Guns & Roses

Scenario-Based Analysis of the Robustness of Police Interventions in the Flower-Oriented Sector: Strategies for Criminal Apprehension

Hillary Lopes Mendes

TU Delft

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Scenario-Based Analysis of the Robustness of Police Interventions in the Flower-Oriented Sector: Strategies for Criminal Apprehension

Thesis report

by

Hillary Lopes Mendes

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Thesis committee:	
Chair:	Prof.dr.ir. A. Verbraeck
Supervisor:	Prof.dr.ir. A. Verbraeck
Advisors:	Ir. I.M. van Schilt
	Dr. J.A. Annema
External examiner:	T. Torrensma
Place:	Faculty Technology, Policy and Management, Delft
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Student number:	4960823

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Delft University of Technology

Preface

This report marks the completion of my Master of Science program in Engineering and Policy Analysis at the Technology, Policy and Management faculty of the Delft University of Technology. The success of this report cannot solely be assigned to myself, I could have never done this without the people around me.

Firstly, I would like to thank the Transport Facilitated Organised Crime (TFOC) organisation for giving me the opportunity to work on this dynamic topic. TFOC, more specifically Tom Torensma, has taught me a lot about the workings of the Dutch police and their enthusiasm always gave me more energy to get to work.

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I would also like to express my gratitude to my supervisors. I would like to thank my chair, Alexander Verbraeck, for always staying positive, patient, energetic and resourceful. Our meetings always gave me more ideas and made me excited to continue. I would also like to thank my advisor, Isabelle van Schilt, for always being approachable and pro-active. I enjoyed our cooperation and could not have reached this result without you. Furthermore, I would like to thank my second chair, Jan Anne Annema, for his invaluable feedback on my drafts. I started my first day at the faculty with you and I find peace in closing this chapter with you as well.

I have enjoyed my time as a student, but I am ready to start a new journey. This process has not been easy, but fortunately, I had my family and friends to support me. Without you I could not have overcome the challenges I was faced with and I thank you immensely for your ongoing support.

Enjoy the reading!

Hillary Lopes Mendes
Schiedam, June 2024

Executive Summary

The Netherlands is not only one of the biggest exporters of flowers globally, but according to the United Nations Office on Drugs, the country is also very successful when it comes to exporting illegal goods (UNODC, 2018). This unfortunate success comes paired with negative economic effects, criminal activities, e.g., liquidations, explosions and health risks, therefore the smuggling of illegal goods must be suppressed. The Transport Facilitated Organised Crime (TFOC) program of the Dutch national police is focused on both preventing and interrupting crime. However, even though the program combines multiple public organisations, TFOC often finds itself lacking sufficient information to successfully interrupt criminal organisations. Therefore, this research aims to investigate the effectiveness of different intervention methods. This research focuses on the export of flowers and plants to the UK, as these products are perishable and have to be handled carefully and fast, leaving room for criminality as checks cannot be as thorough.

This research uses a mixed-method approach to map the legal supply chain, identify the criminal modi operandi and test the robustness of possible intervention methods. The robustness of the interventions entails the positive functioning of interventions given a set of scenarios. Interventions that are more or as effective in scenarios compared to the base case are considered robust in this research. To map the legal supply chains, experts are interviewed to gain more information about the different transport configurations that are available for flower export. More experts are interviewed to gain more insight into the malpractices in this sector. With this input, the modi operandi of criminals are identified and combined with the transport configuration based on their likeliness. In addition, existing literature was consulted to gain more academic insight into the workings of criminals.

The qualitative methods form the base for the quantitative approach. A discrete event simulation model is made in Simio. The routes that are plotted in conceptual models, e.g. IDEF-0, flow charts and BPMN models, with the use of interviews, are translated into the model. The interviews gathered 4 modi operandi for criminals in this sector, namely:

- Addition of a bag with illegal goods to a trailer.
- Hiding illegal goods between the legal goods, e.g. in the soil or between boxes.
- Using vases and pots with a hidden compartment
- Planting illegal goods inside flowers and plants

These modi operandi are added to the model in combination with the different flower types, as certain combinations are more likely than others. The model is also expanded with the three different intervention methods that were distinguished in the interviews as well, namely:

- Checks with the use of sniffer dogs
- Checks with the use of the X-ray scans
- Physical checks with the use of customs employees

The intervention methods are not as effective for every type of modi operandi. In the discrete event simulation model, the effectiveness of the intervention methods is approximated with the use of the interviews.

The simulation model is tested with the use of a scenario-based analysis. 15 scenarios are created, that investigate different aspects of the model. These scenarios range from criminals investing more in specific modi operandi, to customs increasing their amount of employees and even the distribution of Authorised Economic Operator certificates, which increases the efficiency of companies by decreasing the chance to be checked, is taken under the loop.

When it comes to the robustness of the intervention methods, the dog check is only significantly negatively influenced when criminals use less of the Transport MO. The physical check is also only

significantly negatively affected in this scenario and the scan intervention is not significantly affected by any of the scenarios in this exploration. However, these results can also be led back to the exploration of the scenarios. Maybe a broader group of scenarios could lead to different conclusions about the robustness of the interventions. For instance, focusing more on specifically the grower MO, which is one of the hardest MOs to detect, could result in less robust interventions.

Based on the study findings, further research could extend the scenario analysis with scenarios that take the dynamics between criminals and law enforcement into account. In addition, further research can add to the research with a supply of empirical data.

Contents

List of Figures vii

List of Tables ix

Abbreviations ix

1 Introduction 1
- 1.1 Problem Statement 1
- 1.2 Scientific Relevance 2
- 1.3 Research Objective 2
- 1.4 Research Scope 2
- 1.5 Research Questions 3
- 1.6 Research Approaches 4
- 1.7 Reading Guide 5

2 Literature 7
- 2.1 Search strategy 7
- 2.2 International impact 7
- 2.3 Smuggeling methods 7
- 2.4 Business plan for illegal organizations 8

3 Routes 9
- 3.1 Growers 10
- 3.2 Buyers. 11
- 3.3 Royal Flora Holland 12
- 3.4 Transport companies 14
- 3.5 Dutch customs 14
- 3.6 Quality Control Bureau 15
- 3.7 Opportunities routes 17

4 Criminal modi operandi 19
- 4.1 Criminal Interference 19
- 4.2 Likeliness of MOs. 20
- 4.3 Lawful interference 21
- 4.4 Effectiveness of interferences 22

5 Model setup 24
- 5.1 Setup 24
- 5.2 Model objectives 24
- 5.3 Model assumptions 25
- 5.4 Key performance indicators 26
- 5.5 Model verification 26

6 Validation 28

7 Experimental Design 31
- 7.1 Bonafide world 32
- 7.2 Trust of dutch customs 32
- 7.3 Dutch customs employees 32
- 7.4 Authorised Economic Operator 32
- 7.5 Transport modi operandi 32
- 7.6 False positives 33
- 7.7 Specialized modi operandi 33

7.8 Pressure on dutch customs 33
8 Results **34**
9 Discussion **38**
9.1 Research findings 38
9.2 Implications of the limitations 39
9.3 Implications of Simulation 39
10 Conclusion **40**
10.1 Further research 41
References **41**
11 Literature list **42**
A Appendix A: Methodology **45**
A.1 Interview structure 45
A.2 Consent form 47
B Appendix B: Legal routes **48**
C Appendix C: AEO **54**
D Appendix D: Sensitivity Analysis **55**
E Appendix E **56**
F Appendix F: Simio model **57**
F.1 Growers 58
F.2 Consolidation 60
F.3 Auction 60
F.4 Modi Operandi 61
F.5 Intervention methods 62
G Appendix G: Results **65**

List of Figures

1.1 Export to the UK. 3
1.2 Scope demarcation 3
1.3 Research flow diagram. 6

3.1 Formal Chart of the system with the most important players. 10
3.2 Grower route choice flow chart 11
3.3 IDEF-0 transport activities 12
3.4 IDEF-0 consolidation process 13
3.5 flowchart box choice 14
3.6 flowchart customs 15
3.7 flowchart KCB 16
3.8 IDEF-0 overview direct lines 18

4.1 Effectiveness of interventions 23

5.1 Simplifications 25
5.2 Assumptions 26

6.1 Sensitivity results 30

7.1 Overview experiments 33

8.1 significance level scenarios 36

A.1 Consent form 47

B.1 Swimlane, direct buyer with own box but third transportation 49
B.2 Direct buyer consolidates in other box and third transportation 50
B.3 Buyer with consolidation at RFH and third transportation 51
B.4 Buyer with own transportation and consolidation 52
B.5 Full flow chart diagram 53

F.1 Overview Simio parts 57
F.2 Simio growing flowers 58
F.3 Simio Batching flowers Part 58
F.4 Simio Grower Part 59
F.5 Simio Consolidation Part 60
F.6 Simio Auction Part 60
F.7 Simio MO Part 61
F.8 Simio process MO 61
F.9 Simio Intervention Part 62
F.10 Simio check AEO 62
F.11 Simio Dog check 63
F.12 Simio scan availability 64

G.1 Independent sample t-test Base case and Scenario 2 65
G.2 Independent sample t-test Base case and Scenario 3 65
G.3 Independent sample t-test Base case and Scenario 4 66
G.4 Independent sample t-test Base case and Scenario 5 66
G.5 Independent sample t-test Base case and Scenario 6 66
G.6 Independent sample t-test Base case and Scenario 7 67

G.7 Independent sample t-test Base case and Scenario 8 67
G.8 Independent sample t-test Base case and Scenario 9 67
G.9 Independent sample t-test Base case and Scenario 10 68
G.10 Independent sample t-test Base case and Scenario 11 68
G.11 Independent sample t-test Base case and Scenario 12 68
G.12 Independent sample t-test Base case and Scenario 13 69
G.13 Independent sample t-test Base case and Scenario 14 69
G.14 Independent sample t-test Base case and Scenario 15 69
G.15 Independent sample t-test Base case and Scenario 16 70

List of Tables

1.1 Interviews 4

3.1 Likely transportation routes 17

4.1 Mala fide distribution 21
4.2 Mala fide distribution RFH 22

5.1 Key Performance Indicators 26

6.1 Different values used for sensitivity analysis 28
6.2 Sensitivity analysis scenarios 29

7.1 Experimental Design 31

8.1 Means for KPI different scenarios 34
8.2 Difference means for KPI different scenarios 36

D.1 Sensitivity analysis part 1 55
D.2 Sensitivity analysis part 2 55

Abbreviations

Abbreviation	Definition
AEO	Authorised Economic Operator
CSC	Criminal Supply Chain
DES	Discrete Event Simulation
DFDS	Det Forenede Dampskibs-Selskab
EU	European Union
IDEF0	Integration DEFinition for Function
KCB	Quality Control Bureau
KPI	Key Performance Indicators
MO	Modi Operandi
NL	Netherlands
NLA	Netherlands Labour Authority
NVWA	The Netherlands Food and Consumer Product Safety Authority
PoR	Port of Rotterdam
PVO	Platform Safe Entrepreneurship
RFH	Royal Flora Holland
TFOC	Transport Facilitated Organised Crime
UK	United Kingdom

1 Introduction

Headlines in Dutch news outlets are often filled with huge amounts of confiscated illegal goods originating from mostly South American countries. Last year alone over 600.000 kilograms of illegal fireworks, millions of illegal cigarettes and almost 50.000 kilograms of cocaine were confiscated in the Netherlands. These big amounts make it clear that the goods are not destined for Dutch use only (UNODC, 2018). Regular goods are often transferred through the Port of Rotterdam (PoR) to other European countries because it is the biggest gateway of Europe, efficiency-focused and well-located. illegal goods most likely follow the same route.

1.1. Problem Statement

The Transport Facilitated Organised Crime (TFOC) program of the Dutch national police is focused on both preventing and interrupting crime. Not only is it important to disrupt criminal supply chains (CSC) because of the negative economic effects that the smuggling of illegal goods has, as it builds up criminal assets and leads to unfair competition in the Dutch retail sector. It is also important because the smuggling of illegal goods is often accompanied by other criminal activities, compromising national safety and health, e.g. liquidations and explosions. However, there are more ways in which smuggling impacts national safety, for example, the recruiting of children for emptying containers filled with illegal goods (Leito et al., 2021), assassinations in public places and not to forget, the overall harm of the use of illegal goods on human health. Besides the health and safety influences, this grand challenge threatens the Dutch government's legal trade and tax income. Therefore the smuggling of illegal goods must be suppressed.

As criminality starts and ends with the transportation of goods or persons, the program focuses on this logistic part of supply chains. The strength of the program is that it combines multiple public organisations, such as Dutch customs, Platform Veilig Ondernemen (PVO), Royal Netherlands Marechaussee and local police departments for expert meetings, hackathons and integral action days. While there are different experts available, TFOC often finds itself lacking sufficient information to successfully interrupt criminal organisations. Therefore this research aims to investigate the effectiveness of different intervention methods.

Interrupting CSC is a complex process. The Port of Rotterdam is one of the biggest ports globally and it is a choice of destination for many importers and exporters. Not only because of its high level of efficiency in handling processes, but also because of its accessibility through international waters, through roads that connect the Netherlands to the mainland of Europe and through the rail network that connects the Netherlands to the rest of the continent and even to China with the Chengdu line.

Unfortunately, all the before-mentioned benefits of the PoR are also the main reasons for criminals to choose the port, as a high level of efficiency and great access to other modalities also benefit their business (Vermeulen, Leest, and Dirksen 2018). For some specific supply chains the level of efficiency is even higher because the products are perishable, such as flowers. Flowers have to be exported as fast as possible because the quality of the product lowers with every additional hour, which makes it harder to check the products thoroughly. Even without the time constraints, flowers cannot be checked thoroughly, because touching them and taking them out of a cooled environment also effects the quality of the product. Therefore exporting flowers leaves more room for criminal activities than other export products. With the Netherlands being the biggest export country for flowers, investigating the smuggling routes from the Netherlands with the use of flowers could lead to more insight into possible interception methods to interrupt these CSCs.

1.2. Scientific Relevance

Besides the contribution that this research will have to criminal detection, it will also contribute to science. Many studies and research about criminality have been conducted, yet there are still crucial parts of CSC that have not been investigated thoroughly.

For instance, even though there is evidence of the Netherlands being a distribution and transit country for, amongst other things, cocaine, the focus of academic research has mainly been on the import side (Nieuwenhuis et al., 2016). However, crime does not stop at the border and the ignored illegal export of one country is the pressing illegal import of the next country. Therefore, to effectively disrupt an entire CSC, only taking the import of one country into account is insufficient. “If the supply side is to be attacked, it should be at the end of the chain, in the rich world, where the product is valuable enough for its confiscation to do some economic damage to those who sell it” (Wainwright, 2017, p. 272). But also more specifically, there is still a lot unknown about the functioning of the legal flower-oriented supply chains in general. Getting a grip on the legal supply chain is crucial for researching the smuggling routes, as the criminal chains are very similar to the legal chains (Kilmer & Hoorens, 2010) and some studies have even found that illegal products are smuggled with the use of legal routes (Nieuwenhuis et al., 2016 (p. 14-15)). Lastly, studies have shown that criminals are very adaptive and creative when it comes to their resources. Criminal organisations can be compared to germs that become resistant after antibiotics, implementing more interventions only makes criminals more resistant to those specific interventions (Taleb 2010). Studies often advise police to take this in regard and choose interventions that exceed the adaptiveness of criminal organisations (Martens & Schreurs, 2020) (Taleb 2010). However, this advice lacks specifics as to how these interventions can be found. This research aims to test the robustness of the intervention methods to ensure the efficient usage of funds, materials and employees in the battle against CSC. Testing the robustness of interventions is often done in the healthcare sector (Duan et al., 2001). In this research, an intervention is considered more robust if it achieves good performance under representative conditions.

This research will provide more insight to fill these knowledge gaps by creating an overview of smuggling routes through the export of flowers from the Netherlands and using scenario-based analysis to test the robustness of intervention methods, given several criminal modi operandi.

1.3. Research Objective

This exploratory research aims to increase criminal detection of illegal product export through the export of flowers, by identifying and modeling transport routes with a high chance of smuggling, using scenario-based analysis. This goal can be split into three objectives, namely:

1. Obtaining an overview of the legal flower-oriented supply chain, using qualitative research. Conducting interviews with experts in multiple relevant fields to obtain insights that can be translated into different figures to create an overview of the system.

2. Identifying smuggling routes, using qualitative research. Conducting interviews and attending TFOC action days to gather more insight into the workings of criminal organisations and to understand the opportunities that the sector provides for criminal activities.

3. Finding robust intervention methods to disrupt CSC, using quantitative research. Creating a simulation model to explore the robustness of interventions and testing the field of transport configurations to gain insight into the robustness of interventions.

1.4. Research Scope

Because of the time restrictions for this research, it is necessary to set the scope. As stated before, this research is focused on the export of flowers from the Netherlands, as this specific product is more difficult to check by customs than other products, given its fragility and perishability, leaving room for criminal activities. However, it is not possible to take the whole export chain from the Netherlands into account, therefore this research will focus on the export to the United Kingdom. Not only is the UK the second biggest import country for Dutch flowers, but it is also one of the biggest markets for Dutch illegal goods (Chessa, Van Mantgem & Vermeulen, 2022). Besides, the accessibility of the country, as it is an island, is limited and easier to monitor. In addition, as the country is not part of the European Union, exported goods from the Netherlands are subject to border control. This makes it easier to implement interventions because certain checks are already in place.

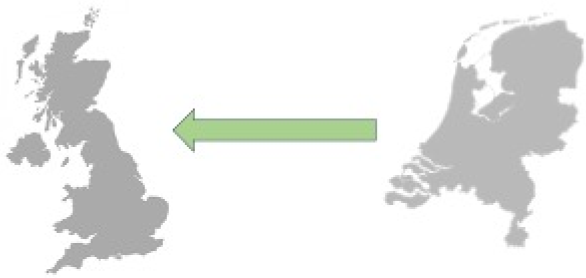

Figure 1.1: Export to the UK.

Within the export from the Netherlands to the UK, the scope is also limited to the processes inside the Netherlands. This means that only Dutch growers are taken into account, only export modalities that leave from the Netherlands are considered and the limit of the scope is set after the goods are loaded on Dutch ferries.

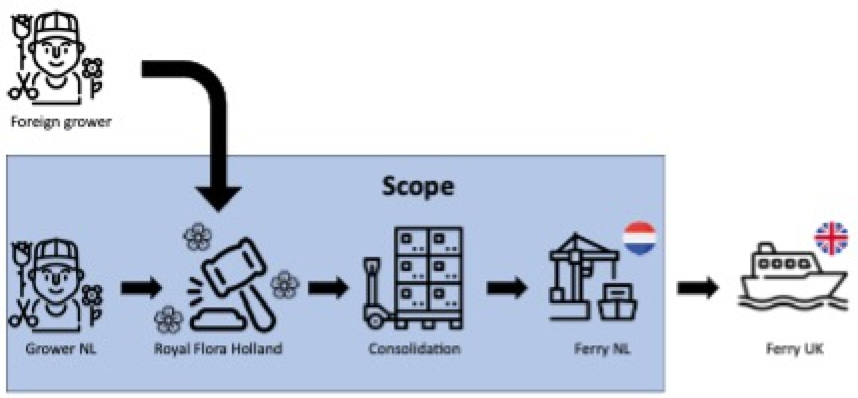

Figure 1.2: Scope demarcation

1.5. Research Questions

This research aims to address the knowledge gaps and to increase the interception of illegal goods by identifying transport configurations with a high chance of smuggling. Therefore the research question, which will be answered throughout the paper, reads as follows: “Which intervention method is most robust for changes in smuggling routes, focusing on the distribution of flowers from the Netherlands to the UK?” This main research question can be split into the following sub-questions:

- SQ1. What are the main transport configurations in legal flower-oriented supply chains?
- SQ2. How do criminals exploit legal flower-oriented supply chains when smuggling illegal products to the UK?
- SQ3. What type of intervention would tackle the most prominent smuggling routes?

1.6. Research Approaches

1.6.1. Qualitative approach

First, this research explains the general workings of CSC. The information about this was collected with the use of a literature search in combination with forward snowballing. However, when the search was limited to flower-oriented supply chains, very little information was found. TFOC provided more literature about the export of illegal goods and again the forward snowballing technique was used, resulting in a clear base that is still insufficient to create a simulation model. Therefore interviews were conducted in addition to the literature studies.

In total 13 official interviews of approximately 60 to 90 minutes were conducted. To gain more insight into different parts of (criminal) flower-oriented supply chains, the interviews were conducted with persons with different backgrounds. Data analysts and security of Royal Flora Holland were interviewed to gather information about the general workings of the legal supply chain and the troubles it faces. Policemen of the Royal Flora Holland (RFH) territory were interviewed to gain more insight into the specifics of criminal interference in the environment and the specific modi operandi. Dutch expediters of flowers to the UK were interviewed to add to the information provided by RFH employees, as not all flowers physically move through RFH. Furthermore, researchers from outside were questioned, because of either their earlier research on criminality in the sector or because of their knowledge on the implementation of interventions. And even officers from Dutch intelligence were interviewed, to confirm and add on to the modi operandi of criminals. Besides, the interviews were not limited to Dutch interviewees, even English customs were interviewed to gather more information about the impact of Dutch exports on the British criminality rate and about the modi operandi that have been recognized on the import side of the process. To keep the engagement of interviewees and create an overview of the system, the interviews were semi-structured and figures were created All the details of the interviews can be found in Appendix A.

Table 1.1: Interviews

1	30-jun	Senior intelligence manager Border Force UK
2	11-jul	Senior Supply Chain Manager Retailer
3	12-jul	Policy employee Integral Safety
4	20-jul	Politiekundige TFOC
5	8-sep	Recherchekundige TFOC
6	12-sep	Supply Chain Strategy & Business Development RFH
7	12-sep	Local police officers industrial sites Westland
8	15-sep	Senior intelligence LE
9	19-sep	Local police officers industrial sites Westland
10	12-okt	Supply Chain Strategy & Business Development RFH
11	13-okt	Supply Chain Strategy & Business Development RFH
12	6-dec	Security analists RFH
13	11-apr	Senior Supply Chain Manager Retailer

Next to the interviews, TFOC organised multiple integral action days at RFH that also contributed to this study. During the action days multiple disciplines, such as Dutch customs, the Netherlands Food and Customer Product Safety Authority (NVWA), Dutch Police, RFH security, Royal military police, Netherlands Labour Authority (NLA) and many more come together to check trucks on abnormalities and invalid paperwork. The main goals of these integral actions are to (1) create awareness among entrepreneurs and employees in the branch, (2) interrupt CSCs and (3) improve the government’s information position. These days were a great addition to the conducted interviews, because of the easy access to the different disciplines. Whereas with interviews everything that is said is registered, which can lead to interviewees leaving out factors because of confidentiality, on the action days people are less hesitant to speak up, as it is not being recorded. This often helped with scoping and gaining new insights.

