Trade and custom risks in a global supply chain

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TRADE AND CUSTOMS RISKS IN A GLOBAL SUPPLY CHAIN

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For reasons of confidentiality, all references to companies, and some of the results in this thesis are anonymized.

ABSTRACT

This thesis describes the results of a Master thesis project conducted at an international technology company. This company has to ship regularly a wide range of products across international borders, while assuring compliance with an extensive framework of regulatory obligations. To control and monitor the fulfillment of customs requirements and to measure control objectives, the company established control management frameworks in each global area. These local frameworks ensure compliance with all applicable trade and customs compliance laws and security regulations. However, in the near future one aspires to merge existing local control frameworks into to one global integrated control framework.

This Master thesis sets out to investigate, assess and prioritize the various potential trade and customs risks on a global scale. First, a risk workshop is conducted to identify the risks in several supply chain areas. Consecutively, by means of a risk assessment survey, stakeholders could score these adverse events on likelihood and compliance impact, resulting in a prioritization of the global trade and customs risks. Furthermore, one high prioritized risk 'Inadequate Customs Master Data Governance' is analyzed and assessed on financial impact, to obtain a thorough understanding of the possible risk exposure. The research focused on HS code classification, as changing these codes may result into a financial impact on customs duties. A model has been developed, incorporating two goods flows: imports into EU, and imports into EU via a bonded warehouse. The model calculates and provides insights into the effects of HS code alterations on import duty payments.

PREFACE

This report is the final result of my master thesis project marks the end of my master in Operations Management and Logistics. But primarily, it marks the end of my student-life. I am thankful for everything I learned during this period and I would like to express my gratitude to all who have helped me to reach this point in life.

First of all, I would like to thank my supervisor at TU/e, Albert Veenstra. I am thankful for all his advises and new insights, and his available time to answer all my questions. His guidance helped me to successfully finish this project. Furthermore, I would like to thank Zümbül Atan for her valuable input and remarks on my thesis.

Secondly, I would like to thank my two supervisors from the technology company. I want to thank my first supervisor for sharing his expertise, his valuable input during our meetings and for all his efforts and feedback. Moreover, thanks to my second supervisor, his always honest remarks helped me to improve my thesis.

I would also like to thank my colleagues for their involvement their kindness to answer all my questions. Besides I enjoyed our many coffee breaks and lunches. Next to my thesis I could participate in a project, which was very interesting and I learned a lot. I wish you all the best for the remainder of this project.

Furthermore, I would like to thank you, mum, dad and Martijn for your unconditional support, not only during this project, but during my whole life. Because of your best efforts I have been able to do everything I wanted to do. Thank you for everything. Next to them, a special thanks goes to Paulo. Paulo, I am very grateful that you choose the Netherlands as your new home so we could be together. Thank you for your endless support and encouragements throughout the last years and especially during the project. I am curious to know what the next phase in live will bring us.

Nienke

EXECUTIVE SUMMARY

This research is conducted at technology company X. On a daily basis, the company has to ship many goods across international borders, while being compliant with an extensive framework of regulatory objectives. To control and monitor the fulfillment of customs requirements and to measure control obligations, Company X established control management frameworks in each global area. These local frameworks ensure compliance with all applicable trade and customs compliance laws and security regulations. In the near future this company endeavors to merge these local frameworks into to one global integrated control framework.

This research project will focus on the initial steps of the risk management process, namely identification and measurement of potential risk events. The first part of the research entails an in-depth examination of the numerous trade and customs risks in a global setting, and consequently an investigation of their possible adverse impact. Prioritizing the global risks for which relevant mitigating controls should be implemented will be the starting point the control framework.

The second part of this project will assess one specific trade and customs risk on financial impact, namely '*Inadequate Customs Master Data Governance'*. We will limit our research to the product classification information. More specifically, we will focus on the Harmonized System classification (HS codes) of a product, which is an internationally standardized system of names and numbers to classify traded products, and is the determinant of corresponding import taxes. Due to the complexity of Company X's products and their ongoing development and improvement, HS classification of a product can be modified overtime. Changing these codes may result into a financial impact on customs duty payments. Company X would like to get more insight in the quantitative effect of altering HS codes on the customs duty payments. The objective is to provide an examination of the impact of HS code changes on duty payments.

To address the problem the following research question was formulated:

What are potential trade and customs risks in a global supply chain and how to assess their impact?

This study presented a two segmented approach to identify and prioritize possible customs risks. The first part focused on mapping the risks, by means of a risk workshop. Internal customs experts distinguished potential risks. The outcomes were examined using current local risk frameworks, Customs and Trade facilities and interviews with internal stakeholders. This resulted in 48 possible risks in 7 categories: inbound, outbound, warehouse, production, transport, infrastructure, and export control. The stakeholders in the workshop selected multiple potential customs risks, and consolidated together a first risk matrix, containing 10 important trade and customs risks.

The second part entailed the risk measurement phase. To prioritize the risks an assessment survey was conducted, which was a solid approach to reach numerous stakeholders in the different geographically regions. Internal stakeholders were asked to assess the inherent risk events on predefined impact and likelihood scales. The final data sample consisted of questionnaires of 24 respondents. The outcomes were used to generate a second global risk matrix, containing 15 key

risks. 7 risks selected in the assessment survey were also selected during the workshop and 8 risks were selected only in the survey, see the table below. Deeper analysis illustrated that some of these 8 risks could be aggregated and combined with the other 3 risks flagged in the workshop,

Risk assessment survey & Risk workshop		**Risk assessment survey & Risk workshop**		**Risk workshop**	
Risk	**Risk name**	**Risk**	**Risk name**	**Risk**	**Risk name**
IB-1	Incorrect import declaration	IF-6	Improper functioning of SAP/R3	WH-1	Incorrect (Bonded) Inventory
OB-1	Incorrect export declaration	G-2	Internal control procedures	IF -3	Unsecure IT Systems /Unauthorized Access and Changes
IF-4	Inadequate Customs Master Data Governance	PD-2	Unsecure and/ or unsafe factory	G-6	Wrong Filing/Record Retention (IB/OB)
G-5	Non regular Shipments (IB/OB)	IB-6	Local customs disagreements regarding declaration		
G-1	Irregularity of goods	IF-7	Improper functioning of SAP/GTS		
IF-5	Inadequate License Management	OB-4	Ship wrong quantity of goods		
PD-1	(Bonded) goods not properly processed in IPR	IF-2	Incompetent brokers		
		TR-5	Information invoice missing		

Table 1 Comparison risk assessment and risk workshop

With the available survey data at our disposal we could add significance to the global overview of customs risks. In conclusion, the outcomes of the survey supplemented the outcomes of the workshop and vice versa and the combination of the two methods provided a reliable and structured approach to analyze, identify and prioritize risk events on a global scale.

The second part of the current study included the analysis of the effects of altering HS codes. The study provided theoretical insights in the global classification system and in the process of a post clearance audit. Altering the HS code of a product results in three possible scenarios: (1) insufficient import duty payment for a particular material and is thereby case of post-clearance recovery of customs duties, (2) excessive duty payment for the particular material which Company X may drawback, or (3) there is no financial impact.

In this research, the CRISP-DM framework, a common tool for data mining, was used to provide a handrail setting up the model. By analyzing the business environment we distinguished two goods flows: direct import flows, and indirect import flows via bonded warehouses. We established a model for these two flows while applying the data analysis exclusively for imported goods in Europe. The data analysis for these two flows encompassed two datasets: a data sample from an internal accuracy check on Master Data in 2015 and a dataset of all HS code alterations in the first

quarter of 2016. The results show a change in tariff payments, implying that company X had to pay €X over these shipments. The difference in duty payment is therefore in total €X.

Our model can be used for Company X's classification processes. The model is programmed in R and is linked to Excel sheets from which the data values are imported. Many of these datasets can be easily changed. Classification experts can apply this model monthly or quarterly to get on an easy and automatic way an overview of which HS code alterations may entail a difference in duty tariff and hence see which shipments are subject to post clearance recovery. In addition, the model can be applied to simulate future HS code alterations i.e. the model can be used to analyze the expected financial effect of a change in HS code classification. Moreover, performing the data analysis on a periodical basis will provide Customs authorities factual evidence corroborating that duty payments are recalculated.

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LIST OF ABBREVIATIONS

AEO	Authorized Economic Operator
APAC	Asia, Pacific and Caribbean region
CBP	Customs and Border Patrol
C-TPAT	Customs-Trade Partnership Against Terrorism
CRISP- DM	Cross-Industry Standard Process for Data Mining
EC	Export control
EMEA	Europe, Middle East and Africa region
EU	European Union
GTS	Global Trade System
GRV	Governance Risk Compliance
HS	Harmonized System
IB	Inbound
IF	Infrastructure
KPI	Key Performance Indicator
OB	Outbound
PCA	Post Clearance Audit
SCRM	Supply Chain Risk Management
TR	Transport
US	United States of America
WH	Warehouse

LIST OF FIGURES

For reasons of confidentiality some figures in this thesis are excluded.

LIST OF TABLES

For reasons of confidentiality some tables in this thesis are excluded.

1. INTRODUCTION

The complex and dynamic business environment of today's economy set various compliance challenges for worldwide enterprises. 'Compliance' refers not only to comply with rules and regulations, but includes all activities supply chains perform to ensure correctness, continuity and effectiveness (Sadiq et al., 2007).

Any good or material that is ocean or air transported across borders becomes subject to customs supervision and controls. The border of a country represents symbolically a change in policies, procedures, rules and often cultures and ideologies. Due these local standards a supply chain with an international dimension faces various challenges concerning cross-border logistics and transportation, prior to reaching the final customer. As such, an organization moving goods across internal frontiers will face adversities and risks that are not experienced when movements are entirely within one country (Sadar & Lee, 2015; Higginson, 2013). Trade and customs risks are defined as adverse events imposed by violation of customs regulation controls. These events, when not properly handled, may lead to shipment delays, goods or document inspection at the border, penalties and fines, or even withdrawal of import and/or export licenses (Ernst & Young LLP, 2006). Inefficient management to comply with customs rules and control may lead therefore to increased inventory costs, delays at frontiers and loss in supply chain responsiveness. Accordingly, it is highly important to understand the numerous possible trade and customs risks and manage them efficiently in order to assure compliance and to reduce the possible negative consequences.

This report presents the results of a Master Thesis project, conducted at an international technology company, hereafter referred as company X. By means of risk management procedures potential trade and customs risks of a global supply chain are identified, assessed and prioritized.

The remainder of this chapter is organized as follows. Section 1.1 elaborates on the research design, including the problem statement, the research questions and research methodology

1.1 PROBLEM STATEMENT

Trade and customs compliance checking and enforcement are the act of establishing internal controls with which adherence to regulation is guaranteed. Trade and customs risk management is the ongoing process of identifying relevant regulations to cross border shipment: assessing the risk of not obeying the identified compliance requirements, creating effective internal controls to prevent and detect violations to compliance and maintain the effectiveness of these controls. To monitor the documenting and tracking of the fulfillment of customs requirements and to measure control objectives, control management frameworks should be established (Awad, 2010).

Company X has in each global area such a control management framework in place. The following global areas can be distinguished: 1) Europe Middle East and Africa (EMEA), 2) Asia, Pacific and Caribbean (APAC), and 3) the United States (U.S.). These local frameworks contain risk management strategies ensuring compliance with all applicable trade and customs compliance laws and security regulations. As a result, company X obtained in the highest Trade and Customs facilities in the world. Even though the local customs frameworks are considered effective and

sufficient, company X endeavors to merge these local entities into to one global integrated control framework. Via a uniform way of working, which refers to the execution of mitigating controls, company X strives to implement a worldwide aligned approach for the most important global trade and customs risks. This global control framework is based on risk management and performance management practices. With the introduction of this global control framework, company X aspires to obtain a more clear and objective perspective of their customs compliance level. Furthermore, the framework will provide factual evidence corroborating that key customs risks are sufficiently in control on a global scale.

The first part of the project aims to identify and examine potential trade and customs risk drivers on a global level and consequently to investigate their possible adverse impact. This will help prioritizing the most important global risks for which relevant mitigating controls should be implemented into the framework.

After identifying and prioritizing the trade and customs compliance risks, the study will highlight one particular risk, namely: '*Inadequate Customs Master Data Governance*'. Master Data is the core data that is essential to operations in a specific business or business unit. Specific for Company X's trade processes Customs Master Data contains, e.g. product classification and shipment data. The product classification information contains the following items; product description, country of origin, codes for export restriction and Harmonized System codes (HS codes). These latter HS codes are an internationally standardized system of names and numbers to classify traded products (WCOOMD, 2016). The close attention in this part of the project will be devoted to the HS classification of a product, being the determinant of corresponding import taxes.

Due to the complexity of Company X's products and their ongoing development and improvement, HS classification of a product can be modified overtime. A change in classification is generally caused by one of the following three reasons: (1) new insights or information regarding the product classification, (2) changed classification policies by trade and customs authorities and (3) correction of classification by the authorities. Although compliance with applicable classification legislation is the primary goal of Company X, one endeavors to attain deeper knowledge on the quantitative and financial consequences of HS code alterations, by means of a duty recalculations framework.

The central idea of the second part of this project is to assess one specific trade and customs risk on financial impact. In order to do so, we make use of the CRISP-DM framework, which is a standard and structured approach for empirical data analysis. Based on this methodology we investigate the financial impact of changing HS codes on the duty payment for various products.

1.1.2 RESEARCH QUESTIONS

Based on the problem statement the thesis is driven by the following research question:

What are potential trade and customs risks in a global supply chain and how to assess their impact?

The research assignment entails an in-depth examination of the numerous trade and customs risks in a global setting, which will be a good starting point for further development of the control framework. This research project will focus on the initial steps of the risk management process, namely identification and measurement of potential risk events. We identify the first three sub-questions, as follows:

1. How can existing methodologies be deployed to identify and prioritize trade and customs risks?
2. Are there similarities and differences in the perspective of risks within and between the regions (EMEA, APAC, US)?

After the possible global trade and customs risks have been fully identified and evaluated we will focus on the quantitative and financial assessment of the detected risks. More specifically, this part of the research aims to provide a structured approach to develop a duty payment calculation model, which will give insight into the financial consequences of a HS code change. We will quantify the impact, for data samples of two consecutive years (2015, 2016) and provide advice on how this framework can be imbedded into day to day business. The fourth and fifth sub-question can be described as follows:

3. What is the financial impact of HS code alterations?
4. How should Company X apply the model to analyze the influence of HS code changes on customs duty payments?

1.1.3 Research Methodology

This section focuses on the design of the research; a brief explanation is given on how this research is approached.

In order to identify the possible trade and customs risks the following steps are taken:

1. First, company documentation is gathered to analyze supply chain activities involving current customs compliance activities.
2. Organizing a workshop provides general understanding of the potential customs risks and obtained a first overview of highly important risks.
3. Additional analyses are carried out to compare the identified risks of the workshop and risks prescribed by authorities, using local risk matrices and customs compliance guidelines. These analyses provided us an extensive list of potential customs risks.

In order to prioritize these identified trade and customs risks, the risks are assessed on impact and probability of occurrence, by applying the following consecutive steps:

4. The probability of occurrence and impact parameters are defined.
5. An assessment survey is designed. Relevant internal stakeholders are asked to fill out a survey by scoring the risks on the previous defined scaling.
6. The results are analyzed and evaluated by relative importance and prioritized from most urgent to least urgent. Additional analyses are performed to examine the consistency of

ranking amongst the stakeholders, and the scores are compared with the first overview of the highly important risks provided by the workshop.
7. The fifteen most important risks are selected, to be implemented into the framework.

The following steps are used to design a mathematical framework, to give insight in the impact of HS code alterations on duties.

8. Desk research is performed generating a theoretical understanding of why a change in HS code entails a change in duty tariffs.
9. Desk research and internal interviews are performed to analyze in which goods flows products are subject to duty payment. Furthermore, the definition and impact of bonded warehouses are explained.
10. After acquiring the theoretical background, historical data is extracted out of several data sources.
11. In order to structure the data analysis, the CRISP-DM framework will be used, which is a standard approach for data mining projects. The data analysis is used to develop a model to recalculate duty payments. This data analysis is performed in programming language R.

1.4 THESIS OUTLINE

Now the research goals are defined, chapter 2 will elaborate on the scientific relevance. Chapter 3 will describe the risk identification procedure. Chapter 4 will elaborate upon the survey results and will provide an overview of the fifteen prioritized global customs risks. After, our focus will shift to the financial impact of Master Data alterations. Chapter 5 will first give a deeper theoretical analysis on how classification alterations may influence duty payment. Furthermore, chapter 5 will show the data analysis and will present the final model. Chapter 6 contains the conclusion and provides future research possibilities.

2 LITERATURE REVIEW

So far, this report has mostly discussed how the research will be carried. However, the aim of the research is to have both practical and scientific relevance. This section will give a summary of the earlier written literature review for this project. This research study gave an overview of the prior literature within the research domains: global supply chain, risk management, customs and compliance. The interrelations are visual presented in figure 2. This extensive summary will show where the research fits in and which research gaps it aims to address.

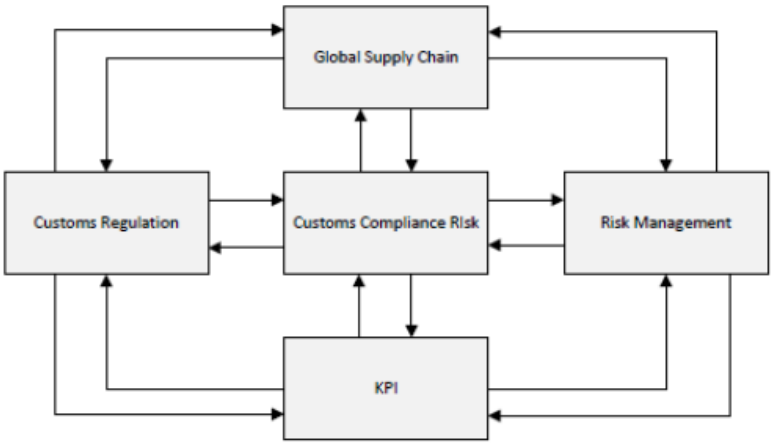

FIGURE 1 INTERRELATIONS RESEARCH DOMAIN

2.1 CUSTOMS COMPLIANCE

First, an in-depth analysis about customs and trade compliance issues within fragmented international supply chains was provided.

Compliance refers not only to comply with regulations and rules, but includes all activities supply chains perform to ensure correctness, continuity and effectiveness (Sadiq et al., 2007). Elgammal et al. (2010) emphasize on the importance of compliance due to the increasing regulatory pressure on companies to meet a variety of regulations. Large enterprises need to have consistent and automatic approaches for compliance management in place to handle the complexity and costs to comply within a framework of regulatory objectives (Elgammal et al., 2010). Globalization and the free market economy require shipping of goods across borders. Keeping up the service performance of a supply chain with an international dimension brings along challenges in customs compliance. Thus, customs compliance is about the fulfillment of all relevant obligations to streamline border crossing.

Driven by economic liberalization and technological developments supply chains become more complex and fragmented considering the decentralization of production, marketing and distribution activities worldwide (Sardar & Lee., 2015). Due to local trade procedures, policies, regulations and cultures, a supply chain that comprehends an international dimension faces several issues concerning cross-border logistics and transportation, prior to reaching the final customer. (Sardar & Lee, 2015; Higginson, 2013). One adversity is that the complex regularity systems and

rigorous business processes involve a much higher number of compliance risks in compare to a company dealing only with international business (Benchley, 2009). An extra component which increases the complexity of the global supply chain is the large quantity of partners involved (Sardar & Lee., 2015; TBG-International, 2007). The prime partners; importer and exporter (or buyer and supplier respectively) have the responsibility to fulfill all required customs formalities in order to ensure compliance regarding the cross border movements (Coyle et al., 2012). The importer-exporter relationship is often extended with third party logistics such as brokers and freight forwarders (Świerczek, 2014).

