible to a third player to acquire their target as one of his side revenue streams without knowing that it was the target fruit of two players.

In the second round, when information is being shared, targets are announced to the whole group. The individual players share their targets with the moderator who then announces it to the group. The moderator notices if multiple players have the same target. In such a case, the moderator provides the two players an opportunity to negotiate and change their targets. As a player, if someone has more than one cards of the same fruit in their hand, then they should stick with the target. If a player only has one card of their target fruit in their hand, it will make sense for this player to change their target. The negotiations will be overseen by the moderator. If one of the players changes their target, then the game becomes normal. However, if both the players stick with the same target then the rules will change while playing. The two players with the same target fruit will not be able to ask each other for the target fruit until one of them has three cards of the target fruit in their hands. The person with three cards of the target fruit can ask the other player for the last target fruit card. If both the players have two cards of the target fruit, then the game ends with a deadlock when other players get their targets. In the case where one of such players collects the cards from the other player, the other player will not be allowed to change their target.

3.4. Linking Reality, Meaning and Play

In this section, so far, the game design methodology has been described. First, the world of reality was studied, and key processes and stakeholders were identified. Then, a meaning was derived from these processes that helped design the gameplay of the game. It is important to check if the game that has been designed in the world of play, links correctly to the conclusions of word of reality and world of meaning.

In the world of reality, the key processes of a supply chain that had to be replicated in the game were the process of obtaining materials and passing them on. In the game, this is made possible by the process of fishing. When it is their turn, players act as procurement managers and try and obtain cards from other players. Cards act as materials in the game. When a player asks another player for a card, the player who is passing the card acts as a sales manager and passes the card to the player who asked. Similarly, in the world of meaning, some key concepts were identified that will have to be present in the game. This is how the game incorporates those processes:

- **Obtaining materials from other players:** This is done by fishing for cards when it is the player's turn.
- **Passing materials to other players:** This is done when someone is asked for a card that he has, and he has to pass that card to the player who asked
- **Collecting materials to manufacture a product:** The product is the target fruit. Players collect 4 cards of the target fruit and then they are able to sell it.
- **Concept of revenue:** The coins act as revenue in the game. Coins are earned by making sets of cards
- **Operational cost:** The operational cost is the coin that has to be paid before every turn.
- **Time: Time is the number of turns.** When someone plays more turn to finish their product, they are taking more time.
- **Traceability of materials:** Traceability is simulated by knowing where the card was obtained from. In round 1, traceability is only known until the last player whereas in round 2 one can find the traceability all the way to the deck of cards.
- **Sharing information with other players:** In round 2, by telling other players' if they have their target, players share information among each other

With these processes, the game is able to simulate a supply chain. Moreover, the game is simple, and the rules of the game do not overshadow the underlying message of the game. In one round, the game is played without sharing data. In the next round, it is played while sharing data among the same players. The results (lowest score and average score) of the two rounds will be compared. The time duration, cost spent, and the score will also be compared across the two rounds. The effectiveness of data sharing will be successfully demonstrated if, in round 2, the average score is higher than round 1, less time is taken by players so make their targets, less operational cost is spent by the players and players are able to provide traceability for each card in their hand.

4. The “Go-Share” Game

This chapter looks at the game designed for this research closely. It describes the main operations of the game, the logic model of the game and how the game links to reality. It also explains how the game caters for trade secrets that cannot be shared.

In this section, the game will be critically analyzed to check if it relates to reality in the right way and if the reservations of managers regarding data sharing have been addressed in the game. Moreover, the operations of the game are also described here to highlight the intricacies of the game design.

4.1. Name of the Game

The game that has been designed for this thesis is named “Go-Share”. The naming represents two important aspects of the game. The first is that the game is based on an existing popular card game called Go-Fish. The game borrows its “fishing” mechanism from Go-Fish. Fishing is when, in the game, a player asks another player for a card based on what cards are in their hands. If the other player has the asked card in their hand, they have to give it to the player who asked. In case of multiple such cards, the asked player has to give all of them. If the asked player does not have the card in their hand, they say “go-fish”. When told to go fish, a player must draw a card from the deck in the middle. Fishing is a very important mechanism of the game since it allows for cards (materials from reality) to be passed and moved around. The second aspect is data sharing. The game revolves around data sharing and demonstrates how data sharing can be effective in supply chain and logistics. The share mechanism comes into play in the second round when players are allowed to share information about other players’ target cards in their hands. Thus, these two key operations have been combined to give a name to the game. The name represents the underlying operations of the game and its intended purpose.

4.2. Logic Model of the Game

A logic model of a game presents the input, the processing performed on that input and the output that is produced as a result of that processing in the game (Hense, Kriz, & Wolfe, 2009). A logic model has been designed for the game developed in this research which provides an overview of the inputs, activities and outputs of the game. The logic model accumulates the analysis and steps of section 3. The logic model follows a simplistic design, but it covers all the inputs processes and outputs sufficiently. The logic model is presented in figure 3. This logic model describes the purpose of the game which is to encourage data sharing in supply chains. The inputs in the logic model are supply chain managers and their behavior in dealing with stakeholders in a supply chain. The behavior act as an input in such a way that if a supply chain manager does not trust the stakeholders of his supply chain in real life, he will also not trust the stakeholders (other players) in the game. The constraint is the reluctance of supply chain managers in sharing data. The processes are the two rounds of the game which produce results that can be compared to notice the effectiveness of data sharing. The ability to hide certain secrets in the game is also a process since it answers the reservations of managers regarding the ability to hide sensitive information. The outputs are the learnings of managers in understanding the effectiveness of data sharing in supply chain and a reduction in their hesitance to share data. The long-term effect of this outcome is that data sharing becomes implemented in supply chains and supply chains become more efficient as a result. The logic model also describes the current conditions of reality which is that data sharing is not implemented in supply chain due to reluctance of managers.

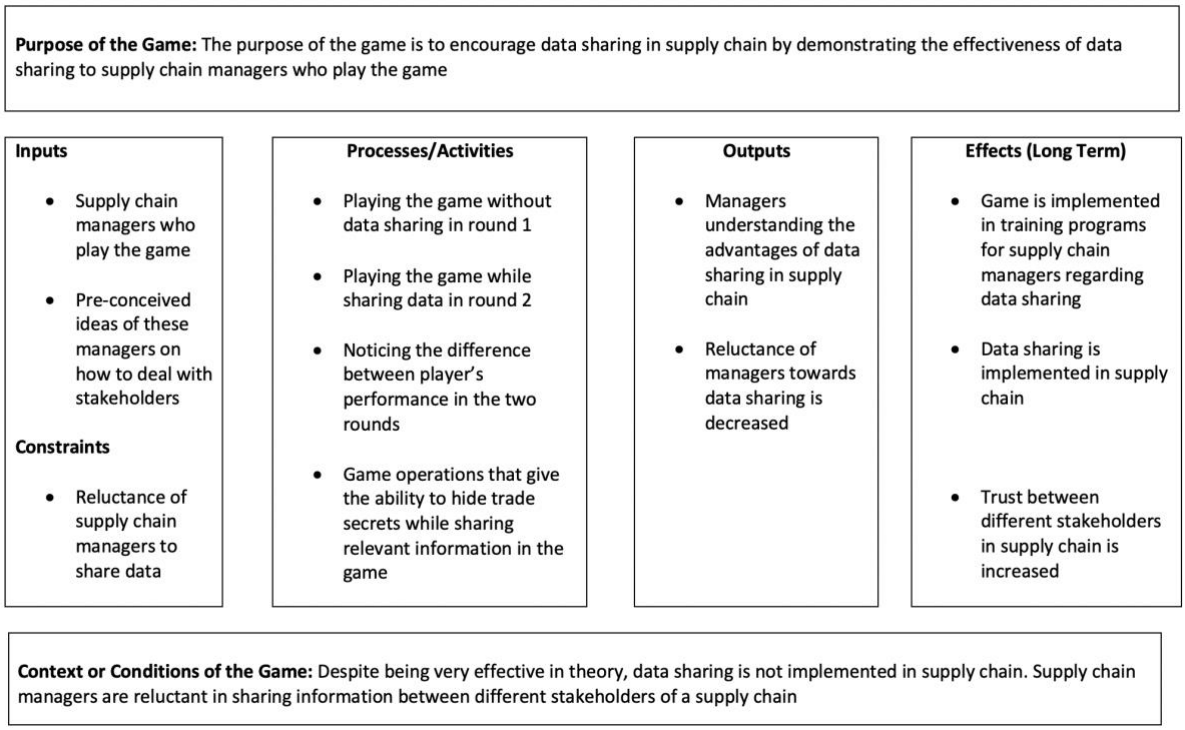

Figure 3: Logic Model of the Go-Share game.