1.6.2. Quantitative approach

The research objective, as stated in the previous chapters, is to gain insight into the different routes smugglers take from NL to the UK in order to recommend effective interceptions. To gain this insight, a modeling approach can be used to visualise the real world and test different interception methods. In this research, the chosen simulation technique is the Discrete Event Simulation (DES). Not only is this technique very accessible to model networks with queues and servers, but it also provides the option to add states to the moving entities, based on their attributes. (Maidstone, 2012). This research will work with Simio, as it is a user-friendly environment and therefore more accessible for TFOC and partners. But also because Simio models are objects that can actually be embedded in other models (Schriber et al., 2012). Besides, Discrete Event Simulation (DES) is a valuable asset in operations research, because it can contain the complexity and uncertainty of real-world systems (Sumari et al., 2013). As stated by Kelton et al (2002, p. 7) “From a practical viewpoint, simulation is the process of designing and creating a computerized model of a real process or proposed system for the purpose of conducting numerical experiments to give us a better understanding of the behavior of that system for a given set of conditions” The strength of this approach is the fact that, if done correctly, it captures the socio-technical complexity of the system. The complexity of CSC is the reason that the distribution of illegal goods is difficult to limit. By capturing this complexity, the interception methods and smuggling routes can be tested under circumstances that are similar to reality (Kaplan, 1964). However, a pitfall is only focusing on simplicity and neglecting the complexity of the system, resulting in a model that is not a representation of reality but instead leads to biased results (Rosen, 2012). To conclude, the chosen approach for this research is the modeling approach. This approach is powerful when it comes to dealing with complex socio-technical systems such as CSC. It is important that simplifying the reality is done carefully, without too many assumptions, as this could impact the quality of results severely.

The data for the model was gathered with the use of interviews, references obtained through the interviews and assumptions as an extension. For instance, for the likeliness of the modi operandi with the different flower types, the policemen of the company area in Naaldwijk shared their knowledge, resulting in the percentages that can be found in Chapter 5. When it comes to the structure of the legal supply chain, e.g. the loading time of a truck and the capacity of the different trolleys, interviews with the different RFH analysts and visits to the RFH location formed the foundation for this data. However, the percentage of mala fide trucks in the system and the effectiveness of the intervention methods are not known and are therefore assumed, based on the interviews.

1.7. Reading Guide

In the figure below, the Research Flow Diagram can be found. This figure entails all sub-questions and the blue bar on the left shows that the questions build on each other. On the left side of the figure, the different phases are described, first the broad orientation, second the qualitative research, third the modelling phase, fourth the model exploration and last the conclusion phase. Under the heading ‘Research activities’ is shown in what phase the sub-questions are tackled. All previously mentioned methods are summarised in the figure below.

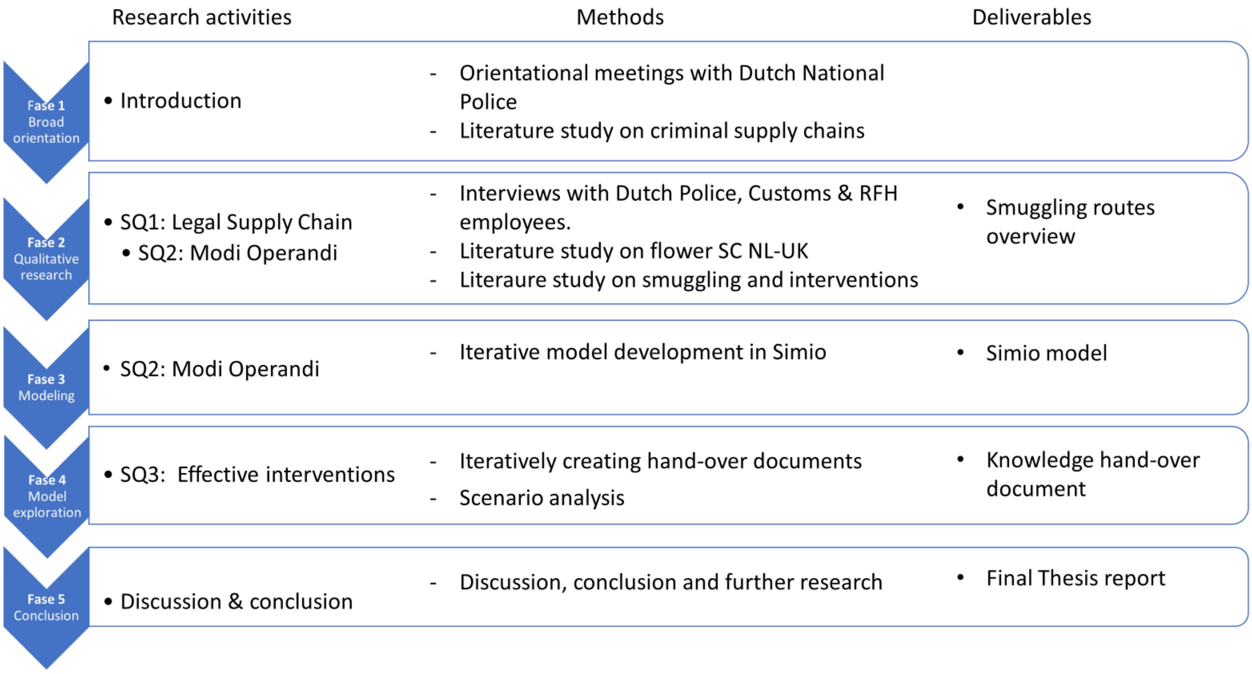

Figure 1.3: Research flow diagram.

2 Literature

As previously stated, this research is conducted to not only help interrupt criminal supply chains, but also to add to academic literature by filling knowledge gaps. This chapter will explore the available literature concerning criminal supply chains, criminal activity in legal supply chains and the testing and implementation of robust intervention methods.

2.1. Search strategy

The entire literature search was executed on Scopus. The used search term was an “AND”-joined string of synonyms and themes related to smuggling, ports and modeling. The term ports was added to the string as this research will focus on the export of illegal goods to the UK that are transported by ferries. By adding this term, on the 14th of May 2023, the number of results decreased to 28 sources. After narrowing these results down to 6 useful sources, forward snowballing was applied. To remove all cases focused on human trafficking, the search query was altered with the ‘AND NOT “Human”’- operator, as this paper is focussing on the smuggling of illegal goods. To gain more insight, as most of the useful literature is not public, TFOC provided several academic student papers. Again the forward snowballing method was used to gather the most important studies.

2.2. International impact

The Netherlands is one of the biggest transit- and distribution countries when it comes to illegal goods (Madarie and Kruisbergen 2019) (Dirksen, Leest, and Vermeulen 2021). Earlier research of Vermeulen et al. (2018) (Vermeulen, Leest, and Dirksen 2018) has shown that in 2015 approximately 95% of the illegal imported goods was destinated for other countries. The same study shows that the United Kingdom is one of the biggest markets for these goods from the Netherlands. Other studies show that the Netherlands is not only a very big transit country but also a big producing country for illegal goods ((Tops, van Valkenhoef, van der Torre & van Spijk, 2018) (Vermeulen and Vertrouwelijk 2019). Even though there is enough evidence of the Netherlands being an export country for illegal goods, the main focus in academic literature has been on limiting the import (Nieuwenhuis et al., 2016). However, this smuggling challenge is not bound to borders. If the export side is not tackled and the demand keeps growing, limiting the production and import will not be successful (Wainwright, 2017). As Vermeulen et al (2018) (Vermeulen, Leest, and Dirksen 2018) states “The fight against drug trafficking would benefit from an integrated approach targeting all links of the chain, including the transit of cocaine via the Netherlands”.

2.3. Smuggeling methods

Studies have shown that criminals use the logistic transport opportunities that are already available for their malpractices (Bervoets, Corsel, Fortuin, Kaal & van de Ven, 2021). According to Nieuwenhuis et al. (2016, p. 14-15) there are four ways to transport illegal goods with the use of legal transport routes.

- The first one is transporting with deck cargo. This entails that the illegal goods are hidden inside or mixed with legal goods. This method is often used in combination with perishable goods, such as fruits and flowers.

- The second method is building illegal goods in. This means that the goods are hidden inside the container or pallet that is being used to transport the legal goods, for instance with a double floor. This method is complex, takes a lot of preparation and is almost impossible to carry out without the knowledge of the company transporting the legal goods. Therefore when this method is used, it is safe to say that the transporter is in on it.
- The third method is the rip-off method. This method takes less preparation, as the illegal goods are simply hidden between the legal goods. To ensure that the illegal goods are not confiscated by border control, the container is opened and the goods are taken out at their destination before the border control gets the chance to go through it.
- The fourth and last method is called dropping. This method is quite similar to the rip-off method, the only difference is that the illegal goods are taken out before the container reaches its final destination, to ensure that border control cannot confiscate the goods. Especially with illegal drugs that come from South America this method is used. When the container reaches European waters, the illegal goods are moved to smaller fishing boats that are not investigated by customs (Nieuwenhuis et al., 2016).

2.4. Business plan for illegal organizations

According to the Dutch legal definition of a company, is a company ”a business structure with legal personality”. Illegal organizations do not register their business, making them not adhere to the definition of a company. This means that illegal structures are legally not companies, but this does not mean that they do not function in similar ways and follow the same objectives. Ossama M (2020) classified different objectives of business into six objectives: self, economic, social, human, national and international. This section will argue that the economic and human objectives are present both in companies and illegal organizations, to show that one can learn from the legal sector for the illegal sector.

Both legal and illegal business-like organizations can be argued to have economic objectives which are targets they try to achieve. A healthy company has a profit motive to keep the business in good health and to be able to expand if possible. Illegal sectors seem to have mimicked this motive. Coleman J. W. (1992) tried to answer the question: ”Does money cause crime?”. Even though he found that money itself doesn’t directly cause crime, he did find that it can play a role in motivating certain behaviors. Research from Hilbig and Thielmann (2017) shows that there might be some truth in the popular phrase says: everyone has a price. In experiments, they found that there are corruptible individuals where incentive sizes matter for ethical decision-making. This seems to indicate that profit motive is a big part of illegal organizations as well.

Human objectives refer to the satisfaction and financial well-being of the employees. Satisfied employees can be vital in criminal organisations, since whistle-blowers could have big legal ramifications. When a criminal is not satisfied with his employment, they could cooperate with the police in exchange for a reduced charge, sentence, or immunity from prosecution, depending on the legal system (Fromiti, z.d.). This is a risk illegal organizations want to minimize. Illegal organizations might not have a Human Resource Management that takes care of their employees, but they do have other ways to control their employees. All from of collaborative crimes seem to have in common that it is very difficult for members to step out (Bovenkerk, 2011). The challenges in leaving can be due to various factors like secrecy, loyalty, fear, social bonds and costs. Criminal organizations pressure participants through these factors to maintain working and minimize the risk of exposing the operation.

As shown, it can be concluded that illegal organizations have the same need for profit maximization as legal companies and an even higher need for risk minimization. What can be derived from this, is the business plan/strategic thinking of criminal organizations. They will always try to maximize their profit, but only if the risks are not so high they risk personal losses like jail time. They will try to protect their employees from getting caught by police, but mostly to keep them from testifying against them (and their organization). In return, the employees will stay loyal to their employer since they want to minimize harm for themselves (either from police or their employer) and maximize their profits.

3
Routes

The first chapter showed that the qualitative research is split into two parts. The previous chapter captured the first part of the qualitative approach, as it gave an overview of the existing literature concerning smuggling within the scope of this research. In addition, this chapter will focus on the second part and provide an overview of the system, based on expert interviews.

To create an overview of the system and to answer the first sub-question, this chapter will explore the possible routes of the flower-oriented sector to the UK. These insights have been gathered with the use of expert interviews, as stated in Chapter 1. To investigate the system from different viewpoints, this chapter has used three different analysis techniques. The first is the use of flowcharts, this type of analysis technique gives more insight into the decision-making process behind the routes. The second method is the use of IDEF0 models, these models give insights into the specific actions that are carried out and the persons and products that are necessary to complete the action. Lastly, Business Process Model and Notation was used to design figures that give an overview of the size of the routes, e.g. how many different actors are involved, and the distance between the persons making choices and the actual goods.

As can be seen in Appendix A, semi-structured interviews were conducted with experts from different backgrounds. These interviews have helped to gain more insight into the sector's operations and its weaknesses for criminal interference. But first and foremost, the interviews have helped in the creation of an actor overview as can be seen in the figure below.

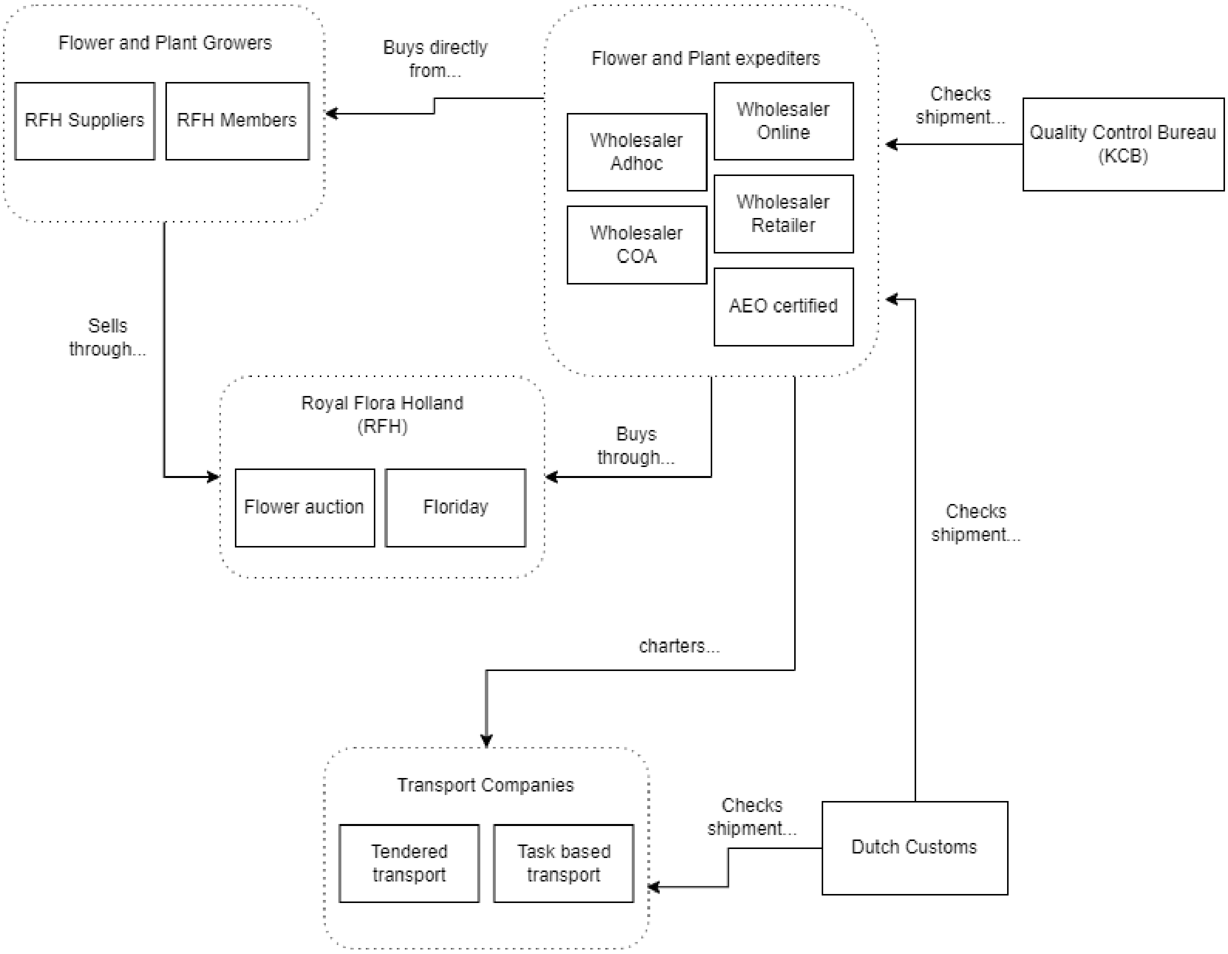

Figure 3.1: Formal Chart of the system with the most important players.

3.1. Growers

The process of exporting flowers and plants to the UK starts with the growers of these goods. Growers can choose to sell the products by themselves or they can use the Royal Flora Holland platform. There are two manners in which a grower can participate, they can either be a supplier or a member. The first group only sells a specific number of their product via the RFH platform, which is agreed upon beforehand. With the rest of their product, they are allowed to do as they wish and they do not have to justify this to RFH. For the latter group, however, this is mandatory. All of their goods should be sold through the RFH platforms. If something is directly bought from the RFH member, this should be communicated to RFH, as a certain fee has to be paid for each transaction (Royal Floraholland, 2022). So both groups have access to the biggest horticultural marketplace in the world, but the extent to which this access is granted differs. The members can use the RFH platform to its full capacity, while suppliers can only sell a maximum number of their flowers and plants on the RFH platforms. Also, the fees for the two memberships differ. A full member pays less commission to RFH because RFH has assurance of more sales in the future. However, suppliers have a higher level of freedom, which means that RFH has less assurance of future sales, so the commission fee for this group is higher.

Both methods have advantages and disadvantages. Members have security when the market crashes, as they are sure of certain orders and prices. Yet at the same time, as prices are fixed, when growers could make more profit in the market, than with the fixed RFH tariffs, it is not possible to lower the RFH order. The same goes for suppliers, when the market is in their favour they are happy with their RFH contract, but when the market is disappointing, they have nowhere to go with their supply. Interviews have made it clear that there are growers that want to benefit from both contracts. When a grower applies for a member contract they have to hand over information about their farm, such as the amount of hectares they have. This is rarely checked precisely, so growers could keep a few square meters off the books. These square meters could be used to sell on the market when this is profitable, but is not too big, for when the market is disappointing.

The first choice that influences the route that flowers and plants take to the UK, is made by the grower. Namely, if the flowers will be sold through RFH or directly to the buyer. This choice is displayed in a small flow chart below.

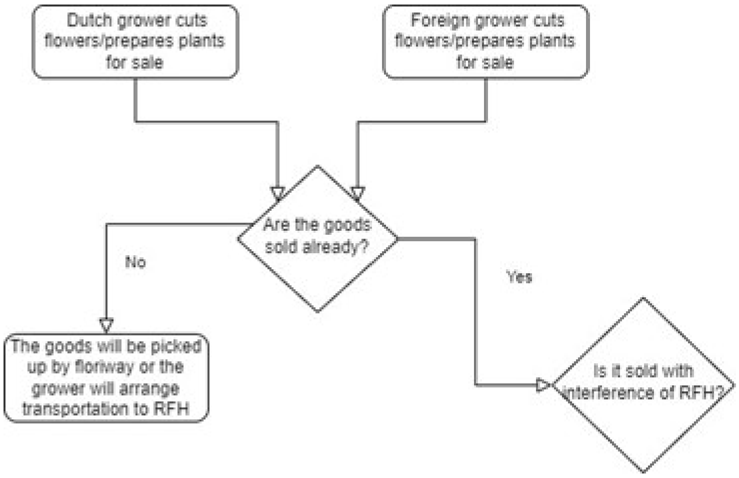

Figure 3.2: Grower route choice flow chart

If the products are pre-sold with the interference of RFH, the buyer will arrange for transportation. If the products are pre-sold without the interference of RFH, e.g. through direct purchase, the buyer and grower will decide who is responsible for the transportation. If the products are not pre-sold, they are meant to be sold at RFH auction and the contract between RFH and the grower will determine who is responsible for the transportation.

3.2. Buyers

There are five main buyers when it comes to the NL-UK route of which four are wholesalers:

- Wholesaler adhoc
- Wholesaler coa
- Wholesaler online
- Wholesaler retailer

The ad-hoc wholesaler is a buyer that only buys during peaks, such as Valentine's Day, Christmas and Mother's Day. This type of buyer rarely does their own transport, as it is just temporary. Also, closing a tender with a transport company does not make sense, as these buyers are not sure of certain order quantities. They book their transport on the spot.

The COA wholesaler is a buyer that sells the COAs they have received from RFH to smaller businesses. COAs are login numbers provided by RFH that are necessary to gain access to the online environment of RFH to buy flowers and plants. This type of wholesaler is very dependent on the orders of the smaller businesses, therefore they also often do not have their own transportation or tender with a transport company. They book their transport on the spot.

The online wholesaler is a buyer that buys from growers, based on the order they receive on their online shop. As with the COA wholesaler, the online wholesaler is very dependent on the orders they receive online, therefore they also often do not have their own transportation or tender with a transport company. They book their transport on the spot. The retail wholesaler is different from the other wholesalers. This buyer buys flowers and plants all year round for their retail clients. This can be big clients, such as supermarkets, but also smaller local shops. Either way, the demand is all year round, which makes it attractive to tender their transport or do their own transport.

The last most common buyer is a company from the UK, with a daughter company in the European Union. The daughter company is necessary because otherwise, the company would not be able to export from the EU, as this can only be done when you are based in the EU yourself. Depending on the type of company, transport can be kept indoors, tendered or booked on the spot.

In addition to growers, buyers also highly influence the route of flowers and plants. Buyers can choose to keep processes indoors, but they can also choose to outsource processes such as transportation and consolidation. The transport of goods is very straightforward and normally does not leave room for imagination, as can be seen in Figure 3.3 below.

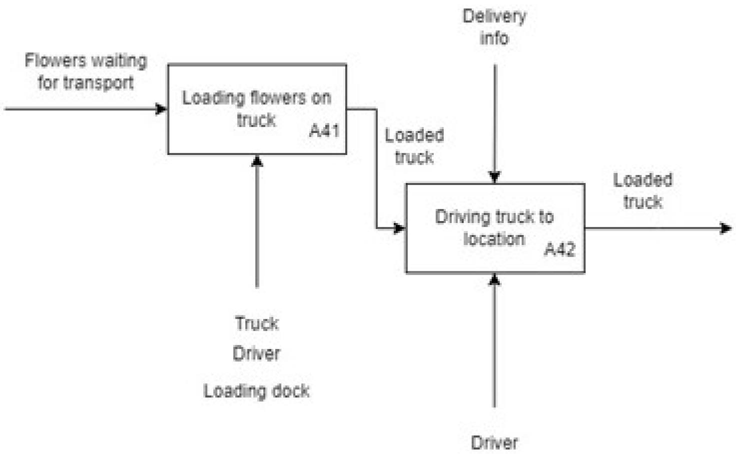

Figure 3.3: IDEF-0 transport activities

However, the consolidation process is not as straightforward. The most complex activity in the legal routes is the consolidation of flowers. There are a lot of smaller activities that take place during that process. Flowers can be rearranged into smaller bouquets, pots and vases can be replaced, sleeves with for example company names can be added, the flowers can be put on other trolleys or the flowers are simply stored to be shipped later. The activities that take place are highly dependent on the type of buyer, wholesale retailers often have warehouses on the other side of the ocean that deal with packaging so the shipment from the Netherlands should be focused on maximizing the quantity of exported goods. Whereas ad-hoc wholesalers, that deliver for big events such as Mother's Day and Valentine's Day, are mostly focused on the packaging of the flowers to promote their products. Figure 3.4 shows the IDEF-0 model which shows the general workings of consolidations.

3.3. Royal Flora Holland

To combine growers and potential buyers from all over the world, the most prominent actor in the flower-oriented sector was created, Royal Flora Holland. With over 145.000 transactions per day, over 400.000 different types of flowers and plants and over 7 billion euros of revenue yearly, RFH is the biggest horticultural marketplace in the world and very important for the overall revenue generated by export in the Netherlands (De Vereniging van Groothandelaren in Bloemkwekerijproducten, n.d.). This Dutch marketplace combines international growers with customers all over the world, through their (digital) auction or by offering a digital platform where growers can advertise their horticultural goods, and customers can buy them.