Customs, as an intermediary partner, has a vital role within the international supply chain. Any good or material that is shipped/ air freighted across border becomes subject to customs supervision and controls (Branch, 2009). Customs facilitates trade while executing and controlling multiple regulatory activities and maintaining control over all international movements of goods (Branch, 2009; Grainger, 2007; Lyons, 2001). Additionally, customs authorities can provide certificates like AEO and C-TPAT to trustful companies that meet required criteria (e.g. customs compliance, appropriate record-keeping, financial solvency, and appropriate security and safety standards) and which lead to customs simplifications and benefits for the company, namely: quality labels towards suppliers and customers, possible preferential treatment and reduction of physical and document-based controls for import and export and a better relationship with customs (CBP, 2004; European Commission 2006). A company must perform a self-assessment to determine whether it meets the criteria before it can qualify for the AEO status including collecting relevant information, identifying risks and identifying implementing mitigating risk strategies. An audit will verify if the company's self-assessment was valid and if all menaces are identified and have appropriate and operational measurements (European Commission 2007).

Inefficient management to comply with customs regulations however may produce border issues such as delays at frontiers or increased inventory costs and loss in supply chain responsiveness. Customs compliance risks are adverse events imposed by violating customs regulation, e.g. valuation, tariff classification, country of origin declaration and product marking and duty payments. These adverse events may lead companies in heavy penalty, shipment delay, product and document inspections and withdraw of the import/ export licenses. Not complying with customs regulations can be catastrophic and may result in customs restrictions, fines and loss of trade privileges (Ernst & Young LLP, 2006; Branch, 2009). Being not compliant may eventually result in logistic inefficiency in the international flow of goods, which might be counterproductive to business and even in the long run an important determinant of the volume of trade between countries (Hausman et al., 2006). These pitfalls need to be managed in order to assure compliance and reduce the negative consequences, which bring us to the second and third topic within this literature review: risk management and performance measurement.

2.2 RISK MANAGEMENT

Since there is lack of scientific sources specific to compliance risk management and especially to customs compliance management, this literature review discussed three well-known risk management theories; supply chain risk management (SCRM), enterprise risk management (ERM) and governance risk compliance (GVR).

SCRM attempts to manage uncertainties and disruptions in complicated and multi-actor involved supply networks. Based on available literature, Ho et al. (2015) defines supply chain risk as; 'the likelihood and impact of unexpected macro and/or micro level events or condition that adversely influence any part of a supply chain leading to operational, tactical or strategic level failures or irregularities'. Supply chain risks can be divided into macro (nature or man-made risks) and micro risks (manufacturing, information, supply and demand risks). Several researchers provide a definition for SCRM, emphasizing on collaboration with supply chain partners (Ho et al., 2015). Along these lines, for complicated multi-actor involved supply chains SCRM is a method to mitigate and avoid detrimental disruptions that hinder of event stop the flow of goods.

ERM is a nowadays a wide used strategy and its practices are still evolving (Oliva, 2015). One frequently used definition of ERM is provided by The Committee of Sponsoring Organization of the Tread Commission (COSO, 2004): 'a process effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and mange risks to be within its risk appetite, to provide reasonable assurance regarding the achievement of organizational objectives'. Furthermore, internal control is seen as one of the main aspects of ERM and aims to assure effective and efficiency of operations, reliability of financial reporting and compliance with applicable rules and regulations (Fraser & Henry, 2007). The COSO 2004 framework will help management to align risk appetite and strategy, makes the risk appetite of the firm explicit, enables better alignment between actual risk and desired risk and ensure effective risk responses (Arwinge, 2013).

Racz et al. (2010) define Governance Risk Compliance (GRC) in the following way: "GRC is an integrated, holistic approach to corporate governance, risk and compliance ensuring that an organization acts in accordance with its self-imposed rules, its risk appetite and external regulations through the alignment of strategy, processes, technology and people, thereby leveraging synergies and driving performance". GRC is complex since compliance requirements can be found in various business segments. Therefore, compliance governance requires understanding and interpreting requirements and implementing and managing a large quantity of control actions across business units of a company (Racz et al., 2010).

One can deduce that these risk management theories deviate on a considerable number of aspects. SCRM is a prudent way to control uncertainties and disruptions in the supply networks and focuses exclusively on macro (nature or man-made risks) and micro risks (manufacturing, information, supply and demand risks). ERM emphasizes the strategy setting of overall business related to internal controls and recommends a holistic and cross-functional approach. GRC concentrates specifically on compliance uncertainties between internal policies and external regulations. None of these theories take specifically customs and trade compliance into account. Nevertheless, they are similar in their objective to mitigate adverse events and share correspondingly partly the same risk management procedures which also may be applicable on customs compliance risks. The risk management approach consists out of: risk identification, risk analysis and evaluation, selection and implementation of risk management strategies (referred to risk treatment) and risk monitoring, in order to meet overall organizational objectives (Manuj and Mentzer, 2008; Arwinge, 2013). We will describe shortly the possible procedures of each step.

Risk identification includes the selection of risk types, factors or both (Ho et al. 2015). Within ERM this step also include the description of the organizational context and the determination of the risks appetite (Arwinge, 2013).

The second step within risk management comprises risk analysis and risk assessment. Khan et al. 2015 refers that semi-quantitative analysis produces are useful when direct measurement of events is impossible and will provide mainly approximate results rather than giving exact/ absolute results. Jordan et al. (2016) describe risk matrices or risk mapping as a common tool for risk assessments and visualizations and ranks risks on a Cartesian coordinate system along the dimensions of probability and impact. This tool is particular important when one desirers to analyze unquantifiable events. Risk matrices go beyond specific events and processes and owing to their symbolic visualization complex processes become imaginable, simple and manageable. Quantitative analysis is preferable having in consideration it provides realistic numerical estimated results for more informed, considerate and sharpened decision-making processes.

Mitchell (1995) suggested that the risk of any particular type of loss is a combination of the probability of occurrence of that loss, *P (Loss),* and the significance (or impact) of its consequences of that loss to the organization, *I (Loss)*. A general accepted formula for quantitative definition of risk is therefore (Manuj and Mentzer, 2008):

Risk = P (Loss) x I (Loss).

The selection of appropriate risk strategies is necessary to reduce the probability of, and/or decrease the losses with, undesired events. Manuj and Mentzer (2008) classify SCRM strategies into seven categories: avoidance, postponement, speculation, hedging, control, sharing/ transferring and security. Within ERM the risk strategies include the following: reduce, accept, share and avoid.

Monitoring and reviewing are required integral actions in the process of managing risk. Its purpose is to determine if previously identified risks are still current, to identify new potential risk events, to reevaluate assigned risks when having updated information, and to evaluate if the undertaken compliance activity or risk mitigation action was effective (Arwinge, 2013). In addition, Mauermair (2013) splits risk monitoring into three categories: criteria extent (total or sampling monitoring), criteria category (continuous, periodical or ad-hoc monitoring) and criteria organization (internal or external monitoring).

2.3 Performance measurement

Furthermore, to control and monitor risk management strategies and to see whether they are effective one can introduce performance measurement systems. Most complex organizations implement performance measurement to be able to debate results, responsibilities and targets and intents to motivate, guide and improve decision making (Franceschini et al., 2007). A Key Performance Indicator (KPI) is a metric used to quantify the efficient and/or effectiveness of an action (Franceschini et al., 2007). A measurement system is needed to check if a process meets stakeholders' requirements and has to include defined performance levels, control activities to meet the targets, selected KPIs, required information, and corrective actions results are lower than the performance level requirements (Franceschini et al., 2007).

There is a lack of academic sources studying the relationship between compliance, risks and performance measurement within the supply chain. However, in the IT sector there is more research conducted towards this subject. Martens and Teuteberg (2011) developed a reference model for Cloud Computing Services that serves to support companies in managing and reducing risks and compliance efforts. This model shows the interrelation between KPIs, risks, compliance and Cloud Computing Services. The risk and compliance components represent both descriptions of risk and compliance factors as well the auditing efforts and results. The KPI component plays a critical role since it offers monitor and control mechanisms to decision-makers and supports the operationalization of measurements and strategic objectives. The KPIs monitor the performance of risks and compliance issues. The difference between a KPI value set as a target and the current performance will prompt actions to improve the value.

Many authors see performance measurement as an internal and external communication protocol i.e. internal to communicate the company's vision on the whole organization and external to communicate organization's health to the outside world (Franceschini et al., 2007). A KPI dashboard/framework is a tool within performance measurement, which allows decision makers to have real time synthetic vision of the main indicators characterizing the business (Ciobancia & Georgescu, 2012). A working framework provides answer to the requirements from compliance management and risk management as well as governance and targets several classes of users, e.g. chief officers of a company, line of business managers, internal auditors and external auditors (Silveira et al., 2010).

2.4 Research gap and research relevance

In conclusion, the analysis of existing literature on customs compliance and risks management shows that this field of research still leaves a lot of opportunities for further exploration. Existing research regarding risk management mainly focuses on overall supply risks or strategic business risks. Most researchers consider compliance only as direct influence by government agencies and ignore its operational impact on global supply chains, cross-border movements and trade processes, or analyze risks only from customs authority's perspective. Even though researchers admit in prior studies that compliance risks and the consequences of these adverse events exist everywhere in the supply chain when companies try to comply with regulations, no scientific studies elaborate on compliance risks related to trade or customs. Another limitation within the existing literature is that one cannot find approaches to analyze or assess customs compliance risk exposure. In addition, there is a lack of academic sources studying the relationship between compliance, risks and performance measurement within the supply chain, not to mention the relationship between customs compliance, customs risks and performance measurement. These knowledge gaps need to be filled considering the major negative consequences of non-compliance related to customs regulations e.g. penalties, overpaying duties, trade restriction and violating licenses, which can lead to catastrophic supply chain disruptions, lost opportunities or failed corporate strategies. Understanding and managing customs compliance hazards will allow companies to gain and assure trust by customs in order to get the AEO and C-TPAT status, a better supply chain performance, reduced costs of non-compliance and increased competiveness. New studies on managing and controlling customs compliance risks will definitely contribute to an improvement of cross-border and trade processes, by mitigating customs compliance risks and

thereby reducing logistic inefficiency, encouraging trade and improving supply chain performance. By investigating the subject of customs compliance and risk management within an international supply chain, this thesis adds something new to existing literature. On top of that, instead of considering compliance only as a direct influence by government this thesis aims to provide a general insight, while offering practical usability.

3. IDENTIFICATION TRADE AND CUSTOMS RISKS

Risk identification and risk measurement are prime steps in a risk management process (Manuj & Mentzer, 2008). These steps are essential to get a thorough understanding of the possible trade and customs risk events threatening an international supply chain. Correspondingly, this will provide a solid basis for prioritizing risks, in order to implement relevant mitigating controls.

This chapter focusses on the identification of potential trade and customs risks and provides a first overview of highly important risks. We split the analysis process into two distinct steps. The first one being the supply chain analysis to describe the trade and customs processes which involves customs activities. This provides a structured approach for the second step: the risk identification process. In order to identify and come to a scope of potential risk events, the following activities are undertaken: a risk workshop with internal customs experts, desk research and interviews with relevant stakeholders.

3.1 SUPPLY CHAIN PROCESSES

In this section we present Company X's trade and customs processes, referring to current literature and discussion with internal experts. As described by Hausman et al. (2010) the trade process contains four elements: pre-export, transport arrangement and export declaration, transport and import declaration and post-import customs clearance and payment. These steps rely largely on import and export processes, while traditionally trade and customs compliance is applicable to more supply chain processes. Therefore the steps of Hausman et al. (2010) are adjusted and extended on basis of compositions of internal interviews. This provides an overview of the supply chain areas relevant to customs compliance. The relevant areas are: inbound, outbound, warehouse, production, transport, infrastructure, and export control. Figure 3 presents a schematical depiction of company X's trade processes.

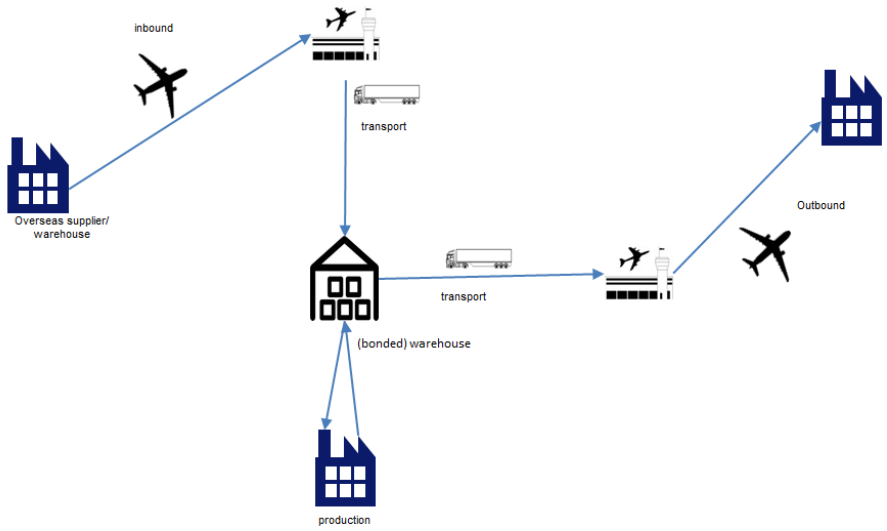

FIGURE 2 SCHEMATIC DEPICTION OF COMPANY X'S TRADE FLOW

The international trade process starts with the *'inbound'* process. The start of this process is initiated by a filed purchase order. The process deals with shipping/ airfreighting of goods,

generating and submission of import documents, and import customs clearance. This procedure is concluded when the import declaration is released by customs and the goods have received a free status. So, trade and import formalities are executed to fulfill customs requirements and release the goods, in order to transport a shipment (bonded goods) from a port of entry further inland.

The second process is initiated at the moment the (bonded) goods are received at the dock. This process includes the storage of goods and internal movements of goods at the warehouse facility. We therefore identify this process as '*warehousing'*. This process is completed when the goods are placed at the dock for further transport to a production facility or for export.

The *'production'* cycle is initiated when the (bonded) goods are liberated from the warehouse and are moved to a production facility. This process is completed when the assembled and/or modified goods are transported back to the warehouse facility.

The *'outbound'* process starts when a purchase order is received. Trade and export formalities need to be fulfilled in order to ship compliantly from the warehouse facility to the port of exit, which is also the disclosure of the outbound process. On top of that, this process covers preparation for exportation.

The (bonded) *'transport'* process is divided into two steps. The inbound transport process is initiated when goods arrive at the country of destination and ends at the moment when the goods are placed at the warehouse facility. The outbound transportation process starts when the goods are picked from the warehouse and ends when the goods arrive at the port of exit or leave the territory.

The category *'infrastructure'* relates to systems, people and other facilities serving a business process. In this case the infrastructure facilitates the trade processes, and also requires compliancy with customs regulation. The infrastructure for the identified supply chain processes includes:

- *Licenses*: An international company is required to have the complete, correct and up to date licenses for all trade processes. Licenses are the approval documentation issued by an authority, accrediting the recipient to proceed with the trade processes or other regulated activities specified on the license.
- *IT systems*: Company X's IT systems relevant to the trade processes.
- *People*: People refers to all the parties involved in the trade process e.g. own personnel, temporary personnel, forwarders, customs brokers, third party logistics (3PLs), transporters etc.
- *Master Data*: Master Data is the core data that is essential to operations in a specific business or business unit. Customs Master Data contains e.g. product classification information and all relevant shipment data to enable border crossing and fulfill all formalities during the shipping process.

The category *'Export Control'* is however a different discipline than customs, yet Export Control yet is also taken into account within this thesis. Export Control regulations aim to prevent the unlawful trading of goods, software and technology to embargoed countries, sanctioned entities or persons,

or for illegal purposes. This requires a process to ensure for example not transacting business with terrorists and terrorist organizations, drug traffickers, human rights violators, regimes producing weapons of mass destruction, or other restricted parties. It also requires a process of export control classification of goods, software and technology and adhering to governmental licensing. In other words, the total process has to ensure and prove that a company is complying with all applicable national and international export control laws and regulations.

3.2 RISK IDENTIFICATION

With the trade and customs processes/ categories mapped, risks can be singled out. To identify and prioritize potential trade and customs risks a risk workshop session is organized for various customs specialists from different continents, which is an effective manner to quickly get a good qualitative sense of the relevant risks. Furthermore, by pinpointing ten global key risks a first overview is created of which risks should have priority to be implemented project.

3.2.1 SETUP RISK WORKSHOP

Four internal customs experts from different regions took part in the risk workshop (two international trade & customs managers EMEA, one trade & customs manager APAC and one trade & customs analyst U.S.). The aim of this workshop was to identify possible inherent global customs risks. Inherent risks are risk that an activity would pose if no controls or other mitigating factors were in place (so called gross risk or risk before controls). The risk events are categorized based on the seven relevant areas, as we described in section 3.1.

The workshop consisted of the following phases:

1. *Introduction (±15 min by facilitator)*: The facilitator explains the purpose and the goals of the workshop. Company X's ambitions and the objectives of the project are introduced to the participants.
2. *Risk identification (± 75 min)*: For each process an individual session takes place, where participants write down the possible global risk events related to a particular process.
3. *Risk discussion and consolidation (± 60 min)*: After seven sessions the identified risks are shared and explained in the group in order to obtain a general understanding. Risks which are related to each other will be consolidated into one single risk event.
4. *Identification 10 key risks (± 90 min)*: After the group discussion, the participants identify the risks they deem the most important. The group will orally assess together the final risk set on frequency of occurrence and on compliance, financial and operational impact. The consolidated impact scores singles out ten prioritized risks.

3.2.2 CONCLUSION RISK WORKSHOP

The participants identified multiple risks for each category. Table 1 demonstrates the number of risks identified per category.

Category	Number of risks
Inbound (IB)	11
Outbound (OB)	12
Warehouse (WH)	9
Production (PD)	13
Transport (TR)	7
Infrastructure (IF)	13
Export Control (EC)	13

TABLE 1 NUMBER OF IDENTIFIED RISKS PER CATEGORY

These various identified risk events were individually ranked on importance by the four participants, after which a list with a reduced number of risks remained. The group together orally projected the remained risks on frequency of occurrence and the three impact categories: compliance, financial and operational. A first insight into this analysis is that the scores on the three scales were very similar and did not disclose extra information. Combining the scores on the different scales resulted that a first risk matrix with ten high prioritized risks was generated. Note that the risks are independent of each other, as they cover different processes, supply chain segments or stakeholders. The ten key risks are listed in the following table; table 2.

Risk #	T&C Risks
1	Inadequate Customs Master Data management (IF)
2	Non regulated Shipments (IB/OB/TR)
3	Incorrect Inbound declaration (IB)
4	Incorrect Outbound declaration (OB)
5	Goods not properly processed (PR)
6	Irregularity of goods (General)
7	Incorrect Bonded Inventory (WH)
8	Unsecure IT Systems /Unauthorized Access and Changes (IS)
9	Inadequate license management (IS)
10	Wrong Filing/Record Retention (WH)

TABLE 2 RISK TOP 10 WORKSHOP

The outcomes of the risk workshop are reliable owing to the expertise and experience of the people involved, and gave us thereby a good initial insight of potential global risk events and of which risks require priority.