4.3. Operations of the Game

Section 3.3 explained the rules of the game while describing the world of play in Triadic game design. These rules of the game enable a player to perform certain operations while playing the game. The operations are different from player moves and strategies. A strategy consists of doing certain moves in a certain order. A move is performing an action in the game within the rules of the game. Operations are more underlying, behind the scene phenomenon. Operations are a result of the game design. These operations are based on the factors of motivation and networked learning from the world of meaning. In order to motivate supply chain managers to learn about data sharing and understand the advantages of data sharing, the game will consist of the following operations:

- Roleplay
- In-Game Learning
- Replay Ability
- Revenue
- Debrief

4.3.1. Role-play

The roleplay operation is concerned more with how players act in the game rather than how the game is played. In the game, players play as suppliers or other counterparts of a supply chain. This enables them to keep the goals of a supplier in mind while making a move in the game. When, in the role of a supplier, the player is motivated the right way i.e. by showing the advantages of data sharing or by fear of other suppliers teaming up against them, a player might keep their personal competitiveness aside and cooperatively share data with other players.

4.3.2. In-Game learning

The best learning is the one that occurs in realistic environments (Harteveld, 2011)**.** While playing the games, the supply chain managers will use their own strategies and also evaluate the strategies of their fellow players. A player might play their initial round with one strategy and then decide to change the strategy in the next round. In such a case, players learn the strategy of other players and evaluate it against their own strategy. If they believe that a new strategy can yield better results for them, they are all but free to follow the new strategy. The game facilitates in-game learning in a way that once they have played the game multiple times, the players will have different ideal strategies for different situations. This will also help them judge data sharing in every situation.

4.3.3. Replay Ability

One game iteration consists of two rounds. In one round, the situation of the players might be different from the previous round. In a card game, the randomization of the deck plays a vital role. In one game, a player might have a good hand in one round but a pretty lousy one in the next round. This is analogous to the real world where the materials might be readily available in some cases and suppliers might achieve their goals quickly whereas the materials might not be available quickly in other cases and the goals of the suppliers might be delayed. The changing scenarios of the quality of cards in a player's hand reinforces the operations of roleplay and in-game learning such that in every round the players might find themselves in a different situation and might have to use a different strategy. However, with different hand in different rounds, players can still apply similar strategies. The replay ability of the game hinges

on the fact that strategies that are relevant to one iteration can also be applied to another iteration. The results might change but that can be attributed to the difference in data sharing and cards in hand. The replay ability operation is important since when same players get different results across the two rounds, the difference can be attributed to the change of data sharing.

4.3.4. Revenue

One important operation of the game is revenue. In a supply chain, like most other businesses, revenue is the best indicator of a company's success. No firm will implement a data sharing strategy unless it results in a higher revenue stream for them. The revenue operation will be very important in the game since it will determine the extent of a move that a player can make. Different moves would have different costs associated with them. Revenue will also act as an indicator for winning the game and the difference in revenue across two rounds will act as an indicator of the value of data sharing.

4.3.5. Debrief

The players can learn the rules of games quickly, but there will still be a necessity for the supply chain managers to strongly grasp the advantages of data sharing in a supply chain (Harteveld, 2011). The players will be debriefed by the moderator after the game regarding the operations in the game and how they relate to supply chain. The player's feedback will be noted, and their questions will be answered. The debrief will be held as a discussion of what went right and what went wrong and how can the wrong be made right. This will link to the in-game learning operation and how the players can learn from their mistakes. More importantly, the debrief will be driven by discussion around the topic of data sharing. The two rounds will be compared to see if the second round which was with data sharing was easier than the first. The results will be compared for the purposed of research to verify if results of the second round show a higher average score and a better worst-case score than the first round.

4.4. Linking the Game to Supply Chain and Logistics

It is important to note how the game links with reality of the logistics and supply chain industry. Some small analogies to real life in the game are the number of turns being the time, points

being linked to revenue, unsuccessful fishing being a failed supply attempt and the target being the final, finished product. The information shared in the second game is the ideal scenario when suppliers in the real-world share information with their managers. Although, playing the game is not part of this research but as a moderator, the researcher has noted a few interesting caveats when it comes to strategies used by the players. These strategies can also be analogous to the real-life supply chain and logistics scenario. While playing the game in the roles of supply chain managers, players used strategies that were in line with the real-life strategies of suppliers. This demonstrates the accurate mapping of reality in the game world. A few parallels between the strategies in the game and the strategies in real life are given below:

4.4.1. What data is shared?

The game is an abstraction of the real-life supply chain processes. In section 3.4, we saw how the game abstracts the reality and how each concept in the game has a counterpart in real life. One major concept is data sharing which enable the players to share data in round 2. The data that is shared in the game is information about targets i.e. players are allowed to tell each other if they have the other players' targets. How does this relate to real-life or in other words, what real-life data is being shared in the game? The player whose turn it is, if they have a fruit in their hand that is another player's target, tells that player that they have their target. Thus, the player who just received this information, in their turn, can ask the original player to give them their target. This way, the probability of a failed fishing attempt is decreased and the players who receive information get the most out of their turns i.e. they are able to get their target cards in most of the turns. This means that the operational cost for these turns is spent efficiently. In real-life, this information can be anything that makes sure that the procurement manager who places the order knows the availability and exact time of delivery of the order. In our example of the fruit trader, fruit farm and wholesaler, this information will be something like the farm telling the trader that they have just grown more pineapples or the trader telling the wholesaler that he has just imported fresh pineapples from the farm and they are ready for delivery. Conversely, if a player doesn't have any other players' target fruits, he does not share any information. In the example, this relates such that if the farm or trader does not have the ability to fulfil the order, the wholesaler would know automatically to not place orders and pay unrequired cost.

4.4.2. Keeping your goals hidden

Let's imagine the game is being played. The targets have been selected and we have the 5 cards that we received. At least one of these five cards, has our target fruit which we determined in the beginning. When it is our turn, should we just go ahead and start asking for our target card randomly? The answer can be yes or no and that corresponds to two different strategies. Players can choose to wait before asking for their target cards until a little more information is available about who may have that card in their hand. This is a commonly used strategy. It corresponds directly to real world scenario where supplier might be hesitant to show extraordinary interest in a supply due to fear of revealing their dependency on that supply and risking a higher cost (Y. H. Kim & Henderson, 2015). Players can thus, choose to either play with a brute force strategy of asking for their target card in every turn or they can focus on other non-target sets in the beginning until they acquire information about who might have their target cards. Playing with this strategy has its risks as well. There is always a chance that someone else might ask you for your target card because either it is their target as well and you do not know it or because they have multiple cards of those fruit, and they want to finish a non-target set. Non target sets are also worth one coin, so they provide a good source of decreasing cost. Like in reality, when a firm keeps its goals hidden and focusses on the activities required to complete the goal without sharing any extra information with other stakeholders, a player can choose to not ask for their target fruit until they are certain that another player has it.

4.4.3. Focusing More on Alternative streams of Revenue

In real world, suppliers have more than one customer. Some customers are large organizations that buy more materials in every supply run whereas others are smaller organizations who buy less. One supply order of the large customer organization might bring in more revenue than several supply orders of many small customers combined. This approach of diversifying your customers is in line with recommended business practices (Johnson & Selnes, 2005). This is modelled in the game by providing the players the opportunity to collect non-target sets. A target set is worth 8 coins and a non-target set is worth 1 coin which is enough to cover the operating cost i.e. the cost of performing a turn. Players can choose to focus on getting their target quickly, so they have to spend less on performing a turn or they can take longer but try and make as many non-targets sets as possible in order to receive the operating cost back. In cases where players make more than one non-target set in a single turn, they are able to earn

coins even after paying the operational cost. Similarly, in reality, a supplier would not only depend on a single customer, no matter how large their orders might be. Some suppliers will prefer to have multiple customers to keep a steady flow of revenue.