RFH has developed an online platform called Floridays. On this platform, buyers can directly buy flowers and plants from growers. The advantage of this platform is that the grower will always be paid directly, even if the buyer has not paid yet. RFH will make an advance payment, which also encourages suppliers to sell more via RFH. As stated before, it is also possible to buy directly from the grower, for

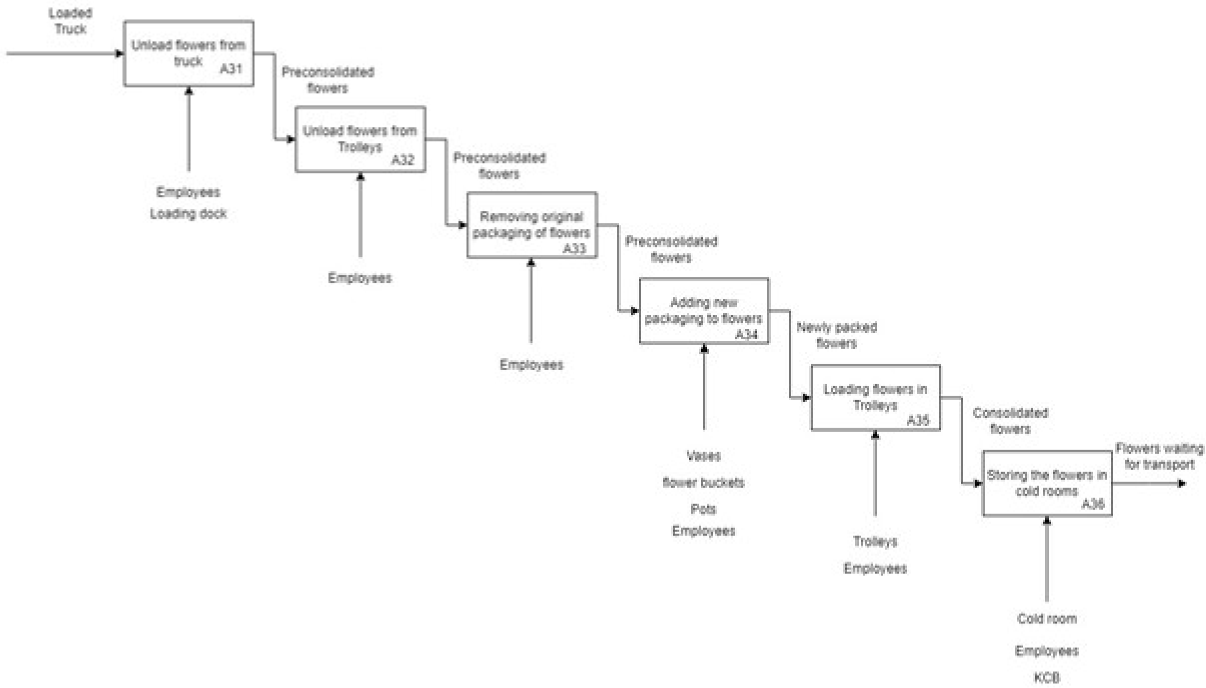

Figure 3.4: IDEF-0 consolidation process

instance by calling.

Flowers and plants can be picked up from growers by FloriWay, the official transport company of RFH, or other transport companies if that is what the grower prefers. FloriWay also controls the transport of goods between auction locations. There are 5 auction locations in the Netherlands, namely Aalsmeer, Naaldwijk, Eelde, Rijnsburg and Veiling Rhein-Maas.

Besides the Floridays platform, RFH also offers a (digital) auction to connect growers to buyers. As was discussed during the interviews and supported by a visitation to the RFH Naaldwijk location, the auction process works as follows: buyers will be given login credentials, known as COAs, to digitally see the goods that are being auctioned, while the goods are collected at growers and put into cooled storage until the auction starts. The RFH infrastructure is based on the dimensions of RFH trolleys, so the small forklift trucks that are used inside the RFH buildings and boxes cannot process other trolleys. Therefore when goods arrive on other trolleys, they first have to be unloaded and then loaded on RFH trolleys, before processing can start.

When the auction starts, a specific product will be visible to the buyer with additional information such as stem length, origin, vase life and quality (Harkema et al., 2017). The timer and price will be counting down and the person that bids the most, so presses earliest, buys a specific amount of the shown product. After the auction process, the picking process starts. First, RFH employees will get random anonymized forms with orders that they can pick from a cooled picking hall. After the first picking round the orders will again be picked, but this time without the anonymization, and then transported to the box that was indicated by the buyer, with the use of small RFH forklifts. The goods will be transported to the boxes with RFH trolleys, however, the trolleys can not be used for export so during the consolidation in the boxes, the goods have to be unloaded and loaded on regular trolleys again. To ensure that buyers do not export the RFH trolleys, RFH has issued a deposit on their trolleys and installed cameras and smart devices to detect trolleys leaving the premises.

Lastly, RFH also has a consolidation service that they offer for a fee to customers that use their auction. This service comes in handy for buyers without a box on the RFH premises who have bought COAs of another company or buyers who do not have enough space in their own box. After the auction the order picking starts, depending on the consolidation location of the buyer, RFH employees will transport the goods or the goods will be picked up. The choice for consolidation by the buyer, consolidation by a third party or consolidation by RFH is visualised in the flowchart in Figure 3.5

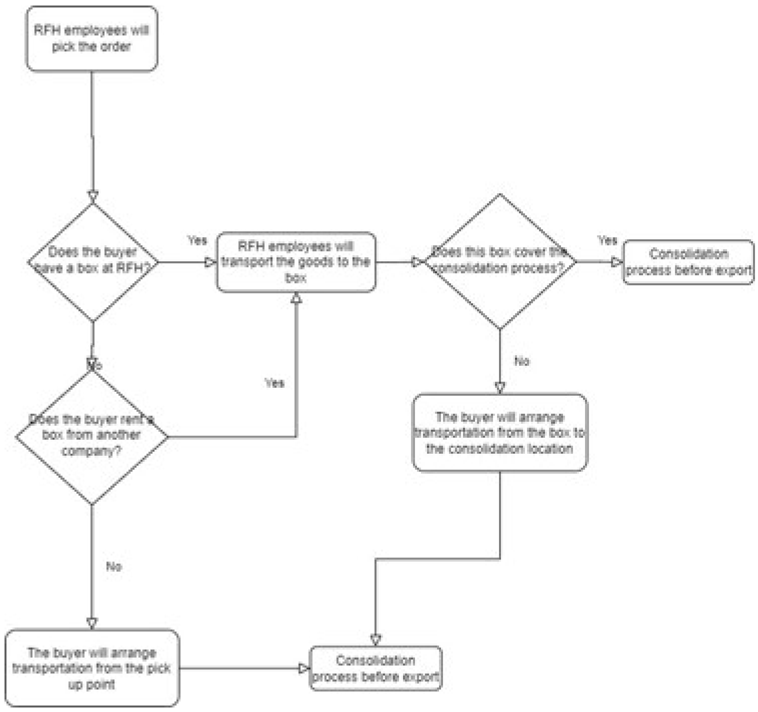

Figure 3.5: flowchart box choice

3.4. Transport companies

Earlier FloriWay was named as a transport company, but more companies deliver to/pick up from RFH locations. Growers can choose to use FloriWay, at a rate, but if another transporter is cheaper or preferred, they can also choose to get their goods picked up by them. The same goes for buyers. However, leaving the transport of goods to third parties also comes with risks. Because of the high number of transport companies and the competition in this market, bona fide companies can save transport costs by outsourcing it to a transport company. However, how the transport company handles the transportation is not always investigated thoroughly. Transport companies can use truckers without licenses or other documentation because they are cheaper and they can even outsource again to a freelancer. Because of the time limitations, it is not always possible to do a background check on the truckers, so both the transport companies or the hired freelancers could have a second agenda and use the bona fide companies as a cover-up. This makes it even harder for bona fide companies to get a hold of possible criminal activities. In addition, transport companies that also earn money from illegal activities can keep their prices low and attract more small bona fide companies. According to Vermeulen (2019), this contributes to an unfair competition, where valid transport companies cannot easily compete with transport companies that are involved in criminal activities because they do not get additional profits. The legal activities of transport companies can be found in 3.3

3.5. Dutch customs

To enforce legislation, Dutch customs check trailers that are ready to leave for the UK. Customs can choose to notify the expediter of a check beforehand, but can also choose to perform a random check at the port. The chance to be checked can be lowered when the expediter has an Authorised Economic Operator (AEO) certificate. This certificate was introduced to increase the level of efficiency, as flowers are perishable goods, and to ensure cooperation between businesses and national customs (European Commission, 2023). Businesses, that operate internationally, can apply for this status. Here are two different AEO statuses that can be applied for, namely the AEO- C, for customs simplification, and AEO-S, for security and safety. The main differences between the conditions to apply for and the benefits of the two different statuses are shown in the two tables in the appendix C.

However, this is also a trait that is attractive to smugglers. If smugglers can choose between companies that are checked randomly and often, and companies that are checked less regularly, it is more likely that they choose the latter. Criminal supply chains are also looking to increase their profit with the least risk.

The choice of customs to check a trailer and the odds of this choice are shown in figure 3.6 The checks, as shown in the figure, will be further explored in the quantitative part of this research. It is assumed that the check that is indicated beforehand might help in keeping companies aware, but is not designed to catch criminal activity. Therefore, the exploratory model will focus mainly on the random check by customs and other law enforcement.

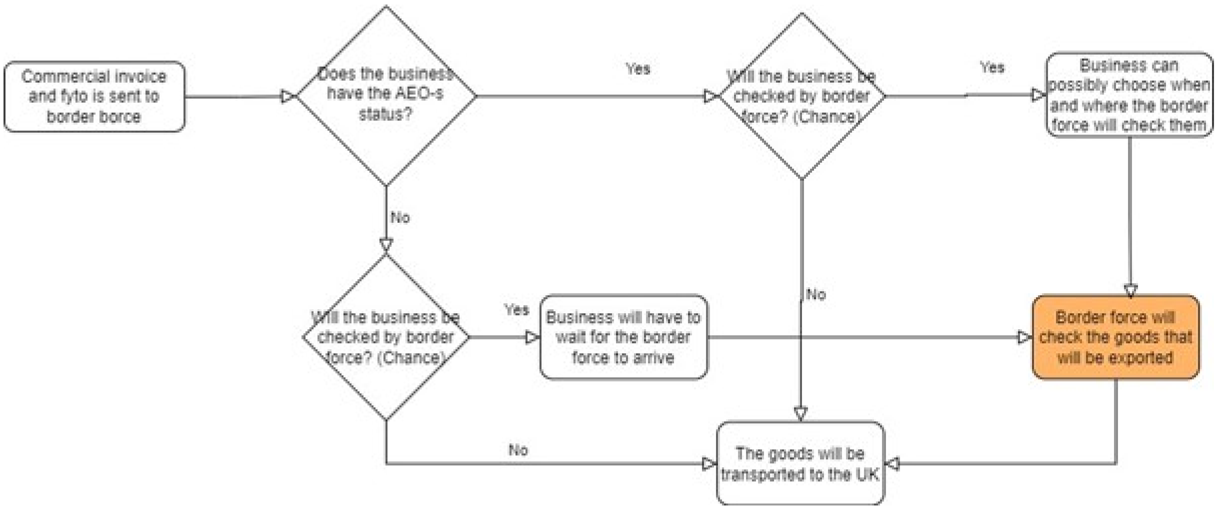

Figure 3.6: flowchart customs

3.6. Quality Control Bureau

Besides customs, there is another time-consuming organisation that is important for the efficiency of the process, namely the NVWA, more specifically the Quality Control Bureau (KCB). The KCB is a government institution responsible for ensuring the quality of goods that are being exported outside of the EU (Kwaliteitsinspecties, n.d.).

For the KCB to check a shipment, the exporting business needs to file a request. Based on the type of product being exported and the regulations for those products, the KCB can pay a visit to check the quality of the product. However, this check can not take place everywhere. The KCB has set standards for the location of the check, if the consolidation location does not suffice, the check will take place elsewhere. The Fyto certificate is needed to get customs approval for export. This process is shown in Figure 3.7. It is important to know that this check is only to ensure the quality of the product, e.g. the pesticides and bugs, not the possible criminal activity in the shipments.

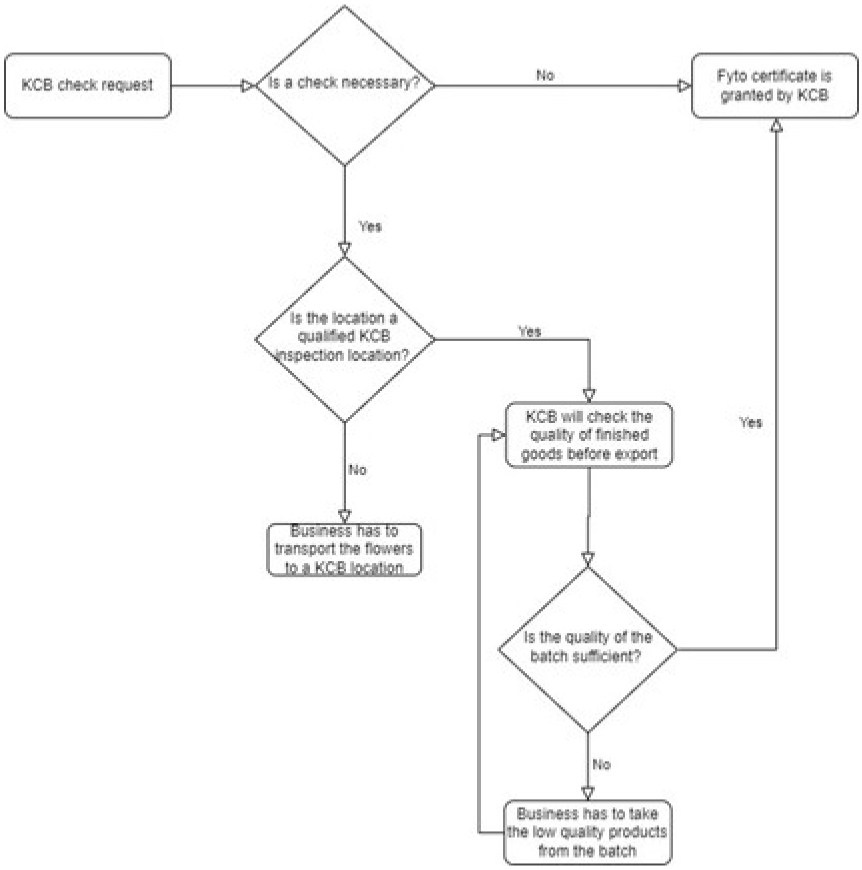

Figure 3.7: flowchart KCB

3.7. Opportunities routes

To summarize, three choices are crucial to determine the route flowers will be following. Firstly, the destination of the goods after growing is important. So, are the goods destined to go to the RFH auction or are the flowers ordered by the buyer? If the goods are destined to go to the auction the buyer is still unknown, as this depends on who bids the most. If the flowers are pre-sold, either by directly messaging the grower or by buying through Floriday, the goods will directly be sent to the consolidation box that is either owned or rented by the buyer.

Secondly, the location of the consolidation process is important. As stated before RFH also has a consolidation service, however, this is only available for auction products, so this is not an option when products are bought directly. A distinction between owning and renting a box can be made, however, the risk of criminal activity is similar, as both boxes are not accessible or verifiable by others.

The last choice is the choice of transport. Buyers can rent trailer space from transportation companies or they can own a truck. The visibility of criminal activity is limited in both options. Even when choosing a bona fide transport company mala fide practices can occur because of tendering during peak seasons or bribery. If a buyer owns a truck it is easier to detect malpractices and ensure a bona fide status. However, if a buyer chooses to be involved in criminal activities using their transportation, this is as hard to detect as deceitful transport companies. These choices result in 8 likely route options as can be seen in the table 3.1.

Table 3.1: Likely transportation routes

	Route nr.	Buying	Consolidation	Transport
1	Route 5	Direct	Box consol	Transport company
2	Route 6	Direct	Box consol	Own transport
3	Route 11	Floriday	Box consol	Transport company
4	Route 12	Floriday	Box consol	Own transport
5	Route 15	Auction	RFH consol	Transport company
6	Route 16	Auction	RFH consol	Own transport
7	Route 17	Auction	Box consol	Transport company
8	Route 18	Auction	Box consol	Own transport

All previously mentioned processes add up to the following IDEF-0 model in Figure 3.8, when the flowers and plants are bought either directly from the grower or through the RFH platform Floriday. The complete overview of the system in a flowchart can be found in Appendix B

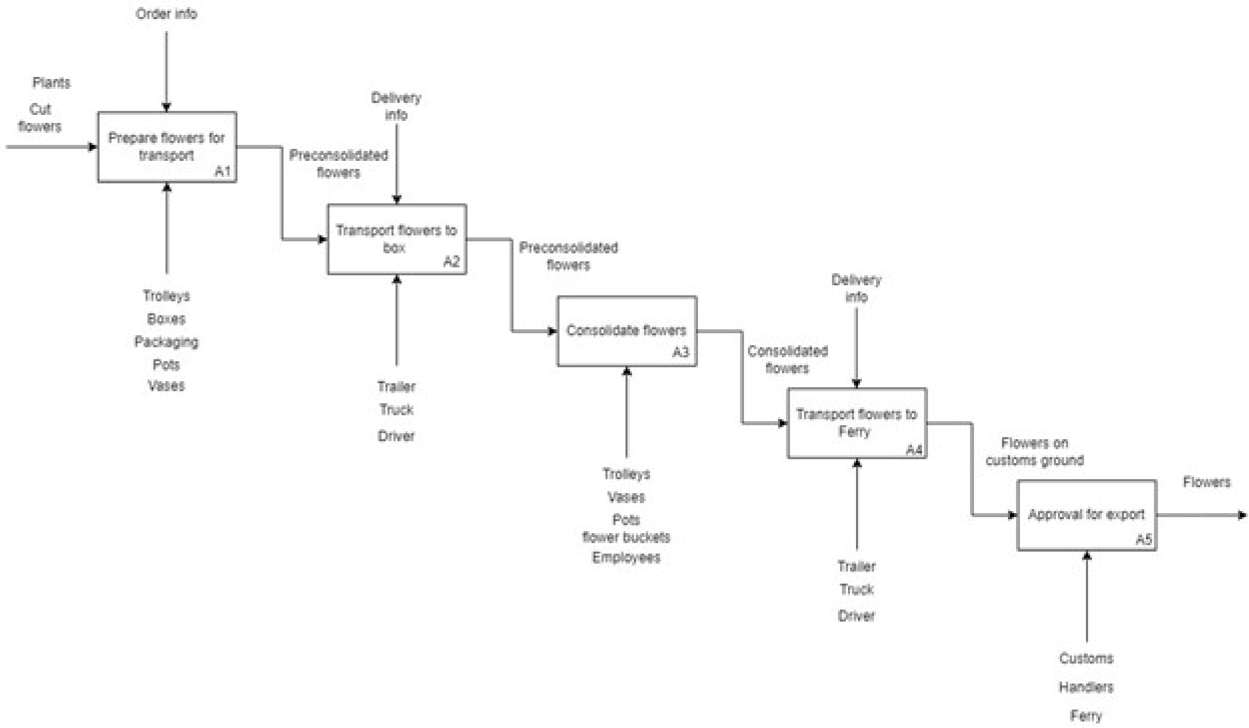

Figure 3.8: IDEF-0 overview direct lines

The IDEF-0 models and flow chart have given insight into the activities that occur and the choices that have to be made inside the different routes. In addition to these models, BPMN figures, also known as swimlane figures, have been created. The figures consist of different lanes that represent actors. The strength of this method is that the size of the figure already shows how many persons are involved. Small figures show that there are less actors involved, thus fewer extra eyes that can detect malpractices. The figure also shows the difference in the information and money routes from the physical movements of the shipment. These differences can be quite big, resulting in the persons making the choices not being able to see the goods, so not being able to determine malpractices. As stated before the sector often books transport last minute based on the lowest price. If a buyer books transportation from a consolidation box, that is not used by themselves, to the ferry and they are not physically available to assess the transportation, this leaves room for criminal activity. As Vermeulen (2019) also explains, the transport companies with the cheapest prices are more likely to be mala fide as they do not have to profit from the actual transportation because they earn more than enough money with other practices.

In appendix B the swim lanes of the most routes with the highest chance of smuggling activities, according to interviews with policemen of the Naaldwijk RFH location, have been added. Comparing the figures shows that the direct routes have fewer lanes, thus fewer actors to check for malpractices. When it comes to the information versus physical stream, in direct routes these streams follow a similar route, whereas with tendering the routes are spread out.

The used analysis techniques from this chapter will form the basis for the quantitative approach in Simio.

4

Criminal modi operandi

The previous chapter explained the different legal routes that flowers can follow from grower to buyer. In this chapter, an explanation will be given as to how those routes can be altered both negatively, with criminal interference, as well as positively, with law enforcement interference. First, the different ways (modi operandi, MOs) of adding illegal goods to the flower shipments are explained. Secondly, the different types of intervention methods by the police and their success rates on all different MOs are being laid out.

4.1. Criminal Interference

Expert interviews, more specifically interviews 7, 8 and 9 with local policemen from Appendix A, have led to eight distinctive MOs. The first one is the addition of a sports bag to a trailer. This MO is not specific to this sector, it happens in almost every sector. When a check is performed, the chance of getting caught is very high. On the other hand, the MO does not take much preparation, is easy to perform, hard to trace back to a person and easy to collect in the UK. A bigger version of this MO is the addition of a trolley with illegal goods, the advantages and disadvantages of this MO are similar to the first one, only is this one harder to collect in the UK. The whole trailer has to be unloaded before gaining access to the illegal goods. For modeling purposes, this research will assume that these MOs most likely happen in transportation. Those two MOs will from now on be called the mala fide transport MO.

The third option is hiding illegal goods between the legal goods, e.g. between boxes or in the soil of plants. The chance to get caught with this MO is lower than with the previously mentioned MOs and the preparation is also not that difficult. The collection across the border is not as easy as with a sports bag, the truck has to be unloaded at a dock to collect the goods. It is assumed that this MO takes place in the consolidation process. If this happened at an earlier stage, the chance of getting caught during the consolidation process would be very high. On the other hand, using it after consolidation might be suspicious as transport normally does not rearrange the load of the trailer. This MO will be called the mala fide simple consolidation MO.

The fourth option is the replacement of normal vases and pots with ones with a hidden compartment. The chance of getting caught with the MO is even less likely, but both the preparation and the collection of the illegal products will be very hard.
The fifth option is a version of the fourth, instead of vases and pots this MO is focused on trolleys. For modeling purposes, this research will assume that these MOs will take place in the consolidation process, as this is the only place where packaging and trolleys are normally switched. Besides, adding this MO beforehand does not make sense as the trolleys might be changed later on and later on it is very suspicious if someone is rearranging trolleys. These MOs will from now on be called mala fide complex consolidation MO.

The sixth option is the last option that this research will take into account. This MO is focused on planting illegal goods inside flowers and plants. This MO takes a lot of effort to collect, but even more to prepare. However, the chance to get caught is very low. It is assumed that this happens at the grower, as the conversion without severely damaging the quality of the flowers cannot be done by just anyone. This MO will be called the mala fide grower MO.

Besides these MOs, the interviews have indicated two other options, namely bribing and conversion of the cabin or trailer. Due to time constrictions not all intervention methods could be explored. Besides, the bribing option would only accommodate the other options or result in a combination of multiple MOs, which can be explored in further research but is too extensive for the demonstrative nature of this research.

4.2. Likeliness of MOs

The before-mentioned MOs cannot be used in every route of the system. Some combinations of routes and MOs are not (very) likely and will therefore not be used in the following chapters of this research. But also, some MOs are not likely to be used with specific flower types. The following paragraphs will get into the likeliness of MOs based on the routes and the flower types.