However, even though the risk identification workshop provided a solid underlying support to discern multiple potential risks, one should be prudent on relying on only one method (Tversky and Kahneman, 1974). Using this strategy we have to take three aspects into account:

- Individuals are prone to biases in their judgment that affect the outcome of the risk identification processes (Tversky and Kahneman, 1974). An example of such biases is that a person is more likely to remember and name events that are familiar. Therefore it may be reasonable to suggest that the participants, although they were asked to provide global trade and customs risks, had only their own local risks in perspective.

- While identifying the risks, the group provided risk names but discussed the relevant definitions only briefly due time constraints. This may entail that the risks will not be fully understood by everyone involved in the project. It is recommended to determine a detailed description of risk events to create a more general understanding about the adverse events (Isaac, 1995).

- No Export Control expert could attend the session. Besides, due to limited experience in this specific expertise area of the stakeholders, it was decided not to rank the Export Control risks in the top ten yet. Before making such an important decision, desk research and interviews with Export Control experts are required to obtain a better understanding of the importance of the Export Control risks.

To broaden and deepen the analysis, a different form of risk analysis method is used, in the form of a risk assessment survey. Section 4 will elaborate upon this risk assessment.

3.2.3 DESK RESEARCH

After the workshop, desk research and interviews with internal stakeholders are conducted to deepen, extend and/or consolidate the identified risks within the workshop and to be able to describe in a detailed manner the several risks. In addition, extra interviews with Export Control managers were held to (re)identify and describe the Export Control risks.

The desk research consisted of an investigation and comparison of the existing local risk frameworks, the potential risk list identified in collaboration with Dutch customs authorities and the AEO and C-TPAT guidelines. The guidelines are divided in multiple sections and subsections containing over 200 relevant points of attention. These points of attention are used to identify the customs risks in an international enterprise.

3.2.4 RESULTS RISK IDENTIFICATION

The trade and customs risks defined at the risk workshop are taken as initial input for the final risk list. We compared, aggregated and categorized the information of the several sources by consolidating similar risks and points of attention into single events. Likewise, additional relevant trade and customs risks relevant but not mentioned in the risks workshop, are listed. This combination provides detailed risk description and additionally reduces the length of the final risk list.

The desk research resulted in 48 potential risks, listed in the table depicted below. Most risks are independent of each other, since they cover different processes in different categories, yet some risks may be applicable to two or more categories. Table 22 in appendix A demonstrates the risks including the detailed descriptions.

Category	Risk #	Category #	Risk name	Ranking in workshop
General: The general category contains risks which are applicable for every category	1	G-1	Irregularity of goods	6
	2	G-2	Internal control procedures	
	3	G-3	Financial insolvency	
	4	G-4	Inadequate Safety and Security internally and in business activities	
	5	G-5	Non regular Shipments (inbound/outbound)	2
	6	G-6	Wrong Filing/Record Retention (inbound/outbound)	10
	7	G-7	Inadequate physical security	
	8	G-8	Incorrect scrap procedure	
Inbound	9	IB-1	Incorrect import declaration (including input information of suppliers is wrong)	3
	10	IB-2	Wrongly declared goods	
	11	IB-3	Declaration not cleared within required time	
	12	IB-4	Incorrect Airway Bill information from forwarder to customs	
	13	IB-5	Broker systems disconnected to Customs system	
	14	IB-6	Local customs disagreements regarding declaration	
	15	IB-7	Incorrect drawback	
Outbound	16	OB-1	Incorrect export declaration	4
	17	OB-2	Declaration not cleared within required time	
	18	OB-3	Shipping area unsafe and unsecure	
	19	OB-4	Ship wrong quantity of goods	
	20	OB-5	Every warehouse uses own shipment reference number	
Warehouse	21	WH-1	Incorrect (Bonded) Inventory	7
	22	WH-2	Inadequate access security/ rules in warehouse	
	23	WH-3	Unsecure and/or unsafe warehouse	
	24	WH-4	Lack of stock movements control	
Production	25	PD-1	(Bonded) goods not properly processed in IPR (Inward Processing Relieve)	5
	26	PD-2	Unsecure and/ or unsafe factory	
	27	PD-3	Inadequate Quality Control	
Transport	28	TR-1	Incorrect Transport declaration	
	29	TR-2	Unsecured transport modality/ unsecure transporter	
	30	TR-3	No clearance of Transport declarations	
	31	TR-4	Wrong Customs Reference number processed in SAP	
	32	TR-5	Information invoice missing	
Infrastructure	33	IF-1	Incompetent people	

	34	IF-2	Incompetent brokers	
	35	IF-3	Unsecure IT Systems /Unauthorized Access and Changes	8
	36	IF-4	Inadequate Customs Master Data Management	1
	37	IF-5	Inadequate License Management	9
	38	IF-6	Improper functioning of SAP/R3	
	39	IF-7	Improper functioning of SAP/GTS	
	40	IF-8	Improper functioning of Customs IT Systems	
	41	IF-9	Payment request Wrong Invoice	
	42	IF-10	No back up available IT systems	
	43	IF-11	No back up available employees	
Export Control	44	EC-1	Inadequate Screening relating to sanctioned parties and embargoes	
	45	EC-2	Unauthorized technology transfer	
	46	EC-3	Risk of incorrect export control classification of items (goods, software and technology)	
	47	EC-4	(Re) Exports of (in)tangible items without a valid export license or license exception, or in violation of a license condition or restriction	
	48	EC-5	Risk of violating U.S. antiboycott laws	

TABLE 3 FINAL TRADE AND CUSTOMS RISK LIST

3.3 CONCLUSION

This chapter provided a methodology to identify customs risks. It is based on linking a risk workshop and additional desk research. First a workshop was organized where four participants selected multiple potential customs risks, and consolidated together a first risk matrix with 10 important risks by assessing the risks on three impact scales. Second, the initial identified risks were compared, aggregated and combined with the risks included in current local risk frameworks and the C-TPAT and AEO guidelines. This resulted in 48 possible risks in 7 categories: inbound, outbound, warehouse, production, transport, infrastructure, and export control. These 48 risks will be the basis for the analysis in the following chapter.

4. RISK ASSESSMENT

In the previous chapter, 48 potential trade and customs risks were identified. This chapter will focus on the second step within risk management practices; risk measurement analysis.

For the risk measurement we will create and design a risk assessment survey. This technique enables us to reach multiple stakeholders in the different locations worldwide, and is a structured, convenient and user friendly approach. The stakeholders will be asked to score the risks on impact and probability of occurrence, as will be explained in the following section.

The information extracted out of the survey will be used to evaluate the global customs risks on relative importance and will be prioritized from most to least significant. This indicates which important global risks should be implemented in the framework. There is chosen to select the fifteen highest important risks. These risks will be used to broaden, verify and deepen the first overview of high potential risks generated in the workshop. Additionally, the final risk matrix will be complemented with three Export Control risks. We chose to list the Export Control risks separately, since different internal experts will develop applicable mitigating controls measurements.

4.1 METHOD

Internal stakeholders of different departments within the different regions are carefully selected, as the participants in the survey need to have a substantive knowledge on the risks and experience in the risk environment. In the survey, they are asked to score previous defined inherent trade and customs risks (table 3), on frequency of occurrence and impact. Fields are included where they can add risks when they credit complementing risks should be taken into account. They can also report the reasons that led them score the specific magnitudes.

The final data set and the results obtained during the process will be compiled and analyzed in order to examine the received data quality. After this data analysis we will create a risk matrix.

As elaborated in the literature review, a generally accepted formula will be used to measure inherent risk events Mitchell (1995). This formula combines the probability of occurrence of that loss, *P (Loss),* and the significance (i.e. impact) of its consequences of that loss to the organization, *I (Loss)*, i.e.

$$Risk = P\ (Loss) * I\ (Loss) \tag{4.1}$$

Note that hereinafter probability of occurrence will be referred to as likelihood. The mean of the global risks will be measured by the average likelihood multiplied with the average impact scored by all the interviewees, independent of the region.

$$Global\ Risk\ (X) = \ E[P] * E[I] \tag{4.2}$$

Results will be depicted in a so-called 'heat-map' a common tool for risk assessments and visualization, which ranks the risks on a Cartesian coordinate system along the dimensions of

likelihood and impact (Jordan et al., 2016). This is a practical and convenient tool since it will act as a mediating technology between the different regions and departments. The heat map will be created to visualize the relative importance of the global risks.

After generating the risk matrix with fifteen highly severe risks, we will conduct additional analyses. Evaluations take place on global level, as well on regional level to analyze dissimilarities in risk perception amongst the regions. Consecutively, the risk matrix will be compared with the ten key risks ranked in the workshop.

To create more insight in the different risk perception amongst the individuals we will measure how much the scores of the interviewees deviate from the average score. Assuming independency of likelihood and impact we will use sample variances,

$$Var(Risk) = Var(I)Var(P) + E[I]^2Var(P) + E[P]^2Var(I)\,, \tag{4.3}$$

and standard deviations,

$$SD = \sqrt{Var(Risk)}\,, \tag{4.4}$$

which will give an indication of the spread of risk perspectives. We will perform an additional analysis by using a one-sample t-test we will generate the 95% confidence interval about the mean, which is defined by;

$$T = X \pm t_{1-\frac{\alpha}{2},N-1}\frac{SD}{\sqrt{N}}. \tag{4.5}$$

4.1.1 LIKELIHOOD AND IMPACT SCALING

The risk assessment requires a clear definition of the scope of the adverse effects; the impact and likelihood terms. The prior assessment in the risk workshop revealed similarities of scorings on all three impact scales (compliance, financial and operational), where the financial and operational scorings did not disclose new insights and are assumed as a possible result of (non)compliancy. This appoints the importance of the compliance scale, and therefore we will select exclusively this impact scale as input for the risk assessment. Additionally, taking only one impact scale into account will limit confusion for the respondents while assessing the adverse events and will speed up the process.

The likelihood and impact scores can be indicated using a five point scale from rare to very high. Those ranges can be adjusted, depending on the project specific characteristics. In this project, for the scaling of compliance impact and likelihood the definitions as determined by an internal department are used. These definitions are developed over time by risk experts and are therefore also known by management. Hence, using the same predefined assessment scales for all risk assessment ensures alignment between the different departments and management. The definitions of the likelihood and impact scale are presented in table 4 and 5 respectively. Note, since it is possible that particular risks may not occur in some regions we defined an extra level in the scaling. For both the likelihood and impact scales a distinction is made between a rare likelihood or

insignificant impact and no likelihood or impact at all (N/A). Hence, if a certain risk is not applicable in the region/country of the participant, the participant may select this score.

Likelihood rating	Description	Occurrence
0	n/a	0 - n/a
1	Rare	1 - Once every >5 years
2	Unlikely	2 - Once every 2-5 years
3	Possible	3 - Once a year
4	Likely	4 - Once a month
5	Almost Certain	5 - Once a week

TABLE 4 LIKELIHOOD SCALE

Impact Rating	Description	Compliance
0	0 - N/A	0 - N/A
1	1 - Insignificant	1 - X
2	2 - Minor	2 – X
3	3 - Moderate	3 – X
4	4 - High	4 – X
5	5 - Very High	5 – X

TABLE 5 IMPACT SCALE

4.2 DATA COLLECTION AND FINAL SAMPLE ANALYSIS

The survey is sent to 58 customs and supply chain experts within different departments around the globe. The survey was distributed by sending an email announcement with an excel file containing the survey attached. Reminder emails were sent after one week.

The response rate was 41.4% corresponding with a total of 24 submitted questionnaires. The composition of the participants within the final sample is evenly distributed over the regions, as follows: 8 participants from Europe, 9 participants from Asia and 7 participants from U.S. Out of the 24 submitted assessments six surveys were complete, i.e. all risks were assessed on impact and likelihood. Nevertheless, the complete and incomplete surveys combined provided us sufficient information for further analysis.

After analyzing the comments in the survey and conducting additional interviews with respondents, we can distinguish three explanations for the low response rate, each one being outlined briefly below:

- Unfamiliarity with a particular supply chain process. A significant amount of participants notified that they were unable to score a particular risk, since a certain category did not entirely meet their field of expertise.

- Risk definitions may have been too complex. Aggregating and combining multiple sources of information to create detailed risk descriptions have led to long risk definitions. These long descriptions could have contributed to discouraging the participants while scoring the risks, and increased the high amount of blank values.

- The compliance impact and likelihood scaling referred to two aspects. The first aspect does not always apply and may have therefore been confusing.

4.3 DATA TREATMENT

A first data analysis shows that the 'not applicable' options were interpreted by the interviewees in two ways. The reasons for not scoring are: (a) the respondent did not know how to score the risk due to lack of required knowledge and/or experience or (b) the risk is not applicable within their region. When the participant gave evidence that the risk is not applicable within his/her region, we kept the 'not applicable' as value. If the participant did not gave any evidence/ comments why they choose zero, when stating they did not know the answer (e.g. not in their field of expertise), or let it blank completely, these 'missing values' were listwise deleted. This entails that if a respondent scored a risk solely on likelihood or solely on impact, both values were deleted since a risk can only be measured knowing both determinants.

Considering the high amount of incomplete surveys, in order to have a valid analysis we should determine an adequate sample size. The research of Sandelowski (1995) suggests that determining an adequate sample size in qualitative research is matter of judgment in evaluating the quality of the information collected against the uses to which it will be put. For this research project we will assume a threshold of $N \geq 5$ i.e. when a risk is assessed by less than five participants the scores are invalid, when the sample size is equal or bigger than five the scores are valid and can be analyzed. Table 6 depicted below demonstrates the number of risks assessed by more than five respondents globally and regionally.

Region	**# of risks for N≥ 5**
Global	48
APAC	15
EMEA	32
US	2

TABLE 6 NUMBER OF RISKS FOR N > 5 PER REGION

Interpreting the previous table we can conclude that only two risks were scored by five or more U.S. stakeholders. This phenomenon can be justified by the explanations of the low sample size given in the previous section. Hence, due to high amount discarded values, we are unable to perform a regional analysis for the U.S. The results of Asia and Europe demonstrate a higher validity with 15 and 32 risks respectively that meets the threshold of $N \geq 5$. For these two regions we are able to conduct a regional analysis. This will be further elaborated upon in section 4.4.5. As can be concluded from table 6 for the worldwide analysis all risks are assessed by five or more respondents, independent of the domestic location. Consequently, we are able to analyze all the

risks on a global level and to create second uniform risks matrix. The content of the risks matrix will be clarified in the following section.

4.4 GLOBAL RISK MATRIX

As we set criteria of selecting fifteen key risks, the fifteen highest scored risks are presented in the table 7. This risk matrix also provides information about the variance and confidence levels of the risk levels, which is further illustrated in section 4.4. Furthermore, the presented heat map (figure 4), graphically demonstrates the rating of these global risk events. The heat map provides an overview of the results of the risk analysis. The fifteen risks assessed and diagnosed as high priority are presented in black.

Risk #	Risk identity	Risk name	E[P]	E[I]	E[Risk]	SD Risk	95% confidence interval
1	IF-6	Improper functioning of SAP/R3	3.50	3.88	13.56	5.07	(9.32;17.80)
2	IB-1	Incorrect import declaration	4.24	3.06	12.96	3.95	(10.93;14.99)
3	OB-1	Incorrect export declaration	4.19	3.06	12.82	4.48	(10.43;15.21)
4	IF-4	Inadequate Customs Master Data Governance	4.07	3.07	12.51	5.33	(9.44;15.60)
5	G-5	Non regular Shipments (IB/OB)	4.59	2.65	12.15	5.89	(9.01;15.29)
6	G-1	Irregularity of goods	4.40	2.73	12.03	4.87	(9.33;14.73)
7	G-2	Internal control procedures	3.00	3.64	10.91	6.68	(6.20;15.61)
8	IF-5	Inadequate License Management	2.90	3.60	10.44	4.65	(7.16;13.72)
9	PD-2	Unsecure and/ or unsafe factory	3.13	3.25	10.16	8.17	(3.32;16.99)
10	IB-6	Local customs disagreements regarding declaration	3.58	2.83	10.15	4.40	(7.35;12.95)
11	IF-7	Improper functioning of SAP/GTS	2.67	3.78	10.07	5.63	(5.73;14.41)
12	PD-1	(Bonded) goods not properly processed in IPR	3.56	2.67	9.48	6.21	(4.71;14.25)
13	OB-4	Ship wrong quantity of goods	3.54	2.62	9.25	3.95	(6.74;11.76)
14	IF-2	Incompetent brokers	3.38	2.63	8.86	5.70	(4.1;13.63)
15	TR-5	Information invoice missing	3.47	2.53	8.78	5.98	(5.46;12.09)

TABLE 7 TOP 15 GLOBAL RISKS

4.4.1 GLOBAL RISK MATRIX ANALYSIS

The table depicted below demonstrates the global and regional top fifteen inherent risks. The regional risks listed are independent of the sample size. The risks set in green present the risks that are pinpointed as key in 2 or 3 regions. The risks set in yellow are the risks flagged in a single region, except PD-1 '*Bonded goods not properly processed'.* This event is not ranked as important in any region, yet is rated in both APAC and EMEA as risk number 16. Sample size apart, the flagged risks represent multiple regions and give us thereby a clear perspective of the global dimension of the prioritized risks.

Global risk name	Global risk	APAC risk	EMEA risk	US risk
Improper functioning of SAP/R3	IF-6	G-1	IB-1	IF-6
Incorrect import declaration	IB-1	IF-4	OB-1	IB-7
Incorrect export declaration	OB-1	IB-1	PD-2	G-4
Inadequate Customs Master Data Governance	IF-4	OB-1	OB-3	OB-1
Non regular Shipments (IB/OB)	G-5	IB-6	G-5	G-5
Irregularity of goods	G-1	IF-6	G-1	G-2
Internal control procedures	G-2	G-5	IF-6	IF-4
Inadequate License Management	IF-5	IF-5	IF-4	G-6
Unsecure and/ or unsafe factory	PD-2	TR-5	IB-3	IB-1
Local customs disagreements regarding declaration	IB-6	OB-4	IF-7	TR-1
Improper functioning of SAP/GTS	IF-7	IF-2	G-2	OB-4
(Bonded) goods not properly processed in IPR	PD-1	IF-7	IB-2	TR-5
Ship wrong quantity of goods	OB-4	G-6	WH-4	IF-5
Incompetent brokers	IF-2	IB-4	IF-5	OB-5
Information invoice missing	TR-5	IB-3	WH-1	IF-3

TABLE 8 COMPARISON GLOBAL AND REGION TOP 15

Table 9 demonstrates the number of risks relevant to a supply chain area per region. We observe that in the three regions infrastructure compliance is the most valued indicator. The inbound and outbound risks are likewise detected in all regions. The general category is often selected since this category contains risks that are relevant to multiple areas. Additionally, we see that the European interviewees flagged one production risk and two warehouse risks while the other regions did not select any risk applicable to these categories. A solid reason for the Europeans to prioritize these risks is the familiarity with these categories since production facilities and bonded warehouses are placed in Europe. It is admissible that other regions have scored these risks as less severe since they are less familiar to these areas.

Category	APAC	EMEA	US
Infrastructure	5	4	4
General	3	3	4
Outbound	2	2	3
Inbound	4	3	2
Transport	1	0	2
Production	0	1	0
Warehouse	0	2	0

TABLE 9 NUMBER OF RISKS PER CATEGORY

4.4.2 COMPARISON WITH THE RISK WORKSHOP

As can be concluded from the table below (table 10), seven risks selected in this desktop assessment survey were also selected during the workshop, and eight risks are selected only selected by the survey. The outcome of the survey illustrates that three risks of the workshop were not re-assessed as important. Some insights are briefly outlined below.

