Master Thesis

Identifying Blockages and Unblocking Strategy for Digital Trade Infrastructures Innovation Process

Siti Arna Arifah Arman

4625188

Management of Technology

TU Delft

This page is intentionally left blank

Identifying Blockages and Unblocking Strategy for Digital Trade Infrastructures Innovation Process

Master thesis submitted to Delft University of Technology

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in Management of Technology

Faculty of Technology, Policy and Management

by

Siti Arna Arifah Arman

Student number: 4625188

To be defended in public on August 27th 2018

Graduation committee

Chairperson : Prof.dr. Y. (Yao-Hua) Tan, ICT section

First Supervisor : Dr.ir. G.A. (Mark) de Reuver, ICT section

Second Supervisor : Dr.ir. R.A. (Rudi) Hakvoort, E&I section

External Supervisor: Dr. B.D. (Boriana) Rukanova, ICT section

This page is intentionally left blank

Acknowledgements

This master thesis project serves as the final effort to obtain Master of Science degree from TU Delft's Management of Technology master program. This work represents an understanding of the innovation process of IT-related supply chain innovation. The critical point of this study is how to manage such digital innovation to successfully improve the trade flow, which further generates advantages for both governments and corporates. Even though I have big interests to do research about the international supply chain, this research has challenged me as the field is somewhat new for me. I have to incorporate my limited knowledge of international supply chain and ICT innovation management to execute this research. With this condition, I spent some months to read all the relevant documents to get myself familiar with this domain. Besides, there are so many people who keep supporting me through the journey of my master thesis project execution. In this page, I would like to thank those amazing people.

First, I would like to thank and acknowledge my deepest gratitude to all of my supervisors: Prof. Dr. Yao-Hua Tan and Dr. Boriana Rukanova, for giving me the opportunity to explore and learn in depth about this interesting research, letting me enrich my understanding and knowledge in the research domain, and providing me direction for the research execution. They provide sincere guidance, extensive insights, and endless support toward my thesis completion. There would never be a chance for me to have some parts of my work accepted in Conference for E-Democracy and Open Government 2018 (EGOV-CeDEM-ePart 2018) and join CORE project's final event which allows me to enrich my knowledge in international trade domain. Second, I want to thank Dr.ir. G.A. (Mark) de Reuver, who showed his interest in my research topic, for always providing critical feedback for my research. His help and feedbacks were very insightful for improving my research quality. I would like to express my gratitude to Dr.ir. R.A. (Rudi) Hakvoort, who showed his interest in my research topic and motivated me to be an optimistic person when conducting research.

I want to thank the interviewees for their willingness to share needed information and insights, not only for the research, for my knowledge development in international trade field. Additionally, I would like to thank my project partner, Anil Ravulakollu, for being a helpful partner to share the discussion regarding the research and projects. Nonetheless, this research would never have been finished without endless support from both of my family and friends in Indonesia and The Netherlands, especially my parents and my siblings. All friends from Management of Technology program, Indonesian Student Association in Delft, and Merijn Hoogeveen, I would like to thank them for bringing me 'home' no matter wherever I reside. I am so grateful to have the opportunity to do this master program with the support from LPDP scholarship provided by Indonesian Ministry of Finance, and also to CORE project that gives me a lot of support in research execution and valuable working experience.

I hope this thesis will be an insightful paper for you.

Delft, July 2018

Siti Arna Arifah Arman

This page is intentionally left blank

Executive Summary

Research Background

More complicated physical checks and paperwork procedures at the cross-border level for international trade flow are triggered by terrorism attack. At the same time, administrative burden should be reduced and global supply chains efficiency should be improved, to enable economic growth. Enabling information exchange system between parties with digital infrastructures innovation is considered as one of the solutions for improving trade efficiency. Digital infrastructures (DI) concept is explained as a shared system consisting of an installed base of diverse information technology capabilities and their user, operations, and design communities. If reliable information can be accessed by the authorized parties, complex declaration submission to different public agencies can be minimized. The application of digital infrastructures in trade domain can be mentioned as digital trade infrastructures (DTI).

In this research, we use an example of such DTI, namely the *data pipeline*, which is a web-based digital infrastructure that enables the data elements assimilation from different sources along the international supply chain. The benefits of data pipeline in reducing administrative burden which also leads to trade and compliance costs reduction appear as a favourable innovation for all actors in the whole supply chain. For instance, shippers do not have to submit different documents as cross-border procedures as data pipeline will support the integrated data exchange mechanism along supply chain, while customs can reap advantage on getting more timely and accurate transaction data from business by accessing original business data at the source. Even so, the benefits do not guarantee fast adoption rate. Like most of the innovation, there are always issues that contribute to the difficulties of initial market penetration. For instance, such common issues can be categorized as regulation and resources issues.

In Europe, the data pipeline concept has been developed in the environment of EU-funded projects for more than a decade. Along the innovation-development process, numerous stakeholders from different levels in international trade are participating in the projects to improve the data pipeline innovation and bring it to adoption. Remembering that stakeholders spent so much time and cost for data pipeline development, the expectation from stakeholders to tackle issues that halt data pipeline implementation are rising. Particular unblocking strategy should solve these issues. It becomes crucial to understand the development of data pipeline from its initial to later stages so that eventually data pipeline reaches the implementation phase as the results of unblocking strategy.

This research is conducted and built on the previous study from Rukanova et al. (2017), which explained unblocking mechanisms of DI innovation in banking domain. It discussed what blocks innovation process and unblocking mechanisms of digital infrastructures innovation in banking domain based on collective action model. However, in this research, we are interested to analyse digital infrastructures innovation in trade domain based on its innovation system to get richer understanding on DTI innovation process. The reason of choosing innovation system analyses as the theoretical lens to understand DTI innovation

process is based on the arguments by Edquist (2001) and Hekkert et al. (2007) which stated that an innovation involves both collective and individual act during the innovation process, and these acts occur within such innovation system. Moreover, Hekkert et al. (2007) argued that the dynamic of innovation system influences the speed of innovation process. To understand more regarding innovation system evolution, *structural analysis* has to be conducted. It explains the changes of the actors that contribute as the structure of innovation system. In addition, speed of innovation process is also influenced by functions of innovation system (FIS). The notion of FIS represents some functions that should be covered by an innovation system to support the innovation process. Hence, we also proposed *functional analysis* to understand the performance of an innovation system in fulfilling its functions.

Research Objective and Question

The objective of this study is to address the knowledge gap of the existing studies about the unblocking strategy, which aim to mobilise digital trade infrastructures innovation process from initiation phase to implementation phase. By formulating this objective, it is expected that a conceptual framework which can explain the unblocking strategy of the digital trade infrastructures innovation process, can also be used as a tool which can support actors in international trade domain, to speed up innovation process and deal with innovation system weakness. Based on research background and objective, the main research question was formulated as follows:

*"*How does structural and functional analysis contribute to explain blockages and unblocking mechanisms of digital trade infrastructures innovation process from initiation to implementation phase?"

Research Methodology and Deliverables

To get the richer understanding on innovation process which occurs in a longitudinal manner, this is not to deny that valuable data may be gathered from a qualitative study. In order to answer the research question, we conducted two main research strategies. A desk research strategy which consists of literature survey was conducted. The main deliverable of the desk research is the initial conceptual framework which explains the combination of existing studies regarding unblocking mechanisms of the digital innovation process. Furthermore, the framework was studied in-depth using case study strategy. This step aims to evaluate the conceptual framework in empiric cases. This framework was applied in the four different EU-funded supply chain projects (ITAIDE, INTEGRITY, CASSANDRA, and CORE) which represent DTI innovation system in different phases. The evaluation of the framework combined two data collection methods, which are documents analysis, which serves as first stage data collection, and an immediate analysis. We reviewed project documents which consist of information related to innovation process that occurs in the era of ITAIDE until CORE. The second methods are interviews and a workshop session, which serve as the second stage data collection, followed by final analysis. Semi-structured interviews with some project participants were carried out next to project's workshop participation. Based on the findings of these two stages, the applicability of the conceptual framework was identified.

From this research, we answered the research question as follows:

The structural analysis explains how actors enter an innovation system, how networks are constructed, and how institutional settings are changed. The blockages identified from the structural analysis are rather limited as they explain issues that are discovered in a discontinuity of collective action process, such as the stakeholders' participation issues. On the other hand, the functional analysis explains how the innovation system achieves its goal. To successfully mobilise the innovation process from initiation to implementation phase, the innovation system has to perform all functions. The blockages identified from functional analysis are the indicators that weakened innovation system to perform its functions. It was found that the combination of these analyses provides richer explanation on issues that blocks the innovation process. This study helps to understand what issues that limit the innovation system structure and weaken the functions of innovation system. Furthermore, the unblocking strategy which represents efforts to handle blockages based on structural analysis can also be used to address the indicators that weakened the functions. This unblocking strategy helps to strengthen weak functions in the later phase of the innovation process. However, some weakening indicators may not always be addressed by this unblocking strategy. The indicators that cannot be addressed by this unblocking strategy serve as one of the problem backgrounds for further innovation project and they do not merely block the whole innovation process. Overall, this study is capable to present a theoretical lens to identify blockages and unblocking strategy of DTI innovation process by looking at the innovation system's structural and functional characteristics.

Contributions, Limitations, and Recommendations

This research provides both academic and practical contributions:

Regarding the academic relevance:

- The research contributes to filling the gap of limited studies regarding digital infrastructures innovation process management.
- It also contributes to bodies of knowledge such as innovation management, collective action model of institutional innovation, functions of innovation system, digital trade infrastructures, and digital infrastructures.
- The result of this research can support other digital infrastructures innovation research, or even in entirely different fields such as energy and healthcare domain.

Regarding the practical contribution:

- The conceptual framework can be used by practitioners to understand success and failure of a technological innovation, especially digital infrastructures innovation by looking at the dynamic of innovation system.
- The framework can be used as a tool to identify strategy to speed up innovation process to reach implementation, by identifying what could possibly blocks the innovation process and further planning the unblocking strategy to ensure the continuity of innovation process.

This research has several limitations. First, the case study done in this research is only concerned with data pipeline as digital trade infrastructures innovation. Second, the discussion limits the scope of innovation system into EU-funded project setting. Moreover, biases may appear as the author is a part of project participants and most of reviewed documents sourced from project deliverables. Addressing

these limitations, further research is suggested to improve the conceptual framework based on the empirical study to other DTI innovation, such as single window concept. Additionally, it is also suggested that the observed innovation system in further research can incorporate all networks and regulations that provide the innovation system and not limited to project setting. Incorporate other perspectives besides innovation system to extend the innovation process study can also be done for future research. It is also suggested to apply this framework to other domain which also characterized by a highly-regulated environment, so that it can be used to explain digital infrastructures innovation process in other domain. Other possible suggestion for future research is to look into detailed the functional analysis and developing a tool to evaluate the performance of innovation system function.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

3PL	Third Party Logistic
AEO	Authorized Economic Operator
B2B	Business to Business
B2G	Business to Government
CASSANDRA	Common assessment and analysis of risk in global supply chains
CCC	Community Customs Code
CORE	Consistently Optimised Resilient Secure Global Supply-Chains
C-TPAT	Customs–Trade Partnership Against Terrorism
DG TAXUD	Directorate-General for Taxation and Customs Union
DG TREN	Directorate-General for Transport and Energy
DI	Digital Infrastructures
DTCA	Dutch Tax & Customs Administration
DTI	Digital Trade Infrastructures
EC	European Commission
ECITL	European Conference on ICT for Transport Logistics
EDI	Electronic data interchange
EMCS	Excise Movement and Control System
ENS	Entry Summary Declaration
ESC	European Shippers Council
EU	European Union
FIS	Functions of Innovation System
FP	Framework Program
G2G	Government to Government
GTD	Global Trade Digitization
ICS	Import Control System
ICT	Information and communication technology
INTEGRITY	Intermodal Global Door-to-Door Container Supply Chain visibility
ISL	Institute of Shipping Economics and Logistics
ISPS	International Ship and Port Facility Security
ITAIDE	IT for Analysis and Intelligent Design of e-Government
MASP	Multi-Annual Strategic Plan
MCC	Modernised Customs Code
NIS	National Innovation System
NTA	National Tax Administration
PCS	Port Community System
PPP	Public-Private Partnership
R&D	Research and Development
RFID	Radio-frequency identification

RIS	Regional Innovation System
SAFE	Secure and Facilitate Trade
SCS	Supply Chain Security
SICIS	Shared Intermodal Container Information System
SIS	Sectoral Innovation System
SOA	Service-oriented architectures
TIS	Technological Innovation System
TTL	Trusted Trade Lanes
UCC	Union Customs Code
UNECE	United Nations Economic Commission for Europe
WCO	World Customs Organization
WTO	World Trade Organization

This page is intentionally left blank

1. INTRODUCTION

This chapter presents the main motivation and general idea for this research. The chapter starts with a discussion of the research background, the problem statements, the research objectives, the research framework, the research question and its sub-questions, and the research scope. By the end of this chapter, the thesis structure will be presented.

1.1. Research Background

1.1.1. Importance of Digital Trade Infrastructures

Safety and security issues such as terrorism lead to more complicated physical checks and paperwork procedures at the cross-border level for international trade flow. At the same time, it is necessary to support global economic growth by reducing administrative burden and enabling more efficient global supply chains. One possible solution for improving international supply chains is enabling better information streams of end-to-end supply chains. If all stakeholders in the supply chain can access good quality of logistics-related information, then unnecessary waiting time on the port of destination can be avoided. Hence, trade and compliance costs will be reduced.

However, in international supply chains, information related to supply chains and transactions resides in both business and government information system. Some institutions are reluctant to share their data or even legally restricted to spread their transactions information to other parties (Jensen & Vatrapu, 2015). As a result, the quality of international supply chain visibility is still weak due to incomplete and unreliable trade flows data. In regards to the large trade data, both public and private institutions are interested in making the data accessible only to authorised parties in the chain, to achieve the desired level of security and safety while at the same time reducing trade costs which results from complex border activities. While private institutions need an efficient process to minimise trade costs, government border agencies have the task of ensuring safety and security on the trade lanes. To tackle those issues, the *digital trade infrastructures* (DTI) concept is proposed to facilitate better supply chain information exchange system.