4.2.1. Mala fide flowerboxes

For the flowerboxes, two MOs are presumed to be used limited, or not at all, according to expert interview 9. The complex MO, rebuilding the packaging, is not likely at all with boxes, as it is not firm and easy to detect. The grower MO is also not very likely with boxes, the stems of flowers that are transported in boxes are most of the time quite slim. Also, the flowers are transported horizontally, making it easy for the illegal goods to fall out and be detected. The transport MO and the consolidation MO are very likely to happen. The transport MO can be put in between the trailers with boxes, as the trailer can be quite chaotic when it is filled with boxes. The consolidation MO can also make use of this chaos and the illegal goods can be put in between or in the boxes.

4.2.2. Mala fide flowerbuckets

For the flowerbuckets only the consolidation Mo is not very likely. The buckets are filled with water, which makes it harder to smuggle something without notice. Again the transport MO is easy to use, as there are many corners and holes that can be used to hide the sports bag. The flowerbuckets are also ideal for the complex MO. The buckets could have a double floor, which would not be noticeable. This MO takes more effort and is therefore assumed to happen less than the transport MO. For this flower type the grower MO is also possible, but not that likely, as the flowers are not as easy to inspect. To reach the stems of the flowers, customs will most likely touch the flowers, which damages the quality of the flowers. This provides an opportunity for criminals to use this MO. However, the stems of the flowers are not that thick, so only specific illegal goods would fit.

4.2.3. Mala fide plants

The plants leave room for all types of criminality. The soil that is used for plants, can be used to smuggle illegal goods. Not only is this easy to do, it can also be hard to detect. For instance, the scan intervention does not see the difference between illegal organic goods and the soil of plants. The pots that the plants are put into can also have a double floor, so the complex MO is also possible. In addition, the stems of plants are often a lot thicker than those of flowers, making the plants more beneficial to use for the grower MO. Lastly, the transport MO can also be used for plants, however, the phytosanitary check is more often performed for plants than for flowers, because of the possible pesticides in the soil. Therefore it is assumed that criminals would be more likely to buy another type of flowers to use this MO.

Table 4.1: Mala fide distribution

Flowerbox	Bonafide	80%
	Transport MO	10%
	Grower MO	x
	Consolidation MO	10%
	Complex MO	x
Flowerbucket	Bonafide	80%
	Transport MO	10%
	Grower MO	3%
	Consolidation MO	x
	Complex MO	7%
Plant	Bonafide	80%
	Transport MO	2%
	Grower MO	4%
	Consolidation MO	10%
	Complex MO	4%

4.2.4. RFH route

Another combination that is not likely to happen is the MO mala fide grower and routes that go to the auction. When flowers are auctioned, the buyer of the flowers is unknown until the bidding process. The only way to ensure getting specific flowers is to overbid, which might be suspicious. But if someone else bids more, the preparation will be for nothing as the goods will go to the bona fide buyer. But also, the picking process is done anonymously. According to the Supply Chain Strategy and business development analyst from Figure 1.1, RFH employees do not know who they are picking for and to ensure the anonymity of the process, RFH employees do not know where they will be working that day, in the cooling, picking or driving around. Therefore ensuring to obtain the illegal goods in these routes is very hard and most likely a risk that criminals are not eager to take.

Also, because of the magnitude of the RFH property, the high number of employees and the accessibility to the open boxes, adding illegal goods to the RFH boxes is considered high risk. Not only is there a high risk of being caught adding the products, there is also a high chance that the goods will be detected and destroyed by other RFH employees who are not mala fide. Therefore this research will also not further investigate the combination of MO simple consolidation and MO complex consolidation with the routes that use RFH consolidation. According to one of the local policemen, with a background in business, criminals try to minimize their risk. "Criminal organisations work similar to legal organisations, the goal is to minimize the risk while maximizing the profit." *interview 9* The distribution of the mala fide options for flowers that are consolidated by RFH can be found in Table 4.2

4.3. Lawful interference

The previous chapters have illustrated the workings of the legal supply chains and the MOs on the specific routes. To answer the research question and gain more insight into how to interrupt criminal supply chains, this chapter will explore the different intervention methods that can be used to reach this goal. These intervention methods were used during the TFOC action days and are available for future interventions.

4.3.1. Scans

Once a container is chosen for scanning, the expediter is obliged to let the container be transported to (and afterwards from) the X-ray scan. At the terminal, there are a few designated companies that provide the transportation and inspection of the containers. This happens mostly at their own company grounds and, with the newest technologies, up to 10 containers can be scanned at the same time. X-rays are used

Table 4.2: Mala fide distribution RFH

Flowerbox	Bonafide	80%
	Transport MO	20%
	Grower MO	x
	Consolidation MO	x
	Complex MO	x
Flowerbucket	Bonafide	80%
	Transport MO	20%
	Grower MO	x
	Consolidation MO	x
	Complex MO	x
Plant	Bonafide	80%
	Transport MO	20%
	Grower MO	x
	Consolidation MO	x
	Complex MO	x

from both sides and the top of the container to look inside and the images are checked live from the offices at an alternative location on the terminal. This makes the process go very fast and minimizes the waiting time for the expediter. Only when customs spot any anomalies, the container can be taken to physical inspection. Otherwise, it will be cleared to leave.

4.3.2. Physical checks

Customs can also decide to carry out a physical check. During a physical check, a container is opened and optionally (partially) unloaded. A customs officer physically enters and searches through the goods inside the container. The checks are meant to find any form of illegal goods in the container, but by doing this the customs officer does not want to compromise the quality of the goods. Therefore, the check has to be carried out very cautiously. Once finished, the container gets sealed off and cleared to leave.

4.3.3. Dogs

As a third option, the containers can be checked by using sniffing dogs. This can be done in two different ways. The first method lets the dogs enter the container to search for any smells that are out of the ordinary. The second method is a bit more complex; air is being sucked out of the container through a tube and guided through some sort of sieve, where the molecules from inside the container are collected. Then, the dog can sniff the sieve and recognize if there are any illicit goods inside the container.

4.4. Effectiveness of interferences

As stated before, previous studies often advise the use of interventions that are effective and adaptive to changes in criminal activity, however, these studies do not go in-depth about how this can be achieved (Martens & Schreurs, 2020; Taleb, 2010). The strength of this research is to show that the robustness of interventions can be tested, given several MO and intervention methods using DES. To test the robustness of interventions, it first has to be determined how well interventions can detect criminal goods for specific MO.

4.4.1. Transport

The MO transport is limited to a sports bag or similar item being dropped in the trailer last minute. The bag is visible and it is clear that it does not belong between the boxes, buckets and trolleys inside the trailer.

Therefore it is safe to say that if the trailer is checked, all intervention methods will detect the criminal goods.

4.4.2. Consolidation simple

This MO consists of multiple different smuggling options. The goods can be smuggled between boxes, inside soil or even inside the buckets underneath flowers. When it comes to search dogs there is a chance that if the goods are located close to flowers with a strong smell, the goods will not be detected. The search dogs are trained to deal with compromising circumstances, however, if the smell of illegal goods is covered with wrapping and strong floral smells, the functional abilities of search dogs will be lowered. The functioning of scans does not have to be affected. If the mass of the illegal goods does not match the legal goods, the scan can still detect the difference. However, if the mass of the illegal goods does match the mass of the legal goods, e.g. organic illegal goods inside the soil, the scan will not show this. Physical checks will still work, but it will be a bit harder to detect the goods given the loading of trailers and the goal of preserving the quality of the goods. The intervention that would work best is the X-ray scan, followed by the dogs and physical check.

4.4.3. Consolidation complex

This MO is limited to the conversion of packaging, e.g. buckets and boxes, to packaging with a false bottom and illegal goods built in. If this is done correctly, physical checks will not spot this MO. Only if the packaging is visually different or one of the packages breaks, will this be discovered. The scans will have an easier job detecting this MO, except for metals. If the goods are built into metals, it will not show clearly on the scan. The success rate of dogs will also be slightly lowered, as built-in products are more difficult to smell in addition to the flower scent. The intervention that works best would be dogs, followed by scans and a physical check.

4.4.4. Grower

The MO grower entails the packing of illegal goods within the flowers, e.g. within the stem of flowers. For this specific MO, physical checks have a low success rate, as the quality of the flowers has to be preserved during these checks and the only way to detect this MO is by affecting the quality of the flowers. However, the quality of the flowers will most likely be poor, which can be an indication that something is wrong. For dogs, this MO is also very hard to detect as the scent of the goods is almost completely faded away by the scent of flowers. An X-ray scan could see the difference between the masses of illegal and legal products. However, depending on the level of conversion, the scan might have more trouble with detecting the difference. The intervention that scores best would be a physical check, followed by scans and dogs. An overview of the effectiveness of the different intervention methods can be found in Figure 4.1

	MO	Effectiveness
Dog check	Grower	20
	Transport	100
	Consolidation	80
	Complex	70
Scan check	Grower	30
	Transport	100
	Consolidation	90
	Complex	50
Physical check	Grower	40
	Transport	100
	Consolidation	70
	Complex	30

Figure 4.1: Effectiveness of interventions

5 Model setup

The previous chapter explored different parts of the system. The legal routes were drawn, the actors were inventoried, the MOs were explored and the interventions were investigated. This chapter will implement the previous chapter into a discrete event simulation model using Simio.

5.1. Setup

The model mainly focuses on the processes with its chances to get infected and chances to catch illegal goods, where the leading time of individual trucks will not be explored. The model will run between 4 in the morning and 10 in the evening. The starting time is based on the RFH auction, as this process starts at 7 and the trucks will have to arrive in time. The ending time is based on the departure of the last Ferry at DFDS in Vlaardingen.

The model can be split into 5 different parts:

- The grower part. This part of the model focuses on the production and packaging of flowers and the placement of flowers and plants on the packaging.
- The consolidation part. This part focuses on the transport from the growers to the consolidation boxes. In order words the ”direct lines”. It also shows a simplified consolidation process.
- The auction process. This part of the model focuses on the selling of flowers and plants through the RFH auction.
- The MO part. This part focuses on the assignment of MOs to trucks in the system.
- The intervention part. This part focuses on the assignment of the different intervention methods to the trucks that are to be checked.

The complete overview of the model can be found in Appendix F

5.2. Model objectives

The objective of the model is to gain insight into the robustness of police interventions given a specific set of modi operandi of criminals. To reach this objective, the model will visualize the previous chapters. The first objective is to create flowers with different attributes that influence the route they follow. These flowers will be put on trolleys based on the capacity of that trolley and the type of flowers. After, the trolleys with flowers will be picked up and put on trucks. These trucks drive the flowers to their destination where they will be processed until they are again put on trucks, but now to be transported to the ferry. The second objective is for the flowers to be assigned mala fide chances, there are different ways for flowers to be infected and the model should be able to assign all these options. Thirdly the model should include a chance to be checked by police or customs based on the attributes of the expediter. If the expediter has an AEO status the chance for a check should be lowered. Fourthly, when a truck is checked, the model should be able to assign the three different intervention methods. So the trucks should be able to be checked by humans, dogs or scans, either randomly or with a specific distribution. Lastly, when a check is performed with a specific method, the model should be able to show that a check does not necessarily mean a catch, some MOs are harder to detect than others.

5.3. Model assumptions

The assumptions that are made in creating the model can be divided into two categories: assumptions for simplification and assumptions because of data scarcity. This section will present both categories.

5.3.1. Model simplifications

To simplify the model, the chances for the different options to be mala fide are not linked to the type of flower or transporter. In reality, some MOs are more likely in combination with specific products, e.g. adding illegal goods inside the flowers is easier and more beneficial if the stem is bigger, so with plants. However, because the model is complex enough with the different chances that are combined, the choice was made to not implement this. Another simplification is the picking of flowers to load trolleys. In reality, sometimes different types of flowers can be put together on one trolley. The flower types are also simplified, additional attributes could have been added to flowers, e.g. strong scents vulnerability, but to keep the model clear, the choice was made to limit to plants, buckets and boxes. Another simplicity, that was briefly explained earlier, is the choice of MOs. It was also possible to look into bribing and the conversion of the cabin, but since bribing is not a MO on itself but enables the other MOs and because the cabin is often not transported with the ferry, solely the trailer, these MOs were not further explored. The legal routes are also simplified. It is also possible that goods move directly from the grower to the ferry, but this is something that is not very likely to happen and is therefore not further explored. This is also the case for shipments that move directly from the auction to the ferry. Within the routes there are also some simplifications. For example, the model only shows the loading and unloading in the consolidation, while this process contains more processes. The last important simplification is the assignment of mala fide labels in the model. In reality the flowers become mala fide during specific processes. For instance, the MO grower would happen at the grower. However, in the model all mala fide labels are assigned simultaneously after the consolidation process. This is an addition to the assumption that trucks will only be mala fide with one MO at a time. An overview of the simplifications can be found in Figure 5.1.

Simplifications
In the model trucks are labeled mala fide, in reality the load of the truck is mala fide.
Trucks that are filled with flowers from the auction, but are consolidated in a private box,can have the grower MO option, due to the limitations of the model.
Every truck only contains one type of flower, in the model mixed load trucks do not exist, while in reality it is possible. Only for plants that have to be transported at room temperature and cut flowers that have to be cooled, this is harder to combine.
The model has trucks and trolley in abundance, which appear when the waiting line is big enough to fill the truck or trolley.
The consolidation process is much more complex in reality, packaging such as sleeves and ribbons are also added, trolleys are transported to cold rooms and many more actions that are not represented in the model.
The auction process of RFH is also simplified in the model. In reality, this process consists of more rooms, actions and employees.
The concept of time in the model is not a representation of reality. This model is created to show the logistical process of the system, but due to time restrictions and data scarcity the concept of tme was left out of this model. Therefore the interarrival times of the different types of flowers are not a representation of reality.
For the creation of flowers in the system the choice was made to do this randomly for 20 growers of each flower type. Each arrival stands for one grower.

Figure 5.1: Simplifications

5.3.2. Data scarcity

Because of the confidential nature of this research, data scarcity was a real issue. Many assumptions have been made to deal with this scarcity. The biggest assumptions will be shortly enlightened

The effectiveness of the intervention methods on the specific MOs is not known. This is not data that can be found online and is also not something that policemen and customs are eager to speak about. Therefore in this study, these numbers are fabricated. This is similar to the check likeliness. It is not clear how much percent of the trucks will actually be checked and it is also not known what the effect of an AEO status could be on this likeliness. Besides, it is also unknown how much percent of the trucks are mala fide and which methods are more likely, that is one of the main reasons this research is conducted. Lastly, it is also unknown what intervention method is preferred or often used by police and customs. All these inputs are estimated with the use of expert inputs. During the TFOC action days, the three interventions as presented in this research were mainly used. Therefore the assumption was made that these are the only interventions that can be used. However, this research is exploratory, meaning that its strength is showing that DES models can be used in the future to test intervention methods. It is also quite easy to build onto, so future research can use the model as a base and add different interventions, the likeliness of interventions, the effectiveness of interventions and even different modi operandi. An overview of the main assumptions of the model can be found in Figure 5.2

Assumptions
Consolidation through RFH is not susceptible by the consolidation MOs.
When flowers are bought through the RFH action, the grower MO is not possible.
It is only possible for trucks to be mala fide with one MO.
The allocation of AEO certificates does not say anything about the likeliness of trucks to be mala fide, due to the tendering of the consolidation process and transport to third parties.

Figure 5.2: Assumptions

5.4. Key performance indicators

To check the functioning of the model and test the main objective, key performance indicators (KPIs) are added to the model. The first KPI is called KPI passage mala fide. This KPI calculates how much percent of the goods that have arrived on the ferry are mala fide. In addition to this KPI, 3 KPIs are added that count how many mala fide trucks have passed the checkpoint and how much percent of those have been detected; the effectiveness of the intervention methods. Lastly, the chance to be caught for the mala fide trucks is explored. All KPIs can be found in Table 5.1.

Table 5.1: Key Performance Indicators

Key Performance Indicator	Explanation
Dog check effectiveness	How much percent of the mala fide truck that enter this check are actually detected.
Scan check effeciveness	How much percent of the mala fide truck that enter this check are actually detected.
Physical check effectiveness	How much percent of the mala fide truck that enter this check are actually detected.
Mala fide passage	How much percent of the trucks that reach the ferry was actually mala fide.
Chance to get caught	How much percent of the mala fide trucks in the system is detected.

5.5. Model verification

To verify the model the distributions of the input variables have been checked, so triangular distributions are added to the processing times and normal distributions are not added to variables that cannot have a value below 0. Secondly, the structure of the model has been checked regularly with the use of discrete-event simulation experts. Lastly, the nodes, combiners, separators and servers of the system have been checked on their input and output nodes. Everything that enters should also leave, except in the production of flowers, where it is assumed that only full trolleys and full trucks are processed.

6 Validation

To check the influence of differences in value for specific uncertain variables on the output of the model, a sensitivity analysis is conducted. In this sensitivity analysis, a pre-determined set of variables will have their values altered with 10 percent (upwards as well as downwards). The variables concerning the effectiveness of the different checks will be varied during this sensitivity analysis. The choice was made to increase and decrease the effectiveness of the different interventions with 10 percent because the base case was solely an approximation. The values were chosen based on the information provided by expert interviews. However, these numbers are not exact. The difference between 4 out of 10 and 5 out of 10 could not be distinguished solely based on the interviews, this difference is based on assumptions. The purpose of this validation is to check the effects of these assumptions on this ten-point scale on the KPIs. Therefore the choice was made to move one up and one down on the ten-point scale for this exploration.

Table 6.1 will show the current, base case values for all variables, along with their respective adjusted variables.

Table 6.1: Different values used for sensitivity analysis

Variable	Standard value	10% added	10% deducted
Dog_effectiveness_grower	0.2	0.3	0.1
Dog_effectiveness_transport	1	1	0.9
Dog_effectiveness_consol	0.8	0.9	0.7
Dog_effectiveness_complex	0.7	0.8	0.6
Scan_effectiveness_grower	0.3	0.4	0.2
Scan_effectiveness_transport	1	1	0.9
Scan_effectiveness_consol	0.9	1	0.8
Scan_effectiveness_complex	0.5	0.6	0.4
Physical_effectiveness_grower	0.4	0.5	0.3
Physical_effectiveness_transport	1	1	0.9
Physical_effectiveness_consol	0.7	0.8	0.6
Physical_effectiveness_complex	0.3	0.4	0.2

The addition and subtraction of 10 percent are translated into scenarios, as can be seen in Table 6.2 It is important to note that for the effectiveness of the interventions for the MO transport, it is not possible to add 10 percent as the effectiveness is already 100. This results in 21 feasible scenarios and 1 base case, 22 options in total. To verify the results 50 replications were run of each scenario.

Table 6.2: Sensitivity analysis scenarios

SA 1	Dog effectiveness grower	+10	SA 11	Scan effectiveness consol	+10
SA 2	Dog effectiveness grower	-10	SA 12	Scan effectiveness consol	-10
SA 3	Dog effectiveness transport	-10	SA 13	Scan effectiveness complex	+10
SA 4	Dog effectiveness consol	+10	SA 14	Scan effectiveness complex	-10
SA 5	Dog effectiveness consol	-10	SA 15	Physical effectiveness grower	+10
SA 6	Dog effectiveness complex	+10	SA 16	Physical effectiveness grower	-10
SA 7	Dog effectiveness complex	-10	SA 17	Physical effectiveness transport	-10
SA 8	Scan effectiveness grower	+10	SA 18	Physical effectiveness consol	+10
SA 9	Scan effectiveness grower	-10	SA 19	Physical effectiveness consol	-10
SA 10	Scan effectiveness transport	-10	SA 20	Physical effectiveness complex	+10
			SA 21	Physical effectiveness complex	-10

6.0.1. Analysis of results

In Figure 6.1 the results of the sensitivity analysis are shown. The results show that the chance of getting caught by the different intervention methods varies over the different scenarios.

To interpret the results of the sensitivity the results were categorized. If a KPI was changed significantly, so the effectiveness of an intervention method would increase by 10 percent or more, the result got an orange colour. If the KPI was just slightly changed, with a minimum of 5 percent, it was given a yellow colour.

The two scenarios with the biggest influence are scenarios 18 and 19, more and less effectiveness of the physical check for the consolidation MO. It is evident that less effectiveness of this method for one of the MOs that it normally thrives in, results in a decrease in the overall effectiveness of this method. At the same time, if the method works even better, while other methods are not as suitable, it can be expected that this results in an increase in the overall effectiveness of the method.

This also applies to the scan effectiveness, this method works well for the complex MO. When the effectiveness of this method for the complex MO decreases, the overall effectiveness of the method as a whole also decreases. The share of the complex MO weighs significantly in the effectiveness of the intervention method. If the method can not perform by detecting the complex MO the method will work detect less, as it detects less of the other MOs.

The sensitivity of the model for the different MO-focused effectiveness of the different intervention methods is limited. Most of the time an increase of 10 percent results in a change of around 5 percent or even less in the KPIs. The few occasions in which the 10 percent increase and decrease have a bigger impact are logical and do not compromise the validity of the model. However, it has to be taken into account during the interpretation of the results.

	KPI_passage_malafide	KPI_scancheck	KPI_dogcheck	KPI_physicalcheck	KPI_Chance_caught
Base	0.00	0.00	0.00	0.00	0.00
SA1	0.00	0.00	-0.01	-0.04	-0.03
SA2	0.00	0.00	0.00	0.01	0.02
SA3	0.00	-0.01	-0.01	0.00	0.00
SA4	0.00	-0.04	0.03	0.00	-0.01
SA5	-0.01	0.06	-0.03	0.05	0.02
SA6	0.01	0.05	0.01	0.02	0.01
SA7	-0.01	0.00	-0.04	0.06	-0.01
SA8	0.00	0.01	0.00	0.00	0.00
SA9	0.00	0.00	0.00	0.00	0.00
SA10	0.00	0.00	0.00	0.00	0.00
SA11	0.00	0.03	0.00	0.00	0.02
SA12	0.00	-0.07	0.00	0.00	-0.04
SA13	0.00	0.09	0.00	0.00	0.02
SA14	0.00	-0.07	0.00	0.00	-0.02
SA15	0.00	0.00	0.00	0.02	0.01
SA16	0.00	0.00	0.00	-0.01	-0.01
SA17	0.00	0.00	0.00	0.00	0.00
SA18	-0.01	0.00	0.00	0.12	0.09
SA19	0.01	0.00	0.00	-0.10	-0.08
SA20	0.00	0.00	0.00	0.08	0.05
SA21	0.00	0.00	0.00	-0.07	-0.05

Figure 6.1: Sensitivity results

7 Experimental Design

In order to check the model's outcome in alternative realities, a scenario analysis is being implemented. In this analysis, the model can be used to determine what would happen if the criminal circumstances, by which the outcome of the model is influenced, change significantly. For example, what would happen to the effectiveness of search dogs if criminality with the use of transportation doubled?

For this scenario analysis 16 different, alternative scenarios, along with the base case, have been constructed, which will be explained in the paragraphs below. The explanation of the base case can be found in Chapter 5. The results will be conducted with a replication size of 50 to ensure the representativeness of the results. An overview of the different scenarios can be found in Table 7.1 and the actual changes to the base case for each scenario can be found in Figure 7.1.

Table 7.1: Experimental Design

Scenario 1	Base case
Scenario 2	Bona fide world
Scenario 3	Mala fide world
Scenario 4	A trustful dutch customs
Scenario 5	A distrustful dutch customs
Scenario 6	More customs employees
Scenario 7	Less customs employees
Scenario 8	No AEO
Scenario 9	More transport MO
Scenario 10	Less transport MO
Scenario 11	More false positives
Scenario 12	Less false positives
Scenario 13	Less specialized MOs
Scenario 14	More specialized MOs
Scenario 15	Less pressure on customs
Scenario 16	More pressure on customs

7.1. Bonafide world

The scenario analysis starts with the most obvious scenarios, namely a world in which there is very little criminality (scenario 2) compared to the base case and a world in which there is a lot more criminality (scenario 3) compared to the base case. Normally, it is assumed that approximately 80 percent of the trucks are bona fide. However, in the case of a less criminal world, this increases to up to 90 percent. On the other hand, when there is more criminality in the export of flowers to the UK, the percentage of bona fide trucks decreased to up to 70 percent.