Risk assessment survey & Risk workshop		Risk assessment survey & Risk workshop		Risk workshop	
Risk	**Risk name**	**Risk**	**Risk name**	**Risk**	**Risk name**
IB-1	Incorrect import declaration	IF-6	Improper functioning of SAP/R3	WH-1	Incorrect (Bonded) Inventory
OB-1	Incorrect export declaration	G-2	Internal control procedures	IF -3	Unsecure IT Systems /Unauthorized Access and Changes
IF-4	Inadequate Customs Master Data Governance	PD-2	Unsecure and/ or unsafe factory	G-6	Wrong Filing/Record Retention (IB/OB)
G-5	Non regular Shipments (IB/OB)	IB-6	Local customs disagreements regarding declaration		
G-1	Irregularity of goods	IF-7	Improper functioning of SAP/GTS		
IF-5	Inadequate License Management	OB-4	Ship wrong quantity of goods		
PD-1	(Bonded) goods not properly processed in IPR	IF-2	Incompetent brokers		
		TR-5	Information invoice missing		

TABLE 10 COMPARISON RISK ASSESSMENT AND RISK WORKSHOP

The risk *'Incompetent brokers'* is set as a new high prioritized inherent risk. Asia and the US work in close collaboration with customs brokers. Since the broker is the first and direct connection with customs authorities, an unreliable an unskilled broker constitutes a risk as e.g. incorrect declarations of mishandling of classification or customs values.

The risks *'Improper functioning of SAP/R3*' and '*Improper functioning of SAP/GTS'* are both assessed as highly important inherent risks in the survey. In the workshop the risk '*Unsecure IT Systems/Unauthorized Access and Changes*' was identified and ranked as a high prioritized. As follows from the definition of this risk, it covers the two first mentioned risks. Therefore, we suggest including the risk '*Unsecure IT Systems/Unauthorized Access and Changes*' in the control framework, since it covers and reinforces more aspects related to IT systems, including SAP/R3 and SAP/GTS.

Another reflection on these two events is that even though these risks are independent, participants may be led to conclude that these risks are linked, purely based on similarities in nomenclature and terminology. This phenomenon is called presumption of independence i.e. if one risk is rated high the other risk should also be rated high accordingly (Hubbard, 2009).

This phenomenon could also apply to the following four risks: '*incorrect import declaration'*, *'incorrect export declaration*', '*information invoice missing'* and '*local customs disagreements regarding declaration'*. One could have interpreted similarities amongst them since they all entail the incorrect use of information of goods on a declaration, i.e. customs value, HS code, local

currency, quantity, Country of Origin and Incoterms. There are also similarities in respect of occurring consequences: delays, penalties, or duty payments. However these risks are unique and independent since they apply to different supply chain areas, and should therefore be handled separately and individually when implemented in the framework.

In addition, the risk '*Wrong filing/ record retention'* is not ranked as a top fifteen adverse event. This could be a consequence of the respondents' unfamiliarity with this risk as record retention is in most countries outsourced to a 3PL.

Likewise the risk '*Incorrect bonded inventory*' was not assessed as a global key risk. The strongest possibility of not scoring this risk as severe is the limited experience with it, since only the Netherlands, some Asian countries have bonded warehouses and in some countries bonded licenses are under the 3PL's name.

The risks '*bonded goods not properly processed*' and *'unsecure and / unsafe factory'* are the risks related to the production category. Furthermore, the latter one is the only pinpointed safety and security risk in the risk survey. We observe that these risks are dealing with the high variances. In this case the high variances can be associated with lack of experience with this supply chain category considering that not all countries possess production facilities. The perceptions of this risk highly differ amongst the participants, and should be taken into account when deciding to implement relevant controls in the control framework.

4.4.3 EXPORT CONTROLS

A brief overview of the ranking of the Export Control risks is provided in table 11. Since these risks were identified by the export control experts we chose to highlight them separately from the other global customs risks. The three export control risks rated as most urgent by all interviewees are EC-4, EC-2, and EC-3. These three export control risks were initially based in the uniform global risk matrix, rated on place 7, 9 and 11, which shows the overall importance of export control.

Risk #	Category #	Risk name	Average Likelihood	Average Impact	Average Factor
1	EC-4	(Re) Exports of (in)tangible items without a valid export license or license exception, or in violation of a license condition or restriction	2.86	4.14	11.84
2	EC-2	Unauthorized U.S. controlled technology transfer	3.00	3.50	10.50
3	EC-3	Risk of incorrect export control classification of items (goods, software and technology)	3.64	2.82	10.25

TABLE 11 EXPORT CONTROL RISKS

4.4.4 REGIONAL COMPARISON

This section will provide a regional analysis in order to investigate if there are regional differences in risk perception

As mentioned in section 4.2, we set the minimal sample size at N of ≥ 5. Following this constraint it is not possible to take U.S. in consideration for the regional analysis, since only two risks are valid. Asia and Europe had 15 and 32 risks respectively that are valid. Consecutively, we will conduct an

analysis for these two regions. Nonetheless to analyze the risk perception between these two regions, we should only take the risks scored by both regions constraining N of ≥ 5 into consideration. These are the following twelve risks: G-1, G-5, G-6, IB-1, IB-3, IB-6, IB-7, OB-1, TR-1, TR-5, IF-4, and IF-11.

The twelve Asian risks are allocated on a relatively wide likelihood scale. The European risks are more clustered and skewed to the right. After a deeper examination we determine that the likelihood is scored higher for 9 risks by EMEA than APAC, while the impact is scored higher at 8 risks by the Asian interviewees. These discrepancies in risk perception could be the result of local trade and customs regulation. Local trade procedures, policies, regulations and ideologies may result in differences of sanctions and severity of customs risks. Additionally, we cannot exclude the impact of cross-cultural influences. With the regard to the latter a research was carried out before by Botempo et al. (1997). This study assessed cross-cultural differences in perception of financial risks and suggests that when scoring a risk stakeholders may assess first the risk as a whole and after think about the corresponding scaling (i.e. likelihood and impact are depended variables). Taken this into consideration, the research indicates that risk judgments differ with nationality, where the risk perspectives of the respondents in Eastern countries differ from those respondents from Western countries. Even though the results of this research and of our research should be generalized with caution, as respondents are in both studies not random samples from each society, we can conclude that the results of our findings are in line with the previous research. Further research is however recommended in order to investigate the causes and impact of cross-cultural differences in risk perception, yet this is for the present study not in scope.

4.5 Validity and Reliability

In section 4.2 a significant part of the validity and reliability analysis was described. We concluded that the quality of a data sample can be negatively impacted due to the existence of three scenarios:

- Lack of knowledge and or experience in the specific risk areas required to properly assess the risk.
- The considerable complexity in risk descriptions and characterization.
- Some aspects of the impact scaling' were not relevant for this specific business area.

A first reflection is the values of the 95% confidence intervals presented in table 7. These intervals indicate that there is a 95% chance that the confidence interval contains the true population mean. In example: we are 95% confident that the mean risk level of *'incorrect import declaration'* is between 10.93 and 14.99.

Another reflection regards the high standard deviations depicted in table 7. Given the standard deviations of the scores, we are able to indicate the spread of the risk perception amongst the participants. The standard deviations vary between 3.95 and 8.17 which may be indicated as a high variation i.e. the range spanning the values is relatively wide. As previously stated, the risks '*bonded goods not properly processed'* and *'unsecure and / unsafe factory'* are the production risks dealing with the highest variance; standard deviations of 6.21 and 8.17 respectively. The essential element

generating the high variance observed is the different experiences of the stakeholders with the relevant supply chain process since not all countries have production facilities in place.

In parallel with the already identified regional inconsistency in risk perception, the high variances show that also on individual level risks perceptions differ. This is in line with the suggestion in the research paper of Hubbard (2009); the risk scores can be distinctly perceived by various individuals. This is motivated and depends on one's experience and reference.

Additionally, the high standard deviations are plausibly correlated to the request of scoring the 'inherent' risk (as explained before, the risk that an activity would pose if no controls or other mitigating factors were in place). However deeper analysis of the survey data at hand, when assessing the risks, some stakeholders had existing local control processes in mind, which results in biased scoring. Combining inherent risk scores and residual risk (the risk that remains after controls are taken into account score) may have increased the variances.

Another subjectivity, yet not directly related with the variances, that can be present is that people tend to score a risk event with a high impact by intuition with a low likelihood and the other way around, which results in biased scorings (Simon, 2003). Risk event G-1 *'Irregularities of goods'* could be an example of this in the survey (see table 12 depicted below). All stakeholders scored this adverse event as a result of a high likelihood and a lower impact. Similar, yet less obvious, this may also apply for the risks IB-1, OB-1, TR-1 and TR-5. This subjectivity can possibly be avoided when scoring the likelihood and impact in isolations e.g. one group rating the likelihood and another group the impact (Simon, 2003). Note that taking this hypothesis into consideration will make the likelihood and impact scores dependent of each other.

Participant	G-1 Likelihood	G-1 Impact
1	5	3
2	4	3
3	3	3
4	5	3
5	5	2
6	5	3
7	5	3
8	3	3
9	5	3
10	5	1
11	5	3
12	1	1
13	5	4
14	5	3
15	5	3

TABLE 12 RISK G-1 SCORING

4.6 CONCLUSION

This chapter provided a methodology to measure and prioritize global trade and customs risks, by means of an assessment survey. Even though the response rate was 41.4% and not all scores could be taken into consideration, the data at our disposal provided sufficient amount of information to perform global and regional analyses. Likewise, the outcomes were used to generate a global risk matrix. Due the individual and regional differences in risk perception, the low sample size and the other remarks on validity and reliability one should be cautions handling and interpreting the findings of the risk assessment on its own. However, with respect to the workshop 7 risks out of the top ten were verified and additional global risks were listed. After further analysis we acknowledged even more similarities between the flagged risks of both methods. We can conclude that the outcomes of the survey supplemented the outcomes of the workshop and vice versa.

When combing the risks *'Improper functioning of SAP/GTS'* and *'Improper functioning of SAP/R3'* as '*Unsecure IT Systems /Unauthorized Access and Changes*', we can conclude that the top most important risks are '*Incorrect import declaration*', *'Incorrect export declaration',* and *'Inadequate customs Master Data governance'.* These were scored in the assessment survey as number 1, 2 and 3, and in the risk workshop as number 3, 4 and 1. For the financial impact analysis, presented in the following chapter, we will take the risk *'Inadequate customs Master Data governance'* into consideration.

5. HS CODE RECALCULATION MODEL

As can be seen from chapter 4, '*Inadequate Customs Master Data Governance'* (IF-4) is a possible risk that is measured as highly significant on a global scale. Even though Master Data contains an extensive amount of information on numerous aspects, we will limit our research to the product classification information. This information contains the following items e.g. product description, HS codes, country of origin, and codes for export restriction. Even more specifically we will limit our scope to HS codes, as changing these codes may result into a financial impact on customs duty payments, as will be outlined in the following sections.

The technology company strives the quantitative effect of this risk on customs duty payments. Therefore, the focus of this research will now shift towards the financial analysis of this specific trade and customs risk. The objective of this chapter is to provide an examination of the impact of HS code changes on duty payments. This research entails data analysis techniques to develop a model in order to automatically measure the risk impact. The objectives of this model are in summary:

- Give insight into the effect of a HS change on import duty payment in order to recalculate the duties and get a thorough understanding of the possible risk exposure
- Use a simple and structured approach to develop the duty payment calculation model.

A solid methodology is required to provide guidance for the data analysis and to structure the project; therefore we adopt the data mining methodology CRISP-DM, which consists out of six phases. The following section will clarify in detail this data mining technique.

The model will be implemented using the programming language R, and using the package SQL. Data should be gathered from multiple sources (as will be explained in section 5.3). We aim to make the R implementation compatible with Excel data and to make the use of data clear and flexible.

5.1 THE CRISP-DM METHODOLOGY

The CRISP-DM methodology stands for, Cross-Industry Standard Process for Data Mining, and makes use of a standard framework for data mining projects which is dependent of both the industrial sector as the technology used (Wirth & Hipp, 2000). This process aims at making large data mining projects less costly, more reliable, more repeatable, better manageable and faster. The data mining framework consists of six phases: business understanding, data understanding, data preparation, modeling, evaluation and deployment. Figure 6 gives an overview of the phases. These steps are in sequential order, yet figure 6 shows that there are multiple feedback loops between the steps which makes backtracking and repeating of previous actions possible. In the following we outline each phase briefly:

- *Business understanding:* This initial phase aims to understand the problem, the objectives and requirements from a business perspective.

- *Data understanding:* This second phase starts with collecting the relevant data and proceeds with activities in order to get familiar with the data, to identify data quality problems and to discover

first insights into the data. Phase one and phase two are closely interconnected; the formulation of the research problem requires at least some understanding of the available data.

- *Data preparation:* This phase covers all activities in order to construct the final dataset that will be used for data analysis. Tasks include table and variable selection, data cleaning, construction of new attributes and transformation of the data for modeling.

- *Modeling:* In this phase the final model is selected and applied to the prepared data. This phase has a close link to data preparation; often data problems are detected while modeling or other findings in the modeling process can lead to necessary changes in the data preparation.

- *Evaluation:* In the fifth phase the model is evaluated. It is important to evaluate the model, the modeling steps and the results of the model to be certain that it properly achieves the business objectives. In addition, to evaluate the model one can apply different scenario's to perform a sensitivity analysis.

- *Deployment:* When there are no quality issues with the model one continues to this final phase. In this phase the model will be organized and presented in a way that the customer can use it. In this phase decisions are made on what actions will need to be carried out in order to actually make use of the created models.

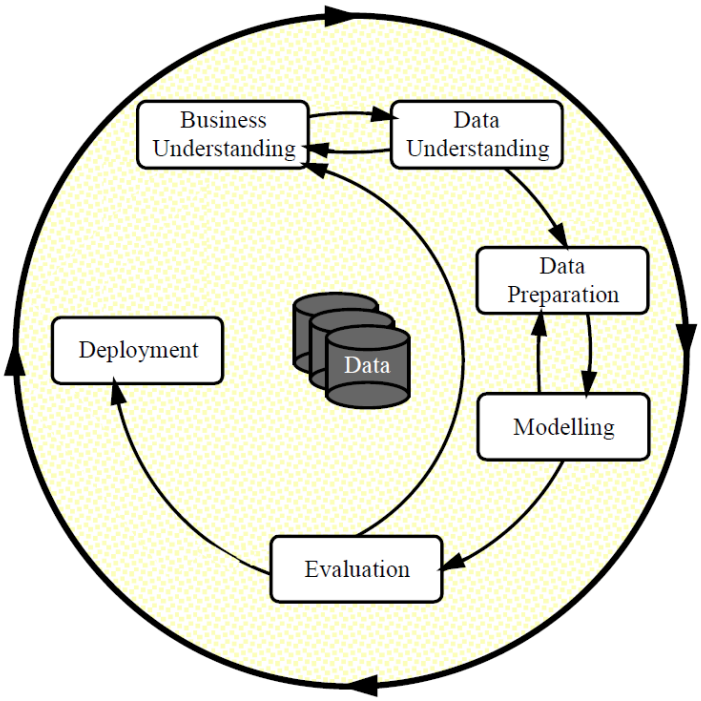

FIGURE 3 CRISP-DM FRAMEWORK (WIRTH & HIPP, 2000)

The following sections include the first five steps of the CRISP-DM methodology in practice. The 'deployment' step is discussed in the conclusion of this section and in the final conclusion presented in chapter 6.

5.2 PHASE 1 BUSINESS UNDERSTANDING

The business understanding section provides a clarification of the research goals and describes the research environment. The research objective is covered in the problem statement and in the introduction of this chapter. On the other hand, the research environment is not yet in scope and will be studied in this section. Theoretical background will be provided to examine the classification process, the possible effects of HS codes alterations, the goods flows which are subject to duty payment and eventually the scope of the model will be addressed.

5.2.1 HS CODE

The Harmonized Commodity Description and Coding System, also known as the Harmonized System is an internationally standardized system to classify globally traded products (WCOOMD, 2016). HS codes, also referred to as HT codes or HTS codes, are used by customs authorities around the world to identify the duty tariff and tax rates for specific types of products. The duty tariff is assessed on the customs value of a product indicating import duty i.e. a classification leads to a certain tariff (%), this multiplied by the value determines the import duties for a specific product. In example HS code '85131000' has a duty tariff of 5.7%, suppose the value is €100 than the duties are €5.70.

Fundamentally, the Harmonized System is organized logically by economic activity or component material (WCOOMD, 2016). The system is divided into sections and chapters which describe broad categories of goods, while headings and subheadings describe products in more detail. Generally, the sections and chapters are arranged in order of a product's degree of manufacture or in terms of its technological complexity. Chapters within the individual sections are also organized in order of complexity or degree of manufacture. Finally, the headings within individual chapters follow a similar order. The HS code consists of 6-digits, which are common to all countries and therefore useable as a universal classification code. The first two digits designate the chapter, the second two digits designate the heading and the third two digits designate the subheading. Many governments add numbers beyond the 6-digits to suit their tariff and statistical requirements. These additional digits are typically different in every country. They often set their customs duties at the 8 to 10-digit "tariff code" level.

The process of assigning HS codes to products is known as 'HS classification'. The HS code of a good can be determined by a variety of factors including a product's composition, its form and its function. The classification process is a specialized discipline and is performed by classification experts.

5.2.2 POST-CLEARANCE AUDITS

Post-clearance audits (PCAs) are checks performed periodically by Customs to verify the accuracy and authenticity of declarations by structured examination of relevant documents, records or Customs declaration systems (UNECE, 2016). A PCA is conducted after the release of the goods from Customs control.

When customs authorities at the moment of a PCA detect that an insufficient amount of duties is paid, they can impose additional duty payment with a penalty. Duties issued may be imposed an

additional three years after the release of goods from Customs control (douaneadvies, 2015). In other words: Customs remains the opportunity to review a declaration if this one is not verified by them during the last three years, and the particular declaration is subject to post-clearance recovery. Note that the timeframe of three years is mainly relevant for EU member states. In other countries this period can be longer, however our scope will only focus on the post-clearance time of the EU, as will be explained in the following sections.

Within a high tech a company, ongoing innovation, product developments and new insights causes that products and as a consequence HS codes may change overtime. As briefly listed in the problem statement the causes of a classification change are the following:

- Different classification by trade and customs authorities.
- Changes in the Bill of Material (BOM), changes in functions or characteristics or new information about the classification of the products.
- Customs directives based on audits.

As stated in the previous section a HS code identifies the import duty and tax rates, therefore adjustments may involve a change in tariff at the same time. Altering the HS code of a product is exposed to three possible scenarios:

- (1) the new duty tariff is higher than the original one implying insufficient import duty payment for the particular material and is therefore case of post-clearance recovery of customs duties, or
- (2) the new duty tariff is lower than the original one implying excessive duty payment for this material over the last three years and Company X may apply for drawback this excessive duty payment, or
- (3) the duty tariff is equal to the old one, which has no financial impact.

Table 13 summarizes the three scenarios.