4.4.4. Supply Chain Visibility

Supply chain visibility is the extent of information about the whole supply chain available to one supplier in the chain (Parry, Brax, Maull, & Ng, 2016). The sources of this information vary from articles in the press to noticing the changes in order of suppliers. Because of the limited nature of information from such sources, supply chain visibility is not very high in most cases. The game highlights this fact in the first round. In the first round, players are not allowed to share data with each other. However, the moves of every player are visible and audible to all the other players involved. If a player asks another player for a certain fruit, that means that the player who asked for that fruit, has that fruit in his hand. This creates visibility for other players who understand that the player has that fruit in his hand and that the fruit might be his target. Thus, if another player wants to take the same fruit and has that fruit in his hand, he knows who to ask in order to fish that fruit successfully. This is in line with supply chain visibility in the real world. Because there is no streamlined sharing of data, suppliers have to rely on alternative sources of information to create visibility for their operations.

4.4.5. Production Delays of Agricultural Products

In fresh chains and in the agri-food industry as a whole, the supply of products like fruits and vegetables depends on their agricultural production and growth. Agricultural production and growth are dictated by nature. The weather conditions and soil fertility determine how much and how quickly can a fruit be harvested and delivered. This is a very important aspect of fresh chains and any game targeted at the fresh chain industry will need to incorporate these natural factors. The go-share game, designed in this research, caters for these natural factors by utilizing the randomization of the deck of cards used for this game. Each player has five cards in their hands which means that at the start of the game, 20 cards are in the hands of the players while the remaining 32 are still in the deck. Mostly, every player will have multiple target cards in the deck and the order of picking up the cards from the deck will determine which player gets what cards. This can be analogous to the growth of fruits in the real world. If a fruit has not yet grown, it is not in the hands of any supplier. It is not part of the chain yet and no

information can be shared about that fruit. It is only when the fruit is harvested, can the delivery process of the fruit be started. Similarly, in the game, when a card is in middle pile and not in the hand of any player, no information can be shared about it. However, as soon as someone picks that card up, the information for that card can be shared. Therefore, the pile of cards in the middle acts as the source or growth of fruits in the game.

4.5. Trade Secrets

In the literature review, a growing concern of supply chain managers was pointed out. The supply chain managers were reluctant in sharing information that could either hurt them or could reveal valuable trade secrets. Some examples of trade secrets are information regarding the whole clientele, plans for a new product and information regarding the market strategy of the firm. To cater for that concern, the game still allows the players to hide information that they feel is important to them. One such information in the game is the number of cards of their target fruit that the player has in their hand. Players are asked to share their targets, but they are not asked to share how many target cards they already have in their hand. This is a trade secret since if other players knew that one player already has two of their target cards in their hand, they will be reluctant in sharing further information with this player. For example, player A gets the first five cards, two of which are pineapple and chooses to select pineapple as their target fruit. When asked for their target, player A has to reveal “pineapple”, but they do not have to reveal how many cards of pineapple are already in their hand. This way the game’s in-built mechanism and rules protect valuable and confidential information while still being in a data sharing environment. Another trade secret in the game is information regarding non-target sets. Players are only asked to share information regarding target sets. They do not have to share information regarding other sets that they might want to complete. This is in-line with supply chain firms only sharing the relevant information with one partner and not the information of other partners.

5. Results and Evaluation

This chapter looks at the results of the game across several play sessions. It also describes the playtests with experts and the learnings from those playtests. Lastly, it evaluates the game using dominant frameworks from literature.

In this section, a comprehensive analysis of the game and its rules will be provided along with the results of the play tests. The operations of the game will be matched with real life and the game will be evaluated using suitable frameworks from literature.

5.1. Playtests

Once the game design was complete, the next step was to test the game by playing it more and more. Playtesting is one of the most common methods to test functionalities of a game (Korhonen, 2010). In the design iterations of the game, it was played with volunteers who were students. Once the game had been modified through these playtests and it started to make more sense i.e. each operation in the game was coming more and more in use while playing the game and the volunteering players were successfully using these operations, then the game was played with experts from the fields of game design and supply chain. Through these expert playtests the game was validated for its gameplay and relevance to real-life supply chain processes. The details of the playtests with game design experts and supply chain experts are given below:

5.1.1. Playtests with Game Design Experts

The game was played with game design experts to test the mechanics of the game and ensure that the rules of the game make sense. The expert, in this case, was the director of the GameLab at the Delft University of Technology. In such playtests, the real-life relevance of games is not tested to a rigorous extent, but the game mechanics are closely observed. These playtests were helpful in updating the game based on anomalies in the game play. The learnings from these playtests will be discussed in detail below:

5.1.1.a. Learnings from Game Design Experts

In some playtests, the game ended with unexpected results such that the target cards of some players remained in the deck of cards on the table until very late in the game. Further research into the matter revealed a randomization bias within the shuffling of the deck of cards (Trefethen & Trefethen, 2000). For this purpose, instead of putting the cards as a pile in the middle of the table, the cards were spread out in the middle faced down, so players were allowed to choose whichever card they wanted instead of drawing the top card from a pile. Moreover, after this iteration the setup of the games was changed so that players may be allowed to pick up cards more often.

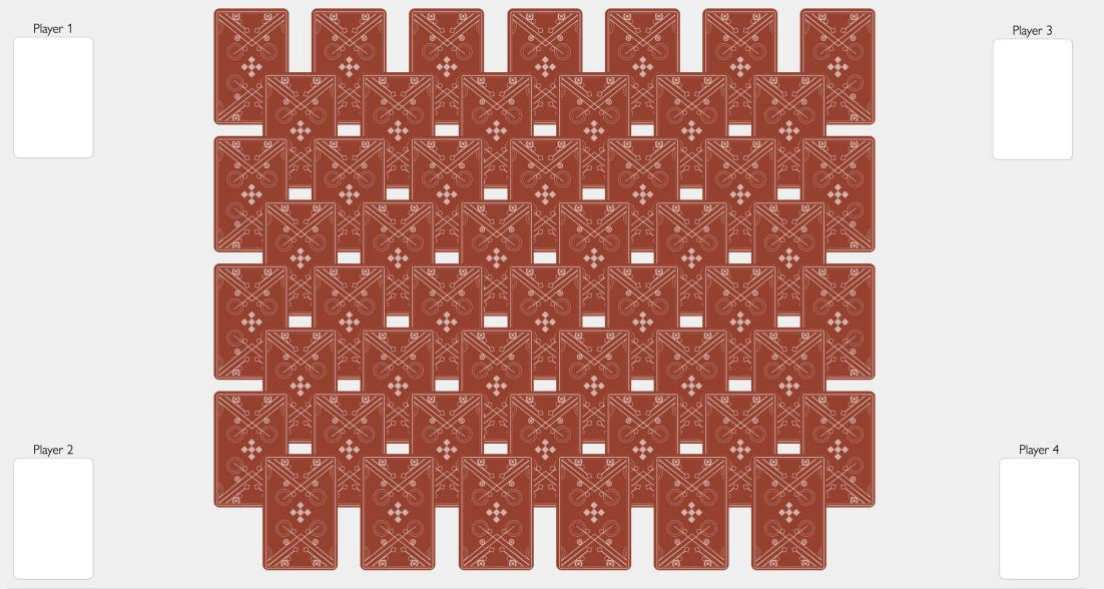

Figure 4: Arrangement of cards in the middle of the table

Another important change within the rules of the game, as a result of a playtest, was the payment mechanism. Initially, players had to pay only for an unsuccessful fishing attempt. This created problems in cases where players completed their target set in the middle of a turn or where players completed their target after drawing the card from the deck. In such a case, the players did not have to pay a cost for their last turn since there was no unsuccessful fishing. This was contradictory to real life. Since, in real life any supply operation has a cost associated with it. Hence, the game was updated, and the rules were changed such that players would have to pay the cost at the start of a turn in line with real life supply chain operations. Consequently, it also increased the value of successful fishing since as a result of successful fishing players

were able to acquire the required cards and get another go at asking for a card without having to pay an extra cost.