7.2. Trust of dutch customs

The second set of scenarios concerns the trust of dutch customs. In the base case, customs have a lot of trust in companies with an AEO status. Where companies without this status have a 20 percent chance to get checked, the ones with the status have a 5 percent chance to be checked. Scenarios 4 and 5 will increase and decrease the number of companies with this status in the system. When customs are more trustful of companies and hands them the AEO status more easily, the percentage of companies with the status increases from 40 to 50 percent (scenario 4). On the other hand, when customs is more hesitant to hand out this status the percentage of companies with the status decreases from 40 to 30 percent (scenario 5). These increases and decreases are assumed to affect the outcomes of the model, while not disrupting the system significantly.

7.3. Dutch customs employees

The third set of scenarios dives into the availability of customs employees. As stated before, the 20 percent chance to get checked by customs is an approximation. This number is used for modeling to get a grip on the effectiveness of the intervention methods. However, on a bad day, customs might have fewer employees that are trained to walk and read the dogs, so instead of 1 on 5, solely 1 on 10 can be checked. Oppositely, customs could also combine forces with the national police for a day, which would result in more possible checks. Scenario 6 will represent an increase in employees. The percentage of checks will increase from 20 to 40 percent for non-AEO businesses and from 5 to 10 for businesses with this status. Scenario 7 will represent a decrease in employees. The percentage of checks will decrease from 20 to 10 percent for non-AEO status holders and from 5 to 2 percent for businesses with this status. The choice was made to double and half the percentages for the scenarios as customs probably only has 5 to 10 dogs available. An increase or decrease in this number is assumed to have a big impact on the number of checks that can be performed.

7.4. Authorised Economic Operator

Scenario 8 completely removes the concept of the AEO status. In this scenario, customs concluded that the AEO status was beneficial for criminals, as they piggybacked these companies because of their low check rate. The efficiency benefits do not stand up against the harm that the criminality, that comes with this status, causes. Interviews with policemen at the RFH location in Naaldwijk have made it clear that there are some suspicions about the room the AEO leaves for criminality, therefore this scenario is very relevant. In the base case, the percentage of companies with the status is 40 percent. In this scenario, no company will have this status, as it does not exist anymore.

7.5. Transport modi operandi

The fourth set of scenarios focuses on the distribution of the modi operandi, more specifically the transport MO. As stated in Chapter 4, the transport MO is very easy for criminals. Not only because the flowers do not have to be manipulated, so it does not take much effort, but also because it is easy to remove in the UK. At the same time, this MO is also very easy to be detected by customs and police. Scenario 9 and 10 will explore these two extremes. In scenario 9 the criminals make more use of the transport MO than in the base case. Normally 50 percent of the mala fide trucks are mala fide with the transport MO for boxes and buckets and approximately 20 percent of half of the mala fide trucks, so 10 percent of all the mala fide trucks, are mala fide with the transport MO for plants. In scenario 9 the 50 percent is increased to 75 percent and the 10 percent is increased to 20. In scenario 10 the 50 percent is decreased to 25 and the 10 is decreased to 5 percent.

7.6. False positives

With the dog check, there is a chance to get a false positive and to get a false negative. The false negative is taken into account in the effectiveness of the intervention method for the different MOs. The false positive is a separate variable in the model. In the base case, it is set at 20 percent. So 20 percent of the checks that are not mala fide, is ought to be mala fide by the detection dogs. However some external factors, such as the weather, strong flower scent or cross-contamination can make the dogs think that there are mala fide goods inside the trailer when this is not the case. In the base case, the dogs have a false positive rate of 20 percent. In scenario 11 this is increased to 30 percent and in scenario 12 it is decreased to 10 percent.

7.7. Specialized modi operandi

Scenarios 13 and 14 combine the bona fide world scenario and the transport MO scenarios. Where scenarios 9 en 10 only adjust the distribution of the MOs compared to the base case, scenarios 13 and 14 will add an adjustment to the amount of mala fide trucks in the system as well. Fewer trucks will be mala fide, 10 percent instead of 20. In scenario 13 the criminals will use the transport MO more often and in scenario 14 the criminals will use the more specialised MOs more. If there are fewer mala fide trucks, and the trucks that are mala fide use the transport MO, which is easy to detect, this is assumed to result in a higher chance of getting caught. If there are fewer mala fide trucks and the trucks that are mala fide use the more complex MOs, the effectiveness of the intervention methods is assumed to be the bottleneck in detecting more mala fide trucks.

7.8. Pressure on dutch customs

The last two scenarios combine the trustfulness of customs with the bona fide and mala fide world scenarios. Scenario 15 explores a system in which only 10 percent of the trucks are mala fide, so a more bona fide world, while customs is also more trustful and hands out more AEO permits, resulting in fewer checks. As there are fewer mala fide trucks in the system, fewer checks should not have a significant influence on the results. However, if the wrong trucks are picked out for checks, this could have a significant influence. Scenario 14 explores a system in which 30 percent of the trucks are mala fide, so a more mala fide world, while customs is less trustful and hands out fewer AEO permits, resulting in more checks. More mala fide trucks and more checks should result in more mala fide trucks being detected. However, the effectiveness of the intervention methods could still be the bottleneck and could prevent the detection of more mala fide trucks.

Figure 7.1 shows the design of the experiments. The differences of the 15 scenarios compared to the base case can be seen in bold.

		Repl.	Bonafide	AEO certificates	Check Likeliness with AEO	Check likeliness no AEO	False Positive	MO transport box	MO transport bucket	MO transport plant
Scenario 1	Basecase	50	0.80	0.40	0.05	0.20	0.20	0.50	0.50	0.20
Scenario 2	Bonafide	50	**0.90**	0.40	0.05	0.20	0.20	0.50	0.50	0.20
Scenario 3	Malafide	50	**0.70**	0.40	0.05	0.20	0.20	0.50	0.50	0.20
Scenario 4	More trust AEO	50	0.80	**0.50**	0.05	0.20	0.20	0.50	0.50	0.20
Scenario 5	Less AEO	50	0.80	**0.30**	0.05	0.20	0.20	0.50	0.50	0.20
Scenario 6	More Checks	50	0.80	0.40	**0.10**	**0.40**	0.20	0.50	0.50	0.20
Scenario 7	Less Checks	50	0.80	0.40	**0.02**	**0.10**	0.20	0.50	0.50	0.20
Scenario 8	No AEO	50	0.80	**0.00**	0.05	0.20	0.20	0.50	0.50	0.20
Scenario 9	More Transport MO	50	0.80	0.40	0.05	0.20	0.20	**0.75**	**0.75**	**0.40**
Scenario 10	Less Transport MO	50	0.80	0.40	0.05	0.20	0.20	**0.25**	**0.25**	**0.10**
Scenario 11	More False positives	50	0.80	0.40	0.05	0.20	**0.30**	0.50	0.50	0.20
Scenario 12	Less False Positives	50	0.80	0.40	0.05	0.20	**0.10**	0.50	0.50	0.20
Scenario 13	Bona+ trans +	50	**0.90**	0.40	0.05	0.20	0.20	**0.75**	**0.75**	**0.40**
Scenario 14	Bona+ trans -	50	**0.90**	0.40	0.05	0.20	0.20	**0.25**	**0.25**	**0.10**
Scenario 15	Bona+AEO +	50	**0.90**	**0.50**	0.05	0.20	0.20	0.50	0.50	0.20
Scenario 16	Bona -AEO -	50	**0.70**	**0.30**	0.05	0.20	0.20	0.50	0.50	0.20

Figure 7.1: Overview experiments

8 Results

In this chapter the experimental design from the previous chapter will be executed and the results will be examined. The results from Simio have been converted to IBM SPSS, to perform statistical tests. The complete overview of results can be found in appendix G

In Table 8.1 the results for the different scenarios can be seen. Scenario 1 shows the results for the base case. At first glance, it seems that the scenarios do not impact the KPIs significantly. But to gain more insight in Table 8.2, the differences are shown in percentages.

Table 8.1: Means for KPI different scenarios

	Dogcheck	**Scancheck**	**Physicalcheck**	**Passage_malafide**	**Chance_caught**
Scenario 1	0.960	0.660	0.789	0.125	0.094
Scenario 2	0.920	0.495	0.705	0.057	0.121
Scenario 3	0.931	0.780	0.789	0.186	0.106
Scenario 4	0.960	0.725	0.852	0.124	0.096
Scenario 5	0.955	0.828	0.860	0.121	0.117
Scenario 6	0.959	0.878	0.804	0.106	0.223
Scenario 7	0.951	0.533	0.739	0.130	0.051
Scenario 8	0.933	0.855	0.772	0.115	0.147
Scenario 9	0.971	0.771	0.929	0.117	0.122
Scenario 10	0.901	0.613	0.655	0.122	0.081
Scenario 11	0.960	0.660	0.789	0.125	0.094
Scenario 12	0.952	0.680	0.789	0.124	0.096
Scenario 13	0.952	0.575	0.878	0.060	0.138
Scenario 14	0.927	0.603	0.719	0.059	0.108
Scenario 15	0.894	0.583	0.694	0.061	0.093
Scenario 16	0.941	0.833	0.790	0.185	0.114

For the Dog check KPI, scenarios 10 and 15 have the biggest influence, with approximately 6 percent less effectiveness. Scenario 10 is the scenario in which criminals make less use of the transport MO. Because the effectiveness of the dog check is very high for this MO compared to other MOs, a decrease in this MO would affect the effectiveness of the intervention, which can be seen. Scenario 15 is the scenario in which the world is more bona fide and more AEO certificates are handed out, so there are fewer mala fide trucks in the system, but there will also be fewer checks. There are 10 percent fewer mala fide trucks in the system, but 10 percent more of the trucks will have an AEO status and will be checked less regularly. These results show that the check percentage has a higher influence on the dog KPI than the initial number of mala fide trucks in the system.

For the Scan check KPI, scenario 2 has the biggest negative influence, while scenarios 5, 6, 8 and 16 have a great positive influence. Scenario 2 represents a more bona fide world, so fewer mala fide trucks are in the system and the trucks that are mala fide and get detected seem to use MOs that are not easily detected by the scan. Scenarios 5, 6, 8 and 16 have in common that more checks will be performed, either because of fewer AEO certificates or because of an increase in employees. The results are in line with what is expected.

For the Physical check the transport MO seems to have the biggest influence. When more of this MO is used, the effectiveness of the intervention method increases significantly, but when less of this MO is used the effectiveness decreases significantly. The effectiveness of this check for the transport MO is much higher compared to its effectiveness on the other MOs, so these results are also in line with what is expected.

The Passage Mala fide KPI is very susceptible to the scenarios. The scenarios with more initial mala fide trucks, scenarios 3 and 16, increase the value of this KPI by approximately 50 percent compared to the base case. On the other hand, scenarios with more bona fide trucks have the same effect, but negatively, so fewer mala fide trucks will end up at the ferry. This is all in line with the expectations. Another scenario that has a negative influence on this KPI is scenario 6 with more customs employees. This shows that if more checks are performed, fewer mala fide trucks end up at the ferry. This is a result that would be expected of the model and adds to its validity.

The last KPI, the chance to get caught, is also highly affected by different scenarios. The most remarkable result for this KPI is the fact that if the number of customs employees is increased, this would result in a 136% increase in the chance to get caught, while a decrease in the number of employees would only result in a 46% decrease in the chance of getting caught. This suggests that the number of checks is a real bottleneck and a small increase would already deliver great results. This claim is supported by scenario 8, with no AEO certificates in the system, so more trucks will be checked. This scenario shows that the chance of getting caught increases by 55.5 percent by just removing the AEO process.

Table 8.2: Difference means for KPI different scenarios

	Dogcheck	Scancheck	Physicalcheck	Passage_malafide	Chance_caught
Scenario 1	0.0	0.0	0.0	0.0	0.0
Scenario 2	-4.2	-25.0	-10.7	-54.3	28.3
Scenario 3	-3.0	18.2	0.0	49.1	12.7
Scenario 4	0.0	9.8	8.0	-0.3	1.8
Scenario 5	-0.6	25.5	9.0	-2.9	24.3
Scenario 6	-0.1	33.0	1.9	-15.0	136.3
Scenario 7	-0.9	-19.2	-6.3	4.0	-46.2
Scenario 8	-2.8	29.5	-2.1	-7.7	55.5
Scenario 9	1.1	16.8	17.8	-5.9	28.7
Scenario 10	-6.2	-7.1	-17.0	-2.4	-14.6
Scenario 11	0.0	0.0	0.0	0.0	0.0
Scenario 12	-0.9	3.0	0.1	-0.6	1.4
Scenario 13	-0.8	-12.9	11.3	-52.1	46.1
Scenario 14	-3.5	-8.6	-8.9	-52.9	14.2
Scenario 15	-6.9	-11.6	-12.0	-50.8	-1.7
Scenario 16	-2.0	26.2	0.2	48.8	21.1

These results are very interesting and support the expectations. However, some of the scenarios may appear to have a great effect, when in reality this is not the case. To test the actual effects of the scenario an independent t-test was performed in IBM SPSS. The significance of the different scenarios is displayed in Figure 8.1. The hypothesis for the different tests is that the scenarios differ from the base case. If the significance of the scenarios is lower than 5 percent (0.05) this hypothesis is accepted, otherwise, the scenarios do not differ significantly from the base case. The scenarios with the most significant influence on the KPIs are the scenarios with fewer AEO certificates, more mala fide trucks with the Transport MO and more customs checks.

	Name	KPI Dog check	KPI Scan check	KPI Physical check	KPI passage malafide	KPI chance caught
Scenario 1	Base case					
Scenario 2	Bona fide world	0.231	0.091	0.148	0.000	0.028
Scenario 3	Mala fide world	0.081	0.163	0.995	0.000	0.090
Scenario 4	A trustful dutch customs	0.978	0.469	0.069	0.895	0.825
Scenario 5	A distrustful dutch customs	0.742	0.042	0.036	0.247	0.002
Scenario 6	More customs employees	0.921	0.003	0.633	0.000	0.000
Scenario 7	Less customs employees	0.740	0.182	0.357	0.131	0.000
Scenario 8	No AEO	0.109	0.016	0.618	0.003	0.000
Scenario 9	More Transport MO	0.504	0.197	0.000	0.015	0.001
Scenario 10	Less Transport MO	0.003	0.617	0.001	0.332	0.068
Scenario 11	More false positives	1.000	1.000	1.000	1.000	1.000
Scenario 12	Less false positives	0.646	0.828	0.986	0.830	0.857
Scenario 13	Less specialized MOs	0.770	0.378	0.035	0.000	0.000
Scenario 14	More specialized MOs	0.118	0.547	0.220	0.000	0.223
Scenario 15	Less pressure on customs	0.090	0.423	0.110	0.000	0.871
Scenario 16	More pressure on customs	0.233	0.036	0.963	0.000	0.005

Figure 8.1: significance level scenarios

When it comes to the robustness of the different checks, the dog check is only affected by scenario 10 with less Transport MO. This scenario decreases the effectiveness of the dog check. The scan check is influenced by more scenarios. Scenarios 5, 6, 8 and 16 significantly influence this intervention method. However, the influence of each of these scenarios is positive. The scenarios that negatively influence the scan check do not have a significant effect. The physical check is significantly affected by scenarios 5, 9, 10 and 13. Of these 4 scenarios, scenario 10 decreases the effectiveness of the intervention method. all the other scenarios that have a significant influence, positively affect the effectiveness of the physical scan.

9 Discussion

To assess the effectiveness of the before mentioned interventions in different scenarios, this chapter will reflect on the model's validity, the results and the validity of the chosen methods.

9.1. Research findings

The main goal of this research was to gain more insight into the general workings of the flower–oriented sector, focused on the export to the UK. The conducted interviews, attended action days and literature study resulted in flow charts, BPMN figures and IDEF-0 figures. These figures have been of great value to TFOC. As previously stated, TFOC has the means to intervene, yet finds itself lacking the necessary information to intervene efficiently. The figures have given the organisation an overview of what normally occurs in the supply chain, e.g. which routes are most likely and the essence of time. As interviewee 9 states:

”Because of my background in business, I already understand the sector, which is a benefit that most of my colleagues do not have. Creating this overview definitely has an added value... It is impossible to intervene if you cannot detect the abnormalities.”

In addition to the figures, a DES model was created in Simio. This model ought to test the robustness of the specified intervention methods. To test this robustness, scenarios were created that explore the different distributions of smuggling methods. The scenario analysis showed that the effectiveness of the different intervention methods varied significantly for the different runs. At first, for each scenario 10 runs were executed, but this was not sufficient. Therefore the number of runs was increased to 50 runs, which resulted in more representative outcomes.

When it comes to the robustness of the intervention methods, the dog check is only significantly negatively influenced when criminals use less of the Transport MO. The physical check is also only significantly negatively affected in this scenario and the scan intervention is not significantly affected by any of the scenarios in this exploration. However, these results can also be led back to the exploration of the scenarios. Maybe a broader group of scenarios could lead to different conclusions about the robustness of the interventions. For instance, focusing more on specifically the grower MO, which is one of the hardest MOs to detect, could result in less robust interventions.

9.2. Implications of the limitations

In addition to the limits of the scenarios, the data scarcity could also have an impact on the presumed robustness of the interventions. These assumptions were necessary for this exploratory research, but need to be briefly enlightened to capture the entirety of the system.

One of the assumptions in the model that threatens the robustness of the interventions is that all trucks have an equal chance of being inspected by customs upon arrival at the shipping location. However, this is not reflective of reality. Since flowers are perishable, transporters avoid arriving at the ferry too early to prevent the flowers from waiting for several hours before departing to the UK. Consequently, most transporters aim to arrive between 1 and 1.5 hours before the ferry's departure (with 1 hour being the minimum required arrival time for trucks using DFDS Vlaardingen (DFDS, 2024)). This results in a higher volume of trucks needing processing within this narrow time window compared to earlier hours. Additionally, customs has limited resources for inspections. For instance, once the x-ray scan capacity is reached, any remaining trucks needing scans must wait in line, risking missing the ferry departure. Holding trucks when they are scheduled to board the ferry can cause significant issues for customs, as it leads to substantial financial losses for the companies whose trucks were timely. Criminals may exploit this situation, as the likelihood of inspection decreases as the deadline for boarding approaches.

A second risky assumption is that the goods that travel through RFH are not checked by customs, because there is a very high uncertainty for criminals whether their illicit goods end up at the right buyer without this buyer becoming suspicious. But it could be possible that there are ways where criminals make sure their goods end up where they want by for example bribing. When customs does not check those routes, criminals could extort those opportunities and the flow of illegal goods could flourish. Bribing has not been explored in this research but could provide even more insight.

This type of opportunistic behaviour is not investigated in this exploratory research. In this model, the arrival of trucks is based on a random distribution instead of on the preferred arrival time, depending on the goods that are being transported. In reality, this process is more similar to a game theory-like environment where the interaction between criminals and customs authorities can be seen as a complex, adaptive game where both sides continuously adjust their strategies. Criminals aim to maximize their smuggling success by adapting different smuggling methods, while customs seek to minimize this success by varying and enhancing their detection techniques. This creates a dynamic balance where both parties constantly respond to each other's actions.

In addition, criminals can also try to use this adaptive game to their advantage. Knowing that law enforcement will consider finding illegal goods as focusing on the right route, criminals could even go as far as planting false shipments. For instance, small amounts of illegal goods could be planted on the direct routes from RFH, which will result in law enforcement focusing on this specific route. At the same time, criminals could try to smuggle larger amounts of illegal goods through another route, e.g. directly from a grower.

9.3. Implications of Simulation

Another aspect that has to be investigated: Can Discrete Event Simulation be used to gain more insight into the robustness of interventions in the flower-oriented sector? The DES may not be the most suitable simulation for the testing of intervention methods. A lot of parts of the system are unknown, such as the percentage of mala fide trucks, the usage of MOs and the effectiveness of the intervention methods. In the DES model, these variables are all assumed to be known, when in fact this is not the case. The combination of this simulation technique and the limited scenario analysis could result in distorted outcomes.

10 Conclusion

In this chapter, the research questions from the first chapter will be answered with the use of literature, interviews and the discrete event simulation model. The main research question reads as follows:

"Which intervention method is most robust for changes in preference for smuggling routes, focusing on the distribution of flowers from the Netherlands to the UK?"

This main research question can be split into the following sub-questions:

- SQ1. What are the main transport configurations in legal flower-oriented supply chains?
- SQ2. How do criminals exploit legal flower-oriented supply chains when smuggling illegal products to the UK?
- SQ3. Can Discrete Event Simulation be used to gain more insight into the robustness of interventions in the flower-oriented sector?

The first question was answered in chapter 3, the exploration of legal routes, and was supported with IDEF-0, flow charts and BPMN figures. The main routes are a combination of consolidation in a box or by RFH, own transport or a transport company and directly bought, bought through Floriday or bought through auction. An overview of the most likely routes can be found in Table 3.1.

The second question was answered in Chapter 4 the criminal modi operandi. 8 different modi operandi were distinguished, of which 6 were used in this research and combined into 4 different modi operandi, namely:

- Addition of a sports bag to a trailer (MO transport)
- Hiding illegal goods between the legal goods (MO consolidation)
- Replacement of normal vases and pots with ones with a hidden compartment (MO consolidation complex)
- Planting illegal goods inside flowers and plants (MO grower)

The simulation model was created to answer the third and main question. The results show that the most robust intervention method, given the set of criminal modi operandi and the scenarios as described in chapter 7, would be the check with the use of scans. However, as stated before the validity of the model can be questioned because of the high number of unknown variables in the system.

In summary, this research has given an overview of the most prominent routes, the smuggling routes that are known to be preferred by criminals according to expert interviews and has provided a DES model in Simio. The research has concluded that in the case of the export of flowers and plants from the Netherlands to the UK, given the specific set op modi operandi and interventions, the most robust intervention method is the usage of scans. The DES model is considered suitable for a scenario analysis in this scope but leaves room for improvement.

It can be concluded that to calculate the effectiveness of the intervention methods, the DES model is a great mean. The results have shown that the model functions as expected. Therefore this model is a great addition for TFOC, as it can use this model as a base and add more confidential information to the model. Instead of the qualitative manner that is currently often used to share information between the different public organisations, TFOC can focus on this quantitative method to effectively disrupt CSC.

10.1. Further research

As stated before, this research is conducted as an exploratory analysis for TFOC. The goal was to gain insight into the workings of the legal supply chain and to test the effectiveness of Discrete Event Simulation in testing the robustness of intervention methods in this sector. The exploratory nature of this research leaves room for adjustments. For instance, the set of scenarios could be taken under the loop. The current scenario analysis is quite simple and could be extended with scenarios that take the dynamics between criminals and law enforcement into account. Further research could also dive into a more quantitative approach. This research consisted of a qualitative part, in the form of interviews and conceptual designs, and a quantitative part, which consisted of a simulation model. Future research can put more effort into the quantitative part, with for example a supply of empirical data. In addition, further research could try to embody the element of time into the simulation model. For instance, the sailing times and auction process could be added to the model completely, which could result in more insights into the bottlenecks in the system.

11

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A

Appendix A: Methodology

As stated before, the academic literature review for this smuggling topic is not very extensive. Therefore multiple interviews were conducted. The interviews with the RFH employees, the security analysts and the supply chain strategy and business development analyst, formed the base for chapter **??**. These experts shared a lot of insight about the activities at and around the RFH locations. To gain more insight into the workings of the system outside RFH, interviews were conducted with multiple Senior Supply Chain Managers of wholesale retailers. Also, a policy employee for integral safety was interviewed. This person had previously worked together with different disciplines to create more awareness of criminal activity at RFH locations.