Old HT code	**New HT code**	**Impact**
Old Tariff	New Tariff > Old Tariff	- Post-clearance recovery by Customs
Old Tariff	New Tariff < Old Tariff	- Duty drawback at post-clearance audit by Company X
Old Tariff	New Tariff = Old Tariff	- No impact

TABLE 13 SUMMARY DIFFERENT SCENARIO'S CHANGE IN HS CODE

5.2.3 GLOBAL SUPPLY CHAIN

This section will analyze the global goods flows of the technology company. This analysis will provide insight in how to set up the model. Figure 8 shows Company X's global supply chain network on a high level. The network can be separated into three parts: supply network, storage network and customer network.

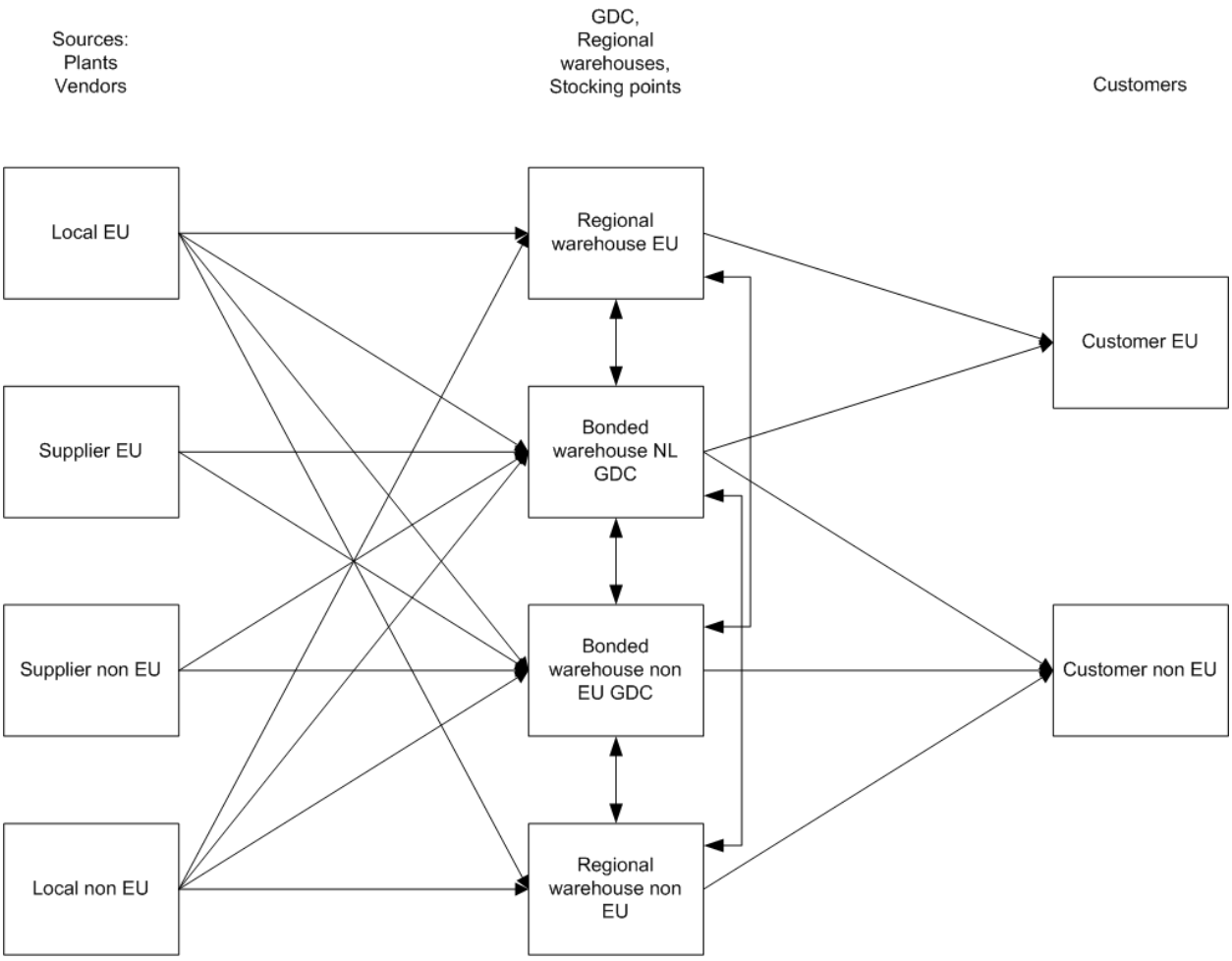

FIGURE 4 COMPANY X GLOBAL SUPPLY CHAIN

Supply network

The supply network focuses on the various suppliers and local factories (in the figure referred as local plants). The supplier refers to the term vendor and manufactures and sells his goods to the next link in the chain, i.e. suppliers are entities that provides goods. In this project we distinguish suppliers located in the EU and outside the EU. Suppliers' goods are only directly shipped to a Global Distribution Centre (GDC), which is bonded. The difference between bonded and non-bonded warehouses will be clarified in the second part: storage network. Another source for goods within the supply network is Company X's own manufacturing/ assembly plants. These may also be located in the EU or outside the EU. In contrast to the goods flow from supplier to a GDC, intercompany shipments may be transported to both GDC's and regional warehouses.

Storage network

The storage network is the second part of the global supply chain. The company operates globally to support her customer service supply chain. The GDCs have several functions, as can be seen from

figure 8. Firstly, these warehouses are utilized to replenish the continental and local warehouses (referred to as regional warehouses in figure 8), or serving customers directly.

Another difference between the GDCs and regional warehouses is that the GDCs are so called bonded warehouses. A bonded warehouse is a building or other secured area in which dutiable goods may be stored, modified, or undergo some allowed manufacturing operations without payment of duty. Bonded warehouses are an integral part of the global supply chain.

During the period that goods are stored in a bonded warehouse, they can, under supervision of the customs authority and under strict conditions be subject to certain treatments, such as, cleaning, sorting, repacking.. The bonded GDCs are thus storage locations with consolidation processes in place that combine the products of an order from different manufacturers. After these types of handling, the goods may be exported without the payment of duty, or they may be withdrawn for import upon payment of duty at the rate applicable to the goods in their manipulated condition at the time of withdrawal.

Company X contains several bonded warehouses worldwide. The NL warehouses and in Asia are considered as GDC as mentioned above.

For this study, the internal goods flows and operations in the warehouses or production facilities are out of scope.

Customer network

The customer network focuses on the various customers. For practical reasons we made a distinction between customers located in the EU and customers located in other global regions. Customers can be served both by a GDC or a regional warehouse.

5.2.4 GOODS FLOWS SUBJECT TO DUTY PAYMENT

As explained before, import duty is a tax collected on imports by the customs authorities of a country. In practice, import duty is levied when imported goods first enter the country, e.g. from a local factory outside Europe shipped to a European regional warehouse. When shipping a product via a bonded warehouse no duty payment is asked until the moment the product is imported and is cleared by customs authorities.

Since the European Union is also a customs union, member states have removed customs barriers between themselves and introduced a common customs policy (European Parliament, 2016). The amount of import duty is the same for all EU countries, alternately stated: it makes no difference whether one imports a good into the Netherlands or into France; in both cases, the same amount of import duty is required. Furthermore, free movement of goods between the member states is secured through the elimination of customs duties and quantitative restrictions. Thus, movements of EU goods or goods which are cleared before entering the EU are not subject to duty payment. Additionally, for intra-country shipments are also no duty payments requested. Therefore, both conditions are not in scope within this study.

In summary, a shipment is subject to import duty payment at the receiving party when shipped from:

- Local plant EU to regional warehouse non-EU.
- Local plant/ supplier EU via bonded warehouse to regional warehouse/ customer non-EU.
- Local plant non-EU to regional warehouse EU
- Local plant/ supplier non-EU via bonded warehouse to regional warehouse/ customer EU
- Local plant/ supplier non-EU via bonded warehouse to regional warehouse/ customer non-EU.

For this project we will analyze the data for two of the global good flows: (1) local plant non-EU to regional warehouse EU and (2) local plant/ supplier non-EU via bonded warehouse to European regional warehouse or customer. The bonded warehouses in scope are located in the Netherlands. Yet the same procedures with some alterations can be followed for the other international goods flows.

5.3 PHASE 2 DATA UNDERSTANDING & PHASE 3 DATA PREPARATION

In this section the data understanding phase is described. During this phase, data is collected and interesting subsets of the available data are selected. There is chosen to combine this phase with the next iterative step 'data preparation', which contains data transformations and cleaning the data in order to find the final modeling dataset. Combining these analyses will be used to get familiar with the data and to discover initial insights.

5.3.1 DATA COLLECTION

Data for this project is extracted from multiple sources, what will be explained below. Table 14, depicted in section 5.3.2, provides a brief overview of the extracted datasets and the selected variables in order to construct the defaulted dataset. Appendix C describes more detailed how the datasets should be extracted from SAP. In the following we outline each data set briefly:

- *HS change*: Internal employees perform a monthly accuracy check on a random sample of the Master Data; 100 materials are checked per month. The reviewed data is collected in an Excel spreadsheet. Of the checked 1200 NCs per year, a sample of these set will entail HS code changes during the year. The materials corresponding to the changed HS codes are used as input to acquire relevant SAP data.

- *Opex Matrix:* In the Opex Matrix all relevant HS codes and plants (warehouses) are listed, and provides information on the corresponding duty tariffs.

- *Shipments into EU:* This dataset is extracted from SAP. The list contains the good received during the last three years (post-clearance recovery time), at the European local warehouses.
- *Shipments into NL:* This data is on the same manner extracted from SAP. Yet, the dataset consists of the good received at the Dutch bonded warehouses.

- *Shipments from NL:* This dataset incorporates the materials sent from a bonded warehouse to a customer. Again this list is extracted from SAP.

- *Vendor & Customer list*: These last two datasets are the vendor and customer lists. The vendor list includes all information on suppliers, code, name, location, address etc. The customer list contains the same information yet for customers.

5.3.2 SELECTION OF VARIABLES

Table 14 provides an overview of the information the dataset contains and the selected variables in order to construct the defaulted dataset. Appendix D clarifies briefly the different variables.

Table name	Name in code	Description	Variables
HS Change	HSChange	- Shows which materials have an altered HS code - Provides information on why the HS code is changed	- $Month(t)$ - $Material$ - $Material_{clean}$ - HS_{old} - HS - $Reason\ HS\ change$
Shipments Into EU	ShipmentsIntoEU	- Dataset containing information the shipped materials, with a change in HS code, into EU regional warehouse - Information on supplier or local plant (i.e. vendor) and incoming regional warehouse (i.e. plant) - Amount in local currency is the customs value	- $Material$ - $Vendor$ - $Plant$ - $Quantity$ -$Amount\ in\ Local\ Currency$ - $Currency$
Shipments Into NL	ShipmentsIntoNL	- Dataset containing information on the shipped materials, with a change in HS code, into NL bonded warehouse - Information on supplier or local plant (i.e. vendor) and incoming regional warehouse (i.e. plant) - Amount in local currency is the customs value	- $Material$ - $Vendor$ - $Plant$ - $Quantity$ -$Amount\ in\ Local\ Currency$ - $Currency$
Shipments out NL	ShipmentsOutNL	- Dataset containing information on shipped materials from NL bonded warehouse with a change in HS code - Information on the local plant (i.e. plant) and incoming customer (i.e. customer) - Amount in local currency is the customs value	- $Material$ - $Customer$ - $Plant$ - $Quantity$ -$Amount\ in\ Local\ Currency$ - $Currency$
Customer List	CustomerList	- Provides the connection between customers and their locations	- $Customer$ - $Country\ of\ Customer$
Vendor List	VendorList	- Information on suppliers and their locations	- $Vendor$ - $Country\ of\ Vendor$
OPEX Matrix	OpexMatrix	- Provides the connection between HS codes and the corresponding import tariff	- HS_{Opex} - $Plant$ - $Tariff$

TABLE 14 OVERVIEW OF THE DATASETS USED AND THE SELECTED VARIABLES

5.3.3 TRANSFORMATION AND CLEANING DATASETS

The process of constructing the modeling dataset starts with cleaning the datasets. Data cleaning comprises the filtering of incorrect data, unnecessary variables and treatments of missing and inconsistent data (Garcia et al., 2015). In this section we will describe several data transformations, data cleaning steps and first data insights.

HT change transformation

At first we will analyze and clean the dataset '*HS Change*'. The first observation shows that the variables HS_{old} and HT_{new} may differ in the amount of digits; between 8 and 10 digits. The variable HT_{Opex} however holds only 8 digits. Since we have to link in the final modeling step (see section 5.4) these datasets in order to find the corresponding tariffs of the shipments, it is required to select only the first 8 digits of the HS codes.

For example (HS codes are anonymized for reasons of confidentiality):

$$HT_{new} = XXXXXXXXXX \Longrightarrow HT_{new} = XXXXXXXX \tag{5.1}$$

A random sample of the Master Data is checked during the internal control procedures, meaning that it includes also materials with unchanged HS codes are not change. The '*HS change*' dataset must however include only HS code alterations plus the corresponding materials. Therefore, we select exclusively new HS codes that are not equal to their old HS codes:

$$IF\ HS_{old} \neq HS_{new}\ THEN\ HS_{new} \tag{5.2}$$

Furthermore, it is possible that an HS code of a material is modified multiple times throughout a year. In order to assure that a unique HS code change is represented for a specific material, the HS change within the latest month is selected. The other duplicated entries, i.e. rows containing identical information, are removed as these do not contain new information:

$$IF\ HS_{new} \neq HS_{old}\ AND\ HS_{new} > 1\ THEN\ HS_{new} = \max\left(HS_{new}, month(t)\right) \tag{5.3}$$

First insights HT change

The initial dataset '*HS Change*' had 1054 values. The final data sample consists of 148 altered HS codes during 2015. In other words, from the 1200 materials that were checked on accuracy in 2015, 148 had a change in HS code. Table 23 in appendix E shows the materials with corresponding altered HS codes (i.e. HS_{old} and HD_{new}). Table 15 presents a sample of the query after applying the previous data processing steps.

#	$Material$	$Material_{Clean}$	HS_{old}	HS_{new}
1	XXXX.XXX.XXXXX	.XXX.XXXXX	XXXX XXXX	XXXX XXXX
2	XXXX.XXX.XXXXX	.XXX.XXXXX	XXXX XXXX	XXXX XXXX
3	XXXX.XXX.XXXXX	. XXX.XXXXX	XXXX XXXX	XXXX XXXX

4	XXXX.XXX.XXXXX	. XXX.XXXXX	XXXX XXXX	XXXX XXXX
5	SERV. XXX.XXXXX	. XXX.XXXXX	XXXX XXXX	XXXX XXXX

TABLE 15 SAMPLE CLEANED HS CODE CHANGE QUERY
(HS codes are anonymized for reasons of confidentiality)

For preliminary insights we are interested in how often a specific HT_{new} occurs:

$$IF\ HS_{new} \neq HS_{old}\ THEN\ (HS_{new} = 1) \tag{5.4}$$

$$sum(HS_{new})$$

Table 23 in appendix E shows the frequency per HS_{new}. Noteworthy is that 34.4% of the materials is changed to a new HS code comprehending the digits 'XXXXXXXX'.

Note that the corresponding materials for these 148 modified HS codes are used as input to extract the other datasets out of SAP and are accordingly used as input for the other analyses presented in this chapter.

Incoming Shipments

We will analyze and clean the dataset of '*shipments into EU*' and '*shipments into NL'.* The completeness of these datasets has to be assessed by analyzing missing values. Based on these analyses, corrections have to be made.

Note that, for the following analyses and the further development of the model we assume that a product is originated at the same location (or country) as the corresponding supplier.

Looking at both initial datasets it became clear that the variable $Vendor$ is often not included. This entails that we are not able to make a distinction between non-EU and EU based suppliers for the specific materials and subsequently we cannot determine the corresponding duty tariff.

From the shipments to a European regional warehouse we cannot determine directly the supplier of 201 materials, which represent 9.8% of the total dataset. These shipments have no values, and are therefore considered as e.g. shipments within a warehouse. Taking a closer look to the $Vendor$ of the shipments to a bonded warehouse, we see that 4536 of the 14939 (30,4%) materials the location of the supplier cannot directly be assigned.

Since we are not able to apply a fix, these observations have to be excluded from the data set which is according to Tan et al. (2006) an option of dealing with missing values i.e. elimination of the data objects or attributes containing missing values. We will further elaborate upon the missing suppliers in section 5.4.3.

Material

The dependent variable within the datasets is $Material$, as multiple datasets will be linked by this variable. A first insight makes it clear that this variable may differ between the numbers of

characters (see appendix C), as differentiation of the characters indicates specific applications of the same part e.g. service parts. However, a HS code is relevant for all these differentiations. Therefore, to be able to link this dependent variable between the different datasets we have to select the 5th until the 14th characters. For example:

$$Material = XXXX.XXX.XXXXX \implies Material_{clean} = .XXX.XXXXX \quad (5.5)$$

Outgoing shipments

The last insight is relevant for the goods shipped via a bonded warehouse. A particular part number can have multiple initial suppliers or production plants. For this model it is not necessary to know the exact original location of a part, yet we should distinguish if a part is originated in the EU or non-EU. Likewise, a particular material can be shipped to multiple customers. Consequently, and to be able to link the datasets '*shipment into NL'* and '*shipments out NL'* with each other, we create for the shipments via a bonded warehouse a new variable '$Global\ Vendor$' and aggregate the variable $Country\ of\ Vendor$ into two groups 'EU' and 'Non- EU' by using:

$$IF\ (Country\ of\ Vendor =' NL' OR\ 'BE' OR\ 'DE'\ OR\ 'FR'\ OR\ 'IT' OR\ 'IL'\ OR\ 'UK'\ OR\ 'GB'\ OR\ 'IE')$$
$$THEN\ (Global\ Vendor = EU)\ ELSE\ (Global\ Vendor = non\ EU) \quad (5.6)$$

We will do the same for the $Country\ of\ Customer$:

$$IF\ (Country\ of\ Customer =' NL' OR\ 'BE' OR\ 'DE'\ OR\ 'FR'\ OR\ 'IT' OR\ 'IL'\ OR\ 'UK'\ OR\ 'GB'\ OR\ 'IE')$$
$$THEN\ (Global\ Customer = EU)\ ELSE\ (Global\ Customer = non\ EU) \quad (5.7)$$

So far, we have given a theoretical background of the aspects involved with HS code alterations. We collected relevant data and variables, cleaned and transformed the data where necessary and data analyses are used to discover initial insights and to familiarize oneself with the data. Now, the acquired final dataset can be used in the following phase; the modeling phase.

5.4 Phase 4 Modeling & Phase 5 Evaluation

This chapter gives an overview of the modeling phase and evaluation phase, which is carried out using R (see appendix F). The steps described provide a general understanding of the model. The model is evaluated by providing the results of the data analysis of the aforementioned global goods flows: (1) non-European local plant to regional warehouse EU and (2) local plant or supplier from outside the EU to a European customer via the bonded warehouse in the Netherlands.

The model will be set up using the data sample of the internal Master Data accuracy check. Additionally we will perform a worst case scenario. Furthermore, we will apply the model on a second dataset, containing HS code changes of the first quarter of 2016. Finally, we will conduct a brief sensitivity analysis.