The apparatus used by the game is very important in creating an atmosphere of supply chain. When the game is played with a regular deck of cards, it feels more like a recreational game that does not link well to supply chain managers and their learning. Such an atmosphere also goes against the principle of situated learning (Harteveld, 2011). Thus, feedback from one of the gaming experts was that specialized apparatus should be created for the game. Instead of using a regular deck of cards, the game uses a customized deck of cards that shows fruits as suits (see appendix B). This was decided in line with the focus of the research being on fresh chains and green logistics. When players from our hypothetical fruits' supplier play the game with customized cards that show fruits, they will be able to relate more to the operations of the game and the message will also be retained longer since they use similar product supplies in real life.

The game is kept free from external biases and contextual factors by introducing randomization where necessary and countering randomization where required. In line with this idea, at the start of every game a dice is rolled to determine the order of turns. The player going first has a disadvantage because no information is available regarding the placement of cards. The player who goes last already has an idea of what cards some people have and not have, since there have been fishing attempts before this turn. To make the process more fair, the order of turns is decided at random based on the rolling of the dice. Moreover, this operation is performed at the start of both rounds i.e. with data sharing and without data sharing to ensure both rounds are free from any contextual factors.

It is also important to note that the game is playing on two existing card games, Go Fish (Bicycle Playing Cards, n.d.-a) and Rummy (Bicycle Playing Cards, n.d.-b). These games are created for purely recreational purposes whereas the serious game created for this research has a deeper meaning of encouraging data sharing in supply chain. This means that all the rules of the existing card games could not be relevant for the serious game and many new rules had to be introduced to embed the message of data sharing. However, play tests have identified that players who had played the games of go-fish and rummy prior to the playtest were able to use similar strategies in this game. The strategies had no implications on the underlying message or the overall trends of the scoring across rounds. However, in such cases, players with prior

experience were able to do better than those who were playing the game for the first time. Similarly, subjects who had been used for multiple playtests had predetermined strategies and were able to outplay first timers. However, it did not take long for a player to conjure his own strategy and such players were quick to challenge other players with prior knowledge. Whereas this reinforces the idea of practice and replay ability of the game, it can also be considered as a reason for skewed results or counter intuitive scoring in second rounds of the games.

5.1.2. Playtests with Supply Chain Experts

In addition to the game design experts, the game was played with experts from the field of supply chain. The expert was a supply chain professional who had a background with a similar project of designing a game for data sharing in supply chain. The expert was associated with the University of Applied Sciences at Windesheim and had designed a modified version of the Beer game to demonstrate the effectiveness of data sharing. The objective of the playtests with this expert was to evaluate the game for its relevance to the real world and to ensure that the game is analogous to the real world. The reaction of these subjects validated the idea of the game being closer to the reality of supply chain. Experts were mainly concerned with operations and asked questions pertaining to the operations of the game that were supposed to map the real-life supply chain processes. The experts were able to relate to the game from a supply chain point of view. The researcher played the part of a moderator and was promptly available for any questions throughout the game. The moderator also debriefed the players at the end of the game and the experts found this debriefing relatable. As experts, the roleplay operation of the game was natural for the players. When asked to play the role of a supplier, the experts clearly knew what to do and how to interact with other suppliers. There were some discrepancies about the rules of the game for some suppliers. In one case, the game had to be started over, because the experts had missed out an important rule while doing their turns. However, this was taken as feedback by the researcher and the explanation of the game was modified for next playtests to stress on the rules that were overlooked. The in-game learning operation was also successful since the subjects were able to learn the rules in one round and did better in the next. Subjects also changed their strategies while playing the game such that sometimes they played one round with one strategy and the next round with a different strategy. This was in line with the replay ability operation of the game since it stressed that practice in one play provided feedback to the subjects and they could change their strategies in the replay.

One of the experts from the field of supply chain also had a background in game design. He played the game in different roles. In order to highlight how the game will handle misuse of information, in this playtest, few rounds were played with one player misusing information shared by other players. This led to some interesting scenarios being discovered.

5.1.2.a. Scenario Discovery

The game was played with an expert who had a background in supply chain. Along with the expert, the game was used to discover different scenarios of how a supplier can act during the information sharing round. The underlying assumption was that when provided with information in the information sharing round, the suppliers are free to do whatever they want to do with that information. At that point, there is a chance that a supplier might turn hostile and misuse the information i.e. ask other players for their targets instead of giving them their targets. Moreover, while playing the game or even in real life, a supplier can be hostile right from the start of the partnership, or he can turn hostile after some time. This reflects the different relationships between suppliers as highlighted in section 3.1.3 of this report. The game was then played with both these scenarios and the results were as follows:

Hostile Supplier from Start

In one game, one player was hostile from the beginning of the round i.e. as soon as the information sharing round started and the targets for each player were announced. Obviously, the other players had no idea about the intention of this player but as soon as the hostile player made the first hostile move i.e. asked for another player's target, it was understood by all the other players that this one player was being hostile. At that point, naturally, the other players had two options. They can either all turn hostile against each other or the remaining three can continue to share information. In our playtest, the other three players continued to be cooperative and kept sharing information among themselves. Moreover, the player whose target was stolen by the hostile player was able to select a new target, as per the rules of the game. Luckily, that player had 3 cards of their new target already in their hand. In the next turn they got the fourth target and ended up making their target first of all the other players.

After completing their target, the winning player was still able to share information with the two cooperative players and they were next to complete their targets. The hostile player ended up being the last to get to his target.

	Revenue at the end of the round	
	Round 1	Round 2
Player 1 (hostile)	15	9
Player 2	13	15
Player 3	9	10
Player 4	11	12

Table 1: Game results when one player (player 1) was being hostile from the start

It can be seen that in the case of a player being hostile from the start, the hostile player did considerably better in round 1, when there was no information sharing. This was because, as the moderator noted, the hostile player spent more time asking for cards that other players were asking rather than focusing on their own target. As an example, if a hostile player, player A has target fruit of grapes, but they see player B asking for pineapple and player C asking for mangoes. Player A, if they have a pineapple or mango in their hand, will ask player B and player C for mangoes and pineapples rather than focusing on their target grapes. This hostile behavior without data sharing allowed player A to gather cards other than their target and trade them in for revenue. In the end, player A was also able to collect their target and achieve a high score. In the second round when the game started, as soon as player A targeted the first player for their target card, the other players realized what this player was up to. The other players were hostile against this player while continuing to be cooperative among themselves. Thus, the other players can choose to withhold information regarding the target of the hostile player while continuing to share information about other people's targets. This resulted in a scenario where the hostile player ended up doing worst as compared to other players. If no information regarding their target was available to a player, they will still ask the hostile player for their target, knowing that he might be withholding the information while having the target. For the hostile player, since asking for another player's target costs 2 coins, they were not able to target more than one people for acquiring the target of that player.

Hostile Player in the middle

Another important scenario is that of a slumbering agent. A player that starts off the game with the idea that they will cooperate and share information but as the game progresses and their position weakens, they decide to turn hostile. This player can be called a slumbering agent. This was an interesting scenario. As the game started, everyone was cooperative and sharing information. Once a few players started getting their targets cards and the one player started to lag behind the group, he decided to sabotage other players if he cannot make his own target. Halfway through the game (or later), this player made a surprising move and asked for the target of the leading player. At this point, it was pretty late in the game and most of the cards were out of the deck and in the hands of the player. The player who lost his target had a few cards in his hands and knew which set he was more likely to make so the decision of choosing his new target was easy. However, based on the information shared in the previous turns, the slumbering agent also knew how close this player was to making their target. The slumbering agent stepped in to stop the player from making a product before him at the cost of his own revenue. As the rules of the game dictate that asking for another player's target card requires you to pay 2 coins which is 20% of the starting revenue, the hostile player could not sabotage other players due to the risk of being bankrupt. The results of this game were as follows:

	Revenue at the end of the round	
	Round 1	Round 2
Player 1 (slumbering agent)	15	14
Player 2	13	13
Player 3	9	11
Player 4	11	16

Table 2: Game results when one player (player 1) acted as a slumbering agent

The results of the game show similar trends such that the worst-case results have increased from a 9 to a 11 and the hostile player did worse than before. However, because the hostility of the supplier was revealed later in the game, he was able to misuse some information to his advantage and ended up doing better than some players. This means that while sharing information the whole chain Is able to react to a hostile agent in a better way since everyone still ends up with a profit. By cooperating among the remaining friendly players, the

cooperation can work towards saving their own revenue and control the damage of the hostile player. For the hostile agent, it can be clear that cooperation will lead to better results. There might not have been a loss to the hostile player, but he did worse than the previous round despite all other players doing better.