In addition, multiple law enforcement officers were interviewed. The TFOC officers had a lot of general knowledge as to how criminals operate, which gives a better understanding of criminal thinking. The interviews with local policemen of the RFH location in Naaldwijk were specifically very useful, since they elaborated on the modi operandi of criminals that they have seen before. Their statements in combination with that of the Senior intelligence officer of the national police unit, as he was previously also a senior local policemen at that same location, formed the base for chapter 4

Lastly, as this research is about the export of flowers and plants to the UK, a Senior Intelligence UK Border Force manager was interviewed. This was a great addition, as this person could elaborate more on the magnitude of the problem and the modi operandi that have caught their eye.

A.1. Interview structure

The interviews were conducted with a semi-structured interview style. This way, interviewees felt more comfortable to provide more information. The interview felt more like a conversation rather than an interrogation, which resulted in new insights and perspectives. To not stray from the topic too much, a few questions were prepared, namely:

- How do you think criminals smuggle through export? and more specifically through the export of horticultural goods?
- Do you think piggybacking is often used or do you think companies are often aware of the criminal interference on their products?
- Do you think the criminal activities in this sector can be stopped? And how could it be limited as much as possible?

  For interviewees with a background in the horticultural sector additional questions were asked, namely:
- How are goods normally bought and exported to the UK?
- Who handles the transportation more often, the buyer or a third party?
- Are there a lot of tenders in the sector?
- How does the sector leave room for criminal activity?
- How are flowers and plants bought normally? Through auction or directly?

- How often is the consolidation done by someone other than the buyer?

  These questions resulted in a lot of different insights and perspectives. To gain even more information and to get a clear overview, figures such as flow charts and IDEF-0 models were created and shown to the interviewees. They could elaborate on the correctness and extensiveness of the figures, resulting in the figures as can be seen in chapter 3

To ensure the validity of the provided information, the different interviewees could react to the adjustments to the figure from other interviewees. The figures were cross checked until the participants could not add to the figures. To fully incorporate this cross checked interview style, multiple interviewees were interviewed more than once, or multiple employees from the same company were interviewed.

A.2. Consent form

The participants of the interviews approved the usage of their information by signing the consent form in Figure A.1. This form was approved by the Human Resource Ethics Committee (HREC) of the Delft University of Technology. The HREC approved the usage of information provided by the interviewees, as long as the HREC checklist is followed and the interview structure remains the same as it was during the application for the board's approval.

You are being invited to participate in a research study titled "Flower-facilitated criminal supply chains". This study is being done by Hillary Lopes Mendes from the TU and the Transport Facilitated Organised Crime (TFOC) group.

The purpose of this research study is to gain more insight into the workings of criminal supply chains in the flower business from the Netherlands to the UK, and will take you approximately 30-45 minutes to complete. The data will be used as input to create a model of the criminal flowers supply chain in the context of my master thesis. We will be asking you to provide information about the working of criminal supply chains and their modus operandi, from what type of trailers are used to smuggle, to who are involved in the smuggling process and everything in-between, based on your personal expertise.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by not publishing the results of this interview, but simply holding on to a short summary that will be used as background information and will be published without your personal data (except your expertise and gender) in the appendix of the final paper. This summary will also be shared with you.

The interview data will be stored in the national police's data storage until the research is finalized. All personal data will be deleted at the latest 2 years after the completion of the project. The data will be used to support scientific publication. Should the results be published in a scientific paper regarding criminal supply chain modelling, you will be anonymous in this paper as well.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions.

Figure A.1: Consent form

B

Appendix B: Legal routes

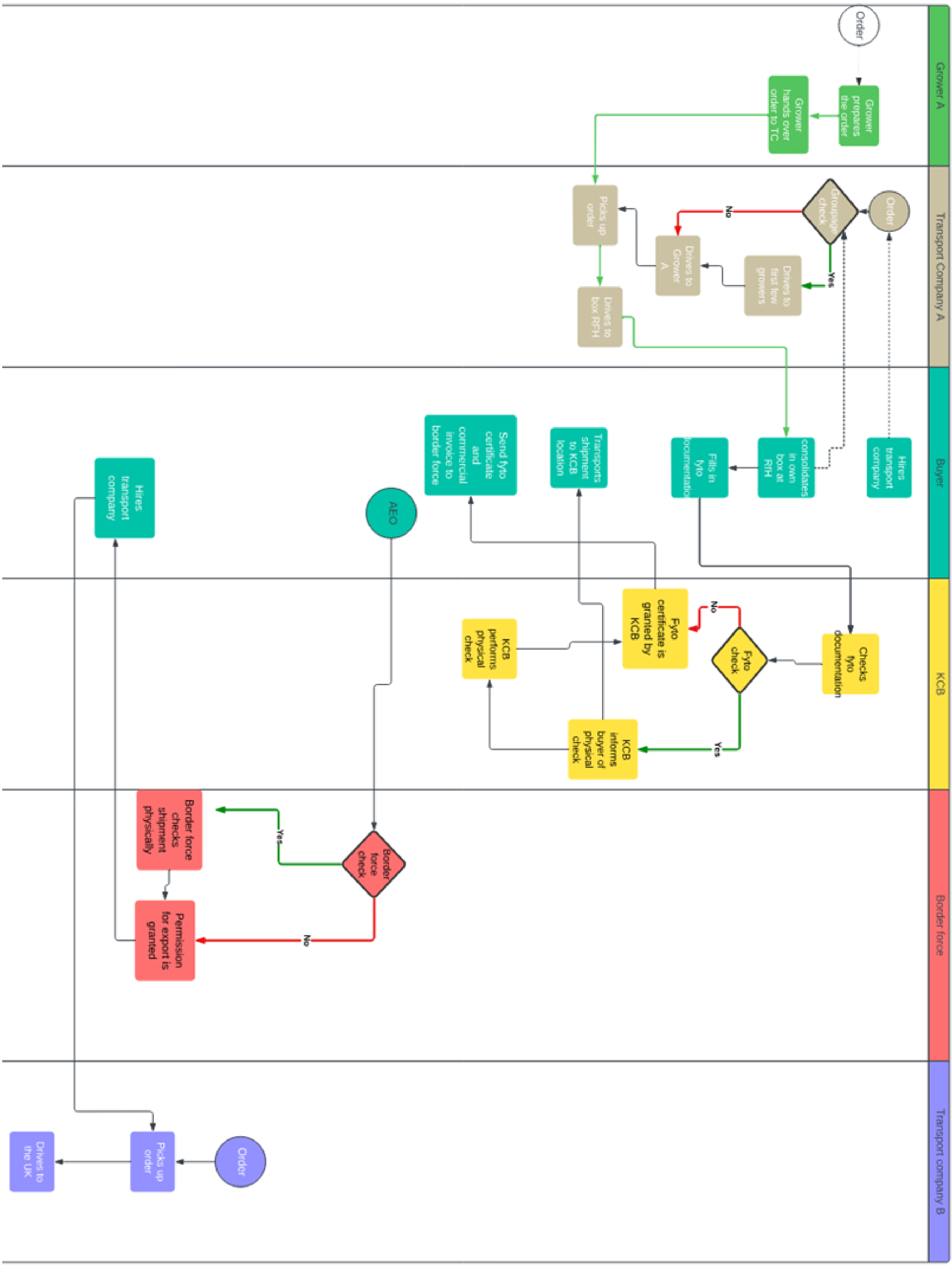

Figure B.1: Swimlane, direct buyer with own box but third transportation

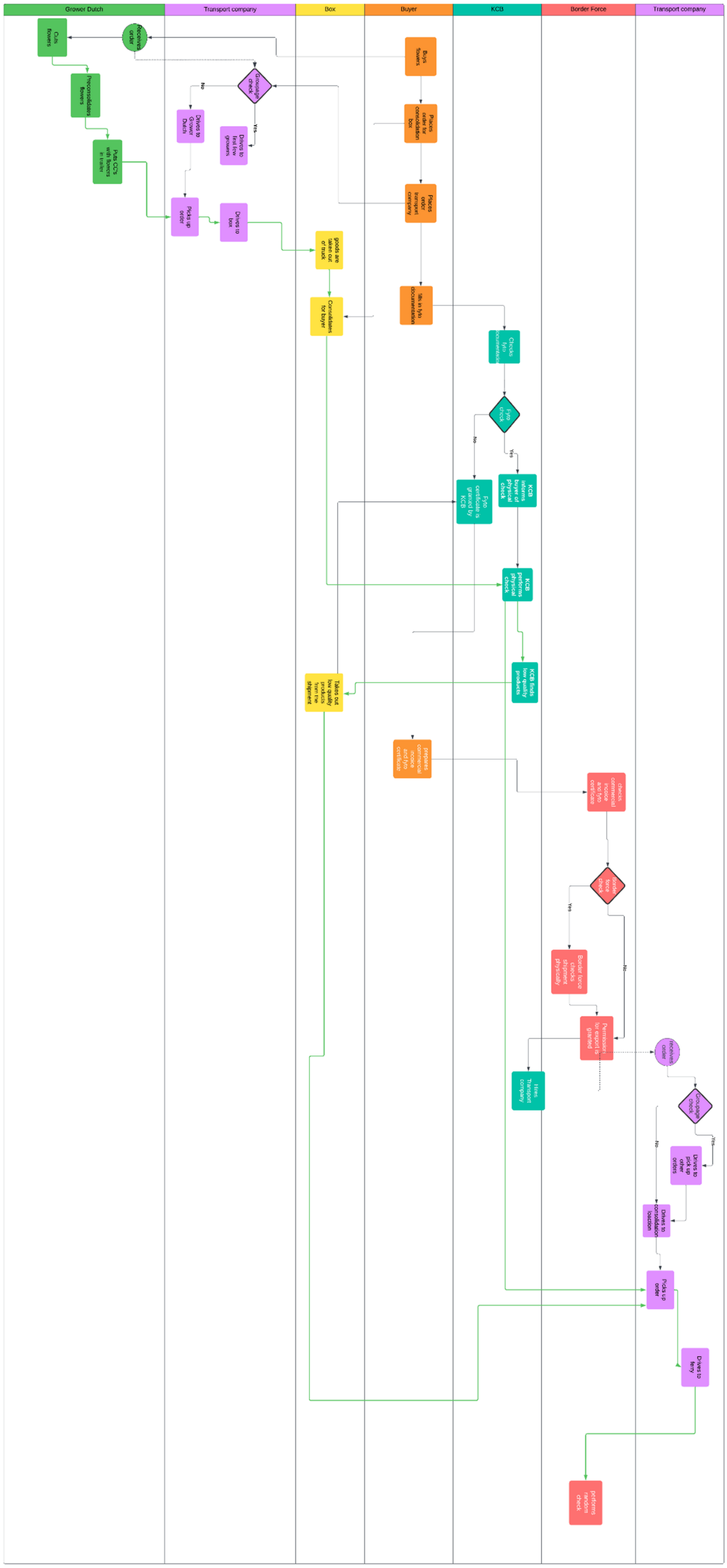

Figure B.2: Direct buyer consolidates in other box and third transportation

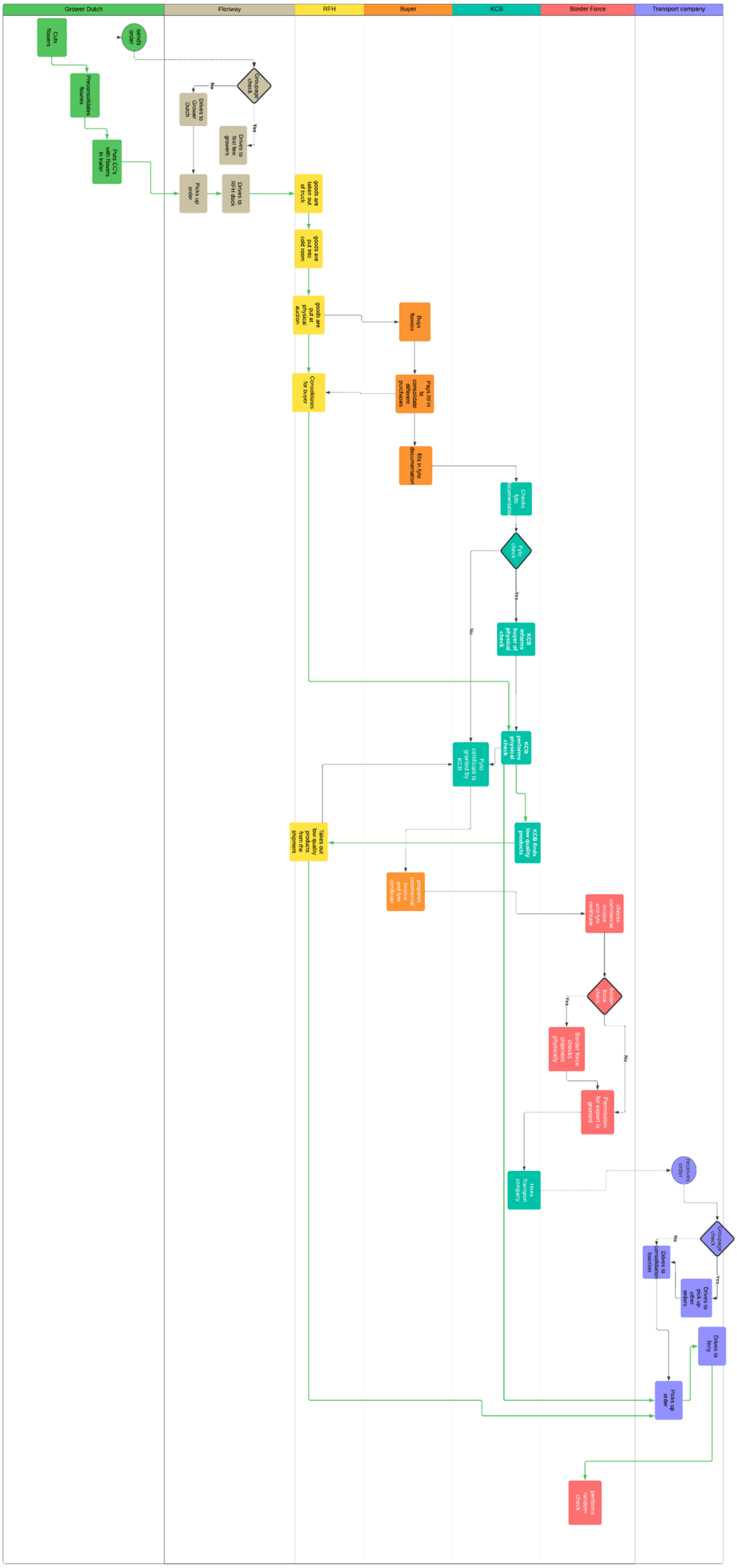

Figure B.3: Buyer with consolidation at RFH and third transportation

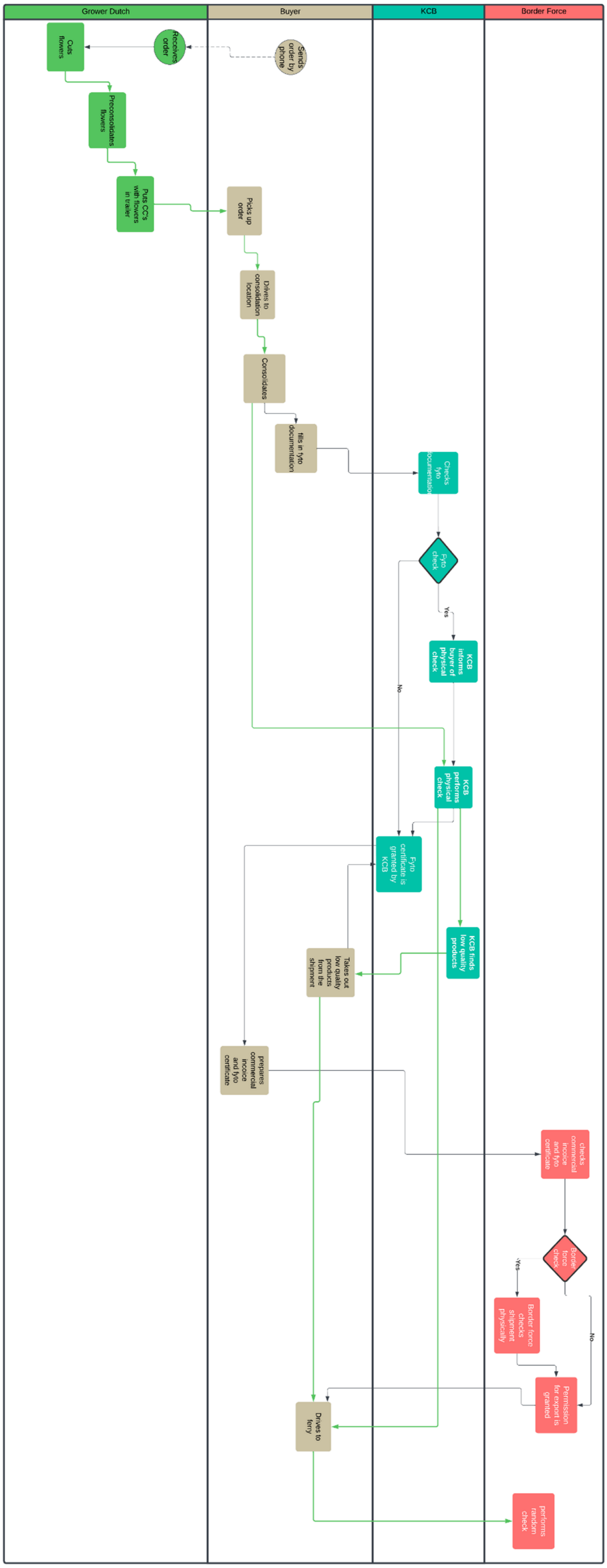

Figure B.4: Buyer with own transportation and consolidation

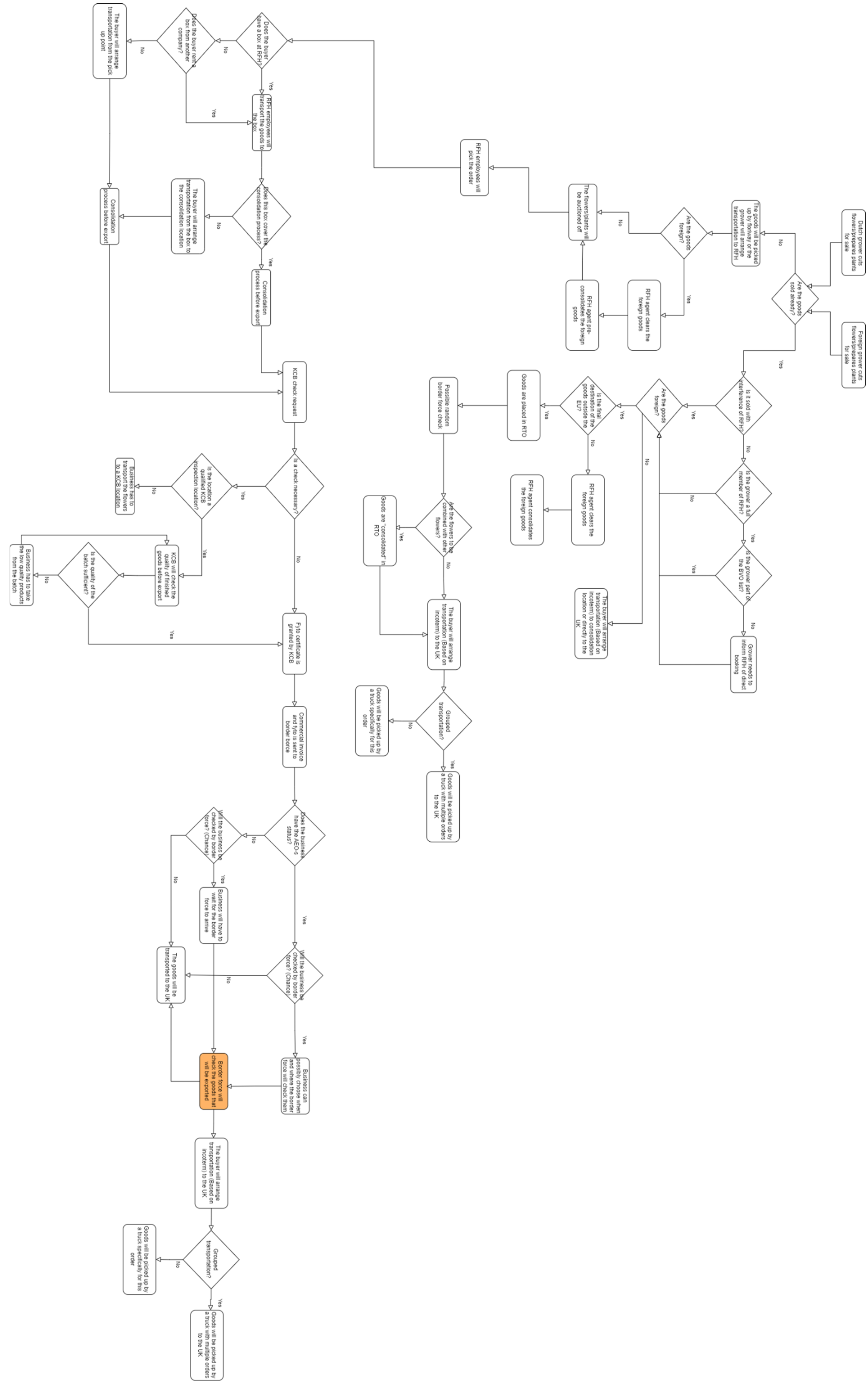

Figure B.5: Full flow chart diagram

C
Appendix C: AEO

Businesses can be granted both licenses to benefit fully from the advantages that are offered. But depending on the type of business and the business' role in the logistics supply chain, this might not be beneficial. Normally the AEO status is only recognized by the European Union member states, but some countries outside of the EU do acknowledge the AEO-S license, among which the United Kingdom. For businesses interested in the export to the UK, obtaining solely the AEO-C status is not beneficial. Because of the efficiency that is accompanied by obtaining the AEO-status, a lot of businesses are interested. However the standards for this license are set high. The extensive application form consists of six parts. (Belastingdienst, 2023).

The first part focuses on general information about the business, for instance how does the business operate, who is in charge of the customs matters, how much profit does the business make yearly and what part of that is spent on the import/export of goods? The second part asks about previous violations of tax and/or customs regulations, and what measures were taken to avoid this from reoccurring.

Thirdly, the administrative tasks of the business are taken under the loop. Every move of the transported goods, from entering until leaving the business, should be accounted for administratively. As a fourth, the financial stability of a business is at question. Questions about the financial situation over the past three years are asked and whether there are factors that can influence the financial stability in the short term.

The fifth point on the list is about the capabilities of the person who is in charge of customs within the company. What are his/her qualifications? Does he/she have any experience in the field of customs?

The sixth and last point is the safety demands that take place within the company. Whose responsibility is it that they are followed? Have there been any incidents during the past few years? What insurances does the company have? What are the regulations when it comes to the loading dock?