5.4.1 DATA ANALYSIS NON-EU TO EU LOCAL

As mentioned before, the corresponding materials for the 148 modified HS codes are used as input for the following analysis. After dealing with the missing values in section 5.3.3, we are interested in knowing where the plant is based by allocating the variable $Vendor$ with the variable $Country\ of\ Vendor$. To summarize the number of shipping (intercontinental and intracontinental) to EU while counting the number of shipments between these locations and correspondingly summing the customs value, we use:

$$count\ (case\ when\ Material > 0)\ as\ number\ of\ Shipments, \tag{5.8}$$

$$IF\ (number\ of\ Shipments > 0)\ THEN\ sum(amount\ in\ local\ currency),$$

$$Group\ by\ Country\ of\ Vendor, Plant$$

As explained in previous sections, shipments between European Union members are so called 'Free Goods', and are therefore not taken into account. The intercontinental shipments are selected using:

$$select\ case\ (Country\ of\ Vendor =' KR'\ OR\ 'US'\ OR\ 'TW'\ OR\ 'SG'\ OR\ 'MY'OR\ 'JP'OR\ 'HK'OR\ 'CN') \tag{5.9}$$

The table below is depicted using the same approach, however shows only the relevant shipments, from non-EU to EU. In total 295 items are imported into EU.

#	Country Of Vendor	Plant	# Shipments	∑ Amount in local currency	Currency
1	KR	BE	1	X	EUR
2	KR	DE	125	X	EUR
3	KR	FR	86	X	EUR
4	KR	FR	94	X	EUR
5	KR	IE	28	X	EUR
6	KR	IT	68	X	EUR
7	TW	DE	1	X	EUR
8	TW	FR	1	X	EUR
9	TW	FR	1	X	EUR
10	US	BE	3	X	EUR
11	US	DE	21	X	EUR
12	US	FR	5	X	EUR
13	US	FR	2	X	EUR
14	US	IE	10	X	EUR
15	US	IT	1	X	EUR

TABLE 16 NUMBER OF SHIPMENTS AND CORRESPONDING VALUE BETWEEN NON-EU SUPPLIER AND AN INCOMING EUROPEAN PLANT (SAMPLE 2015)

After we are interested in the corresponding tariff percentages for the HS_{old} and the HS_{new} of the incoming materials. To do so we will first connect two datasets, by linking variable

$Material_{clean}$ from the '*Shipment into EU*' dataset with the variable $Material_{clean}$ from the '*HS change*' dataset. We create two new variables: $Tariff_{old}$ and $Tariff_{new}$, which represent the corresponding tariff rate, in percentages, for HT_{old} and HT_{new} per incoming plant respectively. Consecutively, we have to find the corresponding $Tariff$ in the Opex Matrix for HS_{old} and HS_{new}. Formula 5.10 shows the calculation of the final difference in duty payment, which represents the difference between the old tariff and the new tariff multiplied by the customs value of a material.

$$Duty\ Difference = \big((Tariff_{new} - Tariff_{old}) * amount\ in\ local\ currency\big)/100 \quad (5.10)$$

65 of the 295 intercontinental shipments have a change in duty tariff. The other 230 shipments contained all an old and new tariff of 0%. The table below contains a small sample, to quickly obtain an understanding of the relation of the shipments, the HS codes and the duty payments.

Material	**Country of Vendor**	**Plant**	**Quantity**	**∑ Amount in local currency**	**Currency**	**HT Old**	**HT New**	**Old Tariff %**	**New Tariff %**	**Difference Duty Payment**
SERV.XXX.XXXXX	KR	IT	1	*X*	EUR	XXXXXXXX	XXX.XXXXX	2.1	0	€X
SERV. XXX.XXXXX	KR	DE	1	*X*	EUR	XXX.XXXXX	XXX.XXXXX	2.3	2.2	€X
SERV. XXX.XXXXX	KR	IT	1	*X*	EUR	XXX.XXXXX	XXX.XXXXX	0	2.4	€X
SERV. XXX.XXXXX	KR	DE	1	*X*	EUR	XXX.XXXXX	XXX.XXXXX	0	1.7	€X

TABLE 17 SAMPLE SHIPMENTS FROM NON-EU COUNTRIES TO EU PLANTS CONTAINING A DIFFERENCE IN DUTY TARIFF (SAMPLE 2015)

The amount of duty Company X has paid before a change in HS code was €X over the corresponding shipments. The change in tariff implies that company X had to pay €X over these shipments. The difference in duty payment is therefore in total €X.

5.4.2 DATA ANALYSIS SHIPMENTS NON-EU TO EU VIA BONDED WAREHOUSE

After modeling the goods flow from non-EU countries to EU countries, we are interested in the second goods flow: from non-EU countries to EU countries via a bonded warehouse. In similar way to the previous model we will only take the corresponding materials for the 148 modified HS codes as input. On the other hand, in comparison with the previous model, this model requires an additional step. We should not only look at the goods entering a bonded warehouse but also know to where these particular goods are shipped after the bonded storage period. This enables us to distinguish charged and uncharged goods.

Again, after handling the missing values (see section 5.3.3) we allocate the supplier or local plant to their domestic country. The following step is to illustrate the number of goods received at a bonded warehouse in the Netherlands. Moreover, this model is also only applicable in the intercontinental shipments. By applying approach 5.9 all the intercontinental shipments are selected, resulting in the table presented below.

#	Country Of Vendor	Plant	# Shipment	∑ Amount in local currency	Currency
1	CN	NL	109	X	EUR
2	CN	NL	2	X	EUR
3	JP	NL	237	X	EUR
4	JP	NL	178	X	EUR
5	KR	NL	1	X	EUR
6	KR	NL	537	X	EUR
7	KR	NL	14	X	EUR
8	MY	NL	11	X	EUR
9	SG	NL	74	X	EUR
10	SG	NL	1	X	EUR
11	TW	NL	247	X	EUR
12	TW	NL	404	X	EUR
13	TW	NL	1	X	EUR
14	US	NL	1597	X	EUR
15	US	NL	483	X	EUR
16	US	NL	22	X	EUR

TABLE 18 NUMBER OF SHIPMENTS AND CORRESPONDING VALUES BETWEEN A NON-EU SUPPLIER AND A BONDED WAREHOUSE IN NL (SAMPLE 2015)

To be able to analyze if a material is subject to duty payment, we evaluate if a good is shipped to a European customer i.e. imported into Europe. Taken this into consideration, the variable *Customer* will be linked with the variable $Country\ of\ Customer$.

Table 27 depicted in appendix E, summarizes all shipments from a bonded warehouse to the customer's country while counting the number of shipments between these locations and summing the corresponding values, using the following:

$$count\ (case\ when\ Material > 0)\ as\ number\ of\ Shipments, \tag{5.11}$$

$$IF\ (number\ of\ Shipments > 0)\ THEN\ sum(amount\ in\ local\ currency),$$

$$Group\ by\ Plant, Country\ of\ Customer$$

Subsequently, we exclude the non-European customers i.e. we select the intracontinental shipments from a bonded warehouse to an EU member state. The European customers are selected as follows:

$$select\ case\ (Country\ of\ Customer =' NL' OR\ 'BE' OR\ 'DE'\ OR\ 'FR'\ OR\ 'IT' OR\ 'IL'\ OR\ 'UK'\ OR\ 'GB'\ OR\ 'IE') \quad (5.12)$$

Table 19 depicted below summarizes the information relevant to the intracontinental shipments.

#	Plant	Country of Customer	∑ Shipment	∑ Amount in local currency	Currency
1	NL01	CY	1	X	EUR
2	NL01	DE	17	X	EUR
3	NL01	IE	2	X	EUR
4	NL01	NL	5	X	EUR
5	NL10	BE	2	X	EUR
6	NL10	DE	3	X	EUR
7	NL10	IE	9	X	EUR
8	NL10	IT	4	X	EUR
9	NL10	NL	7	X	EUR
10	NL11	BE	2	X	EUR
11	NL11	IE	5	X	EUR
12	NL11	NL	1	X	EUR

TABLE 19 INTRACONTINENTAL SHIPMENTS FROM NL TO A EUROPEAN CUSTOMER (SAMPLE 2015)

Now, the additional step will be performed: singling out the part numbers with a supplier based outside the EU, received and stored at the bonded warehouse, and eventually imported into the EU. As explained in section 5.3.3 we will aggregate and combine the $Country\ of\ Vendor$ and $Country\ of\ Customer$ into two groups: 'EU' and 'non EU', using formula's 5.6 and 5.7.

Consecutively, we take the inventory levels of products at the bonded warehouse into account. Considering the dimension of our model, only the quantity derived from a non-EU supplier or plant, can be imported under duty payment. In illustration: five goods are shipped to a European customer, while only 2 of these goods are bought from a supplier outside the EU, than a maximum of two of the five goods consider duty payment. To do so we will use the following:

$$IF(\ Global\ Vendor\ \neq Global\ Customer)\ AND\big(Global\ Vendor\ \neq Global\ Vendor\ (non\ EU)\big) \quad (5.13)$$

$$THEN\ sum(Quantity, Global\ Vendor)\ AND\ sum(Quantity, Global\ Customer)$$

$$AND\ sum(Amount\ in\ local\ currency, Global\ Vendor)$$

$$Group\ by\ Material\ and\ Material_{clean}$$

And:

$$IF\ abs(Quantity, Global\ Customer) > (Quantity, Global\ Vendor) \quad (5.14)$$

$$THEN\ (Quantity, Global\ Customer) = \ max\ (Quantity, Global\ Vendor)$$

Finally, applying the same approach as 5.10, we allocate the corresponding tariff percentages for the HS_{old} and HS_{new} to the materials. The table below shows the 9 non-European shipments via a bonded warehouse that are imported in Europe that consider a change in duty tariff

Material	**Global Vendor**	**∑ Quantity**	**Global Customer**	**∑ Quantity**	**Max ∑ Quantity**	**∑ Amount in local currency**	**Currency**	**HS Old**	**HS New**	**Old Tariff %**	**New Tariff %**	**Diff. Duty Payment**
XXXX.XXX.XXXX	Non-EU	1	EU	-2	1	X	EUR	XXXXXXXX	XXXXXXXX	6.7	0	€X
XXXX.XXX.XXXX	Non-EU	1	EU	-3	1	X	EUR	XXXXXXXX	XXXXXXXX	2.1	2.2	€X
XXXX.XXX.XXXX	Non-EU	11	EU	-3	3	X	EUR	XXXXXXXX	XXXXXXXX	2.1	2.2	€X
XXXX.XXX.XXXX	Non-EU	181	EU	-1	1	X	EUR	XXXXXXXX	XXXXXXXX	4.7	0	€X
XXXX.XXX.XXXX	Non-EU	1	EU	-1	1	X	EUR	XXXXXXXX	XXXXXXXX	14	0	€X
XXXX.XXX.XXXX	Non-EU	4	EU	-1	1	X	EUR	XXXXXXXX	XXXXXXXX	0	2.4	€X
XXXX.XXX.XXXX	Non-EU	2	EU	-1	1	X	EUR	XXXXXXXX	XXXXXXXX	2.1	0	€X
XXXX.XXX.XXXX	Non-EU	4	EU	-2	2	X	EUR	XXXXXXXX	XXXXXXXX	2.1	2.2	€X
XXXX.XXX.XXXX	Non-EU	7	EU	-1	1	X	EUR	XXXXXXXX	XXXXXXXX	2.2	0	€X

TABLE 20 SHIPMENTS FROM NON-EU COUNTRIES TO EU COUNTRIES VIA BONDED WAREHOUSE, CONTAINING A DIFFERENCE IN DUTY PAYMENT (SAMPLE 2015)

The goal is to calculate the total difference of duty payment of before and after changing HS codes. The amount of duty Company X has paid before a change in HS code was €X over the corresponding shipments. The change in tariff entails that Company X had to pay €X over these shipments. The difference in duty payment is therefore in total €X.

5.4.3 SCENARIO: ALL VENDORS NON-EU

As described in section 5.3.3 in both goods flows the source of the product is an often missing value. We eliminated these values, as we could not determine their supplier. The missing suppliers of the first model had no values, and are therefore all intercompany shipments. Replacing the missing vendors will not make any difference in duty payment.

Therefore, this scenario will only focus on the imports via a bonded warehouse. It was not possible to assign the relevant supplier for 30.4% of the shipments. Consecutively, the distinction between charged and non-charged goods could not be made.

In this scenario we assume that all missing vendors are set to suppliers located outside the European Union i.e. all goods of missing vendors are considered to be imported goods. This entails the worst case scenario.

$$IF\ (Vendor = \text{""}\ )\ THEN\ (Vendor = non\ EU) \tag{5.15}$$

The same steps of the previous section are taken, resulting in figure 11.

Replacing all missing suppliers with suppliers based outside the EU, results in extra shipments that are subject to import duty payment. The total duty payment before HS code alterations increases, as well as for the total duty payment after HS alterations. As we can distinct from the figure the ratio of increase is higher for the old tariff than for the new tariffs; 144.1% and 115.4% relative to the original values respectively. This indicates that more original HS codes are changed into HS codes holding a lower tariff. Furthermore, the total duty difference increases with 194.10%. The interval between the worst case scenario and the original scenario is (-€X, -€X).

5.4.4 DATA ANALYSIS SHIPMENTS FIRST QUARTER 2016

The previous sections focused on the data sample acquired by an internal control audit on Master Data accuracy. This data sample contained 148 HS alterations during whole 2015. Yet, we are interested in applying the model to a greater dataset to validate the model. Interviews with classifications experts have indicated that on average 100 to 300 HS code alterations take place a month. To validate the constructed model, data acquired over a period of three months will be used as input (the first quarter of 2016). This analysis follows the same steps as the previous section.

A first analysis shows that there are far more HS code alterations than the internal audit sample of 2015. There are 100 HS changes in February and 157 HS code changes in March 2016. Noteworthy are the number of altered HS codes in January 2016: 4226. The latter is one time high as in January 2016 a new tariff policy was updated. However, most of the HS code changes will entail no change in tariff. The material corresponding to these 4523 HS code alterations are used to extract the relevant data out SAP and are used as input for the further analyses. Additionally for the following analysis we will use the following timeframe: from 01.03.2013 until 31.03.2016.

A second insight is the frequency per HS_{new}. Also in this model we see that the most often occurring HS_{new} is 'XXXXXXXX'. Namely, 60.2% of the HS codes are altered into this particular code.

Even though the high number of shipments with altered HS codes, there are only 470 of these materialss shipped into Europe. More specifically, only 104 materials are imported into the EU. From these 104 shipments 19 shipments had a change in duty. The other materials remained the same tariff.

After analyzing the direct imported shipments, we will exam the goods that are imported into EU but shipped via a bonded warehouse. After performing the required data analyses we observe that 17 materials are subject to duty payment.

Six of the 17 materials that are subject to import duty had an actual change in tariff. The old duty with €X insignificant. Therefore the difference in duty payment equals the amount of new duty payment. This illustrates that these shipments are not subject to recovery at a PCA by Dutch Customs authorities.

5.4.5 SENSITIVITY

This scenario illustrates the sensitivity of the HS alterations, for both models and for both samples. We will not perform the analysis for HT_{old}, since the corresponding duties are already issued by Customs authorities. We will vary $Tariff_{new}$ with 0.1% when this tariff is higher than 0.0%, using the following:

$$Duty\ Sensitivity = Ifelse\ \ (Tariff_{new} > 0, Tariff_{new} + 0.1\%, 0) \tag{5.16}$$

Performing consecutive step 5.10, we will find the final sensitivity of the altered HS code on the difference in duty payment. Table 21 summarized the results of the sensitivity analysis.

Model	Sample	Duty 1	Duty 2 (Tariff new + 0.1%)	Difference
Non-EU Local EU	2015	X	X	7.9%
	2016	-X	-X	0.8%
Via bonded warehouse	2015	-X	-X	23.3%
	2016	X	X	6.3%

TABLE 21 RESULTS SENSITIVITY ANALYSIS HSNEW

Concluding from table 21, for both the models changing the tariffs of corresponding HS codes with 0.1% has a significant impact. For both models the sample of 2015 is more sensitive to change in tariff, than for 2016. The latter is indicated by the fact that for both models the sample size of 2015 contained more frequently a new tariff with positive values.

5.5 CONCLUSION

The aim of this chapter was to analyze the financial impact of altering HS codes. Initially the setup approach was explained, and by means of the CRISP-DM framework we structured the data analysis. This study focused on two goods flows: direct imports and indirect imports via a bonded warehouse. Accordingly a model has been defined for these two flows. Furthermore, we established the data analysis exclusively for imported goods in Europe. The provided framework recalculates the duty payments of shipments with a modified HS code. As initial input for the model we used a

data sample acquired from an internal control on Master Data adequacy of 2015. For this dataset a worst case scenario was applied in which all missing vendors were set as non-European vendors. After, we used the same modeling steps for a data sample of all HS code alterations of the first quarter of 2016. The results for both datasets are completely different. The results differ as the materials and corresponding HS codes differ between the datasets i.e. in 2015 other materials are changed as in 2016, suggesting that these goods are subject to other duty tariffs.

The objective of the model was to serve Company X in obtaining a higher awareness of the financial impact of HS code alterations. A structured framework, combining two models, is developed which can be implemented for analysis of HS code changes and can provide Customs authorities factual evidence corroborating that Company X performs recalculations of duty payments. Furthermore, the model can be applied to simulate future HS code alterations; the model can be used to analyze the financial effect of an expected change in product classifications.

6. CONCLUSION

In this chapter we summarize the findings and we discuss the research questions as stated in section 1.1.2. Despite the strengths, the current study has several limitations which should be taken into account. These limitations and future research opportunities are appointed in section 6.2.

6.1 CONCLUSION RESEARCH QUESTIONS

Sub-question 1: *How can existing methodologies be deployed to identify and prioritize trade and customs risks?*

Chapter 3 presented an approach to identify possible customs risks in an international supply chain. This approach is based on two segments. The first one is a workshop with internal customs experts in order to distinguish potential risks. It acquired an extensive overview in short time frame. The second step was linking these outcomes with additional analyses of current local risk frameworks, Customs and Trade facilities and interviews with internal stakeholders. Chapter 4 provided a methodology to broaden and deepen the analysis of the risk workshop and measured and prioritized the risks, by means of an assessment survey. The survey was a solid approach to reach numerous stakeholders in the different geographically regions (APAC, US, EMEA). Internal stakeholders were asked to assess the inherent risk events on predefined impact and likelihood scales. The outcomes of the survey supplemented the outcomes of the workshop and vice versa.

Sub-question 2: *Are there similarities and differences in the perspective of risks within and between the regions (EMEA, APAC, US)?*

Chapter 4 illustrated that regional differences were found between APAC and EMEA. Local trade procedures, policies, regulations and ideologies may result in differences of sanctions and severity of customs risks, yet one can also speak about cross-cultural differences. The risk perceptions of the respondents in Eastern countries differ from those in Western countries. In chapter 4 additional analyses were conducted on risk perceptive on individual level. The high variance and high confidence intervals entailed that risks are differently perceived by various individuals. These differences can be possible explained by the following: lack of knowledge and or experience of the individual in the specific risk areas, individuals are prone to biases and intuitions in their judgments and the combination of scoring 'residual' risks and 'inherent' risks.

Sub-question 3*: What is the financial impact of HS code alterations?*

The second part of the current study included the financial analysis of altering HS codes. The CRISP-DM framework was used to provide a handrail setting up the model and the data analysis. By analyzing the business environment we distinguished two high level goods flows: direct import flows, and indirect import flows via bonded warehouses. For the first one import duties are levied at the moment a product crosses the border, for the latter one goods are exported or imported after the storage period. Also here duties are levied at the moment of import. We established a model for these two flows while applying the data analysis exclusively on imported goods in Europe. We used the following datasets: a data sample provided by internal Master Data adequacy check in 2015 and a dataset of all HS code alterations in the first quarter of 2016. The results for both datasets differ significantly. The results between the data samples differ as the shipped materials and

corresponding HS codes differ between the datasets i.e. in 2015 are different materials modified as in 2016, entailing that these goods are subject to other duty tariffs.