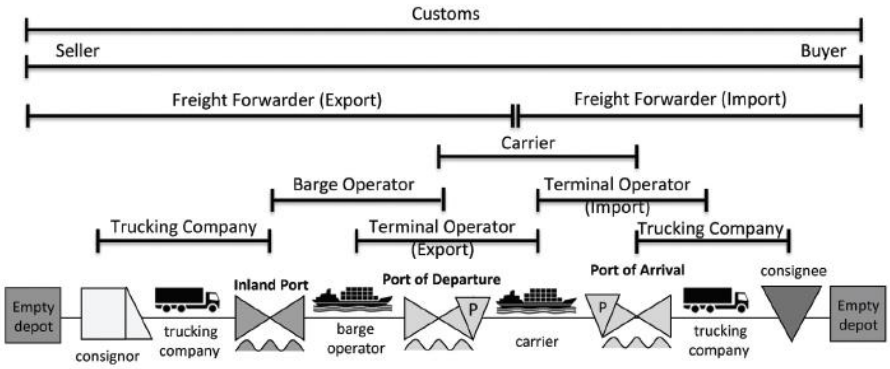


Figure 1: Data visibility for each actor in supply chain (adapted from Klievink et al., 2012)

The DTI concept is mainly used to elucidate digital infrastructures that transcend organizational and systems domains, driven by the expectation to reduce information fragmentation, in order to reach security and efficiency improvement in trade process (Rukanova et al., 2017; Hanseth & Lyytinen, 2010). In this research, we use an example of such DTI, namely the *data pipeline*. It is a web-based digital infrastructure that can be used to exchange information across the international supply chain (Klievink et al., 2012). For instance, information related to container monitoring and tracking can be captured via container tracking and monitoring technologies. Later, the information will be shared real-time with authorised supply chain stakeholders via the data pipeline. Data pipeline plays the role to facilitate trusted traders in providing real-time and accurate cargo import/export declaration data to customs administrations (Klievink et al., 2012). In addition to the data pipeline, other DTI concept such as *single window* and *national community hubs* can be considered to improve the coordination between the logistic stakeholders. The DTI concept will be explained further in section 3.1.2.

1.1.2. The Need of Unblocking Strategy for DTI Innovation Process

As tested in initial projects of DTI development such as ITAIDE[1] and INTEGRITY[2], the benefits of DTI in reducing administrative burden which also lead to trade and compliance costs reduction appear as favourable innovation for all actors in the whole supply chain. For instance, shippers do not have to submit different documents as cross-border procedures as DTI will support the integrated data exchange mechanism along supply chain, while customs can reap advantage on getting more timely and accurate transaction data from the business by accessing original business data at the source. Even so, benefits do not guarantee fast adoption rate. Like most innovations, there are always blockages that contribute to the difficulties of initial market penetration. The 'blockages' term refer to such factors which halt the innovation process. Such common blockages can be categorised as the regulation issue and insufficient resources.

In Europe, DTI has been developed in the environment of EU-funded projects for more than a decade. Along the innovation-development process, numerous stakeholders from different levels in the international trade are participating in the projects to improve the DTI innovation and bring it to market. Moreover, some of them spent an enormous amount of budget on these projects, supported by the fact that the accumulated budget of these innovation projects reached more than 80 million euro[3]. Some private stakeholders put significant investments already for bringing DTI to actual implementation for their business model. Remembering that stakeholders spent so much time and costs for DTI development, the expectation from stakeholders to tackle the blockages that halt DTI implementation are rising. Particular unblocking strategy should solve these blockages. In this research, the term 'unblocking strategy' is used to describe the efforts that could be done by stakeholders in the innovation system to remove the blockages and allow innovation process continuity. It becomes essential to understand the development of DTI from its initial to later stages so that eventually DTI reaches the implementation phase as the results of unblocking strategy. To identify what these unblocking strategies are, we need to observe empiric cases on the actual DTI development in longitudinal approach.

[1] See project's description at https://cordis.europa.eu/project/rcn/79327_en.html
[2] See project's description at https://cordis.europa.eu/project/rcn/90099_en.html
[3] Accumulated from 4 different EU-funded projects

1.1.3. The Need of Innovation System Analysis

Rukanova et al. (2017) have identified factors that block digital infrastructure innovation process and unblocking mechanisms in a highly-regulated domain from the collective action perspective. This study focuses on mobile payment, which is perceived as digital infrastructures innovation in banking domain. Collective action model for institutional innovation theory by Hargrave and Van de Ven (2006) is used as the main concept to explain collective action processes that occur in mobile payment innovation process. Hargrave and Van de Ven (2006) proposed the number of processes related to mobilising collective action, namely framing contests, construction of networks, enactment of institutional arrangements, and collective action process. From this theory, Rukanova et al. (2017) examined unblocking mechanisms for the collective action of institutional digital infrastructures innovation blockages such as network re-configuration, re-framing, and change of governance model.

This research is built on the abovementioned study. However, we are interested to analyse digital infrastructures innovation process, based on its innovation system perspective. Innovation system can be defined as factors such as economic, social, political, organizational, and other that influence the innovation. Its main components, organizations and institutions, can be also defined as determinant of innovation due to its ability to create impacts on innovation. Edquist (2001) and Hekkert et al. (2007) argued that an innovation involves both collective and individual act during the innovation process, and these acts occur within such innovation system. Moreover, Hekkert et al. (2007) also argued that the dynamic of innovation system influences the speed of innovation process. Another argument came from Yoo et al. (2005), stating that innovation system is one of the domains that shape innovation-development process. These arguments show that innovation system cannot be neglected and it is strongly connected to the innovation process. Furthermore, these arguments serve as the reason for choosing innovation system perspective to understand DTI innovation process in this research.

In this research, we mainly argue that the unblocking strategy of DTI innovation process can be identified if the innovation system is examined by looking at two levels of analysis. First, the analysis of changes in networks of actors and collective action which occurs in innovation system represents *the structural analysis* of innovation system. This analysis is inspired by the mobile payment innovation study (Rukanova et al., 2017), built on the unblocking mechanism of collective action discontinuity in mobile payment innovation. Another level of innovation system analysis that should be conducted is *functional analysis*, inspired by Functions of Innovation System (FIS) theory by Hekkert et al. (2007). The notion of FIS represents some functions that should be covered by an innovation system to support the innovation process. These two analyses are expected to solve limitations on preceding studies and give broader insight to understand the DTI innovation process.

1.2. Research Objectives

In order to fill the research gap discussed in the previous section, the main goal of the research is:

Create and apply a conceptual framework that can be used as a tool to identify the unblocking strategy to move the digital trade infrastructures innovation process from initiation to implementation phase by looking at structural and functional analysis of the innovation system

To reach this main goal, other sub-objectives should be completed:

- Indicate relevant theories from existing works of literature about general idea of collective action, digital trade infrastructures, and innovation system
- Identify the relation between current innovation process theories, digital trade infrastructures, functional and structural analysis of innovation system, and build structural-functional analysis framework as the conceptual model
- Evaluate the application of the conceptual framework in empiric case

This research provides academic contribution to the knowledge of innovation process management in digital infrastructures innovation (Hargrave & Van de Ven, 2006; Rukanova et al., 2017) by looking at a different domain, which is international trade. Incorporating collective action for institutional innovation and functions of innovation system theory to achieve the research objective is relevant as this theory directly relates to innovation process and it helps researchers to understand the dynamic of innovation system performance which influences speed and direction of innovation process (Edquist, 2001; Hekkert et al., 2007). This research will also enrich the knowledge of collective action for institutional innovation as well as functions of innovation system theory. As the practical contribution, the framework discussed above is expected to be used as a tool which can support actors in international trade domain, to understand the success and failure of an innovation, speed up collective innovation process, and deal with innovation system weakness. To reach the goals mentioned above, the framework of the research and research questions should be formulated.

1.3. Research Framework

The research framework is a schematic representation of research objectives. It includes the set of steps that have to be taken to achieve the research objectives (Verschuren & Doorewaard, 2010). To build a research framework, research object, fundamental concepts, and theoretical framework should be defined. From the research objective that is mentioned before, those aspects are extracted. The research object is the digital trade infrastructures innovation process case study. Key concepts in this research are digital trade infrastructures (DTI), innovation process, collective action, and innovation system. These key concepts and preliminary research will be used to find the relevant theoretical framework. Chosen theoretical frameworks are described as the theory of digital trade infrastructure, theory of collective action process, theory of innovation process, and theory of innovation system. In the initial stage, these theories are studied and linked with one another, to create a conceptual framework. Figure 2 describes the initial research framework.

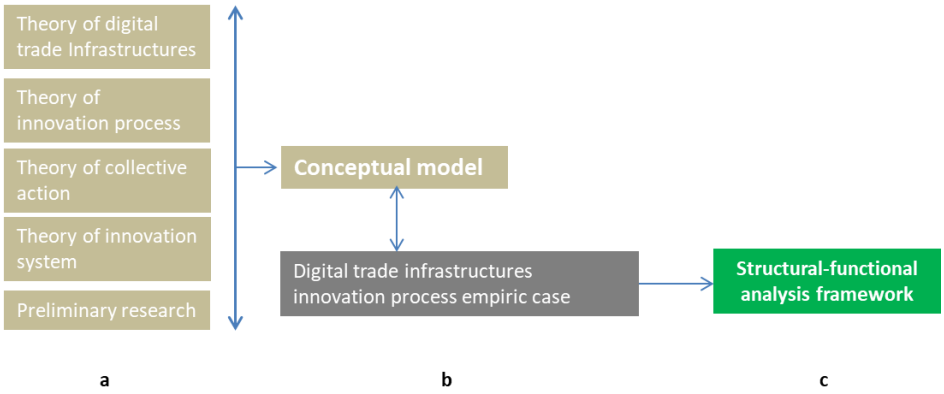


Figure 2: Research framework

This framework can be described as follows:

(a) Study of problems in DTI, innovation process, collective action and innovation system based on scientific literature review and interview with experts (preliminary research), arrow shows the confrontation between theories, yields in a conceptual model;
(b) By means of the conceptual model, using historical event analysis and processual approach, DTI innovation process of an empiric case will be analysed, arrow shows that research perspective is applied to research object;
(c) The applicability of the conceptual model is identified

1.4. Research Questions

The primary research question in this research is:

***"*How does structural and functional analysis contribute to explain blockages and unblocking strategies of digital trade infrastructures innovation process from initiation to implementation phase?"**

The sub-questions related to the sub-objectives are presented as follows:

- **SQ1: What do existing studies explain about digital trade infrastructures, nature of international trade domain, and innovation development?**
  Understanding how previous studies explain the problem is necessary as current studies did not depart entirely from scratch but further developed the earlier studies. To answer this question, any information about the digital trade infrastructures and innovation process were synthesized through desk research. The output of this part suggested the direction of the research focus and provided underlying innovation process theories from the main literature selected as the potential input for the next step.
- **SQ2: What are the blockages and unblocking mechanisms of digital trade infrastructures innovation process from structural and functional analysis perspective based on earlier studies and how can they be combined into a conceptual framework?**

The output of the first sub-question will be explored and expanded to address these gaps. Thus, broader information to explain the necessary aspects of innovation process will be gathered and presented, specifically from the literature in the research domain. This part will be developed as a conceptual model named initial structural-functional analysis framework..

- **SQ3: How does the conceptual framework help to explain digital trade infrastructures innovation process in empiric case?**
  An evaluation process when building a framework is important to ensure that what is created is able to represent reality. The aims are to test the conceptual model, capture the framework's failure and revise it when needed. Evaluation process would demonstrate how this framework is applied to the empirical cases.

1.5. Research Scope

The scope of this thesis is limited to the following discussions:

- The research discussion focuses on Digital Trade Infrastructures instead of Digital Infrastructures in general, within international trade and customs domain, referring to Digital Trade Infrastructures concepts which were previously discussed by Rukanova, Henningsson, Henriksen, and Tan (2017).
- Innovation process discussion focuses on activities and events which occur within innovation system, considering the innovation process concept consists of all efforts that are undertaken to bring the innovation from initiation to implementation phase.

1.6. Organisation of the Chapters

This thesis consists of 6 chapters, as shown in Table 1 below.

Table 1: Organisation of the chapters

Chapter		Research Questions	Discussions
1.	Introduction	-	Research background, research objective and questions, scope, and organisation of the remaining chapters.
2.	Research methodology	-	Discussion of strategies that are used to come up with research findings.
3.	Literature review and conceptual model building	SQ1 & SQ2	Discussion of existing studies related to digital trade infrastructures, nature of international trade domain, and innovation development. This discussion is followed by a description of how existing studies contribute to build structural-functional analysis (SFA) framework.
4.	Case analysis	SQ3	Description of case background and the application of conceptual model to empiric case, to evaluate if it sufficiently explains the reality through iteration of application in longitudinal event.
5.	Discussion and findings	SQ3	Discussion of the main findings within the research and the utility of conceptual framework as the theoretical lens.
6.	Conclusion	RQ	The discussion of conclusion, research contribution, research limitation, future research recommendation, and critical reflection toward the research process.

2. RESEARCH METHODOLOGY

This chapter offers the description of what strategies and approach that is used to answers research questions. Based on the objectives and questions that we are trying to find out, the qualitative study seems to be the appropriate method for this research. As this research aims to identify unblocking strategies of an innovation process which occur in a longitudinal manner and find out whether the analysis of innovation system can help to understand innovation process, this is not to deny that valuable data may be gathered from a qualitative study. There are needs to gather valuable issues regarding the history of DTI innovation development. Literature survey, documents analysis, interviews, and workshop session are the data collection methods that are conducted to get information regarding the phenomenon that happened in DTI innovation system. It allows richer and in-depth observation of events happened within innovation process, from time to time.