D

Appendix D: Sensitivity Analysis

Table D.1: Sensitivity analysis part 1

	Passage_malafide	Scancheck	Dogcheck	Physicalcheck	Chance_caught
Base	0.191	0.716	0.862	0.568	0.074
SA1	0.190	0.719	0.857	0.546	0.072
SA2	0.190	0.716	0.862	0.574	0.075
SA3	0.191	0.706	0.852	0.570	0.074
SA4	0.190	0.690	0.886	0.569	0.073
SA5	0.189	0.756	0.837	0.598	0.075
SA6	0.192	0.753	0.866	0.579	0.075
SA7	0.190	0.718	0.827	0.600	0.073
SA8	0.190	0.726	0.862	0.568	0.074
SA9	0.191	0.716	0.862	0.568	0.074
SA10	0.191	0.716	0.862	0.568	0.074

Table D.2: Sensitivity analysis part 2

	Passage_malafide	Scancheck	Dogcheck	Physicalcheck	Chance_caught
Base	0.191	0.716	0.862	0.568	0.074
SA11	0.190	0.741	0.862	0.568	0.075
SA12	0.191	0.664	0.862	0.568	0.072
SA13	0.190	0.778	0.862	0.568	0.076
SA14	0.191	0.664	0.862	0.568	0.073
SA15	0.190	0.716	0.862	0.578	0.075
SA16	0.191	0.716	0.862	0.560	0.073
SA17	0.191	0.716	0.862	0.568	0.074
SA18	0.189	0.716	0.862	0.635	0.081
SA19	0.191	0.716	0.862	0.509	0.068
SA20	0.190	0.716	0.862	0.613	0.078
SA21	0.191	0.716	0.862	0.529	0.071

E

Appendix E

F

Appendix F: Simio model

This appendix gives an overview of the discrete event simulation model of the flower-oriented export from the Netherlands to the UK. To create this model, several interviews, as can be found in Appendix A, literature studies, as can be found in Appendix **??**, and information gathered at the TFOC action days were used as input. When these information streams were insufficient, assumptions and simplifications were made, which can be found in Chapter 5. Figure F.1 shows a zoomed-out picture of the complete model. In order to get more clarity, the model has been split up in 5 different parts:

- Yellow, the grower part. This part of the model focuses on the production and packaging of flowers and the placement of flowers and plants on the packaging.
- Blue, the consolidation part. This part focuses on the transport from the growers to the consolidation boxes. In order words the ”direct lines”. It also shows a simplified consolidation process.
- Grey, the auction process. This part of the model focuses on the selling of flowers and plants through the RFH auction.
- Green, the MO part. This part focuses on the assignment of MOs to trucks in the system.
- Pink, the intervention part. This part focuses on the assignment of the different intervention methods to the trucks that are to be checked.

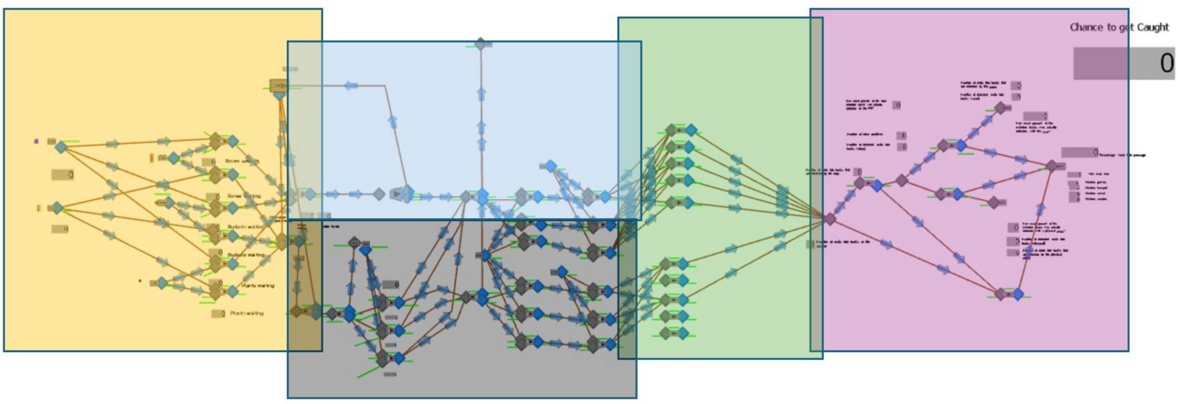

Figure F.1: Overview Simio parts

F.1. Growers

The whole process of exporting flower-oriented goods to the UK starts with the production of the goods by growers. This model shows the production of three different types of flowers, namely:

- Flowerboxes, flowers that are packed in boxes.
- Flowerbuckets, flowers that are packed in the special flowerbuckets.
- Plants, plants that are transported in vases and pots.

Figure F.2 shows the creation of flowerboxes. The batches are created with an interarrival time that follows an exponential distribution a mean of half a minute. The batches are created with a triangular distribution, where the maximum is a full truck load, the mean is half truck load and minimal is 2 to 3 trolleys for each type of flower.

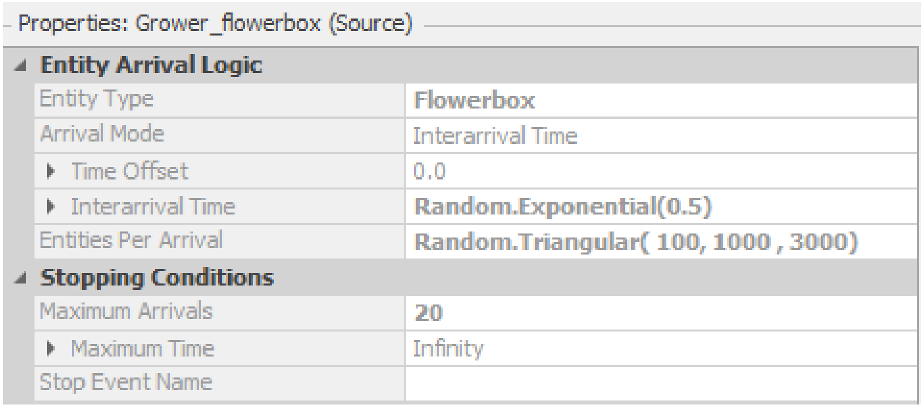

Figure F.2: Simio growing flowers

All types of flowers are put on two different types of trolleys. Trolleys that are bought and can be exported to the UK, shown as regular trolleys in the model, and trolleys that are rented from RFH and cannot be exported, shown as RFHtrolleys. The flowers and trolleys are combined, based on the capacity of the trolley for their respective flowertype. For instance, Figure F.3 shows that the flowerboxes are batched based on the ”TrolleyCapacityBox”. It also shows that the batching process follows a triangular distribution, with a minimum of 3 minutes, mean of 5 minutes and max of 7 minutes. When enough flowers are waiting to fill a whole trolley, a trolley will be ”called” to batch them.

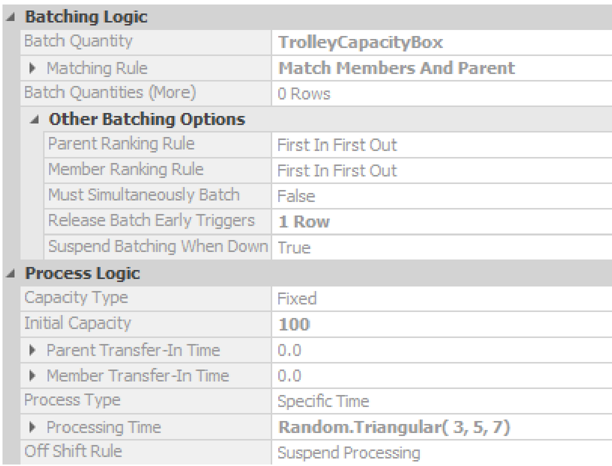

Figure F.3: Simio Batching flowers Part

A complete overview of this part of the model can be found in Figure F.4. After the flowers are batched by the grower they wait until enough is ready to be loaded on a truck, which then is called upon. The flowers that are loaded on RFHtrolleys continue to the RFH auction. The flowers that are loaded on regular trolleys continue to consolidation in boxes.

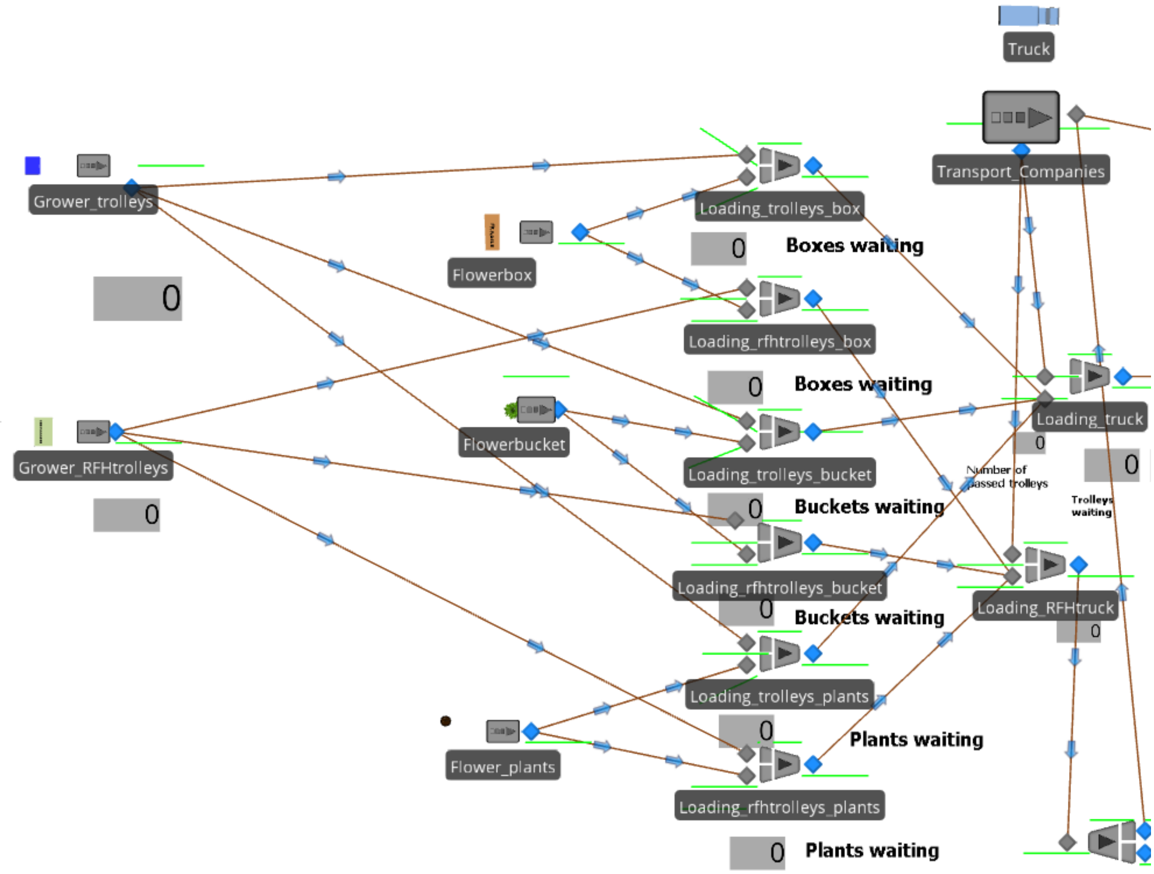

Figure F.4: Simio Grower Part

F.2. Consolidation

The consolidation process, as shown in Figure F.5, starts with the unloading of trucks. In reality, during the consolidation process, the mixes of bouquets, their sleeves, ribbons or other packaging is changed. However, in this model this process is simplified and only shows the unloading and loading of the trolleys with a specific processing time. Again, when enough trolleys are waiting to be transported to the ferry to fill an entire truck, a truck is called upon. The trucks only carry one type of flower, a mixed truck load is not possible.

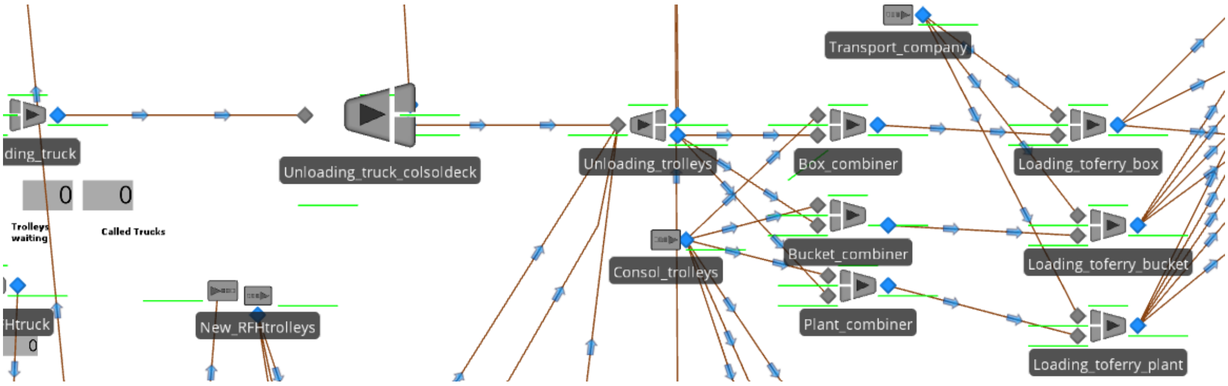

Figure F.5: Simio Consolidation Part

F.3. Auction

Some of the flowers are not presold and must therefore be auctioned off at the RFH auction. In reality, this process is also more complex, but this model only shows the most important parts of this process. It starts with the unloading of the trucks and unloading of the trolleys. Based on the orders of customers of the auction, the goods are picked by RFH employees. If the customer decides to consolidate in their own box or a rented box, the picked order follows the route as showed in Figure F.5. If the customer chooses to let RFH take over their consolidation process, the picked order follows the route as shown in Figure F.6. Again, when enough trolleys are waiting to be transported to the ferry to fill an entire truck, a truck is called upon. The trucks only carry one type of flower, a mixed load is not possible.

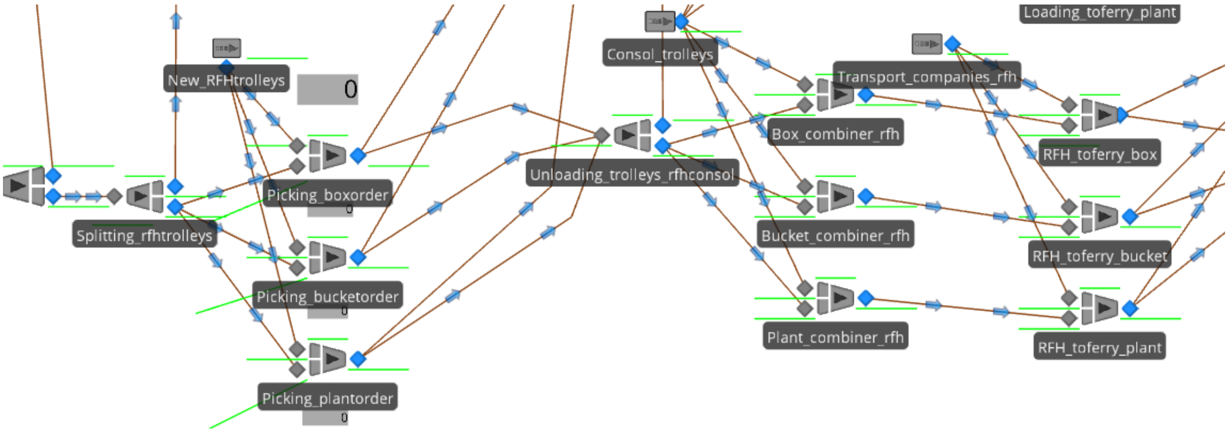

Figure F.6: Simio Auction Part

F.4. Modi Operandi

The four different modi operandi as stated in Chapter 4 are assigned to the trucks in this part of the model. In reality this does not happen at one specific place or time in the system, but, for modelling purposes, the choice was made to add the modi operandi at this specific moment in the system. Based on the type of flower, some MOs are more likely to happen than others, which can also be read in Chapter 4. For instance, for boxes the complex consolidation MO is not likely, as it is very hard to alter boxes without notice. For this type of flowers, interviews also showed that the grower MO is not very likely. Figure F.7 shows which MOs are possible, based on the different flower types, with the different links. It is assumed that the RFH consolidation is clean, so the MO consolidation and the MO complex consolidation is not possible for flowers that are consolidated by RFH. Also, because the destination of the flowers is unknown, it is assumed that the grower does not alter the flowers. So the grower MO is also not possible from RFH consolidation. The paths of the flowers, so the choice of MO option, are chosen based on percentages.

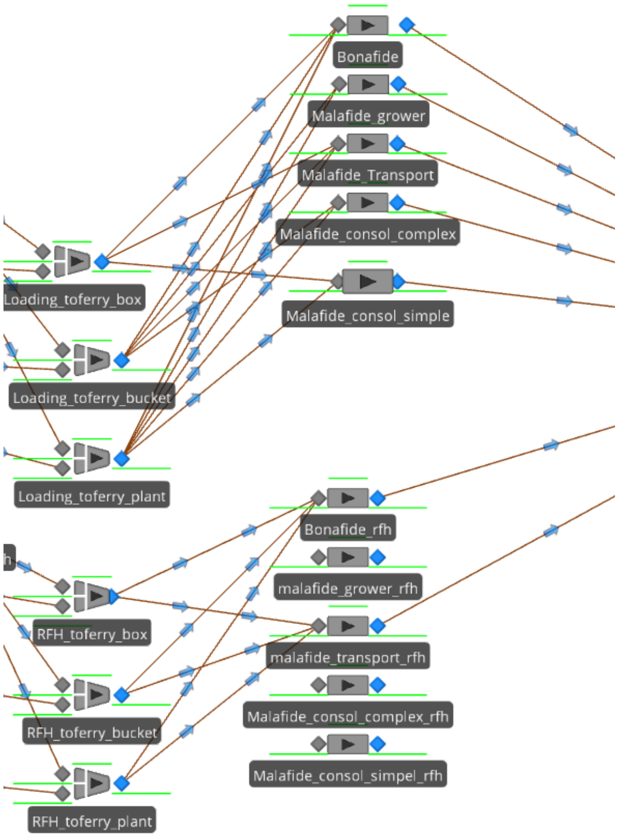

Figure F.7: Simio MO Part

Figure F.8 shows this process. The different nodes are the different MO options and the decide options are chances. For every flower type the odds for the different MOs are different, as explained in Chapter 4.

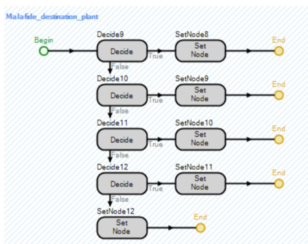

Figure F.8: Simio process MO

F.5. Intervention methods

After the MOs have been assigned to the trucks, the entities enter the final station of the model, namely the intervention part. This part can be seen in Figure F.9 and consists of 4 checkpoints:

- Check likeliness based on AEO
- Dog effectiveness
- Scan effectiveness
- Physical check effectiveness

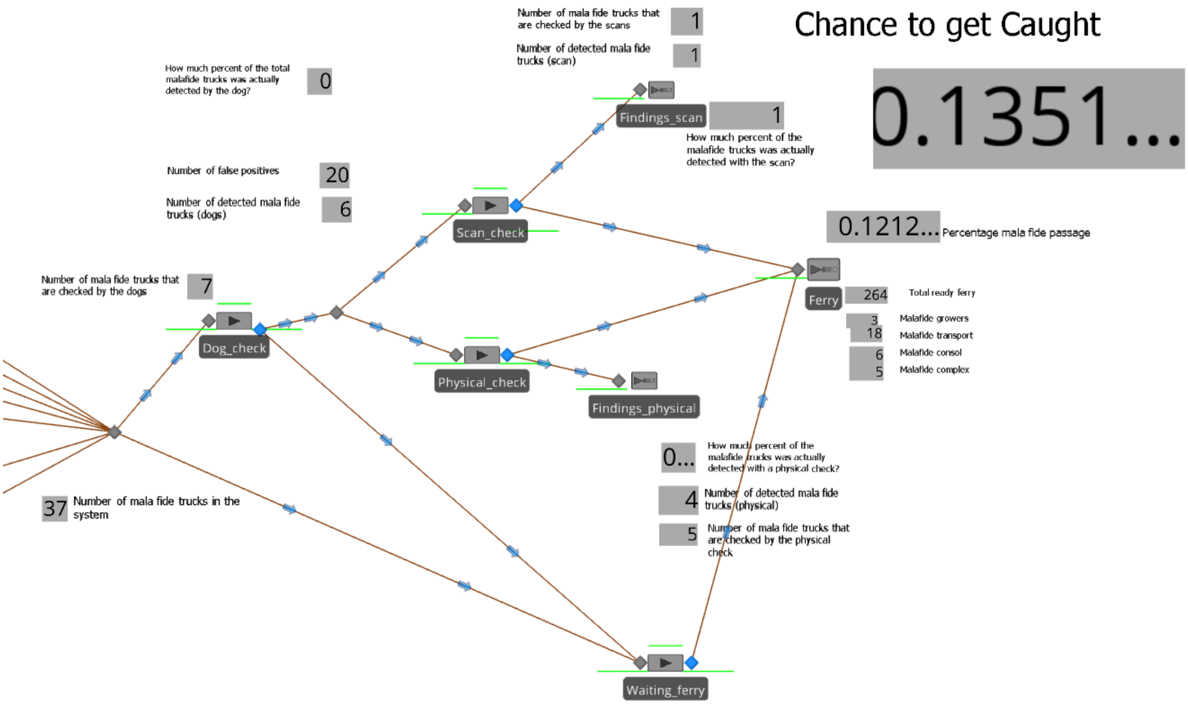

Figure F.9: Simio Intervention Part

The first checkpoint, check likeliness based on AEO starts with checking the status of the truck. If the truck has an AEO status, the chance to be checked is smaller than when the truck does not have this status. The process for these chances can be found in Figure F.10. After this check, the trucks are send to either the ferry or to the dog check.

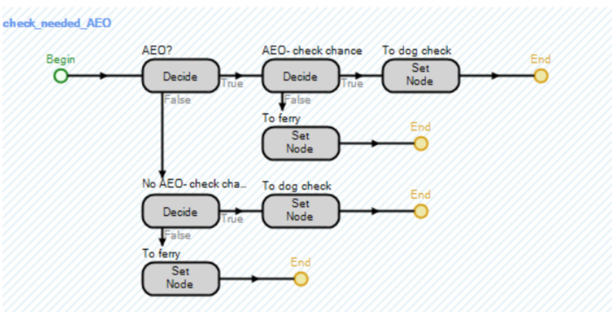

Figure F.10: Simio check AEO

When trucks enter the dog check, a general check by detection dogs is performed. Based on the type of MO, there is a chance that the dog detects illegal goods, also known as the effectiveness of the intervention method. When the truck is not mala fide, there is a chance the dogs will still give a positive reaction, also known as a false positive. After the dog check, the trucks either go to the second check or they are considered clean and continue to the ferry. This process can be seen in Figure F.11. If the truck

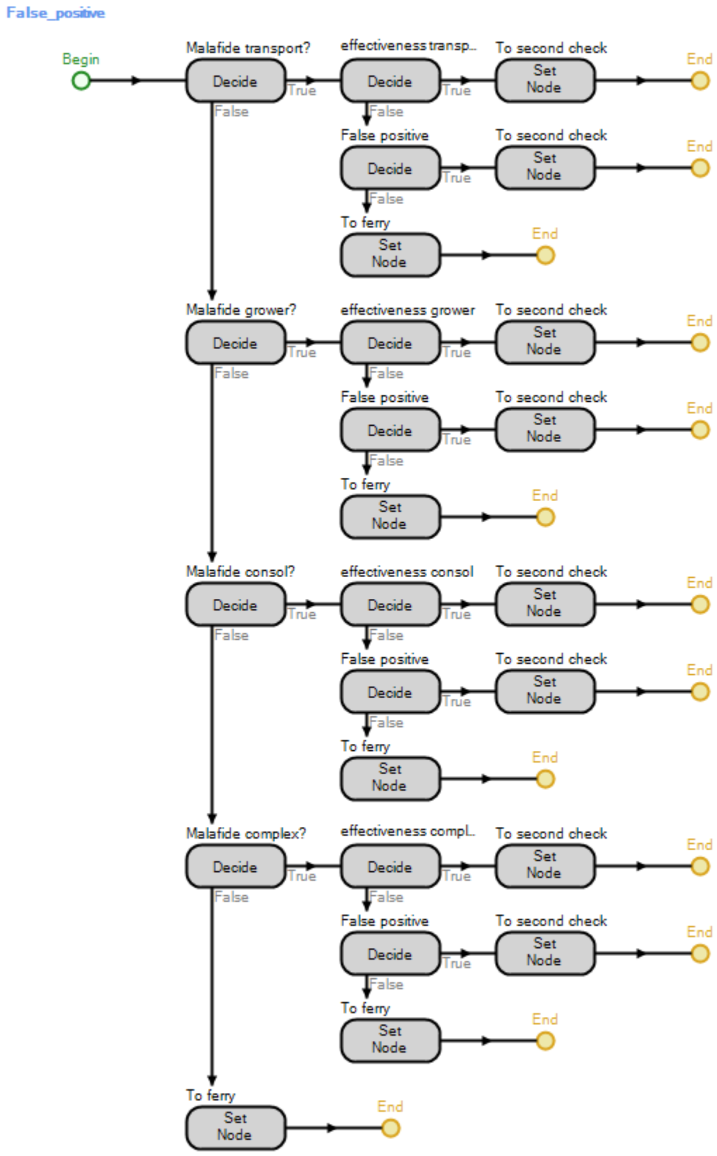

Figure F.11: Simio Dog check

is destined to be checked again, the availability of the scan has to be checked. Only when the scan check is not in use, will the truck be send to that checkpoint. If the scan is in use, the truck that has to be checked will be send to the physical checkpoint. Figure F.12 shows this process. The chances for the scan and the physical check to actually detect illegal goods also depend on the type of MO and the effectiveness of the specific intervention method on the MOs. The process is similar to the process of the dog check in Figure F.11, but without the false positives and with different percentages.