5.1.2.b. *Learning from Supply Chain Experts*

The playtests with experts were very helpful in evaluating the relevance of the game for the supply chain industry. They also helped in mapping different scenarios to test the boundary condition of the game. The game is set to highlight the advantages of data sharing in supply chain and in doing so it takes the advantages of data sharing for granted i.e. this research has not aimed to argue for the advantages of data sharing but to highlight them. However, another approach has been adopted by researchers where games are used for qualitative research by using serious gaming to discover beneficial pathways for disruptive technologies (Tavasszy, n.d, Appendix A). Along the same lines, this research uses serious gaming on two fronts. On one front, it takes the benefits of data sharing for granted and argues for the use of data sharing in industry. However, on the second front this research has used serious gaming for discovering scenarios that test the limit of data sharing (Lempert, Bryant, & Bankes, 2008). A few scenarios that have been discovered so far are as follows:

- One hostile supplier from the start
- One supplier turns hostile mid-game
- Everyone is hostile (the round 1 in the game without data sharing)

5.2. Results

The detailed result of a play session of the game are given in Table 3. The play sessions were held with student volunteers. Students with a background in logistics were especially targeted to play the game because of their background knowledge about the logistics industry. These students were provided with a role description (see Appendix D) which explained the scenario to the players. Table 4 presents some important statistics of the results of some play tests. An analysis of these results in different cases is presented below in regard to the effect that data sharing had on certain aspects of supply chain operations.

Turn	Revenue at the turn							
	Player 1		Player 2		Player 3		Player 4	
	Round 1	Round 2	Round 1	Round 2	Round 1	Round 2	Round 1	Round 2
0	10	10	10	10	10	10	10	10
1	9	9	9	9	9	9	9	9
2	8	8	8	8	8	8	8	8
3	7	7	7	7	7 + 1 = 8	7	7	7
4	6	6	6	6	7	6 + 1 = 7	6	6
5	5	5	5	5	6	6 + 8 = 14	5	5
6	4	4	4	4 + 1 + 8 = 13	5 + 1 = 6		4	4 + 1 + 1 = 6
7	3	3 + 1 + 1 = 5	3		5 + 1 + 1 = 7		3 + 1 + 1 = 4	5 + 8 = 13
8	2 + 1 = 3	4 + 8 = 12	2 + 1 + 1 = 4		6 + 8 = 14		3 + 8 = 11	
9	2 + 1 + 1 = 4							

* "+ 1" denotes the completion of a non-target set and "+ 8" denotes the completion of the target set

** There is a decrement of 1 in revenue at every turn which is paid as operational cost

Table 3: A detailed result of a single game showing revenues at every turn

	Game 1		Game 2		Game 3		Game 4		Game 5	
	Round 1	Round 2	Round 1	Round 2	Round 1	Round 2	Round 1	Round 2	Round 1	Round 2
Best Score	15	16	8	17	13	15	9	13	17	17
Worst Score	7	13	7	15	5	14	8	9	7	14
Average Score	10.5	13.75	7.75	16	7.25	14.25	8.25	10.75	12	15
Variance of Scores	16.25	2.81	0.31	1	19.06	0.31	0.31	4.06	25	2.5
Number of turns for worst score	9	8	12	8	11	9	11	9	13	9
Number of turns for best score	8	6	3	9	10	8	12	7	9	9

Table 4: Results of some playtests of the game

5.2.1. Effects of Data Sharing on Revenue

According to the results, when the game was played without information sharing, using the first round's rules, it took more turns for all the players to collect their targets, and in some cases not all the players were able to collect their target sets, meaning that the points earned by the players were less. The points are linked to revenue, so the revenue earned by players was less in the first round. The players who did not collect their target sets had fewer points than what they started with. This corresponds to a loss in revenue for the supplier firm in real life. There were instances when nobody had completed their target sets. However, when the game was played with information sharing, and players would tell other players when they had the other players' targets, the number of turns taken to complete the target set was less. All the players completed their target sets, so the points earned by all the players were more than what they started with. This corresponds with a profit or surplus in revenue for the supplier firm in real life. Thus, data sharing has a positive effect on the revenue such that revenue is increased as a result of data sharing as evident from table 4.

5.2.2. Effects of Data Sharing on Time

The aim or the objective of the game is to have the most revenue at the end of the game. Depending on their strategy, a player can either try to complete their target set as soon as possible so the operating cost is minimized or they can complete their target set a little late in the game while collecting non target sets along the way to have the most revenue at the end. Companies want to manufacture their products with the best quality in less time and with low costs. According to the rules of the first round, there was no data sharing amongst the players. None of players would know the target cards of the other players. The seller (player whose turn it is) would ask the suppliers (other players) if they had their target supply (cards with target fruits) based on their judgements and barely any information. This way it took longer for the seller to acquire the target fruits (collect the target cards). In some cases, while playing without information sharing, players could not complete their targets at all. Players ended up paying for nothing since most turns did not yield the target results.

On the other hand, when the game was played according to the rules of the second round, data was shared amongst the players. All the players knew the targets of the other players and they

were playing in cooperation through data sharing. The player whose turn it was, would ask other players for their target fruit based on the information that was provided to them. This way less time (turns) was taken by the players because they knew exactly which other player to ask for their target fruits. Hence, data sharing also has a positive effect on the time taken to manufacture a product. It can be seen in table 4, that the number of turns for both the best and worst scores is less in the data sharing round than the previous round in most of the cases.

5.2.3. Effects of Data Sharing on Traceability

In the first round of the game, while fishing for supplies, players can ask other players for any card. A player can trace all the cards in their hands to their last destination i.e. player knows if they received the card from the deck or from another player. In real-life, this is equivalent to a trader knowing that he got his supplies form the farm and the wholesaler knowing that he got his supplies form the trader. However, there is no telling where the previous handler of the supply got them from. In other words, a player in the game only knows the last destination of the fruit. He cannot tell whether the other player had the card from the start or if they drew it from the deck. In round 2, this information can also be shared. When a player passes a card to another, they can tell, if they had it from the start or if they drew it from the deck or if they got it from another player. However, in the playtests so far this information has not been shared explicitly. But it can be implicitly traced. If a player does not share information in the first round, that means he did not have that card from the start. If the information is shared in the second round, that means that the player must have received that card from the deck since no one shared any information about it. In this way, the game brings traceability to the cards in players' hand and implicit data sharing helps the players to keep track of where the card might have come from.

5.2.4. Effects of Data Sharing on Efficiency

The results portray a stark difference in player scores across the two rounds. Generally, there is an increase in scores for all players. However, the increase is greater for players that did worse in the first round and lower for player who did well in the first round. This is analogous to the real-life scenario as a supply chain can never be perfect. There is going to be a limit to how well a supplier can function. However, what the results portray better is that the worst case loses (lowest score of a round) of a supplier are greatly reduced. Thus, applying a maximin

decision making approach (Pearman, 1977), we can see that without data sharing, in the first round of game 1, a supplier got 7 coins in revenue in the worst case which is a loss of 3 coins as compared to the starting position. Whereas in round 2 of the same game, the worst-case result is 13 coins which means that there is a profit of 3 coins as compared to the starting revenue. This is true for all games and shows that in a cooperative data sharing environment, suppliers can cut down their worst case loses knowing that their partners are looking out for them. The probability of unsuccessful fishing or a supply gone bad or delivered late is reduced. The average scores in round 2 of all the games are also higher (see table 4) which means that overall, it was a high scoring round. More revenue was divided among the same players and the lowest score was considerably increased. Thus, the overall efficiency of the chain was increased due to data sharing.

5.3. Evaluation of the Game

The last part of the research, after designing the gameplay and testing it via playtests, was to evaluate the game based on standards defined by literature. The game can be evaluated on two criteria. One criterion is the feedback of the subjects. During their debrief, the subjects can be asked questions regarding the game and asked to rate the game based on their understanding. The other criterion is to take standards used in prior researches and use them to see if the game follows similar standards.