Research strategies are distinguished based on research questions that have to be answered. Table 2 represents the summary of research strategies that are carried out. To collect the evidence, a mixed strategy between *desk research* and *case study* is conducted. In early steps of this research, a desk research strategy which consists of literature survey is conducted. The main deliverable of the desk research is the conceptual model, which is the initial *structural-functional analysis* (SFA) framework. In the later phase, this framework is evaluated using a case study.

Table 2: The research strategies for the research questions along with the deliverables

	Questions	Research strategy	Data collection method	Deliverables
RQ	How does structural and functional analysis contribute to explain blockages and unblocking mechanisms of digital trade infrastructures innovation process from initiation to implementation phase?	**Desk research and case study**	**All of the following methods**	**A framework called structural-analysis framework (SFA) to understand blockages and unblocking strategies of digital trade infrastructures innovation process is generated**
SQ1	What do existing studies explain about digital trade infrastructures, nature of international trade domain, and innovation development?	Desk research	1st Literature survey	The output of this part suggested the direction of the research focus and provided underlying innovation process theories from the main literature selected as the potential input for the next step.
SQ2	What are the blockages and unblocking mechanisms of digital trade infrastructures innovation process from structural and functional analysis perspective based on earlier studies and how they can be combined into a conceptual framework?	Desk research	2nd Literature survey	This part is concluded as a conceptual model of initial structural-functional analysis (SFA) framework

SQ3	How does the conceptual framework help to explain digital trade infrastructures innovation process in empiric case?	Case study	1st stage: Documents analysis 2nd stage: Semi-structured interview	Revised conceptual model based on case study and evaluation to ensure that what is created is able to represent reality

2.1. Desk Research

Desk research strategy enables researchers to gather data produced by others (Verschuren & Doorewaard, 2010). The first sub-research question should be answered with the existing studies regarding the research domain as the source of answers. These existing studies will provide understanding regarding the research domain, problems, and possible relevant theories. Literature survey, a thorough examination of some scientific studies regarding innovation process, innovation system, collective action and digital trade infrastructures, should be conducted in the early step of this research. A review of past, relevant literatures is an important feature of any academic research. It helps theory development and exposes areas where research is (Webster & Watson, 2002). In this case, we conduct a thorough literature review and then propose a conceptual model that synthesizes and extends existing research.

Secondary research as part of desk research strategy will be mainly used to answer the second sub-research question. Secondary research aims to produce summary/synthesis of existing research. Following secondary research, existing studies that are collected using literature survey and their possible relation will be analysed. The relationship between digital trade infrastructures, innovation system, and collective action process will be explained as a conceptual model. Method of developing theory, or in this research can be mentioned as a conceptual model, involves a combination of observations from preceding literature, and author's common sense and experience (Eisenhardt, 1989). This strategy is adequate to collect evidence that can support the answers to sub-research questions 1 and 2.

In identifying relevant literature, this research focuses on concepts that are defined in Figure 2. The concepts are digital trade infrastructures, innovation process, innovation system, and collective action process. To determine the source of material for finding existing studies, a structured approach inspired by Webster and Watson (2002) is used:

- Concept-centric, searching through the online and offline library using key concepts as the keywords to find relevant and highly cited articles or books.
- Snowballing method, it refers to a method of literature sourcing using the reference list of key papers that were collected earlier or the citations to the paper to identify additional papers. It consists of ‘go backwards', which means as viewing the citations for identified key papers to determine preceding articles which you should consider, and ‘go forward’, to identify other articles citing the identified key papers.

The literature review on existing studies will help to make sense of the accumulated knowledge on the domain of research, as well as discovering potential gaps and conceptual framework that will extend current studies. The results of this strategy will be provided in chapter 3.

2.2. Case Study

To answer sub-research question 3 and the main research question entirely, the conceptual framework that is generated through desk research will be studied in-depth using case study strategy. This step aims to evaluate the conceptual framework so that it could be readily used as a tool to foster innovation process. A case study will be utilised as this research focuses on the contemporary phenomenon in the real-life context and mainly conducted in nature where there is a little control over the events, which suits the situation of practical cases and incidents. Those reasons are relevant with the main reasons of a case study approach according to Yin (1994). Moreover, the case study allows the combination of several data collection methods, such as data archives, questionnaires, interviews, and observations, in the form of qualitative or quantitative data, or both (Eisenhardt, 1989).

2.2.1. Case Study Introduction

For this research, a single longitudinal case will be selected as the case study design. This design is relevant to the research background, which is to analyse DTI innovation process that occurs in a particular period. DTI (data pipeline) innovation process is defined as a holistic unit of analysis in this single longitudinal case study design. To apply the conceptual framework, we selected four separate EU-funded projects as the cases studied in this research, namely ITAIDE[4] (2006-2010), INTEGRITY[5] (2008-2011), CASSANDRA[6] (2010-2014), and CORE[7] (2014-2018). Each project has different objectives. However, these projects constitute as data pipeline innovation system in different phases. These projects have the same knowledge field, which is service-oriented architecture (SOA) concept within a digital infrastructure in order to improve supply chain visibility. SOA is an architecture for distributed, web-based access to business data stored in actors' databases. The concept of SOA and piggy-backing principle (re-using business data) is then developed into data pipeline in several configurations from one project to another. However, the last project, CORE faces a problem, which is the difficulty to move data pipeline innovation into the implementation phase. These four projects are suitable to represent empiric cases as they constitute DTI innovation system that is characterised with multi-level actors in a highly-regulated environment. We are interested in analysing historical events and activities of data pipeline innovation development that occurs in these projects so that the applicability of the conceptual framework can be identified. These projects are relevant to the research background as it can represent the natural context of DTI innovation process. More detailed information regarding ITAIDE, INTEGRITY, CASSANDRA, and CORE will be discussed in section **Error! Reference source not found.**.

2.2.2. Data Collection Procedures

Qualitative data will be required to test the conceptual model. Qualitative research allows the more realistic perspective of innovation system dynamics that cannot be understood in numerical data and

[4] See more detailed information regarding ITAIDE in https://cordis.europa.eu/project/rcn/79327_en.html
[5] See more detailed information regarding INTEGRITY in https://cordis.europa.eu/project/rcn/90099_en.html
[6] See more detailed information regarding CASSANDRA in https://cordis.europa.eu/project/rcn/100060_en.html
[7] See more detailed information regarding CORE in https://cordis.europa.eu/project/rcn/188515_en.html

statistical analysis. Yielded results of the data analysis can be helpful in discovering new ways of understanding and richer causal explanations. The qualitative data required for this research are the activities and events that occur in DTI innovation process. To collect these data, two data collection methods are used, such as the *documents analysis* for ITAIDE, INTEGRITY, CASSANDRA, and CORE project documents, also from its official websites, and then followed by semi-structured *interviews* with the experts, who are actors that are involved directly in international supply chains. Moreover, we attended a project workshop and transcribed a field note as the part of the second stage data collection method. The figure below represents how the data were collected and analysed iteratively as part of the case study research strategy.

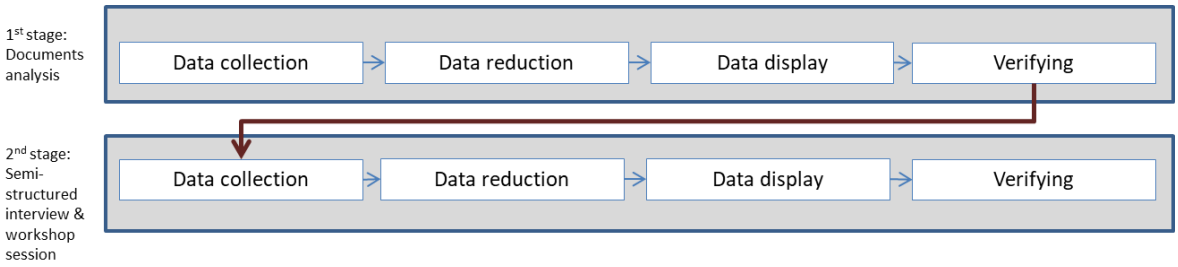


Figure 3: Iterative data collection and data analysis procedure

As the first stage data collection, documents analysis is conducted. A documents analysis will be elaborated with the interpretive and processual approach (Pettigrew, 1990; Walsham, 1993) with focus on events through which the ITAIDE, INTEGRITY, CASSANDRA, and CORE projects unfolded from 2005 until 2018. This strategy can also be explained as theoretical sampling, as we collect events in innovation process as a data which will support the conceptual framework. We examine events data in the form of reports, newsletters, and project deliverables. Later, the collected data are included in the case study database, in the form of documentation of the relevant archives. This method of sourcing evidence can be an inexpensive way to gather information but may be an incomplete data source. Some of the collected documents are available already in public, while other documents such as project deliverables were accessible as the author is a participant of CORE project and also has network with project participants in other projects.

Table 3: List of reviewed documents

Project's code	Project's name/documents' topic	Reviewed documents	Documents code initial
Project 1	ITAIDE	7 academic journals, 3 project deliverables,1 website transcript, 1 book	IT
Project 2	INTEGRITY	2 project deliverables, 1 website transcript, 5 newsletters	IN
Project 3	CASSANDRA	2 academic journals,2 project deliverables, 1 website transcript	CA
Project 4	CORE	4 academic journals, 1 project deliverables, 1 website transcript, 2 newsletters	CO
Others	EU customs report	1 report, 1 proposal	GE

After these documents are collected, the initial data analysis is carried out. The initial data analysis was verified by two project participants who hold the important role as key informants for this research. Data analysis will be described in section 2.2.3. To enrich the data materials, multiple methods of sourcing evidence are elaborated. We use a semi-structured interview with open-ended questions. The interviews thus are aimed to complement findings from documentation. A semi-structured interview offers a live experience while also enabling one to address the theoretically driven variable of study interest and providing a repertoire of possibilities to address the specific topic related to a particular phenomenon in the research. It also leaves enough space for the interviewees to offer new meaning to the research focus, allowing enough space for such empirical and theoretical study (Galetta, 2013).

To facilitate semi-structured interviews, respondents are provided with a copy of the research instruments before scheduled interviews to familiarise them with the questions that may be asked. Questions regarding activities and events that take place in these ongoing projects are asked as research instruments to respondents. We established the requirement for information that should be provided by the interviewee based on the initial conceptual framework (see Figure 10). The semi-structured interview enables respondents to provide information regarding events that occur during innovation process of DTI. The interview protocol is attached in the appendix section. The answers of the respondents should provide information such as:

- Events or activities in the project that are related to structural analysis
  To explain structural analysis, we used a collective action model of institutional innovation (Hargrave and Van de Ven, 2006) and unblocking mechanisms of DI innovation process in mobile payment case (Rukanova et al., 2017). This theory can help to explain how actors join the network, based on the framing and the political opportunity. Interviewees are expected to provide information regarding the concepts of political opportunity, construction of network, and framing.
- Events or activities in the project that are related to functional analysis
  To explain functional analysis, we used the functions of innovation system (FIS) theory, which represents innovation system functioning (entrepreneurship activities, knowledge development & diffusion, market formation, guidance of search, resource mobilisation, advocacy coalitions). This theory focuses on determining the pattern of innovation system function evolution in longitudinal manner by counting the events that constitute each function. As we are interested in deeper understanding of blockages of innovation process, we are interested to apply qualitative approach for this study. Interviewees are expected to provide information regarding the concepts that are included in the FIS theory.

The questions were formulated based on the list discussed above. The relevant actors who are considered to be respondents of the interview are described in Table 4. We selected some project participants as the respondents. The respondents are key participants in some or all of ITAIDE, INTEGRITY, CASSANDRA, and CORE projects who have knowledge on the development of data pipeline from one project to other projects. Although there are numerous actors that participate in these projects, only few people have relevant knowledge regarding the relation between the observed projects. The reason is because there are only one organization that remains participating in the whole

project and only few participants are the representatives of the organization who are actively involved. Therefore, based on the suggestion by a primary informant who is actively participating in CORE, three interviewees were selected. The interviews were conducted by phone and a face-to-face meeting. The conversations were recorded and saved in a case study database. Furthermore, the conversations were transcribed in the form of notes.

Table 4: List of interviewee

Interviewee code	Interviewee category	Organizations	Position of the interviewee
YT	University	TU Delft	ICT department researcher
FH	Government organizations	DTCA (Dutch Tax and Customs administration)	Director National Trade Facilitation
FI	Government organizations	Dutch Ministry of Finance	IT auditor

2.2.3. Data Analysis

From the data collection methods, the required data will be collected in case study database. A within-case analysis is conducted as this research focuses on an in-depth exploration of a single case study. During the data analysis, we used our own observations accumulated through our review on project documentation. From open coding, a priori coding of collected data based on research instruments should be conducted to ensure its relevance to the research (Yin, 1994). Collected data are specified in transcript summaries, by looking at specific characteristics and dimension. All transcribed data are given a specific code, as shown in Table 5, which later these coded data are categorized according to theoretical concepts of the proposed conceptual model (see Figure 10), related to structural analysis or functional analysis as the fulfilment of axial coding. Furthermore, the data that are not relevant to the structural analysis and functional analysis are eliminated, as part of selective coding. This process is known as 'reduction' and will help the author to develop a clearer picture of participants' responses to critical questions posed during the interview.