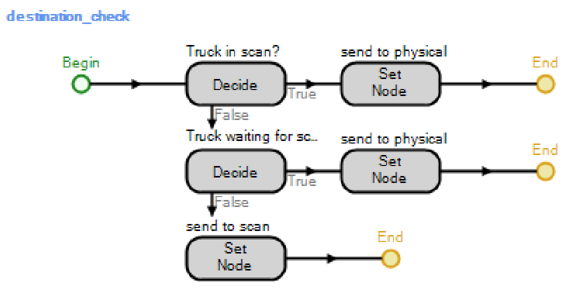

Figure F.12: Simio scan availability

When goods are detected during the second check they are kept seperate from the trucks that are destined for the ferry. On Figure F.9 this is shown with the variables scan findings and physical findings. Based on what is checked by the dog, detected by the scan and the physical check and the mala fide trucks that make it to the ferry, 5 key performance indicators (KPIs) have been fabricated.

- Dog check effectiveness, the percentage of trucks that was actually detected by the dog. This is calculated by dividing the number mala fide of trucks that is forwarded to the second check with the number of mala fide trucks that entered the dog checkpoint in the first place.
- Scan check effectiveness, the percentage of trucks that was actually detected by the scan. This is calculated by dividing the number of mala fide trucks that are detected by the scan with the number of mala fide trucks that enter the checkpoint in the first place.
- Physical check effectiveness, the percentage of trucks that was actually detected by the physical check. This is calculated by dividing the number of mala fide trucks that are detected by the physical check with the number of mala fide trucks that enter the checkpoint in the first place.
- Percentage of mala fide passage, the percentage of trucks at the ferry that is actually mala fide.
- Chance to get caught, the percentage of mala fide trucks that was detected by the different checks as part of the total number of mala fide trucks in the system.

G

Appendix G: Results

This chapter shows the results of the independent test in SPSS of the different scenarios.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	6,059	,016	1,210	98	,229	,0399682540	,0330436133	-,025605721	,1055422291
	Equal variances not assumed			1,210	65,512	,231	,0399682540	,0330436133	-,026014622	,1059511301
KPI_scancheck_eff	Equal variances assumed	7,631	,007	1,708	98	,091	,1650000000	,0966047773	-,026709036	,3567090365
	Equal variances not assumed			1,708	97,424	,091	,1650000000	,0966047773	-,026723201	,3567232010
KPI_physicalcheck_eff	Equal variances assumed	23,436	,000	1,461	98	,147	,0841269841	,0575740904	-,030126924	,1983808927
	Equal variances not assumed			1,461	71,707	,148	,0841269841	,0575740904	-,030652893	,1989068614
KPI_passage_malafide	Equal variances assumed	11,632	,001	23,870	98	,000	,0677100533	,0028366424	,0620808288	,0733392777
	Equal variances not assumed			23,870	85,265	,000	,0677100533	,0028366424	,0620703012	,0733498053
KPI_Chance_caught	Equal variances assumed	20,048	,000	-2,247	98	,027	-,026776816	,0119150034	-,050421752	-,003131879
	Equal variances not assumed			-2,247	70,679	,028	-,026776816	,0119150034	-,050536528	-,003017104

Figure G.1: Independent sample t-test Base case and Scenario 2

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	,138	,711	1,762	98	,081	,0290327976	,0164765557	-,003664391	,0617299862
	Equal variances not assumed			1,762	94,597	,081	,0290327976	,0164765557	-,003679100	,0617446954
KPI_scancheck_eff	Equal variances assumed	7,676	,007	-1,406	98	,163	-,120000000	,0853364689	-,289347445	,0493474452
	Equal variances not assumed			-1,406	94,824	,163	-,120000000	,0853364689	-,289418355	,0494183554
KPI_physicalcheck_eff	Equal variances assumed	4,563	,035	,006	98	,995	,0002050890	,0320940936	-,063484595	,0638947732
	Equal variances not assumed			,006	91,368	,995	,0002050890	,0320940936	-,063542426	,0639526039
KPI_passage_malafide	Equal variances assumed	1,912	,170	-15,253	98	,000	-,061203051	,0040124721	-,069165671	-,053240430
	Equal variances not assumed			-15,253	89,556	,000	-,061203051	,0040124721	-,069175065	-,053231036
KPI_Chance_caught	Equal variances assumed	,311	,579	-1,715	98	,089	-,011950370	,0069675942	-,025777334	,0018765934
	Equal variances not assumed			-1,715	96,908	,090	-,011950370	,0069675942	-,025779283	,0018785418

Figure G.2: Independent sample t-test Base case and Scenario 3

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	,152	,698	,028	98	,978	,0004511600	,0163851221	-,032064582	,0329669014
	Equal variances not assumed			,028	94,122	,978	,0004511600	,0163851221	-,032081336	,0329836557
KPI_scancheck_eff	Equal variances assumed	1,515	,221	-,727	98	,469	-,065000000	,0894075359	-,242426345	,1124263453
	Equal variances not assumed			-,727	97,412	,469	-,065000000	,0894075359	-,242439741	,1124397407
KPI_physicalcheck_eff	Equal variances assumed	,002	,963	-1,842	98	,069	-,063388889	,0344172288	-,131688759	,0049109815
	Equal variances not assumed			-1,842	96,955	,069	-,063388889	,0344172288	-,131697964	,0049201858
KPI_passage_malafide	Equal variances assumed	,459	,500	,132	98	,895	,0004362270	,0033115849	-,006135506	,0070079595
	Equal variances not assumed			,132	97,971	,895	,0004362270	,0033115849	-,006135530	,0070079841
KPI_Chance_caught	Equal variances assumed	,006	,940	-,222	98	,825	-,001707946	,0076888172	-,016966153	,0135502616
	Equal variances not assumed			-,222	97,184	,825	-,001707946	,0076888172	-,016967754	,0135518624

Figure G.3: Independent sample t-test Base case and Scenario 4

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	,157	,693	,330	98	,742	,0053645799	,0162335484	-,026850369	,0375795284
	Equal variances not assumed			,330	93,255	,742	,0053645799	,0162335484	-,026870867	,0376000264
KPI_scancheck_eff	Equal variances assumed	16,034	,000	-2,063	98	,042	-,168333333	,0815888842	-,330243819	-,006422848
	Equal variances not assumed			-2,063	90,195	,042	-,168333333	,0815888842	-,330419122	-,006247545
KPI_physicalcheck_eff	Equal variances assumed	,511	,476	-2,127	98	,036	-,070968254	,0333623683	-,137174788	-,004761720
	Equal variances not assumed			-2,127	95,096	,036	-,070968254	,0333623683	-,137200063	-,004736445
KPI_passage_malafide	Equal variances assumed	5,079	,026	1,166	98	,246	,0035989494	,0030865644	-,002526237	,0097241361
	Equal variances not assumed			1,166	95,215	,247	,0035989494	,0030865644	-,002528478	,0097263763
KPI_Chance_caught	Equal variances assumed	,061	,806	-3,129	98	,002	-,022965099	,0073398323	-,037530758	-,008399441
	Equal variances not assumed			-3,129	97,999	,002	-,022965099	,0073398323	-,037530760	-,008399439

Figure G.4: Independent sample t-test Base case and Scenario 5

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	6,351	,013	,100	98	,921	,0014360071	,0144080512	-,027156301	,0300283157
	Equal variances not assumed			,100	74,872	,921	,0014360071	,0144080512	-,027267108	,0301391225
KPI_scancheck_eff	Equal variances assumed	69,908	,000	-3,032	98	,003	-,217500000	,0717430577	-,359871763	-,075128237
	Equal variances not assumed			-3,032	67,402	,003	-,217500000	,0717430577	-,360684032	-,074315968
KPI_physicalcheck_eff	Equal variances assumed	5,795	,018	-,479	98	,633	-,014965391	,0312657200	-,077011195	,0470804130
	Equal variances not assumed			-,479	87,975	,633	-,014965391	,0312657200	-,077099688	,0471689059
KPI_passage_malafide	Equal variances assumed	,764	,384	5,893	98	,000	,0186948162	,0031722841	,0123995217	,0249901107
	Equal variances not assumed			5,893	96,858	,000	,0186948162	,0031722841	,0123985935	,0249910388
KPI_Chance_caught	Equal variances assumed	7,842	,006	-13,995	98	,000	-,128720741	,0091978982	-,146973671	-,110467812
	Equal variances not assumed			-13,995	86,466	,000	-,128720741	,0091978982	-,147004153	-,110437329

Figure G.5: Independent sample t-test Base case and Scenario 6

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	,867	,354	,333	98	,740	,0086349206	,0259009772	-,042764726	,0600345669
	Equal variances not assumed			,333	77,231	,740	,0086349206	,0259009772	-,042938051	,0602078925
KPI_scancheck_eff	Equal variances assumed	,909	,343	1,344	98	,182	,1266666667	,0942760938	-,060421173	,3137545065
	Equal variances not assumed			1,344	97,908	,182	,1266666667	,0942760938	-,060423380	,3137567129
KPI_physicalcheck_eff	Equal variances assumed	11,405	,001	,926	98	,357	,0493174603	,0532648739	-,056384948	,1550198690
	Equal variances not assumed			,926	75,930	,357	,0493174603	,0532648739	-,056770319	,1554052396
KPI_passage_malafide	Equal variances assumed	,453	,503	-1,522	98	,131	-,004955916	,0032572058	-,011419735	,0015079032
	Equal variances not assumed			-1,522	97,740	,131	-,004955916	,0032572058	-,011419949	,0015081179
KPI_Chance_caught	Equal variances assumed	3,970	,049	6,819	98	,000	,0436671726	,0064035214	,0309595929	,0563747524
	Equal variances not assumed			6,819	89,426	,000	,0436671726	,0064035214	,0309443477	,0563899976

Figure G.6: Independent sample t-test Base case and Scenario 7

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	,167	,684	1,618	98	,109	,0268706734	,0166024481	-,006076344	,0598176913
	Equal variances not assumed			1,618	95,194	,109	,0268706734	,0166024481	-,006088489	,0598298360
KPI_scancheck_eff	Equal variances assumed	24,068	,000	-2,460	98	,016	-,195000000	,0792771338	-,352322892	-,037677108
	Equal variances not assumed			-2,460	86,157	,016	-,195000000	,0792771338	-,352593621	-,037406379
KPI_physicalcheck_eff	Equal variances assumed	1,241	,268	,501	98	,618	,0169203574	,0337891077	-,050133027	,0839737420
	Equal variances not assumed			,501	95,975	,618	,0169203574	,0337891077	-,050150713	,0839914281
KPI_passage_malafide	Equal variances assumed	1,981	,162	3,036	98	,003	,0096300205	,0031719006	,0033354871	,0159245540
	Equal variances not assumed			3,036	96,852	,003	,0096300205	,0031719006	,0033345545	,0159254866
KPI_Chance_caught	Equal variances assumed	8,233	,005	-5,792	98	,000	-,052451979	,0090561788	-,070423671	-,034480287
	Equal variances not assumed			-5,792	87,565	,000	-,052451979	,0090561788	-,070450478	-,034453479

Figure G.7: Independent sample t-test Base case and Scenario 8

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	2,705	,103	-,672	98	,503	-,010551524	,0157089925	-,041725508	,0206224606
	Equal variances not assumed			-,672	89,470	,504	-,010551524	,0157089925	-,041762699	,0206596519
KPI_scancheck_eff	Equal variances assumed	7,275	,008	-1,300	98	,197	-,111000000	,0853973107	-,280468184	,0584681839
	Equal variances not assumed			-1,300	94,881	,197	-,111000000	,0853973107	-,280537843	,0585378433
KPI_physicalcheck_eff	Equal variances assumed	9,730	,002	-4,685	98	,000	-,140601010	,0300135908	-,200162004	-,081040016
	Equal variances not assumed			-4,685	81,405	,000	-,140601010	,0300135908	-,200314137	-,080887883
KPI_passage_malafide	Equal variances assumed	5,688	,019	2,483	98	,015	,0073578364	,0029635810	,0014767064	,0132389664
	Equal variances not assumed			2,483	91,330	,015	,0073578364	,0029635810	,0014713335	,0132443393
KPI_Chance_caught	Equal variances assumed	,027	,870	-3,595	98	,001	-,027085198	,0075341607	-,042036494	-,012133901
	Equal variances not assumed			-3,595	97,716	,001	-,027085198	,0075341607	-,042037038	-,012133357

Figure G.8: Independent sample t-test Base case and Scenario 9

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	4,478	,037	3,052	98	,003	,0593650794	,0194510256	,0207651520	,0979650067
	Equal variances not assumed			3,052	95,945	,003	,0593650794	,0194510256	,0207548154	,0979753433
KPI_scancheck_eff	Equal variances assumed	,143	,706	,502	98	,617	,0466666667	,0929974520	-,137883750	,2312170835
	Equal variances not assumed			,502	97,999	,617	,0466666667	,0929974520	-,137883785	,2312171182
KPI_physicalcheck_eff	Equal variances assumed	,124	,726	3,404	98	,001	,1339682540	,0393575711	,0558644350	,2120720729
	Equal variances not assumed			3,404	95,675	,001	,1339682540	,0393575711	,0558407045	,2120958035
KPI_passage_malafide	Equal variances assumed	3,564	,062	,975	98	,332	,0029693922	,0030457036	-,003074707	,0090134919
	Equal variances not assumed			,975	94,134	,332	,0029693922	,0030457036	-,003077812	,0090165962
KPI_Chance_caught	Equal variances assumed	,004	,951	1,848	98	,068	,0138138746	,0074767898	-,001023571	,0286513207
	Equal variances not assumed			1,848	97,848	,068	,0138138746	,0074767898	-,001023859	,0286516081

Figure G.9: Independent sample t-test Base case and Scenario 10

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	,000	1,000	,000	98	1,000	,0000000000	,0179713603	-,035663580	,0356635796
	Equal variances not assumed			,000	98,000	1,000	,0000000000	,0179713603	-,035663580	,0356635796
KPI_scancheck_eff	Equal variances assumed	,000	1,000	,000	98	1,000	,0000000000	,0928168411	-,184192000	,1841920003
	Equal variances not assumed			,000	98,000	1,000	,0000000000	,0928168411	-,184192000	,1841920003
KPI_physicalcheck_eff	Equal variances assumed	,000	1,000	,000	98	1,000	,0000000000	,0361598971	-,071758139	,0717581389
	Equal variances not assumed			,000	98,000	1,000	,0000000000	,0361598971	-,071758139	,0717581389
KPI_passage_malafide	Equal variances assumed	,000	1,000	,000	98	1,000	,0000000000	,0033401036	-,006628327	,0066283269
	Equal variances not assumed			,000	98,000	1,000	,0000000000	,0033401036	-,006628327	,0066283269
KPI_Chance_caught	Equal variances assumed	,000	1,000	,000	98	1,000	,0000000000	,0073281497	-,014542475	,0145424745
	Equal variances not assumed			,000	98,000	1,000	,0000000000	,0073281497	-,014542475	,0145424745

Figure G.10: Independent sample t-test Base case and Scenario 11

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	,405	,526	,461	98	,646	,0084126984	,0182351036	-,027774271	,0445996680
	Equal variances not assumed			,461	97,919	,646	,0084126984	,0182351036	-,027774644	,0446000410
KPI_scancheck_eff	Equal variances assumed	,116	,734	-,217	98	,828	-,020000000	,0920662287	-,202702435	,1627024346
	Equal variances not assumed			-,217	97,974	,828	-,020000000	,0920662287	-,202703047	,1627030467
KPI_physicalcheck_eff	Equal variances assumed	,139	,710	-,017	98	,986	-,000666667	,0388891909	-,077841000	,0765076670
	Equal variances not assumed			-,017	96,235	,986	-,000666667	,0388891909	-,077858697	,0765253641
KPI_passage_malafide	Equal variances assumed	,001	,979	,215	98	,830	,0007206452	,0033562384	-,005939701	,0073809911
	Equal variances not assumed			,215	97,991	,830	,0007206452	,0033562384	-,005939708	,0073809987
KPI_Chance_caught	Equal variances assumed	,000	,986	-,181	98	,857	-,001322958	,0073072857	-,015824028	,0131781130
	Equal variances not assumed			-,181	97,997	,857	-,001322958	,0073072857	-,015824034	,0131781189

Figure G.11: Independent sample t-test Base case and Scenario 12

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	,552	,459	,293	98	,770	,0076428571	,0260624084	-,044077144	,0593628584
	Equal variances not assumed			,293	76,855	,770	,0076428571	,0260624084	-,044255586	,0595412999
KPI_scancheck_eff	Equal variances assumed	4,501	,036	,885	98	,378	,0850000000	,0960114435	-,105531585	,2755315848
	Equal variances not assumed			,885	97,582	,378	,0850000000	,0960114435	-,105541783	,2755417830
KPI_physicalcheck_eff	Equal variances assumed	,537	,466	-2,137	98	,035	-,089111111	,0416968515	-,171857156	-,006365066
	Equal variances not assumed			-2,137	92,324	,035	-,089111111	,0416968515	-,171920784	-,006301438
KPI_passage_malafide	Equal variances assumed	4,396	,039	21,392	98	,000	,0649837920	,0030376950	,0589555851	,0710119989
	Equal variances not assumed			21,392	93,898	,000	,0649837920	,0030376950	,0589522918	,0710152921
KPI_Chance_caught	Equal variances assumed	9,755	,002	-4,322	98	,000	-,043545629	,0100748482	-,063538838	-,023552421
	Equal variances not assumed			-4,322	80,211	,000	-,043545629	,0100748482	-,063594407	-,023496852

Figure G.12: Independent sample t-test Base case and Scenario 13

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	7,919	,006	1,579	98	,118	,0335396825	,0212378165	-,008606073	,0756854381
	Equal variances not assumed			1,579	90,688	,118	,0335396825	,0212378165	-,008648587	,0757279517
KPI_scancheck_eff	Equal variances assumed	,552	,459	,604	98	,547	,0566666667	,0937805128	-,129437709	,2427710422
	Equal variances not assumed			,604	97,959	,547	,0566666667	,0937805128	-,129438681	,2427720146
KPI_physicalcheck_eff	Equal variances assumed	23,157	,000	1,237	98	,219	,0700317460	,0565931038	-,042275427	,1823389187
	Equal variances not assumed			1,237	72,584	,220	,0700317460	,0565931038	-,042769049	,1828325406
KPI_passage_malafide	Equal variances assumed	6,520	,012	22,349	98	,000	,0659966204	,0029529564	,0601365745	,0718566662
	Equal variances not assumed			22,349	90,904	,000	,0659966204	,0029529564	,0601308516	,0718623891
KPI_Chance_caught	Equal variances assumed	18,715	,000	-1,227	98	,223	-,013419261	,0109325614	-,035114573	,0082760512
	Equal variances not assumed			-1,227	75,196	,223	-,013419261	,0109325614	-,035197110	,0083585876

Figure G.13: Independent sample t-test Base case and Scenario 14

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	10,975	,001	1,722	98	,088	,0664444444	,0385805285	-,010117359	,1430062475
	Equal variances not assumed			1,722	60,752	,090	,0664444444	,0385805285	-,010708460	,1435973488
KPI_scancheck_eff	Equal variances assumed	2,448	,121	,805	98	,423	,0766666667	,0952630920	-,112379839	,2657131723
	Equal variances not assumed			,805	97,749	,423	,0766666667	,0952630920	-,112385912	,2657192456
KPI_physicalcheck_eff	Equal variances assumed	21,743	,000	1,620	98	,109	,0943174603	,0582371890	-,021252346	,2098872665
	Equal variances not assumed			1,620	71,139	,110	,0943174603	,0582371890	-,021800255	,2104351760
KPI_passage_malafide	Equal variances assumed	12,706	,001	22,396	98	,000	,0633598579	,0028290782	,0577456444	,0689740715
	Equal variances not assumed			22,396	84,837	,000	,0633598579	,0028290782	,0577347368	,0689849790
KPI_Chance_caught	Equal variances assumed	12,690	,001	,163	98	,871	,0016070636	,0098488763	-,017937711	,0211518382
	Equal variances not assumed			,163	81,718	,871	,0016070636	,0098488763	-,017986502	,0212006296

Figure G.14: Independent sample t-test Base case and Scenario 15

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KPI_dogcheck_eff	Equal variances assumed	,565	,454	1,200	98	,233	,0193857925	,0161494707	-,012662306	,0514338914
	Equal variances not assumed			1,200	92,732	,233	,0193857925	,0161494707	-,012685079	,0514566639
KPI_scancheck_eff	Equal variances assumed	18,460	,000	-2,134	98	,035	-,172666667	,0809145009	-,333238860	-,012094473
	Equal variances not assumed			-2,134	89,111	,036	-,172666667	,0809145009	-,333439294	-,011894039
KPI_physicalcheck_eff	Equal variances assumed	3,074	,083	-,046	98	,963	-,001493353	,0321504239	-,065294823	,0623081168
	Equal variances not assumed			-,046	91,571	,963	-,001493353	,0321504239	-,065350858	,0623641519
KPI_passage_malafide	Equal variances assumed	,097	,757	-16,978	98	,000	-,060835213	,0035831199	-,067945798	-,053724628
	Equal variances not assumed			-16,978	96,345	,000	-,060835213	,0035831199	-,067947324	-,053723102
KPI_Chance_caught	Equal variances assumed	,430	,514	-2,846	98	,005	-,019947286	,0070095939	-,033857597	-,006036976
	Equal variances not assumed			-2,846	97,160	,005	-,019947286	,0070095939	-,033859100	-,006035473

Figure G.15: Independent sample t-test Base case and Scenario 16