Sub-question 4: *How should Company X apply the model to analyze the influence of HS code changes on customs duty payments?*
Detailed findings of the duty payments are really only applicable to this setting (imports into Europe). However, the methodology used in the research can be applied to any other goods flow as it entails a structural way to calculate duty payments. Our model can be imbedded in Company X's classification processes. Classification experts can run this model monthly or quarterly to get in an easy and automatic way an overview of which HS code alterations may entail a difference in duty tariff and hence see which shipments are subject to post clearance recovery. In addition, the model can be applied to simulate future HS code alterations i.e. the model can be used to analyze the expected financial effect of a change in HS code classification.

According to these sub-questions and additional analysis it is possible to draw the overall conclusion for this project. 48 possible trade and customs risks are detected in 7 categories: inbound, outbound, warehouse, production, transport, infrastructure, and export control. The risk workshop and the assessment survey together singled out the most important risks by measuring the risks on likelihood and compliance impact. By aggregating and combining multiple risks the most important and high prioritized trade and customs risks are found. The risk list provided a clear overview, a sharpened vision and a broader scope of the prioritized global customs and trade risks that could apply to international supply chains and can therefore serve as a valuable input for the control framework. The three most important risks are: '*Incorrect import declaration'*, *'Incorrect export declaration',* and *'Inadequate customs Master Data governance'.* After pinpointing the key risks the study highlighted one important risk: *'Inadequate customs Master Data governance'.* We focused on HS code classification, as changing these codes may result into a financial impact on customs duty payments. We structurally assessed this risk using historical data and created a model which can be reused in the future. The model is programmed in R and is linked to Excel sheets from which the data values are imported. Many of these datasets can be easily changed. A handbook is written in order to help the classification experts running the model. The constructed model served Company X a structured method in obtaining higher awareness of the financial impact of HS code alterations.

6.2 LIMITATIONS AND FUTURE RESEARCH

The first set of limitations and research direction are applicable to the trade and customs identification and prioritization phase.

The first limitation is the number of completed surveys, which influences the validity of the results and caused that the outcomes of the survey on its own must be interpreted with some caution. A bigger sample size may increase the validity and may as well result in an extended regional analysis (e.g. the U.S. could be analyzed as well). Moreover, the survey faces some biased results due to the subjectivity of the responses. However, combining the perceived information with the information from the risk workshop, justifies the outcomes. In future research a couple of things can be done to increase the number of completed surveys and to overcome the biases. At first, by sending a

particular 'risk set' containing exclusively risks relevant to the expertise and/or experience of a stakeholder will speed up the process and respondents will get more encouraged to complete the survey. Secondly, by limiting the length of the risk descriptions (i.e. provide only one aspect per risk definition) the risks will be easier to interpret. Thirdly, the misperception of impact scaling can be corrected by redefining and using only the aspects of the impact scale relevant to the project. Finally, disassociating the assessment of the likelihood from the impact, or grouping participants in two parts: one part assessing the likelihood and the other part assessing the impact will make it unnecessary to switch between the different definitions of the scales.

Another limitation is the scope of the study, which focusses purely on the first two steps of the risk management process: risk identification and risk measurement. Hence, the follow-up process will be creating mitigating controls and monitoring mechanisms on a global level for the prioritized trade and customs risks. Eventually, having all the control and monitoring procedures in place, one can conduct a second survey or workshop, to assess and analyze the 'residual' risks (the risk that remains after controls are taken into account). This will indicate how effective the controls are and how the controls and monitoring processes are perceived by the stakeholders involved. Company X is actively working on the follow up process by developing the control framework.

The following limitations and research directions are applicable to the HS code recalculation model.

The research addressed only the goods flow containing European imports. Time wise it was not feasible to extend the analysis to other regions. In future the multiple other goods flows should be explored and the acquired relevant data should be collected in order to extend the model.

Another limitation is applicable to the indirect goods flow. Dutiable parts may undergo allowed manufacturing operations or be consolidated or assembled into another product during their storage period at a bonded warehouse. Due to these modifications a part number will be altered. These parts are not taken into scope in this study. However, importing these altered products duties are levied as well. Therefore, a future research direction is to investigate the duty payments parts produced at Company X.

An additional limitation regards the assumption that products are originated at the same location as the corresponding supplier. However, a product can be produced in a different country as the supplier is based. For example: A German company may make their products in China. This can, depending e.g. on the incoterm used, have a significant effect on the results. Therefore, to increase the validity of the model future studies may include these 'suppliers – production location' relations.

Finally, the last limitation of this research is that only HS codes are taken into account, as these have a financial impact influencing duty tariffs. As explained, product classification contains however more items e.g. product description, country of origin, and codes for export restriction. These items do not all have a financial impact but are also part of the possible risk '*Inadequate Master Data Managemen*t'. A new research direction leads to the investigation of the other Master Data aspects, and where a more extended model can incorporate multiple classification items.

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APPENDIX A DETAILED RISK DESCRIPTIONS

Risk #	Risk name	Risk description
	General: The general category contains risks which are applicable for every category	
G-1	Irregularity of goods	Irregularities (damage, theft, administration, wrong quantity) in combination with a high volume of business can result in a high financial or non-financial risk a. Goods in bonded warehouse b. Goods received in bonded warehouse c. Goods shipped from bonded warehouse d. Goods used in production process If no proper action is taken in case of discrepancies and/or when irregularities are discovered in incoming of goods, storage of goods or loading of goods this may result in customs restrictions (i.e. more audits and investigations, less autonomy and in worse case consequences for the Bonded warehouse licenses)
G-2	Internal control procedures	Fraud, unauthorized or illegal activities occur (undetected) as no or weak internal control procedures are in place, i.e. inadequate control over the business processes
G-3	Financial insolvency	Financial insolvency resulting in inability to meet financial obligations
G-4	Inadequate Safety and Security internally and in business activities	Inadequate awareness and/or coordination about and/or control over safety & security as a result of - Incorrect and/or incomplete registration of safety and security incidents and/or - Inadequate safety and security measures and/ or implementation requirements and/or - Absence of appropriate countermeasures to safety and security incidents
G-5	Non regular Shipments (inbound/outbound)	Non SAP shipments with manual invoice(inter-company) shipments* are not registered in SAP and therefore will not be controlled by automated compliance checks (export control and master data). As the administration of these shipments is manual this may result in incorrect and unreliable declarations. * Non Regular shipments definition: Shipments outside SAP and/or not interfaced
G-6	Wrong Filing/Record Retention (inbound/outbound)	Incorrect and/or incomplete filing of transactions may induce possible destruction or loss of relevant information which may result in an interrupted audit trail
G-7	Inadequate physical security	Physical security incidents, caused by: - Inappropriate access to internal sections of the premises and/or - Inadequate protection of the premises against external intrusion and/or - Existence of doors/ gates/ gateways which are not monitored and/or inadequate locking and/or - Inappropriate maintenance of the external boundaries of the premises and the buildings
G-8	Incorrect scrap procedure	An incorrect scrap procedure will cause that the (bonded) goods are not under customs supervision
	Inbound: Start: When the Purchase Order is filed. End: When the declaration is released by customs and the goods have received a customs status.	
IB-1	Incorrect import declaration (including input information of suppliers is wrong)	An incorrect import declaration (e.g. customs value , HTS, currency, quantity, lines) of goods may result in an incorrect duty rate and/or penalties from customs.

IB-2	Wrongly declared non goods	Non Company X goods are wrongly declared as a result of: - Lack of control of reception of goods which is not registered in a logistical system and/or - Lack of proper knowledge on security with the consequence of accepting unsafe or insecure goods; accepting goods which are not registered in a logistical system and of which you don't have any control.
IB-3	Declaration not cleared within required time	Import declarations are not cleared within the customs required period (i.e. 7 days transit) which may result in penalties from customs
IB-4	Incorrect Airway Bill information from forwarder to customs	Wrong or no Airway Bill number on declaration resulting in disruption of traceability of the goods
IB-5	Broker systems disconnected to Customs system	IT systems are not available resulting in appliance of customs emergency procedures i.e. manual declarations and recovery work
IB-6	Local customs disagreements regarding declaration	Local customs challenges Company X's classification on HT code, goods description, CoO, customs value resulting in extra work, delays, and extra duties and penalties
IB-7	Incorrect drawback	Incorrect calculations of drawbacks may result in wrong duty payment.
	Outbound: Start: When a Purchase Order is received. End: When the goods leave the territory	
OB-1	Incorrect export declaration	- An incorrect export declaration (e.g. customs value, incoterm, HTS, currency, quantity, ECCN, lines) of the goods may result in incorrect statistics for customs and tax authorities and/or - Incorrect ECCN will result in non compliance regarding export control
OB-2	Declaration not cleared within required time	Transit and export declaration are not cleared within the customs required period (i.e. 7 days transit) which may result in penalties from customs
OB-3	Shipping area unsafe and unsecure	Safety an security incidents in shipping area caused by: - Inadequate safety and security awareness and/or - Incorrect and/or incomplete registration of safety and security incidents - Unauthorized access of vehicles, premises or the loading and shipping area and/or - No proper action if (external) intrusion has been discovered & absence of appropriate countermeasures
OB-4	Ship wrong quantity of goods	Wrong quantity of goods are picked by warehouse resulting in mismatch between physical goods and declaration causing incorrect statistics and potential problems at import
OB-5	Every warehouse uses own shipment reference number	Inadequate use of shipment reference number makes it hard to identify which delivery belongs to which reference
	Warehouse: Start: Moment the goods are moved from the dock to the storage location. End: When goods are picked from the storage location and put onto the dock.	
WH-1	Incorrect (Bonded) Inventory	Incorrect administration of (bonded) inventory (quantity, wrong goods etc.) may have negative consequences because of withdrawal of customs supervision.
WH-2	Inadequate access security/ rules in warehouse	Inadequate protection of the storage area against external intrusion may lead to unauthorized access causing: - Unauthorized substitution of goods and/or tampering with goods. - Unauthorized access to the goods.

WH-3	Unsecure and/or unsafe warehouse	Security and/or safety incidents in the warehouse; caused by: - Inadequate safety and security awareness and/or - Insufficient transport & physical security (transports, vehicles and (un)loading area) and/or - Incorrect and/or incomplete registration of safety and security incidents and/or - Absence of appropriate countermeasures to safety and security incidents.
WH-4	Lack of stock movements control	Lack of control over stock movements (e.g. goods are stored at wrong location in warehouse) offers possibilities to add dangerous and/or terrorist related goods to the stock and to take goods out of stock without appropriate registration.
	Production: Start: Moment the goods are picked up from the warehouse storage location. End: When the goods are transported back to the warehouse storage location	
PD-1	(Bonded) goods not properly processed in IPR (Inward Processing Relieve)	-No full control over the production process (track and trace) may result in interrupted audit trails and withdrawal of customs supervision -If the BOM is not actual and/or correct the article does not meet the physical shipped product this will lead to discrepancy between the declaration and the shipped goods
PD-2	Unsecure and/ or unsafe factory	Security and/or safety incidents in the factory; caused by: - Inadequate safety and security awareness and/or - Incorrect and/or incomplete registration of safety and security incidents and/or - Unauthorized access to the goods and insufficient access and physical security and/or - Absence of appropriate countermeasures to safety and security incidents
PD-3	Inadequate Quality Control	Unsafe goods or packaging causing safety issues during transport and Customs activities.
	Transport: Start IB: Goods arrive at country of destination. End IB: Goods arrive at warehouse facility. Start OB: Goods are put in the warehouse facility. End OB: Goods are at port of exit/leave the territory	
TR-1	Incorrect Transport declaration	Inaccurate and/or missing information in Transport declaration (e.g. incorrect customs value, HTS, currency, material) may result in penalties from customs
TR-2	Unsecured transport modality/ unsecure transporter	Security and/or safety incidents in transport caused by: - A freight forwarder who is no member of a secure transport program and/or - A freight forwaredr who is unauthorized to transport sensitive goods and/or - Lack of proper knowledge on security with the consequence of loading unsafe or insecure goods.
TR-3	No clearance of Transport declarations	Transit and export declarations are not cleared within the customs required period (i.e. 7 days transit) which may result in penalties from customs
TR-4	Wrong Customs Reference number processed in SAP	The wrong registration of the Customs reference number on the transport declaration is attached to the follow up declaration, causing a wrong audit trail during the rest of the goods movements
TR-5	Information invoice missing	An incorrect import declaration (e.g. incorrect customs value, HT code, currency, quantity, material) of goods due to missing information on the invoice may result in an incorrect duty rate and/or penalties from customs.
	Infrastructure: Transactions relating to: Licenses, IT system, People, Master Data	
IF-1	Incompetent people	Incompetent employees (no up to date knowledge, wrong competencies, unsafe/unsecure) may lead to (un)intended non compliant actions and/or incorrect declaration
IF-2	Incompetent brokers	Incompetent brokers may lead to (un)intended non compliant actions and/or incorrect declaration, possible caused by: - No clear instructions for brokers and/or - No broker management in place

IF-3	Unsecure IT Systems /Unauthorized Access and Changes	- Unauthorized access and/or intrusion to the operator's computer systems may lead to possible destruction, undesired change and/or loss of relevant information. - Unavailability and inaccessibility of IT systems which may lead to possible destruction or loss of relevant information. - Inadequate change management
IF-4	Inadequate Customs Master Data Governance	Incomplete, incorrect, outdated export control and customs master data resulting in missing or incorrect classifications of master data which can lead to incorrect determination of applicable licensing obligations and result in unauthorized exports or reexports and/or unreliable customs declarations.
IF-5	Inadequate License Management	Inadequate routines and procedures for administrating licenses related to the import/ production/ warehouse and export of goods may lead to non-compliance (e.g. exports or reexports of tangible or intangible items without a valid export license or license exception, or in violation of a license condition or restriction), which may lead to restrictions/sanctions of customs.
IF-6	Improper functioning of SAP/R3	Not all customs relevant movements are processed via SAP into the other systems resulting in incomplete customs declarations.
IF-7	Improper functioning of SAP/GTS	-Not all customs relevant movements are processed via SAP GTS into the other systems resulting in incomplete shipping invoices. - Export control checks are based on outdated lists and licenses resulting in unauthorized exports or reexports and/or unreliable customs declarations
IF-8	Improper functioning of Customs IT Systems	Not all transactions from SAP/R3 and SAP GTS received in Customs IT system which can cause mismatches with SAP inventory and/or in incomplete customs declarations.
IF-9	Payment request Wrong Invoice	Wrong billing from 3rd party vendor to Trade&Customs cost center might cause additional cost with suppliers integrity issues.
IF-10	No back up available IT systems	Undesired loss of relevant information caused by; - No back up routines in place when IT systems do not function - No procedures bringing the information in the IT systems when they work again
IF-11	No back up available employees	In the situation where employees leave there are no competent employees with critical functions available as backup
	Export Control: Process to ensure and prove is compliance with all applicable national and international export control laws and regulations.	
EC-1	Inadequate Screening relating to sanctioned parties and embargoes	Hiring a potential employee or engaging in a business transaction with a third party who is listed on sanctioned parties lists, or located in an embargoed country may lead to a violation of applicable economic sanctions regulations or embargoes
EC-2	Unauthorized technology transfer	If Company X transfers U.S. controlled technology, either to employees or other persons, without the required U.S. governmental authorizations this may result in unauthorized technology transfer, in violation with U.S. export regulations
EC-3	Risk of incorrect export control classification of items (goods, software and technology)	Missing or incorrect export control classifications can lead to incorrect determination of applicable licensing obligations and result in unauthorized exports or reexports
EC-4	(Re) Exports of (in)tangible items without a valid export license or license exception, or in violation of a license condition or restriction	Unauthorized sale, delivery or transfer of goods, software or technology
EC-5	Risk of violating U.S. antiboycott laws	Unauthorized business transaction in support of a boycott or failure to report an antiboycott request in violation with U.S. export regulations

TABLE 22 FINAL RISK LIST INCLUDING RISK DESCRIPTIONS

APPENDIX C DATA EXTRACTION FROM SAP

- *Shipments into EU:* This data is extracted from SAP, using the 'Material Document List'. The materials out of the internal Master Data accuracy audit have to be used as input in the 'Material' box. Fill in the 'Movement Type' 'X' which gives all the good receipts. In the 'Plant' box the European warehouses have to be filled in. Take a time frame of three years (post-clearance recovery time), here: 01.01.2013 to 31.12.2015.

- *Shipments into NL:* To extract the relevant data from SAP the same procedure as 'shipments into EU' has to be followed. In contrast, in the 'Plant' box the Dutch bonded warehouses have to be filled in.

- *Shipments from NL:* The same procedure as 'shipments into NL' has to be followed. In contrast, within the 'Movement Type' box number 'X' has to be entered, to require all the shipments send from the relevant plants.

- To be able to extract all required materials, and to ensure alignment between the lists, a material is searched using for example *.XXX.XXXXX*.

APPENDIX D CLARIFICATION VARIABLES

- $Month(t)$: the month of the Master Data check. Time frame is from the 1st until the last day of a month in 2015.

- *Material:* relevant for material, part number or shipment.

- $Material_{clean}$: a part number containing the 5th to 14th digit.

- HT_{old}: the old HT code of a material

- HT_{new}: the new HT code of material

- $Reason\ HT\ change$: the reason of a HT code alteration

- $Vendor$: the supplier or local plant

- $Country\ of\ Vendor$: the location of the outgoing supplier or plant

- $Plant$: the incoming or outgoing plant

- $Quantity$: the number of parts numbers within one shipment

- $Amount\ in\ Local\ Currency$: customs value for a shipment

- $Currency$: currency of the customs value

- $Customer$: the customer where a part is shipped to

- $Country\ of\ Customer$: the location of the customer

- HT_{Opex}: the HT code which can be found in the Opex Matrix

- $Tariff$: the tariff corresponding to the HS code and proportionate to the customs value.