Table 5: List of open codes for case study analysis

Levels of analysis	Theoretical concepts	Open code
Structural analysis	**Political opportunity**	standards, customs code, current regulation, politic issue, technology issue, security issue, innovation project evolution, regulation changes
	Construction of networks	actors, stakeholders engagement, stakeholders cooperation, stakeholders interactions, stakeholders participation, boundary spanners
	Framing	project initiation, project concept, compliance vision, project focus, R&D characteristics
	Discontinuity	project ends, project conflicts, bottlenecks
Functional analysis	**Entrepreneurial activities**	innovation project evolution, project initiation, project background, stakeholders participation, effect of networks construction
	Knowledge development	compendium, deliverables, work package, papers, labs, research, test, pilot, development, project concept, pilot description, R&D activities, project focus

	Knowledge diffusion	project publications, workshops, conferences, project dissemination
	Guidance of the search	current legislation, project dissemination, positive interests, driver of implementation, project influence
	Market formation	project influence, positive interests, innovation adoption
	Resource mobilisation	funding effects, total funding, private investments, public funding, stakeholders participation
	Advocacy coalitions	stakeholders participation, quality of stakeholder participation, project influence, stakeholders cooperation, stakeholders management, implementation driver
	Blockages	stakeholder management, governance issue, potential conflicts, different interests, knowledge transfer issue, project bottlenecks

Coded data are analysed and integrated using several techniques that are proposed by Yin (1994) such as:

- Pattern matching
  Coded data are mapped into the conceptual framework and compared if the results have been found as predicted.
- Explanation building
  Based on the comparison between the findings and initial conceptual framework, explanation of the case and set of a causal link should be delivered. An interpretivist approach is used to allow researchers to interpret elements of the study through social constructions such as shared meanings, language, consciousness and instruments. It enables the cases to be studied in a great level of depth.
- Time-series analysis
  As the research focuses on identifying innovation process that occurs over the period, this technique is used to analyse events data, which may show a different pattern from time to time.

According to the scheme on Figure 3, we reviewed the documentation for the first stage of data analysis. We analysed the data and conducted immediate analysis. This immediate analysis then was verified by some project participants. Furthermore, we analysed interviews data to fill the missing information and get richer materials. This mechanism serves as the second stage of data analysis. The second stage of data analysis was verified by the same project participants who verified the immediate data analysis. From this analysis process, the findings can be drawn, and conceptual framework applicability can be evaluated.

This page is intentionally left blank

3. LITERATURE REVIEW AND THE CONCEPTUAL MODEL BUILDING

This chapter presents the overview of fundamental concepts that are relevant to research domain. To answer the primary research question, existing studies that explain key concepts of this research should be described. This chapter also provides the reader with sufficient knowledge, to support their understanding of basic concepts and language which are frequently discussed in this research.

This chapter discusses key theories that construct the research framework based on Figure 2, which are digital infrastructures, innovation-development process, innovation system, and collective action. These sections are followed by the discussion on discovered gaps and conceptual building. Finally, this chapter ends with a presentation regarding the structural-functional analysis framework.

3.1. Digital Infrastructures in International Supply Chain

3.1.1. Digital Infrastructures

Millions of users log onto popular social media accounts, download applications on their smartphone, and use services provided by technology providers to create governance for their business. This phenomenon is commonly referred to as the notion of *digital convergence* (Tilson, Lyytinen, & Sørensen, 2010). According to their study, this phenomenon appears as the impact of *digital infrastructures*. Digital infrastructures (DI) can be defined as shared, heterogeneous, open, and evolving sociotechnical systems comprising an installed base of diverse information technology capabilities and their user, operations, and design communities (Hanseth & Lyytinen, 2010). One of the capabilities of DI is reducing information fragmentation as it also can be seen as system-of-systems that transcend organizational and systems domain (Hanseth & Lyytinen, 2010).

In detail, the properties of digital infrastructures are:

- Shared: the platform is shared across multiple communities
- Openness: components can be included, no clear boundaries on who can and cannot use DI
- Heterogeneous: a number of different technologies are included as it includes very different nature of communities, standardisation, and governance bodies
- Evolve: different designers may discover new technologies and thereby expanding DI

Enabling digital infrastructures made it simple and more cost-saving to provide the number of products and services, as it standardises the interface between elements. Take a look on mobile payment, as the example of digital infrastructures, which is defined as an enabler for the mobile device or contactless card on a SIM to conduct transaction or payment by connecting to a server (Antovski & Gusev, 2003). This example of digital infrastructure indicates that face-to-face contact between buyer and seller will be unnecessary and from that efficiency of the business process can be improved.

Nevertheless, DI characteristics appear as the challenges for DI development (Hanseth & Lyytinen, 2010; Rukanova et al., 2017). First, the problem relies on inertia of an installed base. Installed base refers to pre-existing components that comprise the introduction for any DI development efforts, such as standards. DI development is always confronted with the inertia of installed base as it is scarcely possible to develop DI without the role of an installed base. Whatever is included in the DI configuration has to be compatible with the installed base. Second, the control of digital infrastructures is distributed across multiple communities, each of whom is responsible for DI development (Hanseth & Lyytinen, 2010). DI cannot be controlled by a single designer. As the result, coordination of distributed control emerges as a challenge of DI development. According to these characteristics, collective action is increasingly required to enable DI development.

3.1.2. Digital Trade Infrastructures

Information about international trade transactions resides in business and government systems in the international supply chain. These types of information can bring advantages to both business and government. The government can re-use the data to verify trusted traders and reduce the administrative burden for customs to control Value Added Tax or Excise issues, while from a business perspective, business data exchange can minimize trade costs that is distributed across the whole supply chain. However, some actors involved in international trade are reluctant to share the data. This condition results in poor quality information streams and end-to-end supply chain visibility (Jensen & Vatrapu, 2015). Unreliable data makes it hard to detect safety, security, and compliance risks and makes international supply chain inefficient. To improve this condition, EU has the ambition to facilitate international trade information exchanges and reduce administrative burden within trade flows by adopting digital technologies. Supported by Multi-Annual Strategic Plan (MASP) for customs development and trade simplification, several innovation projects have been initiated to develop the Digital Trade Infrastructures (DTI) concept.

The international trade domain suffices the definition of digital infrastructures because of several reasons. First, in trade domain, multiple communities are at stake to design and control information exchange system of trade flow. For instance, a system that is proposed by customs authorities will affect other stakeholders' business process. However, if the others do not comply with the new system, then it will not give any added value to customs and other stakeholders. Next, in trade domain, there are various stakeholders that come from multiple levels (see Table 8). This characteristic allow open environment for many communities to be involved in the supply chain innovation development. Because of these characteristics, the information exchange system that is developed in international trade domain can be categorized as digital infrastructures, as the system should have properties such as shared (the information exchange system should be shared across different communities), openness (allowing complementary capabilities to be included and multiple actors to have stake at system design), heterogeneous (allowing various types of technology capabilities and communities to be included in the information exchange system development), and evolving (allowing additional IT capabilities to be included as the effect of open environment).

DTI concept has emerged as the *single window*, *national community hubs*, or *data pipeline*. DTI concept is mainly used to describe digital infrastructures that transcend organisational and systems domains, driven by the expectation to reduce information fragmentation, so improved security and efficiency in trade process can be realized (Rukanova et al., 2017). In demonstrator settings, the DTI potential has been revealed, but the adoption in practice is slow. The DTI framework was built to explain dimensions of digital infrastructures in trade domain.

DTI framework consists of architecture, process, and governance dimension which are strongly intertwined (Rukanova et al., 2017). Architecture dimension explains various levels of actors, (national, international, global) actors' interactions and DTI type. Actors that are involved directly in the DTI innovation system are categorised as the business, government, or intermediary, which can be explained more detailed as shippers, carriers, IT developers, customs, national or global regulators, and universities. The complexity in architectural dimension occurs when significant effort and time are put in developing data sharing concepts, but restrictions on a higher level block it from implementation. Process dimension is described as initiation phase, operations and maintenance phase, and new service phase. Unobvious gains of DTI implementation that can be obtained by actors sometimes block the actors' intention to invest, which will halt the DTI innovation process. Governance dimension can be described as infrastructure governance and decision rights. Multi-actor network of stakeholders remains a challenging issue that can hamper the adoption of DTI. Some concepts of DTI such as single window and data pipeline will be explained in this section.

Table 6: DTI Framework (adapted from Rukanova et al., 2017)

Dimensions	Category	Values
Architecture	Levels	National, International, Global
	Actors	Business/ Government/ Intermediary; Direct/ Indirect
	Interactions	Business-to-Business (B2B); Business-to-Government (B2G); Government-to-Government (G2G)
	DTI-type	Data pipeline (thick/ thin); National hub
Process	DTI development phases	Initiation; Operation and maintenance; New services
Governance	Infrastructure governance	Formal/ Informal
	Decision rights	Constitutional rights Collective choice rights -Standards -Cost-benefit sharing -Data access Operational rights

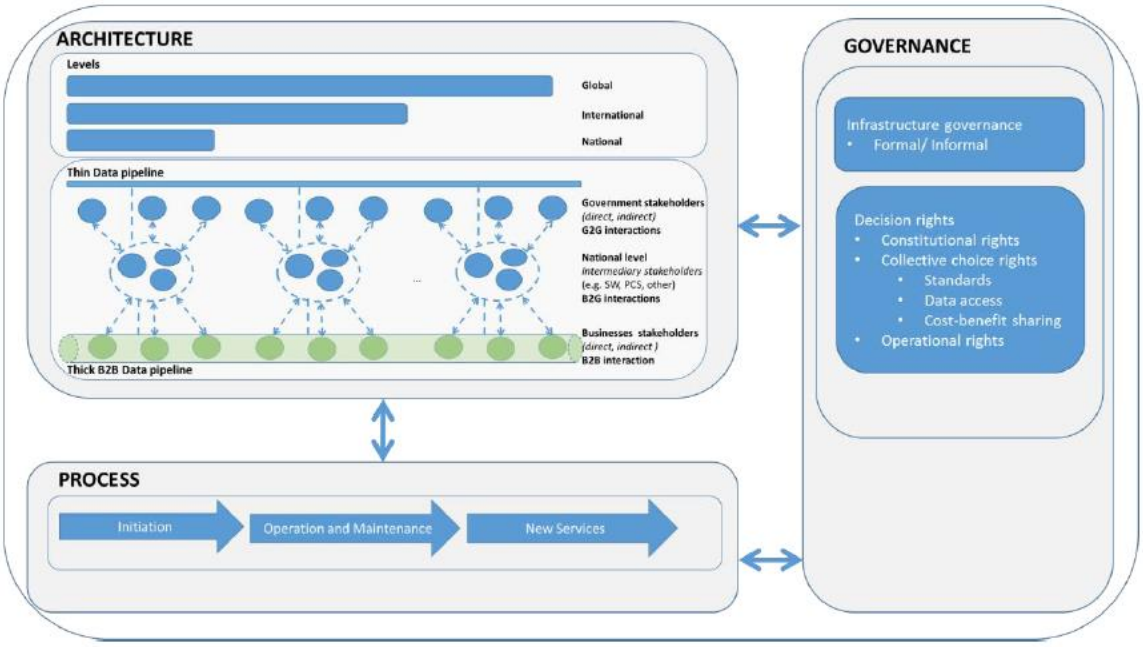


Figure 4: DTI Framework visualisation (adapted from Rukanova et al., 2017)

a. **Single window**

Single Window is a concept to facilitate business processes and information exchange for national export and import. (van Stijn, et al., 2011). This concept is done by intensifying the collaboration and coordination between the public and private institutions. The single window represents a one-stop service portal of an integrated electronic gateway. It enables the actors in the international trade to submit the information and documentation related to export, import, and transit shipments that are needed by other actors in the whole chain. According to Klievink et al. (2012), single window works by interpreting the data from the B2G message interactions and regulating which data is relevant for specific government organization (e.g., customs, food inspection agencies). For example, for a particular waybill, additional insight might be provided for all customs authorities such as insights regarding if there are public agencies that have already accepted or rejected messages that are based on data related to a particular waybill.

The single window concept allows one-time submission instead of submitting same information repeatedly to different public agencies. From this condition, the idea of *data pull* instead of *data push* was introduced. Data pull is promoted to enhance supply chain efficiency and is defined as the concept where public agencies have access to extract business data from the sources (Tan et al., 2011). Based on UNECE (2005) there are three basic models of single window such as:

- Single authority which receives and disseminates the information to the relevant government's authorities, as well as coordinate the controls in the logistic chain
- A single automated system that allows the collection, dissemination, and integration of information and data related to the trade

- An automated information transaction system that allows the traders to submit the electronic trade declarations to other government authorities for further process in obtaining electronic approval in a single application

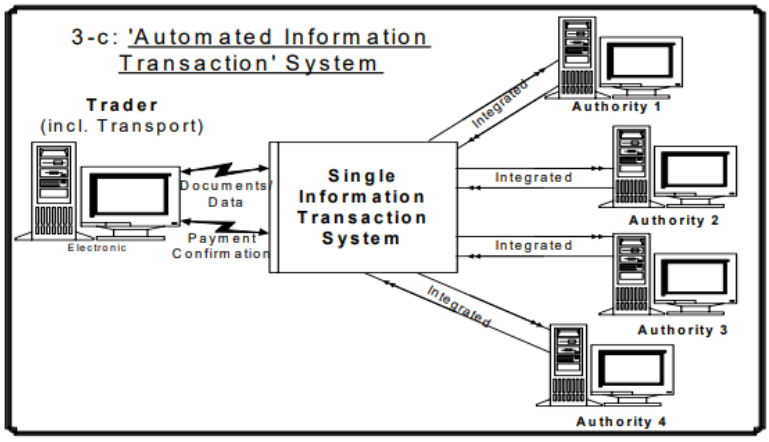


Figure 5: Example of single window basic models (adapted from UNECE, 2005)

In UNECE's report, benefits for both government and traders are described. For the government, the single window provides a benefit mainly to leverage security which in the long-term develops the port's competencies and increases the revenue. For the traders 'side, the single window is more useful to reduce trade costs and increase the transparency. Single window is the practical application of the digital trade infrastructures that can reduce the non-tariff barriers and is supposed to share immediate advantages to the actors in the international supply chain (UNECE, 2005).