There are many different standards to evaluate a serious game designed for learning. One such method is the theory oriented evaluation of a design in serious gaming (Willy Christian Kriz, Hense, & Klabbers, 2006). According to this methodology, evaluation should be kept in mind while designing the game. The logic model of the game should be designed at the first step and re-designed based on the evaluation throughout the game design process. In this way, researchers are able to catch the problems in the design in time and before moving on to the next step. The theory-oriented evaluation approach has been mainly used for simulation games. In a playable game, the inputs and outputs differ based on the pre-game selection of players and in-game strategies of these players. The demographics of subjects, their strategies and the contextual or randomization factor of the deck of cards are among some of the things that differentiate the game designed in this research with a simulation game. However, the processes of the game i.e. how a move is performed within the game and the rules of the game in general remain the same for any input. One type of input would always result in the same

output i.e. if the game is played multiple times with the exact same order of the deck of cards, exact same hands of the players, exact same order of the moves by every player, the output will be the same as well.

Because this research uses the triadic game design approach, each step of the design was already evaluated and re-evaluated while designing the game. Once the reality was analyzed, the next step was to deduce meaning from that reality. While deducing the meaning i.e. extracting meaningful processes and identifying target stakeholders, the reality was re-evaluated as well. If the result after the meaning extraction did not make sense, it meant that either the meaning was not extracted effectively or that the reality was not ideally represented in our analysis. Thus, each step of the triadic game design served as an evaluation phase for the previous step.

The last step was gameplay design. However, since there was no step after it, game design could not be re-evaluated based on the results of a design step. That is why the game was played multiple times with several subjects during playtests and discrepancies in the game were identified during these play tests. As described in section 5.2.1, the discrepancies pointed out during playtests were used to modify the rules of the game. Moreover, having the game played by experts from the field of supply chain and experts from the field of game design served as phases of evaluation as well. Owing to these play tests and their resulting changes, the starting logic model of the game was very different than the final one. The starting model focused more on stakeholders and less on individual processes whereas the final logic model, the one in use now, focusses more on processes of supply chain and data sharing while choosing a minimalistic approach for stakeholder selection.

Another important framework for game design evaluation is presented as a comprehensive methodology (Mayer et al., 2014). The framework is more concerned about the learning as a result of a serious game than the design of the game itself. Mayer et. al. has discovered multiple factors that affect the learning outcome of a game. These factors can be divided into three broad categories of pre-game, in game and post-game (Mayer et al., 2014). For this research, the pre-game factors are pre-determined since the game focusses on supply chain managers as the target audience. The post-game factors are recorded and evaluated during the debrief. An approach beyond the debrief evaluation is outside the scope of this research since it focuses more on the learnings and effects of the game than player experience. However, the in-game

factors remain highly relevant for the purposes of this research. The three in-game factors identified by the comprehensive methodology of game design and research evaluation are:

- Game performance: in-game scores, learning from mistakes
- Gameplay: effort
- Game experience: flow, immersion

An overview of the in-game scores of some play tests was provided in the results section (table 4). These scores were intuitive i.e. in the round without data sharing the worst score was much less than the worst score in the second round with data sharing. The scoring is streamlined such that it follows a prescribed set of rules and players know how much any move will cost or benefit them. No player effort is required in terms of moving the props or keeping track of the score line. The coins that represent revenue are exchanged during the game and counted at the end to reveal the scores. The only effort required from the players is to focus on the game mechanics. In the first round, scoring can be a bit harsh because some players end up losing their targets but this is a design aspect of the game since the idea of the game is to show how bad you can do without data sharing whereas data sharing make things much easier. Moreover, the replay ability operation of the game provides an opportunity to the players to learn from mistakes in round 1 and avoid them in round 2. The game is also based on two existing card games. The flow of the game is inherited from the original games. Having a consistent set of rules ensures that the game proceeds smoothly without any hiccups. The experience of the player is not interrupted by sudden changes or switching of rules. Finally, following the roleplay operation of the game, players are asked to act as supply chain managers in the game. This creates an exalted sense of immersion since players take on the role of supply chain managers and make decision as such. Hence, when judged by Mayer's methodology, the game follows smooth in-game processes with a high immersion and smooth flow (Mayer et al., 2014).

One final note on the evaluation of the game is the use of game to identify different scenarios to test the limit of the effectiveness of data sharing. This is in line with an approach to use serious games to identify benefits of an innovative technologies (Olejniczak, Newcomer, & Meijer, 2020). Serious games themselves span a wide variety of subject matter and characteristics (Mayer, Warmelink, & Zhou, 2016). In the case of this research, the game has

a bi product that it can identify scenarios where data sharing begins to become ineffective. One play test with a supply chain expert revealed two scenarios that made the scores of the data sharing round go down i.e. the effectiveness of data sharing decreased. However, if the game is played more and more, some scenarios might be discovered where data sharing might be less effective.

6. Conclusion

This chapter concludes the report by providing answers to research questions and describing the dead ends during the research. It also includes limitations of the research, recommendations for future work and an academic reflection on the research methods used in this research.

This report has described the process and outcome of a research that was aimed at developing a serious game to encourage data sharing in supply chain. The objective of developing the game was to encourage supply chain managers to share data in a supply chain. The research was able to achieve its objectives and answered the research questions along the way. The research started with a literature review that looked at the reasons for reluctance of supply chain managers in sharing data and the effectiveness of serious games as a medium to spread awareness about the role of data sharing in supply chain. The reality analysis in world of reality identified stakeholders that were relevant to the game and that had to be represented in the gameplay. The world of play provided answers to deigning the game in such a way that it is easy to play and efficient in imparting its message. Finally, the evaluation of the game identified helpful frameworks from literature that helped evaluate the game in term of its ability to impart the message of effectiveness of data sharing in supply chain and its design process.

Why are managers reluctant in implementing a data sharing solution in their supply chain management?

It was identified that managers are reluctant to share data due to fear of misuse of sensitive information and the idea of someone else using their information for better rewards (Bala, 2014). Another reason is that supply chain managers are reluctant in yielding power over to competitors by over-sharing information. Due to such reservations, the willingness to share information among suppliers and distributors is low. Management focuses their activities on enabling the dimension of connectivity in data sharing but the low willingness to do so is neglected (Fawcett et al., 2007). Thus, low willingness in firms of a supply chain leads to an unintegrated chain and lapses in data sharing (Lotfi et al., 2013). Management is reluctant to provide the huge investment cost required to build the infrastructure required for data sharing technologies (Kshetri, 2017). Some of these technologies are fairly novel and unproven in the

field. The proof-of-concepts provided by research and academics are limiting in their complexity and face issues of scalability (Ge et al., 2017).

What are the advantages of using serious gaming to spread awareness regarding the role of data sharing in supply chain?

The gaming literature pointed out some key advantages of using serious gaming for creating awareness regarding a phenomenon. Some of these key advantages answer the question of why serious gaming is the right medium for creating awareness regarding data sharing in supply chain. A game gives the designer the advantage to design in a small-scale environment. The designer can eliminate unwanted variables and control the environment to study the exact phenomenon and relationships (Klabbers, 2003). A message that is imparted through serious gaming is retained longer in the mind of the audience. When a person plays the game, they are involved in every step of the process and hence the message is received better by them because the process is fun and interesting (Mortara et al., 2013). Finally, games require the players to be involved in the process. A supply chain manager might not be able to relate to the actual success of his organization's data sharing activities. However, when the same person plays a game, he controls every move and feels the ownership of the scenario more than the real world. Thus, gaming can be seen as a training exercise for the real world.

What stakeholders have to be represented in the game and what will be their roles?

The stakeholder analysis during the triadic game design brought many important stakeholders to light. For the purpose of the game not all stakeholders had to be represented. A minimalistic approach was followed while identifying stakeholders as in the case of the RFID tag study (Ligang et al., 2016). The game focuses more on representing the processes of supply chain accurately. The stakeholders are kept generic such that players represent suppliers, but no distinction is made along the lines of size, power or revenue between stakeholders. Each player represents a supplier in the game and has the same starting revenue, opportunities and standing as compared to other players. However, the processes are different for each player depending on the cards dealt to the player and the turn order. As the game progresses, the strategies of different players create distinctions in revenue and power. Another important point to note is

that the in-game representation might be minimalistic, but the target audience of the game stays strongly focused on supply chain managers and decision makers in the supply chain industry

How can the gameplay be designed such that it's easy to play but attractive for new users at the same time within the context of fresh chains?