APPENDIX E SUPPORTING TABLES

#	HTNewClean	Frequency	#	HTNewClean	Frequency
1	XXXXXXXX	1	33	XXXXXXXX	2
2	XXXXXXXX	2	34	XXXXXXXX	2
3	XXXXXXXX	1	35	XXXXXXXX	51
4	XXXXXXXX	1	36	XXXXXXXX	1
5	XXXXXXXX	1	37	XXXXXXXX	1
6	XXXXXXXX	1	38	XXXXXXXX	1
7	XXXXXXXX	3	39	XXXXXXXX	1
8	XXXXXXXX	1	40	XXXXXXXX	1
9	XXXXXXXX	1	41	XXXXXXXX	1
10	XXXXXXXX	1	42	XXXXXXXX	1
11	XXXXXXXX	1	43	XXXXXXXX	1
12	XXXXXXXX	1	44	XXXXXXXX	1
13	XXXXXXXX	1	45	XXXXXXXX	1
14	XXXXXXXX	1	46	XXXXXXXX	1
15	XXXXXXXX	1	47	XXXXXXXX	4
16	XXXXXXXX	4	48	XXXXXXXX	1
17	XXXXXXXX	8	49	XXXXXXXX	1
18	XXXXXXXX	1	50	XXXXXXXX	1
19	XXXXXXXX	2	51	XXXXXXXX	2
20	XXXXXXXX	1	52	XXXXXXXX	1
21	XXXXXXXX	2	53	XXXXXXXX	1
22	XXXXXXXX	1	54	XXXXXXXX	1
23	XXXXXXXX	1	55	XXXXXXXX	1
24	XXXXXXXX	1	56	XXXXXXXX	2
25	XXXXXXXX	1	57	XXXXXXXX	4

26	XXXXXXXX	1	58	XXXXXXXX	2
27	XXXXXXXX	2	59	XXXXXXXX	1
28	XXXXXXXX	3	60	XXXXXXXX	2
29	XXXXXXXX	1	61	XXXXXXXX	4
30	XXXXXXXX	1	62	XXXXXXXX	1
31	XXXXXXXX	1	63	XXXXXXXX	3
32	XXXXXXXX	1			

TABLE 23 FREQUENCIES PER HTNEW

#	Plant	Country of Customer	∑ Shipment	∑ Amount in local currency	Currency
1	NL	CN	67	X	EUR
2	NL	CY	1	X	EUR
3	NL	DE	17	X	EUR
4	NL	IE	2	X	EUR
5	NL	JP	20	X	EUR
6	NL	KR	125	X	EUR
7	NL	NL	5	X	EUR
8	NL	RU	1	X	EUR
9	NL	SG	26	X	EUR
10	NL	TR	1	X	EUR
11	NL	TW	142	X	EUR
12	NL	US	29	X	EUR
13	NL	BE	2	X	EUR
14	NL	DE	3	X	EUR
15	NL	IE	9	X	EUR
16	NL	IT	4	X	EUR
17	NL	NL	7	X	EUR
18	NL	RU	1	X	EUR
19	NL	BE	2	X	EUR
20	NL	IE	5	X	EUR
21	NL	NL	1	X	EUR

TABLE 24 SUMMARY OF ALL MATERIALS SHIPPED FROM BONDED WAREHOUSE NL (SAMPLE 2015)

APPENDIX F R CODE

In this section we explain how the model is programmed in R. As it is important to imbed the model into the daily operations of Company X's classifications experts we provide a clear overview of the content of the code. We describe using pseudo code the three parts of the model.

HS CODE REMEDIATION

In the following piece of (pseudo)code the dataset containing the HS codes are cleaned. The final dataset is used for the modelling phase of the two goods flows.

```
# Import datasets
HTChange      <- read.csv("HT change data 1st quarter.csv",
                  stringsAsFactors = FALSE)

## Clean HT code
HTRemediation <- function(HTChange){

  HT            <- data.frame(HTChange$Object.value,
     HTChange$X12nc.clean, HTChange$Old.value.clean,
     HTChange$New.value.clean,
                  stringsAsFactors = F)

  colnames(HT)  <- c("Material", "Material_Clean", "HT_old" ,
                     "HT_new")


  HT <- sqldf("Select * from HT
                where HT_old != HT_new")

  HT        <-  HT[!duplicated(HT), ]

  HT[,"HT_old"] <- substring(HT$HT_old,1,8)
  HT[,"HT_new"] <- substring(HT$HT_new,1,8)

  return(HT)
}

HT <- HTRemediation(HTChange)

rm(list = "HTChange")
rm(list = "HTRemediation")
```

NON-EU TO EU LOCAL

In this section the (pseudo)code for the model of the first goods flow is presented: from non-EU countries to regional warehouse based in Europe.

```
### Import datasets
VendorList      <- read.csv("VendorList.csv",
                   stringsAsFactors=FALSE)

ShipmentsInEU   <- read.csv("shipmentsEU.csv",
                   stringsAsFactors=FALSE)

OpexMatrix      <- read.csv("Opex Actuals Model.csv",
                   stringsAsFactors=FALSE)

CustomerList    <- read.csv("CustomerList.csv",
                   stringsAsFactors = FALSE)

###### Select the shipments from non-European countries imported
into European countries ######

### Select columns in scope
ShipmentIntoEU  <-
     data.frame(ShipmentsInEU$Material,ShipmentsInEU$Vendor,
     ShipmentsInEU$Plant, ShipmentsInEU$Quantity,
     ShipmentsEU$Amount.in.LC, ShipmentsEU$Currency,
stringsAsFactors = F)

colnames(ShipmentIntoEU) <- c("Material", "Vendor", "Plant",
                              "Quantity", "AmountInLC",
                              "Currency")

### Create Material Clean
ShipmentIntoEU[,"Material_Clean"] <-
     substring(ShipmentIntoEU$Material,5,14)

### Create identifier
ShipmentIntoEU[,"ID"] <-
     paste0(ShipmentIntoEU$Material,"_",ShipmentIntoEU$Vendor,"_
     ",ShipmentIntoEU$Plant,"_",ShipmentIntoEU$Quantity)
```

```
### Find missing vendors and exclude them
Empty_ShipmentIntoEU_Temp <- sqldf("Select * from ShipmentIntoEU
                                   where Vendor is ''")

### Excluded missing vendors
ShipmentIntoEU     <- sqldf("Select * from ShipmentIntoEU
                      where ID NOT IN (Select ID from
                      Empty_ShipmentIntoEU_Temp)")

### Add country of vendor based on left join: VendorList
ShipmentIntoEU     <- sqldf("Select a.*, b.Country as
                      CountryOfVendor from ShipmentIntoEU
                      a Left Join VendorList b
                      on a.Vendor = b.Vendor")

### Exclude European countries
countries      <- sqldf("select distinct(CountryOfVendor)
                  from ShipmentIntoEU")

ShipmentIntoEU <- sqldf("select * from ShipmentIntoEU where
                CountryOfVendor = 'KR'
                or CountryOfVendor = 'US'
                or CountryOfVendor = 'TW'
                or CountryOfVendor = 'SG'
                or CountryOfVendor = 'MY'
                or CountryOfVendor = 'JP'
                or CountryOfVendor = 'HK'
                or CountryOfVendor = 'CN'")

##### Get Results by adding the corresponding Tariffs #####

### Add HT codes
ShipmentIntoEU_HT <- sqldf("select a.*, b.HT_old,
                     b.HT_new from ShipmentIntoEU
                     a left join HT b
                     on a.Material_Clean = b.Material_Clean")

### Check if HTNew code is present in Opexmatrix
### Remove product numbers related to HTNew codes which are not
present in the Duty Opex matrix
Opex_Temp <- data.frame(HT_Opex = OpexMatrix$HS.Code)
```

```
CheckMissingOpex_Temp_New <- sqldf("select a.*, b.*
               from ShipmentIntoEU_HT
               a left join Opex_Temp b
               on a.HT_new = b.HT_Opex")

CheckMissingOpex_New <-
     CheckMissingOpex_Temp_New[which(is.na(CheckMissingOpex_Temp
     _New$HT_Opex)==T),]

CheckMissingOpexEU_Temp <- sqldf("select a.*, b.*
                           from ShipmentIntoEU_HT
                           a left join Opex_Temp b
                           on a.HT_new = b.HT_Opex")

ShipmentIntoEU_HT <- sqldf("select *
                     from CheckMissingOpexEU_Temp
                     where HT_Opex != ''")

ShipmentIntoEU_HT <- ShipmentIntoEU_HT[-12]

### Check if HTold is present in Opexmatrix
### Remove products related to HTold codes which are not present
in the Duty Opex matrix
Opex_TempOld <- data.frame(HT_OpexOld = OpexMatrix$HS.Code)

CheckMissingOpex_Temp_Old <- sqldf("select a.*, b.*
               from ShipmentIntoEU_HT
               a left join Opex_TempOld b
               on a.HT_old = b.HT_OpexOld")

CheckMissingOpex_Old <-
     CheckMissingOpex_Temp_Old[which(is.na(CheckMissingOpex_Temp
     _Old$HT_OpexOld)==T),]

CheckMissingOpexEU_Temp <- sqldf("select a.*, b.*
                           from ShipmentIntoEU_HT
                           a left join Opex_TempOld b
                           on a.HT_old = b.HT_OpexOld")
```

```
ShipmentIntoEU_HT <- sqldf("select *
                      from CheckMissingOpexEU_Temp
                      where HT_OpexOld != ''")

ShipmentIntoEU_HT <- ShipmentIntoEU_HT[-12]

### Find corresponding tariffs in OpexMatrix for HTold and HTnew
### Create duty difference
GetDuty <- function(x){
      x[,"OldDuty"] <- c(rep(0,(dim(x))[1]))
      x[,"NewDuty"] <- c(rep(0,(dim(x))[1]))

      for(i in 1:(dim(x))[1]-1){
             x[i,"OldDuty"]  <-
     as.numeric(OpexMatrix[which(OpexMatrix[,1]==x$HT_old[i]),x$
     Plant[i]])
        x[i,"NewDuty"]  <-
     as.numeric(OpexMatrix[which(OpexMatrix[,1]==x$HT_new[i]),x$
     Plant[i]])
      }
      AmountInLC <- as.numeric(x$AmountInLC)
           x[, 'DutyPayment']   <-  (x$NewDuty -
           x$OldDuty)*AmountInLC/100
      return(x)
      }

rm(list = ls(pattern = "Temp"))

##### Results #####
ShipmentIntoEU_HT <- GetDuty(ShipmentIntoEU_HT)

### Write results to Excel
write.csv(ShipmentIntoEU_HT, file = 'Results HT changes nonEU to
          EU local.csv')
```

NON-EU TO EU VIA BONDED WAREHOUSE

In this section the (pseudo)code for the model of the second goods flow is presented: from non-EU countries to a customer based in Europe via bonded warehouse.

```
### Import datasets
VendorList      <- read.csv("VendorList.csv",
                   stringsAsFactors=FALSE)

ShipmentsInNL   <- read.csv("/shipments into nl.csv",
                   stringsAsFactors=FALSE)

ShipmentsOutNL  <- read.csv("shipments out nl.csv",
                   stringsAsFactors = FALSE)

CustomerList    <- read.csv("customer list.csv",
                   stringsAsFactors = FALSE)

OpexMatrixPerCountry  <- read.csv("OPEX Actuals Model
                         Countries.csv", stringsAsFactors=FALSE)

###### Select the shipments from non-European countries to
bonded warehouse in NL ######

### Select columns in scope
ShipmentIntoNL  <-
     data.frame(ShipmentsInNL$Material,ShipmentsInNL$Vendor,
     ShipmentsInNL$Plant, ShipmentsInNL$Quantity,
     ShipmentsInNL$Amount.in.LC, ShipmentsInNL$Currency,
stringsAsFactors = F)

colnames(ShipmentIntoNL) <- c("Material", "Vendor", "Plant",
                              "Quantity", "AmountInLC",
                              "Currency")

ShipmentOutNL  <- data.frame(ShipmentsOutNL$Material,
                  ShipmentsOutNL$Plant, ShipmentsOutNL$Customer,
                  ShipmentsOutNL$Quantity,
                  ShipmentsOutNL$Amount.in.LC,
                  ShipmentsOutNL$Currency, stringsAsFactors = F)
```

```
colnames(ShipmentOutNL) <- c("Material", "Plant", "Customer" ,
                             "Quantity", "AmountInLC",
                             "Currency")

### create Material_Clean
ShipmentIntoNL[,"Material_Clean"] <-
     substring(ShipmentIntoNL$Material,5,14)

ShipmentOutNL[,"Material_Clean"] <-
     substring(ShipmentOutNL$Material,5,14)

### Create identifier
ShipmentIntoNL[,"ID"] <-
     paste0(ShipmentIntoNL$Material,"_",ShipmentIntoNL$Vendor,"_
     ",ShipmentIntoNL$Plant,"_",ShipmentIntoNL$Quantity)

### Find missing vendors
Empty_ShipmentIntoNL_Temp <- sqldf("Select * from ShipmentIntoNL
                             where Vendor is ''")

### Exclude missing vendors
ShipmentIntoNL     <- sqldf("Select * from ShipmentIntoNL
                        where ID NOT IN (Select ID from
                        Empty_ShipmentIntoNL_Temp)")

### Add country of vendor based on left join: VendorList
ShipmentIntoNL     <- sqldf("Select a.*, b.Country as
                        CountryOfVendor from ShipmentIntoNL
                        a Left Join VendorList b
                        on a.Vendor = b.Vendor")

### Exclude missing countries of vendor
countries      <- sqldf("select distinct(CountryOfVendor) from
                   ShipmentIntoNL")

countries      <- data.frame(CountryOfVendor =
                   countries[!is.na(countries)])

ShipmentIntoNL <- sqldf("select * from ShipmentIntoNL
                   where CountryOfVendor IN
                   (select CountryOfVendor from countries)")
```

```
### Make distinction non-EU and EU vendors
ShipmentIntoNL <- sqldf("select *,
          case when CountryOfVendor = 'NL' then 'EU'
               when CountryOfVendor = 'BE' then 'EU'
               when CountryOfVendor = 'DE' then 'EU'
               when CountryOfVendor = 'FR' then 'EU'
               when CountryOfVendor = 'IT' then 'EU'
               when CountryOfVendor = 'IL' then 'EU'
               when CountryOfVendor = 'UK' then 'EU'
               when CountryOfVendor = 'GB' then 'EU'
               when CountryOfVendor = 'IE' then 'EU'
            else 'Non-EU'
            end as GlobalVendor
            from ShipmentIntoNL")

ShipmentIntoNL_Grouped  <- sqldf("select Material,
                          Material_Clean,
                          GlobalVendor,
                          sum(Quantity) as sum_Quantity,
                          sum(AmountInLC) as sum_AmountInLC,
                          Currency from ShipmentIntoNL
                          group by  Material, Material_Clean,
                          GlobalVendor")

###### Select shipment that remain into EU #####

### Add country of Customer based on left join: CustomerList
ShipmentOutNL <- sqldf("Select a.*, b.Country as
                 CountryOfCustomer from ShipmentOutNL
                 a Left Join CustomerList b
                 on a.Customer = b.Customer")

### Exclude customers located out of Europa
countries      <- sqldf("select distinct(CountryOfCustomer)
                   from ShipmentOutNL")

ShipmentOutNL <- sqldf("select * from ShipmentOutNL
          where CountryOfCustomer = 'NL'
             or CountryOfCustomer = 'DE'
             or CountryOfCustomer = 'IE'
             or CountryOfCustomer = 'IT'
```

```
              or CountryOfCustomer = 'BE'
              or CountryOfCustomer = 'CY'")

### Make distinction non-EU and EU Customers
ShipmentOutNL <- sqldf("select *,
          case when CountryOfCustomer = 'NL' then 'EU'
               when CountryOfCustomer = 'BE' then 'EU'
               when CountryOfCustomer = 'DE' then 'EU'
               when CountryOfCustomer = 'FR' then 'EU'
               when CountryOfCustomer = 'IT' then 'EU'
               when CountryOfCustomer = 'IL' then 'EU'
               when CountryOfCustomer = 'UK' then 'EU'
               when CountryOfCustomer = 'GB' then 'EU'
               when CountryOfCustomer = 'IE' then 'EU'
               when CountryOfCustomer = 'CY' then 'EU'
           else 'Non-EU'
           end as GlobalCustomer
           from ShipmentOutNL")

ShipmentOutNL_Grouped  <- sqldf("select  Material,
                          Material_Clean,
                          GlobalCustomer,
                          sum(Quantity) as sum_QuantityOut,
                          sum(AmountInLC) as sum_Out_AmountInLC,
                          Currency from ShipmentOutNL
                          group by Material, Material_Clean,
                          GlobalCustomer ")

###### Match incoming shipments NL with outgoing shipments EU
######
Matched_IntoNL_OutNL <- sqldf("select a.*,
                         b.GlobalCustomer,
                         b.sum_QuantityOut,
                         b.sum_Out_AmountInLC,
                         b.Currency as CurrencyCustomer
                         from ShipmentIntoNL_Grouped a
                         left join ShipmentOutNL_Grouped b
                         on a.Material_Clean = b.Material_Clean
                         where a.GlobalVendor != b.GlobalCustomer
                         and a.GlobalVendor = 'Non-EU'
                               ")
```

```
Matched_IntoNL_OutNL <-
     Matched_IntoNL_OutNL[!duplicated(Matched_IntoNL_OutNL),]

### Set the maximum outgoing quantity equal to the incoming
quantity
Matched_IntoNL_OutNL$sum_QuantityOut <-
     ifelse((abs(Matched_IntoNL_OutNL$sum_QuantityOut))
     >Matched_IntoNL_OutNL$sum_Quantity,
     Matched_IntoNL_OutNL$sum_Quantity,
     (abs(Matched_IntoNL_OutNL$sum_QuantityOut)))

##### Get Results by adding the corresponding Tariffs #####

### Add HT codes
Matched_IntoNL_OutNL <- sqldf("select a.*, b.HT_old,
                        b.HT_new from Matched_IntoNL_OutNL
                        a left join HT b
                        on a.Material_Clean = b.Material_Clean")


### Check if HTNew code is present in Opexmatrix
### Remove product numbers related to HTNew codes which are not
present in the Duty Opex matrix
Opex_Temp <- data.frame(HT_Opex = OpexMatrixPerCountry$HS.Code)

CheckMissingOpex_Temp_New <- sqldf("select a.*, b.*
                from Matched_IntoNL_OutNL
                a left join Opex_Temp b
                on a.HT_new = b.HT_Opex")

CheckMissingOpex_New <-
     CheckMissingOpex_Temp_New[which(is.na(CheckMissingOpex_Temp
     _New$HT_Opex)==T),]

CheckMissingOpex_Temp <- sqldf("select a.*, b.*
                         from Matched_IntoNL_OutNL
                         a left join Opex_Temp b
                         on a.HT_new = b.HT_Opex")
```

```
Matched_IntoNL_OutNL <- sqldf("select *
                         from CheckMissingOpex_Temp
                         where HT_Opex != ''")

Matched_IntoNL_OutNL <- Matched_IntoNL_OutNL[-13]

### Check if HTold is present in Opexmatrix
### Remove products related to HTold codes which are not present
in the Duty Opex matrix

CheckMissingOpex_Temp_Old <- sqldf("select a.*, b.*
                              from Matched_IntoNL_OutNL
                              a left join Opex_Temp b
                              on a.HT_old = b.HT_Opex")

CheckMissingOpex_Old <-
     CheckMissingOpex_Temp_Old[which(is.na(CheckMissingOpex_Temp
     _Old$HT_Opex)==T),]

CheckMissingOpex_Temp <- sqldf("select a.*, b.*
                          from Matched_IntoNL_OutNL
                          a left join Opex_Temp b
                          on a.HT_old = b.HT_Opex")

Matched_IntoNL_OutNL <- sqldf("select *
                         from CheckMissingOpex_Temp
                         where HT_Opex != ''")

Matched_IntoNL_OutNL <- Matched_IntoNL_OutNL[-13]

### Find corresponding tariffs in OpexMatrix for HTold and HTnew
### Create duty difference
GetDuty <- function(x){
      x[,"OldDuty"] <- c(rep(0,(dim(x))[1]))
      x[,"NewDuty"] <- c(rep(0,(dim(x))[1]))

      for(i in 1:(dim(x))[1]-1){
          x[i,"OldDuty"]  <-
     as.numeric(OpexMatrixPerCountry[which(OpexMatrixPerCountry[
     ,1]==x$HT_old[i]),x$GlobalCustomer[i]])
```

```
          x[i,"NewDuty"]  <-
      as.numeric(OpexMatrixPerCountry[which(OpexMatrixPerCountry[
      ,1]==x$HT_new[i]),x$GlobalCustomer[i]])
       }
          x[, 'DutyPayment']   <-  (x$NewDuty -
          x$OldDuty)*x$sum_Out_AmountInLC/100
       return(x)
       }

rm(list = ls(pattern = "Temp"))

##### Results #####
Matched_IntoNL_OutNL <- GetDuty(Matched_IntoNL_OutNL)

### Write results to Excel
write.csv(Matched_IntoNL_OutNL, file = 'Results HT changes via
          BW.csv')
```