Table 7: Benefits of single window (adapted from UNECE, 2005)

Benefits for government	More effective and efficient deployment of resources
	Correct (and often increased) revenue yield
	Improved trader compliance
	Enhanced security
	Increased integrity and transparency
Benefits for trade	Cutting costs through reducing delays
	Faster clearance and release
	Predictable application and explanation of rules
	More effective and efficient deployment of resources
	Increased transparency

b. **Data pipeline**

The systems used in international trade domain have developed since the eighteenth century to procure general cargo and paper-based transaction (van Stijn et al., 2011). The notion such as outsourcing and multi-modal transport chains have allowed the identification of the true seller

or sender to be clouded, leading to increasing complexity of contractual terms. Additionally, increasing trade flows lead to increasing complexity in border management and can cause time delays, cost increases, as well as reductions in supply chains competitiveness. The potential solution to address this concern is *data pipeline*.

The data pipeline is a concept based on the use of Service-Oriented Architectures (SOA) to enable access to the existing information systems which are operated by the various supply chain stakeholders (van Stijn et al., 2011). The data pipeline is a virtual bus, created by linking the companies enterprise systems, inter-organizational systems connecting actors such as freight forwarders and carriers, and systems for tracking, tracing and monitoring the goods. Transactions data has to be fed to data pipeline to create supply chain visibility. Accurate data are available to authorised actors along the chain. The data pipeline works by integrating the available information system, covering the wide range of enterprise systems such as the system used by sellers and buyers, customs system, and inter-organizational information systems. To ensure the data security, the data access is controlled by a particular authorisation. This control restricts any access to data unless the data owner has authorised the organisations.

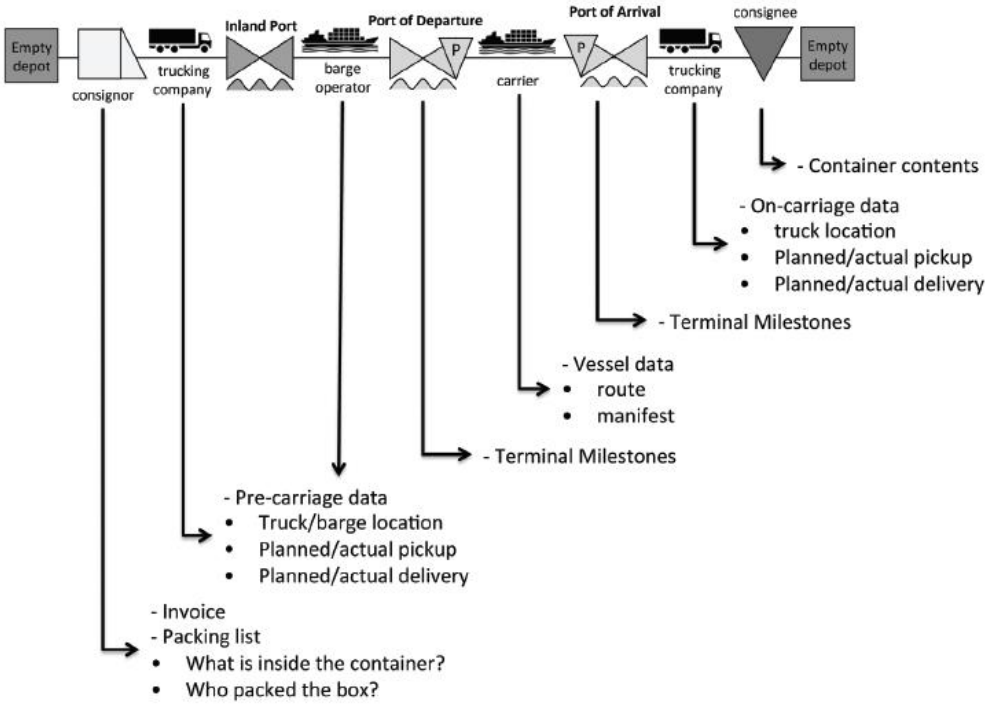


Figure 6: Data sources in international trade (adapted from Klievink et al., 2012)

The data pipeline concept is meant to bring advantages for most of the actors within the supply chain, both for public and private organizations, by increasing the supply chain visibility and the data availability. Data pipeline provides more accurate and timely cargo import/export declaration information to the customs administrations for trusted traders (Klievink et al., 2012). For governments, they use data pipeline mainly to improve the coordination of border management and perform a better risk analysis to reduce the unnecessary administrative burden. Improvement of data transparency to optimise the supply chain further serves as the positive effect to foster the synchro-modality in building a sustainable supply chain (Klievink et al., 2012). It also offers flexibility whether to be conceptualised as *Thick* and *Thin*, dependings on whether the actual documents are exchanged (thick) or limited only to the events (thin) that are exchanged (van Engelenburg, Janssen, Klievink, & Tan, 2017).

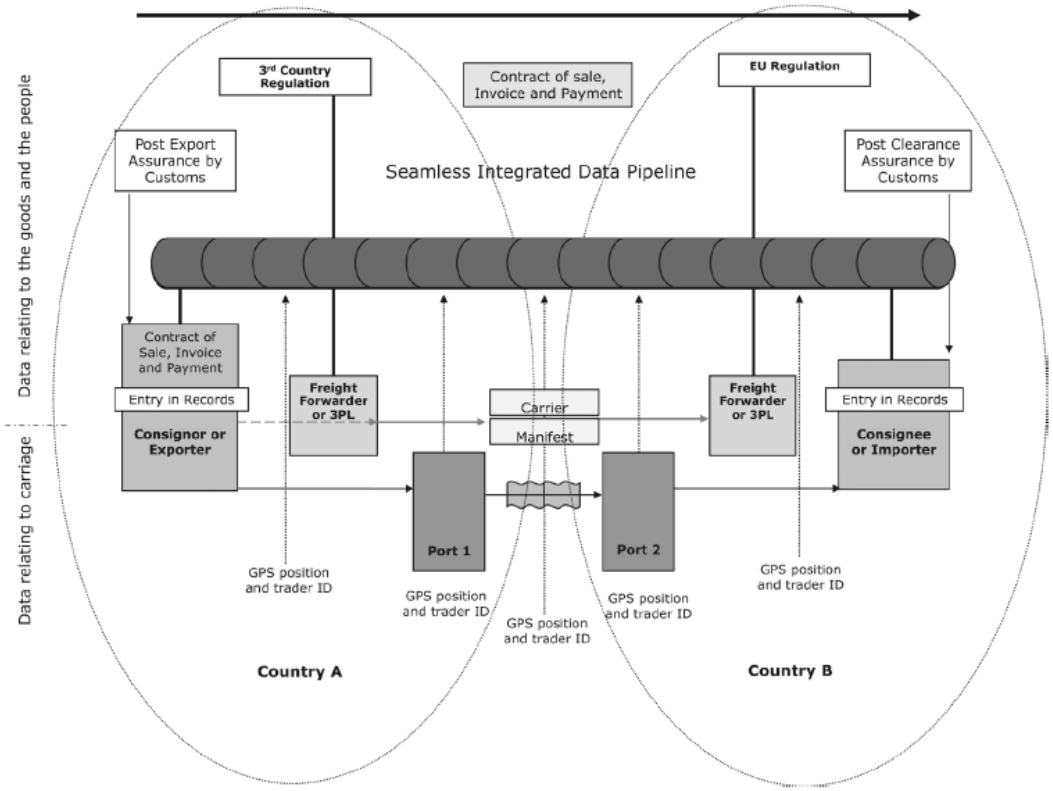


Figure 7: International trade in data pipeline situation (adapted from Klievink et al., 2012; Hesketh and Heijmann, 2011)

3.1.3. Supply Chain Stakeholders in International Trade Environment

The challenge to increase reliability and efficiency of international trade is considered as primary concern in global supply chain due to enormous amount of container flow. To achieve supply chain visibility, there has to be cooperation between government and private business actors. Such Business-to-Business (B2B) and Business-to-Government (B2G) activities should be conducted to mitigate high-cost and high-risk issues, regarding any investments on DTI innovation. In the EU, this cooperation can be defined as *Public-Private Partnership* (PPP) (Tan et al., 2011). For B2B, DTI can bring benefits that

include better traceability to optimize supply chain, such as cost-efficiency and synchro-modality. On the other hand, B2G will reap benefit such as administrative burdens reduction for business actors.

Public-Private Partnership involves many actors. A study by Nijdam et al. (2012) explained supply chain stakeholders analysis, including their involvement and their interests regarding DTI innovation. Data pipeline main users are categorised as the direct involved stakeholders. Furthermore, secondary involved stakeholders are parties who use the pipeline or provide input for the development, but are less involved. The stakeholders involved indirectly may give influence on the data pipeline development but will not directly use the system. Governmental stakeholders are the parties that are most involved in the project. They are very influential on the outcomes of DTI development and have the highest sense of urgency on it. They should be participated actively in the project, but there has to be more attention with other stakeholders to avoid a situation where public parties go for the development only by themselves. For example, some shippers do not see benefits of data pipeline and have issues with data sharing. However, data pipeline will not only be beneficial for public agencies. Other stakeholders that can benefit are parties that have direct involvement of data pipeline development. Different perception on DTI benefits from influential stakeholders may halt the implementation of DTI, which will be further discussed in chapter 4.

Table 8: List of stakeholders in international trade (adapted from Nijdam et al., 2012)

Group	Stakeholders	Involvement
Customers	Shippers	Direct
	Consignees	Direct
Transport operators	Transporters	Secondary
	Terminal operators	Secondary
	Shipping line/carriers	Secondary
Transport organizers	Forwarders/3PL	Direct
Government	Customs police	Direct
	Port Authorities	Secondary-indirect
	Legislative government/WCO	Secondary-indirect
	Other governmental agencies	Indirect
Facilitation	IT providers	Direct-indirect
	Data platforms	Direct-indirect
	Standardisation Bodies	Secondary-indirect
	Branch organization	Secondary-indirect
	Banks	Indirect

3.2. Innovation-development Process

Digital infrastructure is pictured as an innovation that can influence and improve various domains' operational issue. The innovation itself is explained as novel idea or object by an individual or other adoption units (Rogers, 1995). The innovation-development process is critical to understand how to foster DTI innovation to implementation. According to Rogers (1995), an innovation-development process consists of all activities and impacts that occur from recognition of a problem, through research,

development, and commercialisation of an innovation, through diffusion and adoption of the innovation by users.

In another perspective, Van de Ven et al. (1999) examined that in common, innovation process is not linear and overall innovation process is divided into three temporal phases:

1. **Initiation phase**
   Activities occur that set the stage for launching efforts to develop innovation
2. **Developmental phase**
   Efforts that are undertaken to transform idea into reality
3. **Implementation phase**
   Innovation is adopted and institutionalized as an ongoing program

Both theories indicate similarities regarding innovation lifecycle, which there should be recognition of a problem that will initiate efforts to develop innovation, the development part, and diffusion period. The length of each period can be varied. Ortt (2010) divided innovation milestones into two following phases: the innovation phase (from invention to initial market introduction) and the adaptation phase (from an initial market introduction to industrial production and large-scale diffusion). He examined the length of innovation and adaptation phase of five different industries, namely chemicals, pharmaceutical, telecom, electronic equipment, and defence. From his research, the average case of digital innovation requires around 15 years of innovation and adaptation phase before it is diffused in the market, while innovation in pharmaceutical industry can take 21 years on average for its pre-diffusion phase.

Yoo et al. (2005) identified three domains that can shape diffusion of innovation, more specifically, in the telecom industry. The diffusion of this innovation is shaped by relationships among three analytically distinct domains (Yoo, Lyytinen, & Yang, 2005):

1. The Innovation system, which is defined as an interlinked network of sites, ideas, resources, capable over time of developing novel technologies and solutions based on research and development activity.
2. The Marketplace, which explains a set of actors that produce technologies (within a value network) exploiting the technological potential defined within standards
3. The Regulatory regime, which can also be defined as the authority which can influence, direct, limit or prohibit any activity in the innovation system, the marketplace or the regulatory regime itself

Tilson et al., (2010) argue that understanding networks of influence established by institutions from these three domains also help to understand what shapes innovation process. Therefore, to mobilise innovation process, the role of these three domains cannot be neglected.

3.3. Innovation System

An innovation is inseparable from the notion of innovation system. According to Edquist (2001), innovation system is "all important economic, social, political, organizational, and other factors that influence the development, diffusion and use of innovations". This definition strongly emphasizes on how innovation system becomes determinants of innovation. Innovation system approach is generally used in academic contexts as well as a rationale for innovation policy making (Bergek et al., 2010; Edquist, 2001). Variants of innovation system approach are national innovation system (NIS), sectoral/technological innovation system (SIS/TIS), and regional innovation system (RIS). National innovation system revolves around the scope of single country, technological innovation system focuses on specific knowledge field or product areas, while regional innovation system focuses on geographical boundaries of regions within countries or include parts of different countries.

The main components of innovation system are organisations and institutions (Edquist, 2001). Organisations here are defined as formal structures with a definitive aspiration, referring to players or actors. On the other hand, institutions are sets of common habits, established rules or laws that regulate the relations and interactions between individuals, groups, and organisations. For example, this term can be used to explain norms and laws influencing universities and business relationship. These components may interact and have specific ties. For instance, an interaction between customers and business can be a basis for innovation development and learning process. Moreover, most organisations are strongly influenced by institutions. Thus, there is a complicated relationship between institutions and organisations, and this relationship influences innovation processes and thereby also performance and change of systems of innovation (Edquist, 2001).

This research focuses on analysing technological innovation system (TIS) instead of any geographical-based innovation system as the problem background describes the need of digital trade infrastructures in general, not in a specific region. According to Bergek et al. (2008), choosing the focus of attention is the starting point of TIS analysis. The focus of attention can be a *knowledge field* or a *product/artifact*. In common, innovation system is a system which consists of components that support a specific and same product development from time to time. However, TIS can also be analysed by looking at specific knowledge field. The definition the knowledge field may be a narrow field (e.g., digital trade infrastructure) or much broader (e.g., IT). After choosing knowledge field, the decision on choosing range of applications has to be taken. The choice of application will determine actors, networks, and institutions that should be included in the analysis. For instance, banking or energy industry can be categorized as the possible range of applications for digital infrastructures knowledge field.