The game was designed after putting considerable efforts in literature review, critical analysis of the reality to draw meaning and extensive iterative processing to design the rules. The design catered for the context of fresh chains and green logistics while focusing on attractiveness and easiness of the game. The game is based on two existing card games, Go-Fish (Bicycle Playing Cards, n.d.-a) and Rummy (Bicycle Playing Cards, n.d.-b). Although the rules of the game have been changed quiet a lot as compared to the existing games, but the objective of the game is somewhat similar. Moreover, players can make use of similar strategies that are used in these existing games in the game of this research. Basing the game on existing games made it easy since people have played these games or other games similar to them. To be able play the game in a supply chain context, customized cards were designed for this game. The cards have pictures of fruits on them. There is a total of 52 cards with 13 different fruits. Each fruit has 4 cards with its name on it. The design is analogous to a standard 52 card deck with numbers being replaced to fruits. Each fruit having four cards indicates the suit. A player has to collect four cards with the same fruits in order to score points.

How will the game be evaluated to measure if the above goals are achieved? If not, how can the game be modified to achieve said results?

There were many evaluation frameworks for serious gaming in literature. In some cases, serious gaming has been used for evaluating other research models (Olejniczak et al., 2020). Due to such wide variety of content and vast range of applications, finding the right evaluation framework was difficult. The game was first evaluated based on theory-oriented evaluation method which states that evaluation should be a continuous part of the process of game design (Willy Christian Kriz et al., 2006). Using the triadic game design principle in this research gave the ability to re-evaluate one step of the design process while designing the next step. The last step of designing the gameplay was re-evaluated with play tests. The second framework that was used states that there are certain performance indicators that demonstrate the quality of the game. Using the in-game factors of game performance, game play and game experience, it was

argued that the game designed for this research is of high quality due to being based on existing popular card games, having operations of roleplay and replay ability and producing required results in terms of usage of data sharing in the game. Finally, a novel approach of using serous games as a tool for evaluation of other research models (Olejniczak et al., 2020) and evaluating benefits of a new technology (Tavasszy, n.d., see Appendix A) was also looked at. The game was used to find scenarios where data sharing begins to lose its effectiveness.

To answer the main research question described in chapter 1, a serious game has been developed that highlights the advantages of sharing data in a supply chain. The game also helps to overcome the reluctance of managers towards sharing data by demonstrating the effectiveness of sharing data and by providing a mechanism in the game that allows players to hide trade secrets. The game was designed using the triadic game design approach and play tested where it proved easy to play and attractive to volunteers. The game design mechanics were also evaluated using frameworks from literature and the steps of this game design were successfully mapped to the frameworks. The game was successful in delivering its message since people who played the game understood the importance of data sharing straight away.

Finally, it is also important to see how the advantages of data sharing, as seen from this game, will benefit the fresh chains and green logistics. Considering the example of the fruit farm, fruit trader and the fruit wholesaler from the world of reality, it can be noted that their workflow will become more streamlined with data sharing. The farm will tell the trader when the crop of fruits will be ready to harvest and how many units will be in that crop. The trader, knowing that date, will not book orders before that date and will also not book orders for more than the intimated quantity. Similarly, the wholesaler will know from the trader when the fruits will reach him and how many he can expect. This way, data sharing will help the whole chain, that no time will be wasted in over-booking or early arrival expectations. The customers of each stakeholders will know the exact time of delivery. The operational cost will decrease due to on-time deliveries and knowing the exact date of deliveries. The whole process will be more efficient since the cost spent will translate into revenue in a better way.

6.1. Roads not Taken

Research is full of dead ends. There are numerous times when one advances in his research only to fall back to square one later on. Similarly, there were many instances in this research where an option was selected and worked on but had to be scrapped later on.

6.1.1. Choice of a Game

The first such instance of a roadblock was at the game design stage. While looking into options for basing the research game on, a few popular games were identified. One such game was the settlers of Catan (Catan.com, n.d.). Catan is a strategic board game that is aimed at controlling resources and building civilizations on a board. The supply of resources is determined by rolls of a dice. The game has certain characteristics that are linked to a supply chain. However, the game is based on negotiations and involves mechanisms that are deeply linked to randomization bias. The strategies of the game have more to do with placing of pawns and building of roads than gathering materials or making products. In the phase of research, where the gameplay had to be mapped to reality, Catan failed miserably. The settlers of Catan is a long game with complex and tiresome rules. It was not suitable for relaying a message. Players could get too occupied with the rules and operations of the game that they will forget the underlying messages. The gameplay will also be interrupted by negotiation moments after every turn, hampering the smoothness of the game. As a base game, settlers of Catan would have a worse outcome on the evaluation frameworks. Similarly, monopoly was another board game that was considered to save as the basis of this research. The attractive factors in monopoly were the well-defined revenue denominations and the scattering of player products (properties) around the board. Monopoly would have provided a better basis for transactions and players would have been able to better relate with the concept of money being lost or gained. However, monopoly is far-fetched from the concept of supply chain. It is basically a real estate game that focusses more on economical transactions than player relations. Therefore, using monopoly as the base game would have created confusion among players when it came to sharing information.

Another avenue that was considered was developing of a poker game with data sharing. After extensive research into board games and other gaming apparatus, it was clear that a card game will be a better approach. Card games provide one clear advantage of cards being tradeable and

exchangeable. Cards look more like a product or a commodity and are easier to trade and exchange between players than resources in Catan or properties in Monopoly. Once the choice of Monopoly was clear, popular card games were screened. Poker was a suitable option until the round of data sharing was started to look at. Poker is a game that is inherently designed to keep secrets. Bluffing and maintaining a poker face are key aspects of a game of poker. Asking the players to share data in a poker game sounded very counter intuitive. Moreover, everyone has a history of playing poker games. That would mean that every player brings in memorial baggage at the start of the game. If certain moves were added or removed, some players might be at a disadvantage because their strategy might not have been effective anymore.

After going through all the above options, the game of Go-Fish and Rummy were selected. Although the current version of this research game is very far from either of Go Fish or Rummy, but it must be acknowledged that these games were the starting points. They allowed for cards to be exchanged, thereby simulating a supply chain experience and their gameplay was flexible to allow addition of cost mechanisms and data sharing operations. They were also games with simple rules which kept the gameplay smooth and created a feeling of deeper immersion for the players. In all the play tests to date, no complains have ever been received regarding the complexity of the rules or any hidden traps. The game provides a fun environment to learn the advantages of data sharing.

6.2. Limitations of the Research

The research has developed a game that encourages data sharing in supply chain by demonstrating the effectiveness of data sharing in supply chain. However, this research does not concern the technology used for data sharing. The game encourages data sharing in general without focusing on what technology is used for sharing data. Some popular technologies for sharing data are Blockchain, integrated MRP systems and other cloud hosted software. The choice of technology has an impact on cost since some technologies like blockchain and cloud technology have a huge infrastructure cost associated with them (Kshetri, 2017). The revenue outcome will depend on which technology is used for data sharing and in some cases the cost of technology infrastructure might reduce the overall revenue of the firm. There are also issues of standardization within data sharing that this research doesn't take into account (Themistocleous et al., 2003).

Another limitation of this research was that the game was designed following a minimalistic approach while identifying the stakeholders. The stakeholders were kept generic as all the players represented suppliers. There was no differentiation in the size, influence and revenue of the stakeholders. Similarly, the data shared by each supplier was also considered equal in value to the data of other suppliers. In real-life, different stakeholders in the chain have different information and some information might be more valuable than the rest. The game can be improved further by increasing the span of representation of stakeholder. This will also create more scenarios to test the limit of data sharing in supply chain

Finally, the evaluation of the game was done through research frameworks used commonly in the field of game design. The game was also play tested with experts from the field of supply chain and game design. The feedback obtained from these experts was then used to modify the game in order to make it more coherent and realistic. However, there is no systematic mechanism to obtain feedback from supply chain managers and student volunteers other than the debrief after the game. The debrief discussion revolves more around linking the game to the reality of supply chain and explaining the effectiveness of data sharing to the players. In most cases, feedback of the players does not come into discussion. For future works, it will be worthwhile to look into feedback forms or exit surveys to capture the opinion of players regarding their experience.