3.3.1. Functions of Innovation System

When the innovation concept has been sharpened, the concern to identify factors which possibly influence innovation development will emerge. There is a need to know what 'happens' in the systems. To understand innovation process and more specifically, dynamics of the innovation system, analysis regarding what innovation system does and how it can influence innovation process is necessary (Bergek et al., 2010). This theory provides a heuristic view and helps to identify activities in an innovation system and create insight that relates to possible changes in innovation processes. Insights into the current functioning of specific innovation system can affect the determination of optimal policy strategy

(Hekkert et al., 2007). This direction or policy issue will possibly be applied to stimulate weak functions of innovation system. Moreover, they argue that innovation system may be accelerated when functions interact and influence each other, and each function fulfilment is reached.

This approach can be applied by mapping events that occur over time during innovation process and reported at a system level. Using the process approach to map the functioning of several innovation systems over time, allows us to search for patterns related to innovation system dynamics. All events are assigned to seven functions as follows:

1. **Entrepreneurial activities**
   This function can be analysed by aligning the number of activities that represent decisions of actors to develop and adopt the innovation as they perceive the innovation as a new opportunity for their business process, and actors who diversify their business process and develop complementing technologies to take advantage of such innovation.
2. **Knowledge development**
   This function can be analysed by mapping R&D projects, how stakeholders' participation contributes to R&D activities in the system, and R&D investments.
3. **Knowledge diffusion**
   This function can be explained as events related to the workshops and conferences, intensity of dissemination and size of the network of dissemination.
4. **Guidance of the search**
   This function can be analysed by mapping specific target sets by actors regarding the use of specific technology, dissemination activities that raise expectations about new technological development, and positive expectations that are shown by stakeholders in the system.
5. **Market formation**
   To represents this function, niche markets that have been introduced, specific regulations for new technologies, and the real implementation of the innovation can be mapped to this function.
6. **Resources mobilisation**
   Examples of this function are funds made available for long-term R&D programs to develop specific technical knowledge and funds to test new technologies in niche experiments. Funding resources depend on the targets that are related to innovation development.
7. **Advocacy coalitions**
   This function can be analysed by mapping the growth of coalitions' size and how powerful the coalitions are in dictating changes in innovation system.

These functions influence each other. Functions fulfilment can lead to a *virtuous cycle*, which is defined as the cycle that explains process of changes that make functions reinforce each other and hence creating momentum for creative destruction process within the existing innovation system. Negative function fulfilment leads to decreasing number of activities related to the other functions and thus may stop the innovation development within a system. For instance, taxes that provide negative expectations (negative guidance of the search) for a certain technological innovation may limit

entrepreneurs to develop the innovation (negative entrepreneurial activities). Motor C shows that guidance of the search is a common trigger for the cycle. Problem which is discovered by the government leads to a knowledge development hence increasing expectations. On the other part of flow, motor B shows that entrepreneurs may lobby many stakeholders to make technology development possible. Furthermore, the effect of lobbying may lead to increasing resources to support knowledge development. On the other hand, motor A shows how entrepreneurs lobbying efforts can lead to market formation.

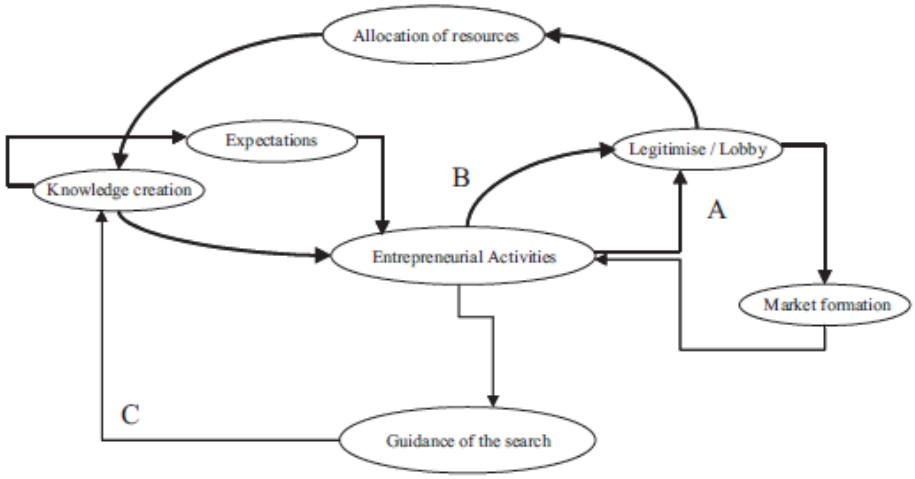


Figure 8: Functions of innovation system's virtuous cycle (adapted from Hekkert et al., 2007)

Besides understanding the dynamic of innovation, these functions will be mainly used for this research as a key concept for the innovation system's functional analysis by specifying which functions that are 'predominant' and 'minor'. A pattern that shows the weakness of innovation system functions is influenced by blocking mechanisms, which is defined as a factor that provides obstacles to the development of functions (Bergek et al., 2010). In this research, we use the term 'weakening indicators' to define blocking mechanisms according to the FIS theory. The strong nature of weakening indicators may commonly limit business communities to address those indicators. Some possible weakening indicators are lack of resources/funding and lack of standards/regulation. Hence, public policy intervention is considered to be more relevant to address such indicators compared to entrepreneurial efforts. From this study, the weakness and strength of innovation system functioning can be used to explain dynamics of an innovation process. This theory is relevant to this research as DTI innovation process can be described in a heuristic approach and blockages of innovation process can be explained.

3.4. Collective Action

Due to the nature of DTI innovation system which consists of multi-level organisations and institutions, collective action is required to achieve the objectives of the innovation project which represents DTI innovation system in a certain innovation phase. Ranging stakeholders may perceive different interests and a shared goal, which is always be a challenge for collective action. This theory is developed by Olson (1965) explains how groups may cooperate for reaching the shared interests. This theory provides the basis for all movement of groups and has been used in numerous branches such as economic and

healthcare sector (Monge et al., 1998; Klein & Schellhammer, 2011). In this research, the shared goal is different from one project to another, as each project aims to achieve different set of targets. However, the idea behind the objectives is developing a digital infrastructures innovation that can improve supply chain visibility and this idea represents similarity of projects' shared goal. Nikayin et al. (2013) have discussed how collective action arise in the environment of digital platform, and it is influenced by some factors such as technical and organisational openness of the digital platform, heterogeneity and interdependency of business ecosystem, leadership, and selective incentives.

The literature explains possible blockages of collective action. In the context of collective action, we refer to blockages as the blocking factors that contribute to discontinuity or failure of collective action. As there are several organisations in collective action, different interests from each actor can be the blocking factor for such collective action. One of the objects of the collective action is a shared goal, and some actors that have the power to realize the shared goal have different interests. According to Klein and Schellhammer (2011), diverging interests may result in conflicts that threaten and block collective action. Second, conflicts between participants of collective action may prevent the continuity of collective action. Conflicts may arise during the process of collaboration between competitors for the common good (Brandenburger and Nalebuff, 1997). Another blocking factor of collective action can be indicated with reduced interdependencies among actors, as interdependencies are the prerequisite for collective action to arise (Heckathorn, 1993). Interdependencies may change along the course of collective action process, for instance as technological alternatives become available (De Reuver, Verschuur, Nikayin, Cerpa, & Bouwman, 2015). Lastly, lack of governance mechanisms between actors in collective action may block the collective action itself (De Reuver et al., 2015). These blockages may become the core of blocking mechanisms of DTI innovation process, as DTI innovation requires collective action to be mobilised.

3.4.1. Collective Action Model of Institutional Innovation

Collective action can also be defined as a dialectic process for institutional innovation (Hargrave and van de Ven, 2006). These theories are relevant for this study as DTI innovation system is characterised by multi-level regulations and tight interactions between actors. Hence, such collective action where different actors collaborate for a common goal, which in this case, improving supply chain visibility with digital infrastructures, is desirable and considered to be able to influence the speed of innovation development process. The relevance of this theory with DTI adoption is also mentioned in previous literature regarding digital infrastructure innovation, which explains that collective action model (Hargrave and Van de Ven, 2006) holds the key to mobilise collective action which is needed for speeding up the innovation process (Rukanova et al., 2007).

This theory takes process perspective and identifies several processes that are critical for mobilising collective action in the environment of innovation development. They argue that the number of processes central to mobilising collective action can be described as framing contests, the construction of the networks, the enactment of institutional arrangements (political opportunities), and the collective action processes.

a. **Framing contest**
   It is defined as creation and manipulation of the meaning of issues.

b. Construction of network
   Hargrave and Van de Ven (2006) propose that the construction of the network plays a key role in institutional innovation change processes, as it explains how resources are mobilised to initiate collective action.

c. Enactment of institutional arrangements (political opportunity)
   The third element in the Hargrave and Van de Ven (2006) model refers to the enactment of institutional arrangements and links to political opportunities.

d. Collective action processes
   Lastly, with insights from the technology innovation management literature, Hargrave and Van de Ven (2006) discuss the collective action processes, which describe the contested political process through which new technologies emerge. As collective action process explains changes in innovation system structure (e.g., partnership, joint learning), this theory can be used to support the structural analysis of innovation system.

This model has been applied in some researches on digital infrastructures development (Rukanova et al., 2007; Rukanova et al., 2017) to analyse innovation processes on the highly-regulated environment. It provides a theoretical lens to investigate dynamics of institutional innovation as it draws attention to complex actors interaction towards such movements related to innovation development.

3.4.2. Unblocking Mechanisms of DI Innovation Process

A study from Rukanova et al. (2017) shows how the model explained in the previous section can be extended to address blockages in digital infrastructures innovation process, looking at the example of collective action initiatives in mobile payment domain. They defined blockages as the blocking factors that halt collective action process and contribute to discontinuity/failure of such process. In their analysis, innovators efforts are central, and the analysis gradually moves to the engagement of relevant actors in different levels, international or global. These efforts can be defined as the unblocking mechanisms, the mechanisms to address blockages that disrupt collective action process. Rukanova et al. (2017) proposed three types of unblocking mechanisms for collective action for digital infrastructure innovation:

a. Network reconfiguration
b. Re-framing
c. Change of governance model.

Reconfiguration of the network can be conducted by excluding collective action participants that hold the same control point, substitution by actors covering the same control point, and substitution by actors covering control point at a different level (geographical coverage). Re-framing mechanisms are divided into two, which are objectives re-framing and re-framing of the level of ambition. Joint venture and partnership can explain the change of governance model. These analyses were based on collective action theory of institutional innovation proposed by Hargrave and Van de Ven (2006) and its application on international trade domain with multi-level analysis proposed by Rukanova et al. (2007).

Additionally, the concept of control points is used as it is defined as a socio-technical mechanism that expresses boundaries of economic control, enabling the controller to exercise power over actors in the socio-technical system (Elaluf-Calderwood et al., 2011). The framework in Figure 7 helps to understand the processes about the movement of parties that has been made to bring digital infrastructures to the market. The framework can also be used to identify other collective movements and potential new network configurations. Learning how to manage blockages with unblocking mechanisms can make innovation process more efficient hence increasing the speed of innovation.

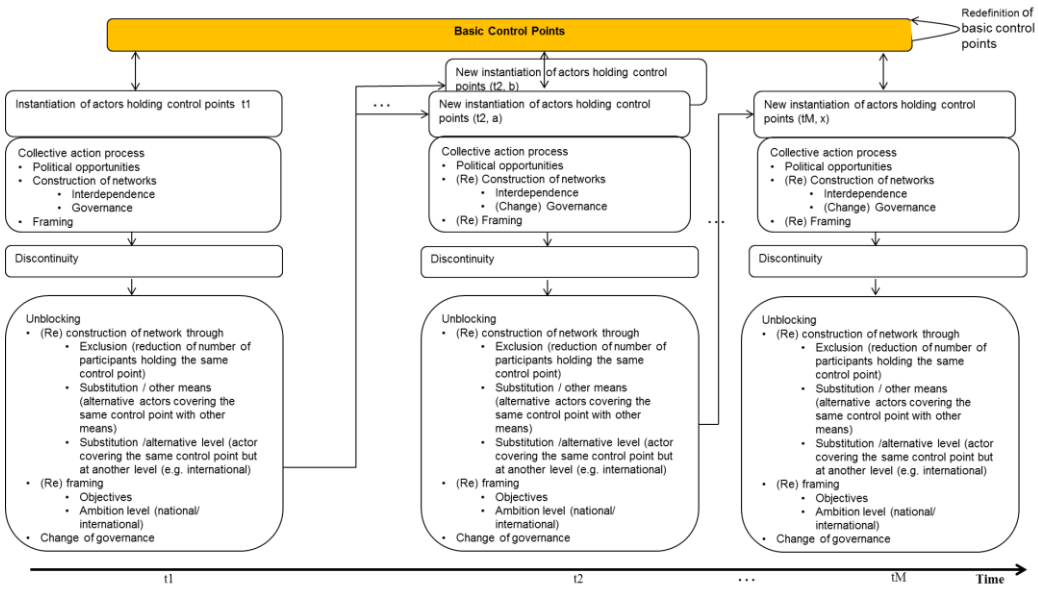


Figure 9: Framework of control point driven collective action process for digital innovation (adapted from Rukanova et al., 2017)

3.5. The Gaps

From the previous discussion, there is a primary concern to increase supply chain visibility with DTI, which serves as the interest of both public and private organisations. Public-private organisations as components of DTI innovation system contributes to the necessity of collective action to mobilise data pipeline to market or implementation phase. After the collective action initiatives have started, there is a need to know what 'happens' in the systems to understand and foster innovation process. We argued that bridging collective action model of institutional innovation theory and functions of innovation system theory can give richer insights concerning factors that shape innovation process in DTI innovation system. However, the study that bridges those knowledges is still lacking. The limitations of existing studies are described as follows:

- Digital Trade Infrastructures anatomy (Rukanova et al., 2017) only explains DTI characteristics and helps to understand complex process of DTI innovation by looking at its architectures, process, and governance components. The study does not discuss what 'happens' in such DTI initiatives and the mechanisms to mobilize DTI innovation.
- Functions of innovation system (FIS) theory by Hekkert et al. (2007) and scheme of innovation system analysis by Bergek et al. (2008) are not sufficient to explain the dynamic of organisations engagement and how the networks of actors change which influences the innovation-

development process. The studies neglect collective action process and possible blockages that halt the collective action to be included in such innovation system analysis.

- Unblocking mechanisms of DI innovation based on collective action model (Rukanova et al., 2017; Hargrave and Van de Ven, 2006) ignore the extent of how unblocking mechanisms can affect the blockages that hamper activities unfolded in innovation system, specifically in international trade domain. They also ignore the possible relation of blockages in collective action and weakening indicators of innovation system functions.

Hence, the main research gap can be formalized that there is no theoretical lens which discusses activities and events happened in DTI innovation system to a detailed breakdown of its structural or functional changes, remembering that those events contribute to bring DTI innovation to later phases and serve as an unblocking strategy for DTI innovation process.

3.6. Merge the Models: Structural-Functional Analysis (SFA) Framework

Based on the research background (see section 1.1), there is an urge to conduct innovation system analysis so that the unblocking strategy to mobilise innovation process can be identified. This motivation supports the needs to create a conceptual framework and provide it as the main deliverables of this research as it is able to explain the proposed relationships among key concepts such as innovation system and innovation process. Moreover, conceptual framework is suitable to represent an analytical order to understand DTI innovation process, including the information on what could possibly halt the innovation process and what can be done to allow the continuity of innovation process. It can help to understand correlational patterns that occur in an innovation system, which further helps stakeholders in the system to make decisions concerning innovation process on the basis of concepts' relationships.

Based on the research gap that discovered before, we develop a conceptual framework which explains the reasoning on innovation system events and characteristics which influence innovation-development process. In this section, an initial framework for analysis is constructed based on digital trade infrastructures, innovation-development process, innovation system and functions of innovation system, and also collective action model. Key concepts that collaborated and built the framework are described as follows:

- **DTI Innovation system** concept is included in this framework as an input variable. We assume that particular innovation project serves as DTI innovation system, as a project consists of both organisations and institutions that influence the development of DTI. As we are interested to discover activities in the innovation system which shapes the innovation process, DTI innovation system should be analysed with the structural and functional approach. The arrow connecting 'DTI innovation system in project setting' and both structural and functional analysis shows information flow, a logical order on how such system is being analysed with those two approaches.
- **Structural analysis** is employed mainly to discuss the structure of innovation system, which consists of organisations and institutions. Instead of seeing it as a static approach, we use unblocking mechanisms framework developed by Rukanova et al. (2017) which is based on collective action model of institutional innovation (Hargrave and Van de Ven, 2006) to conduct structural analysis on DTI innovation system, with specific attention to process perspective.

Core concepts that will become the basis for structural analysis are derived from collective action model of institutional innovation such as political opportunity, networks construction, and framing. A study from Rukanova et al. (2017) adds other concepts such as discontinuity, which explains the activities related to the discontinuity such collective action initiative within an innovation system. The arrow which connects 'collective action process' concept and 'discontinuity' represents the information flow, concerning the identification of discontinuity that may be explained after each collective action process' concept is discussed.

- **Functional analysis** is employed to discuss how innovation system performs concerning its functions. We include the functions of innovation system (FIS) approach (Hekkert et al., 2007; Bergek et al., 2008) as another field of analysis. According to Bergek et al. (2010), structural components of innovation system are related to actors, institutions, and networks, and it is difficult to evaluate the performance of innovation system only with particular structural elements and without making references to its effects on the innovation process. Therefore, we include functional analysis in this framework to enrich the analysis of innovation process that happened in such system. In this research, we will use the qualitative approach to allow richer understanding of functions within a specific project instead of quantitative by quantifying the number of events. The arrow connecting FIS concepts and function fulfillment shows the logic to describe that the functions fulfilment can be inferred after each concept is explained. Further operationalisation of each function's indicators will be discussed in chapter 4.
- **Blockages** concept is proposed as the factors which negatively affect the innovation process continuity. We argued that this concept should be able to explain the combination of 'blockages' concerning collective action process, which is defined as blocking factors that contribute to discontinuity or failure of collective action, and 'weakening indicators' concerning FIS theory, which is defined as factors that prevent functions to be fulfilled and developed. Arrows connecting each of two levels of analysis and blockages concept represent the information flow, which means that blockages may be known after the analyses have been conducted.
- **Unblocking strategy** concept is defined as the strategy to enable innovation process continuity by looking at the blockages from two levels of analyses. The executors of the strategy are the actors within the innovation system. The arrow that links blockages with unblocking strategy represents the information flow. It represents logic which explains that blockages should be identified first before arranging unblocking strategy.
- **Time dimension** concept emphasises the process perspective on DTI innovation system. It serves as the basis of innovation phase development on the framework. Additionally, it implies the idea that innovation system changes may occur as the results of unblocking strategies.

All the concepts discussed above are combined and represented within the framework as shown in Figure 8. This framework does not indicate a cause-effect relationship between concepts, but, it presents an analytical tool for a DTI innovation process. Collective action process is seen as an underlying theory for structural analysis, while FIS is used as the underlying theory for functional analysis. From the analysis with both tools, blockages can be identified as the results of the structural

and functional analysis. From the identification of blockages, researchers can infer the strategy that can be done to address the blockages. We argue that structural changes of innovation system will effectively accelerate innovation process if it does not only address the collective action issue, but also helps to reduce or remove weakening indicators of innovation system functions. Therefore, we build a conceptual framework, named *structural-functional analysis (SFA)* framework which represents an analytical tool to understand DTI innovation process.

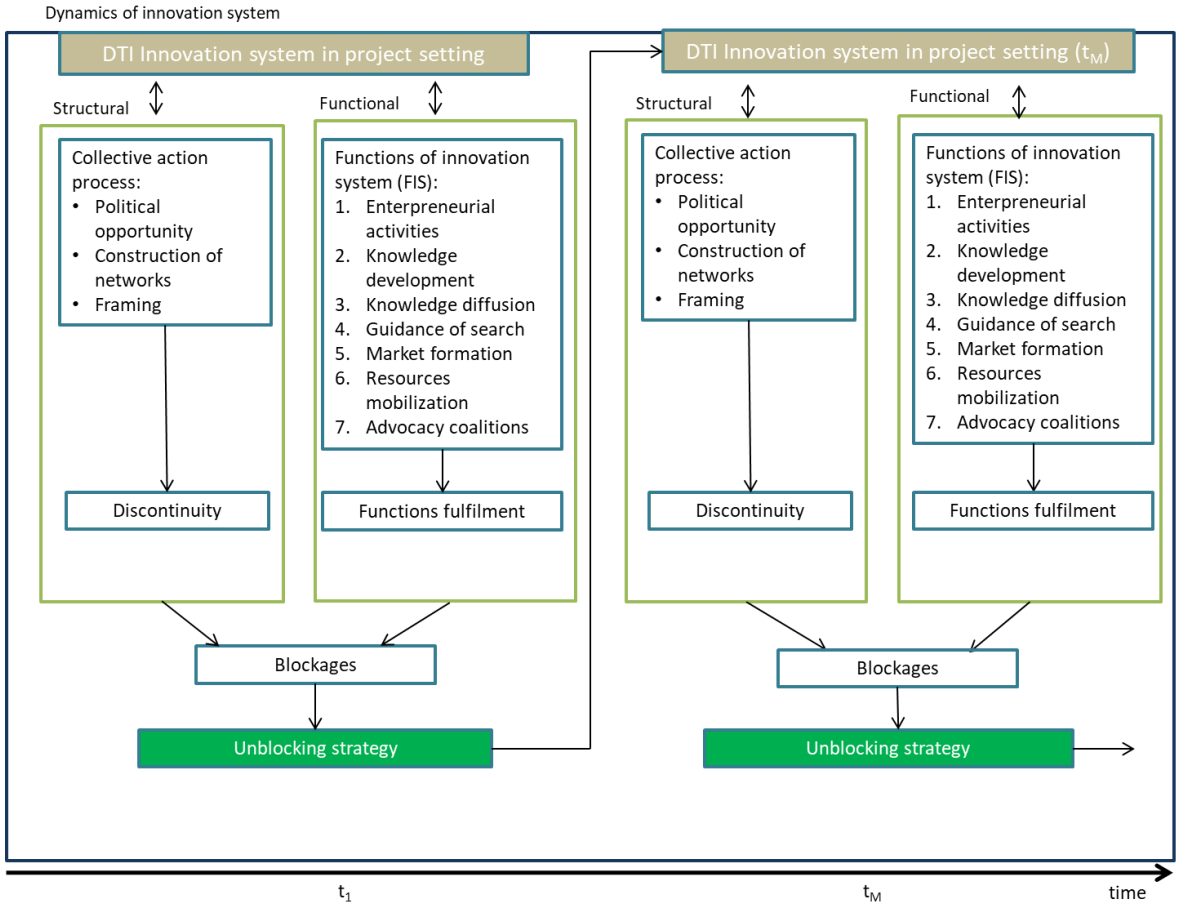


Figure 10: Initial structural-functional analysis (SFA) framework

4. CASE ANALYSIS

The application of SFA framework in empiric cases is required for an evaluation to know whether the conceptual framework is relevant to illustrates DTI innovation process in real-life context. Hence, this Chapter 4 is presented to address this purpose. As mentioned in the methodology section, this evaluation was conducted by adopting the case study strategy that consists of two stages. In this chapter, final analysis based on combined data collection methods is presented. The explanation of this section incorporates the analysis and arguments with the references to the data sources. List of data sources will be provided in the appendix section.

4.1. Case Background

The periods when ITAIDE, INTEGRITY, CASSANDRA, and CORE (EU-funded DTI innovation projects) are conducted represent DTI innovation process trajectory. Furthermore, each innovation project setting (e.g., members, activities, legislation) serves as DTI innovation system along the innovation trajectory. Here we discuss briefly regarding these EU-funded innovation projects which serve as DTI innovation system and empiric cases of DTI innovation process.

This conceptual framework is tested and applied to the case of ITAIDE, INTEGRITY, CASSANDRA, and CORE. We assume that each project serves as innovation system that relies on the specific range of time. Moreover, we also consider that continuum of separate projects regarding DTI development can be explained as DTI innovation trajectory. Reflecting on the study of Rukanova et al. (2017), analysing different innovation projects as part of follow-up specific initial innovation project is essential to understand how digital infrastructures innovations are shaped and brought to implementation. The main reason is an innovation project may not always aim to enhance the implementation of the innovation. Therefore, if innovation process only pays attention to an isolated innovation project, there is a possibility that such process may shows an innovation-development failure, as a project may possibly stop without critical mass effect in the end according to its objectives.

According to Klievink et al. (2012), data pipeline concept is based on the service-oriented architecture (SOA), piggybacking principle and data pull concept which were developed in ITAIDE. Inspired from those concepts, Shared Intermodal Container Innovation System (SICIS) was developed in INTEGRITY. Although INTEGRITY started in 2008 and at that moment the ITAIDE was still on progress, the Beer Living Lab pilot that demonstrated redesign procedures with SOA, smart seal, and open standards, has been done in 2007. Therefore, the results of Beer Living Lab became the inspiration of SICIS when INTEGRITY started in 2008. Moreover, the participation of Dutch Tax and Customs Administration (DTC) in both ITAIDE and INTEGRITY allows knowledge transfer between these projects' communities regarding the proposed innovation. In principle, SICIS allows cargo data to be captured by the system via the responsible actors' existing system. SICIS provides users management to organize data access towards the cargo data. Moreover, SICIS elaborates container security device and the system to provide real-time information about container journey. When the cargo data is captured in SICIS, customs or other parties who have access to the data can re-use the business data, and align with the piggybacking principle. However, the interface was rather simple and depended heavily on messaging feature. In

CASSANDRA, the data pipeline concept is refined. Pipeline architecture which serves as the basis of pipeline configurations in several demonstrations is generated. The architecture incorporates more IT systems such as business and port community systems, stakeholders' back-office systems, and container security device. CASSANDRA also developed the pipeline dashboards which enhance better visualization of data based on different users. In CORE, the data pipeline concept in different configurations is being piloted in large-scale demonstrations. Some concepts were developed in CORE to complement the pipeline configurations, such as coordinated border management which allows customs from two countries to validate the cargo information.

Each project is not directly linked to each other and aimed to develop the same product. However, they satisfy the criteria of constituting the same TIS as these projects develop the same knowledge field (see section 3.3) which is a digital infrastructure based on SOA. Data pipeline concept is preceded by the idea of SOA-based digital infrastructure, which includes the concept of re-using business data and data pull. The idea of applying such digital infrastructures in trade domain to improve supply chain visibility remains constant on the four projects. Moreover, the involvement of DT (a national tax and customs administration) in the four projects plays the role to enable knowledge transfer between different consortium's members regarding the supply chain visibility improvement with SOA-based digital infrastructures. Later, this concept was extended into data pipeline concept.