6.3. Future Works

This research has provided a starting point by creating a game that encourages data sharing in a supply chain. The game was able to achieve its objectives but there still remain a few things that can be added. There are many other things that can be done on this research front. Some recommended future works are below:

The game has to be played further by supply chain managers. For now, the play tests have only included supply chain experts and game design experts in addition to students. Only one supply chain firm's employees have played the game so far. The intended target players of the game are supply chain manager. In the next 6 weeks, the focus will be on getting the game to be played by supply chain managers. Furthermore, a method should be devised to implement the game as an integral part of each supply chain manager's trainings to help them understand the benefits of information sharing. This can be done by providing an online platform targeted to

all the supply chain managers, to play the game with and without information sharing with supply chain managers from different companies or even employees from the same company. Once the managers play the game, it will help them understand the importance of data sharing and help to overcome their reluctance to share information with other stakeholders in the supply chain.

Another aspect of information sharing which needs further research is making policies for the standardization and safety of data sharing processes (Janssen, 2005). This would be to ensure the quality of data being shared is relevant to other companies and the raw data shared could be beneficial and used in meaningful information for other companies. The policies made for the safety of data sharing would be used for protecting sensitive and non-sensitive data ensuring supply chain managers that the data being shared by them will not be misused by anyone (Kang et al., 1998). Apart from this, there should be policies for correctly storing and managing the data so that the information can be available to the concerned parties whenever it is necessary for them. This leads to the original research idea about introducing blockchain in supply chain management. Blockchain is a relatively new technology with a decentralized network of nodes and each node having its own ledger to track transactions of the entire chain. Using blockchain in supply chain management for information sharing would have more transparency and because each transaction is tracked, it would also have more traceability.

6.4. Academic and Personal Reflection

The research described in this report was done as part of a thesis. The author did not have extensive experience as a researcher but used the research practices learned during the course of the master's program to achieve the objectives of the research. Reflecting back, there were a few things that could have been done in a different way. The literature review section was based on looking for literature studies with a high number of citations and snowballing backwards from the references section of that study. The literature review on the topics of supply chain and supply chain management follows a chronological order in terms of dates of publication. Although this is the best practice for a literature review, but the desk research could have been done in a better way instead of just using highly reviewed literature studies and snowballing backwards from there. The papers to be cited should have been searched from independently to argue for certain conclusions. However, this did not hamper the process of answering the relevant research question.

Secondly, the game was designed using the triadic game design approach. Although this was a modular process because the design was divided into three modules of world of reality, world of meaning and world of play but these sub modules were still quite extensive in terms of effort required to complete them. There were several different domains within one sub module and each domain was complex in its own way. Triadic game design method also offered various advantages such as the ability to evaluate one module while working on the next module. So, it is not advisable to change the design method. However, triadic game design can be expanded such that each sub process can be divided into further smaller research processes (Lukosch et al., 2018). This way the research domains would have been easier to manage, and the complexity of each task would also have reduced.

Finally, the major part of research was game design and testing. However, the other parts of game evaluation, discussion of the results and literature review were also equally important. During the course of this research, the most amount of effort and work went into the game design and testing. The conclusion and discussion of the game were only taken into consideration during the last few months. Looking back, the time should have been divided equally such that the results should have been discussed as they came in. The report writing should have been a constant part of the research. After every research module, the report for that section should have been completed. For this report, the introduction, literature review and game design were written parallel to the research. However, discussion and conclusion were left for the end.

Personally, my major reflection is around organizing the playtests. It was really difficult to find volunteers for playing the game. Most of my peers were busy with their own research and thesis. Moreover, the thesis was done during the COVID-19 pandemic when the university was closed down and everyone was working remotely. I had to find an online application for simulating the deck of cards. It was even harder to get experts to play the game because of their limited availability. My advice to future researchers who aim to perform playtests for their games will be to plan ahead. Moreover, during the lockdown period of the pandemic, it was very hard to focus on the research. It was hard for me to manage time during the lockdown period of the pandemic since being confined to a room took away the motivation to work with a proper schedule.

Final Remarks

This report has provided a comprehensive overview of the research that was done as part of this thesis. It has been a long journey since the kickoff meeting and the acceptance of the proposal for this thesis. I have learned a lot regarding supply chain and game design. I have also connected with some experts from these fields. I believe this learning and these connections will really help in my career. I aim to keep working on this game even after my graduation to ensure that the goal of sharing data in supply chain is achieved.

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8. Appendix

Appendix A

KNOWING PROPOSAL Work Package 2 Development and Test of Explorative Model (draft)

The objective of WP2 is to develop a method that allows to identify the impact pathways of disruptive developments, so that they become amenable for quantitative, predictive analysis.

We build on the technique of scenario discovery in a case-based, qualitative context. Whereas scenario discovery is mostly known as a quantitative technique to identify possible critical pathways in deeply uncertain systems[1], by lack of suitable quantitative models (which is the main problem in our case) one can also apply the technique in the qualitative sense, with the objective to identify and map phenomena[2]. Our proposal is to use the technique of serious gaming for scenario discovery, i.e. the identification of plausible impact pathways of disruptive developments (DDs; these can be technological innovations e.g. blockchain, as well as natural hazards e.g. a global pandemic).

Serious gaming will be set up in a way that the interaction between the players of the game (all relevant stakeholders representing the quadruple helix, i.e. industry, government, civil society and the knowledge sector) can be traced to show how the objectives of interest to society as a whole are affected, and how transport system stakeholders will deal with DDs. It is well-known that innovations bring about changes in the roles and functions of stakeholders in the transport ecosystem, driven by changes in business models[3]. The games will use this organic representation of the transport system to bring to the surface the main changes and thus help use knowledge and creativity of the players to create a set of scenarios that would envelop the future.

Specifically, these game simulations will help to understand the changes in interrelations between actors of the freight transport system, the possible impact of these disruptions and innovations and subsequently the essential mechanisms of the freight transport system in relation to DDs. The explorative games will help discover the essential mechanisms that a development (i.e. innovation or disruption) brings and look at the outcome from the “why” perspective. Earlier applications of serious gaming in the context of innovations in freight

transport has proven to be successful[4]. The use of gaming as tool for scenario discovery, however, is new.

As result, WP2 will deliver an explorative game method for discovery of future transition paths related to innovations and disruptions

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Appendix B (Customized Deck of Cards used for the game in this research)

PINEAPPLE

PINEAPPLE

POMEGRANATE

POMEGRANATE

COCONUT

COCONUT

PLUM

PLUM

MANGO

MANGO

AVOCADO

AVOCADO

PAPAYA

PAPAYA

LYCHEE

LYCHEE

KIWI

KIWI

GRAPES

GRAPES

STRAWBERRY

STRAWBERRY

GUAVA

GUAVA

APRICOT

APRICOT

Appendix C (List of volunteers who played the game)

Ahmed Hembel

Chris Verhoef

Hafsah Khizar Usmani

Hamza Ijaz

Hasseb Malik

Imdad Khan

Jacob Hejderup

John Landers

Lala Rukh

Linda Van Veen

Muhammad Bin Tahir Mir

Pablo Secco

Resy

Saad Anwar Ul Haq

Satvik Bhatia

Simon

Sohaib Ahmad

Wardah Khizar Usmani

Zainab Ijaz

Appendix D (Role Description)

The following role description was provided to the players who volunteered to play the game. The players were asked to make decisions while being in this role throughout the game:

- Begin Description

You are a supply chain manager in an organization whose major commodity is exotic fruits. You are in charge of the procurement of incoming supplies and the sales of outgoing supplies. Your boss expects you to make a profit i.e. have more revenue than the starting revenue of 10 units. Thus, revenue is your ultimate target. You have freedom in selecting the product of your company which will be your target fruit in the game. You are free to choose your strategies in the game i.e. you can make your target fruit early and save operational cost or you can spend more operational cost but collect non-target sets to make up for the lost operational cost. In the data sharing round, you are free to share information, but you can also withhold it. If you feel that other people are making better use of your information and you are not getting anything in return, you can stop sharing information. Be aware that if other people realize your strategy of withholding information, they might withhold information from you as well or even turn hostile against you. You must also track cards and ask for the origin of the card when getting it from the player to trace your products and their origin.

- End Description