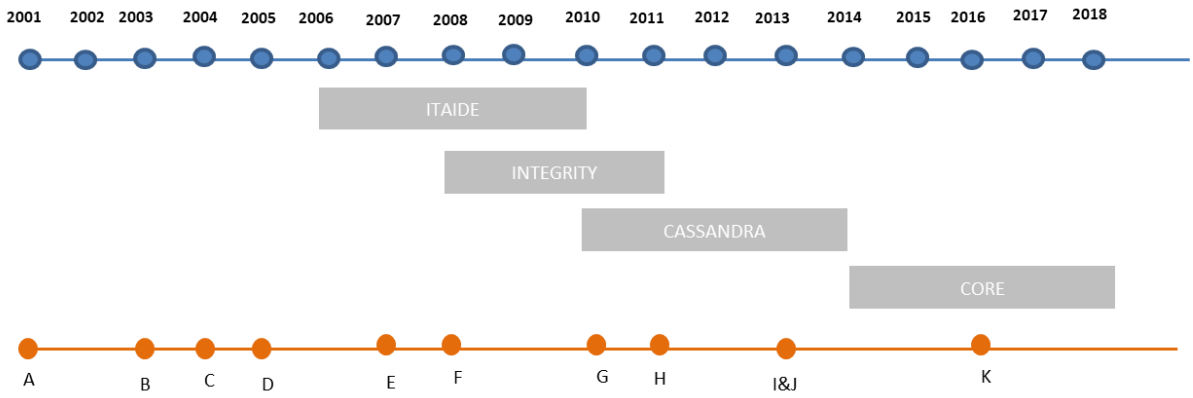


Figure 11: Timeline of the events

Table 9: List of events related to innovation projects

Code	Event
A	9/11 attack
B	MASP
C	ISPS code introduction
D	CCC amendment
E	Beer LL finished
F	MCC came into force
G	SICIS demonstration finished
H	CASSANDRA'S demonstration kicked off

I	MCC provisions deadline
J	UCC entered into force
K	Substantive provisions of UCC apply into force

4.1.1. ITAIDE

The European Commission faces challenges to solve the paradox of increasing security of international trade, while at the same time reducing the administrative burden for both private and public organisations. A proposed solution to those challenges might be the improvement of information exchange system for public and privates. ITAIDE focuses on improving information exchange quality regarding business transactions, as information gathering turned out to be very costly and time-consuming. Improvement of information control can be the key to increase the competitiveness of European businesses.

The EU-funded ITAIDE project was initiated to address these challenges. ITAIDE is the acronym of IT for Analysis and Intelligent Design of e-Government, supported by the European Commission under the theme Information Society Technologies. Mainly ITAIDE activities were coordinated in The Netherlands. The research in ITAIDE and Living Labs were carried out from 2006 to 2010. Living Labs concept was used to test and validate several IT-related innovations. It provides real-life innovation development environment where businesses, governments, and technology providers could explore a win-win scenario [IT-12]. ITAIDE developed ITAIDE Information Infrastructure (I3) framework, which explains core components that are important for trade flow acceleration. This finding was followed by the set of IT-related innovations such as tools and methodologies, which enable companies to have end-to-end control of their goods. Some of the results are common information model for electronic documents and document mapping software to improve the pan-European interoperability of taxation and customs systems. This interoperability is essential to fulfilling e-customs vision such as the introduction of Authorised Economic Operator[12] and Single Window Access. ITAIDE developed a procedure redesign methodology, supported by an intelligent software tool, to improve the simplification of cross-border procedures. To encourage the adoption of these new procedures for all stakeholders, it should be the result of a truly collaborative process. ITAIDE is a project focused on testing some fundamental concepts [YT]. Concepts such as system-based control, piggy-backing (or reuse of business information for government control purposes), and data pull from the source were considered as the key concepts in ITAIDE solutions. Furthermore, these concepts were extended into a data pipeline concept. With all the explanations above, we assume that the ITAIDE project represents DTI innovation system in the initiation phase.

4.1.2. INTEGRITY

From the logistics perspective, there is a primary challenge regarding the efficiency of intermodal door-to-door container transport system [IN-7]. Efficiency of supply chain is essential for business improvement. There is a need to have safe, secure and efficient intermodal transport system. Also funded by the European Commission, INTEGRITY will reconcile these challenges and link all elements of

[12] A party involved in the international movement of goods in whatever function that has been approved by or on behalf of a national Customs administration as complying with WCO or equivalent supply chain standards

the supply chain through accurate, reliable, timely, value-adding tracking and status data thus enhancing trade facilitation through the use of high quality, neutral, sophisticated equipment, including scanning equipment in ocean ports, whilst remaining accessible to all eligible stakeholders, large and small.

INTEGRITY stands for "Intermodal Global Door-to-Door Container Supply Chain visibility", supported by the European Commission under the "Encouraging Modal Shift and Decongesting Transport Corridors" thematic area [IN-1]. The research in INTEGRITY was carried out from 2008 to 2011 and coordinated in Germany, almost parallel with ITAIDE. The main project result is Shared Intermodal Container Information System (SICIS), which is a system to integrate data from the different source along the supply chains, offering door-to-door visibility on containers. SICIS can be considered as the initial prototype of data pipeline [YT]. Technically, SICIS allows cargo data to be captured by the system via the responsible actors' existing system. Additionally, this system could be used as a document repository for Customs to look up additional documentation on high-risk containers. When the cargo data is captured in SICIS, any stakeholders who have access to the data can re-use the business data. How SICIS works indicates the initial idea of data pipeline concept, which is a system that can enable access to existing stakeholders' information exchange system, in order to improve supply chain visibility. SICIS is validated and verified through real operational business and customs operations in door to door supply chains in the major trade corridor of China to the EU via the ports of Yantian, Rotterdam and Felixstowe, using all modes of transports within the EU to various destinations. It was also combined with the AEO concept and scanning/monitoring technology and supported the "trust but verify" approach. The project's description above indicates the efforts that are conducted to transform the idea into a demonstration. Therefore, we assume INTEGRITY represents DTI innovation system in the development phase.

4.1.3. CASSANDRA

This project unfolded from 2010 until 2014, under the European Commission Framework Program 7 (FP7) with Security theme. CASSANDRA is the acronym of "Common assessment and analysis of risk in global supply chains" [CA-1]. The challenges are still similar to problems faced during ITAIDE and INTEGRITY development, which is increasing efficiency, security, and visibility of international intermodal logistics. These issues have a common solution: the *Pipeline Interface*, a supply chain control, and transparency solution, where data can be shared between businesses, business-government, and where applicable, can be sent seamlessly between governments. This basic concept of data pipeline is developed already in thepreceding projects. Hence, the main challenge off CASSANDRA is to integrate all the solutions along the supply chain [CA-1].

CASSANDRA aims to facilitate the adoption of a risk-based approach in the supply chain, from integral monitoring data on cargo flows and container integrity. Additionally, it was intended to improve visualisation dashboards in open architecture and demonstrate the dashboards and data pipeline concept in three different living labs [CA-5, FH]. CASSANDRA also developed a range of dashboards that visualise the data according to the various users: different customs dashboards for authorities and business dashboards for commercial purposes were developed by different IT providers within the three Living Labs, thus stimulating internal competition among the developers in the consortium. The consortium also played a role to facilitate discussions between business and government on the criteria for data sharing between business and government. CASSANDRA project still represents the efforts to

bring the innovation into real implementation. Therefore, CASSANDRA serves as DTI innovation system in the development phase.

4.1.4. CORE

Funded under the same EU Framework Program with CASSANDRA, this project unfolded from 2014 to 2018. CORE is the acronym for "Consistently Optimised Resilient Secure Global Supply-Chains"[CO-1]. CORE is organised in Belgium and consists of around 71 partners. The problem that contributes to the project background is not a new issue, which is the challenge to enhance efficiency, speed, and reliability of the international trade while improving the effectiveness of supervising and safeguarding international trade. This project is supported by enormous amount of funding which supports all the activities within the project, such as ten demonstrations of data pipeline concept.

The aim is to demonstrate the developed knowledge derived from preceding EU-projects in large-scale demonstration. Implementation-driven R&D was undertaken to discover gaps and practical problems on the demonstration of data pipeline concept as part of the supply chain security (SCS) solutions [YT]. One of the successful demonstrations is the Schiphol demonstrator. This demonstration focused on the import of flowers from Kenya to The Netherlands via air. The ideas such as data pipeline, business and customs dashboards, and coordinated border management were demonstrated and had shown potential for cross-borders simplification. Some data pipeline implementations are realised by some specific actors who also play a role as the driver of the pilpt project after the demonstration has been conducted. Hence, CORE can be considered to represents DTI innovation system in the implementation phase.

4.2. Structural Analysis

4.2.1. Political Opportunity

Digital trade infrastructures innovation would have never been discovered and developed if there were no such past political opportunities that influence the initiation of innovation development. Political opportunity is a set of formal and informal political conditions that affect movement activity.

ITAIDE

In 2001, the rise of security wave was influenced by the terrorist attack of 9/11. This tragedy led to a significant shift in thinking regarding global supply chain [IT-12, YT]. Since that tragedy, security in international trade has been strengthened to counteract possible threats, such as the nuclear device in a container [IT-12]. There is a need to protect trade lanes from terrorism and fraud, while at the same time governments have interests in stimulating economic growth [YT]. Physical inspections on cross-border activities became more important to ensure protection for trade flows. However, stimulating economic growth demands reduction of administrative burden and fewer checks at the borders. There are no clear-cut answers for safety, security, and economy issues regarding international trade.

Influenced by international developments and security concerns on the EU political agenda, efforts have been made to facilitate trade using information technology (IT) innovation. Two political initiatives were

established in 2002 to enable the simplification of cross-border activities: *eEurope*[13] and *Better Regulation*[14]. These initiatives have provided grounds for eCustoms, and Communication from the commission on the paperless environment for Customs and trade[15] was published in 2003. Combined IT tools with modern risk management techniques were considered as promising enablers to address inefficiency and security concerns of global supply chains [IT-12].

The issue appears as Member States have developed their own IT systems, which has led to the diversity of Customs procedures. Member States alone are unable to bring necessary legal and IT environment required for EU eCustoms. Hence, European Commission has to bear the eCustoms developments into operation. In 2003, European Commission and the Member States agreed to draw up the *Multi-Annual Strategic Plan* (MASP) [IT-12]. MASP is created with aims of creating European electronic environment which is consistent with operational and legislative developments in the area of Customs and indirect taxations. It reflects the needs set in Modernised Customs Code and Security Amendment of present Customs Code. MASP was a significant inspiration for the *IT for Analysis and Intelligent Design of e-Government* (ITAIDE) project. Moreover, in June 2005 the WCO Council adopted the SAFE Framework of Standards to Secure and Facilitate Global Trade (SAFE Framework) that would act as a discouragement to international terrorism, secure revenue collections and promote trade facilitation worldwide.

ITAIDE can be seen in *Public-Private Partnership* (PPP) context [IT-12]. Governments in EU and across the world are exploring another Customs approach which removes the traditional relationship based on distrust between governments and businesses. Previously, governments are perceived as the source of administrative burden and often disturb the supply chain with complex border procedures. PPP approach will move away from such traditional method, as it relies on businesses-governments trust relationship and creates on governments' societal interests and companies' business interests. Delegating control from government agencies to businesses and distinction between trusted and non-trusted traders to reduce border inspections are the example of PPP approach. Governments can focus their resources to exercise control to non-trusted traders while businesses can benefit from trade electronic data exchange which provides an opportunity for their business intelligence.

The other political background for IT innovation in international trade domain is also Modernised Customs Code ("MCC") [IT-12, FH], which came into force in 2008 and is intended to facilitate legitimate trade and govern the electronic environment for customs and trade. It includes new concepts for trade facilitation such as centralised customs clearance. MCC was started with the amendment of Community Customs Code in 2005, which aimed at tightening security requirements for movements of goods across international frontiers[16]. Although the MCC is already in force, it will only become applicable once the "MCC Implementing Provisions" come into effect [GE-1]. There have to be some efforts to develop the IT system for customs procedures [GE-1].

[13] See http://ec.europe.eu/information_society/eeurope/2005/index_en.htm
[14] See http://ec.europe.eu/governance/better_regulation/index_en.htm
[15] See http://europa.eu/legislation_summaries_customs/111019a_en.htm
[16] See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM%3Al11010

Additionally, from 2002 to 2006, the European Commission established the program of Information Systems Technologies which supports the eEurope action plan. In 2005, the objective of this program was shifting into more Information and Communication Technologies (ICT)-focused research. This program provided the funding and the legitimation for ITAIDE activities to be conducted [IT-1].

INTEGRITY

The political background of INTEGRITY is not different with ITAIDE. Although the 9/11 tragedy was not the primary concern, the project was still influenced by the adoption of SAFE Framework measures and Modernized Customs Code of European Commission [IN-8]. Additionally, there were different measures that emerged such as the introduction of the ISPS code[17] in 2004 and the C-TPAT[18] program in the US which aims to enhance the security in parts of the international supply chain [IN-7, IN-8]. However, global approach to study the chain from origin to destination is still missing. Inspired by MASP and ITAIDE initiative, INTEGRITY was formed and started to refine R&D phase of DTI which were previously developed in ITAIDE [FI]. DTI was applied to a larger-scale demonstration of container shipping from China to EU. Moreover, an essential step towards secure operators, Modernized Customs Code from DG TAXUD with its AEO (Authorised Economic Operator) approach, contributes as the political opportunity for INTEGRITY to start a movement in DTI innovation system [IN-7, IN-8].

From 2007 to 2013, the European Commission arranged framework program which focused on transport development[19]. There was a vision to achieve "greener" and "smarter" European transport systems for the benefit of all citizens [IN-1]. The INTEGRITY project can be seen in the context of improving sustainable surface transport- rail, road and waterborne, by developing intermodal regional and national transport.

CASSANDRA

CASSANDRA was initiated to develop and disseminate the knowledge built in preceding projects by demonstrating the data pipeline in a broader scale [FI, YT]. Again, SAFE Framework standards adopted by WCO still played the role to provide the legal environment for trade facilitation-related innovation project, such as CASSANDRA, to emerge [CA-5]. However, there was a change in Modernised Customs Code (MCC). Regarding MCC, the EC has already indicated that the final deadline of MCC provisions dated 24 June 2013 cannot be met due to technical and practical concerns. Furthermore, about the MCC itself, the Commission is envisaging to postpone the implementation deadline, recast the MCC to align it with the Lisbon Treaty[20] and incorporate some other changes [GE-1].

The UCC entered into force on 30 October 2013, but only the Commission's empowerments took effect on that date while the other provisions of the Code became applicable from 1 May 2016 [GE-1, GE-2]. The UCC defines a legal framework for customs rules and procedures in the EU customs territory that is adapted to modern trade realities, such as the global integration of production and delivery systems, e-

[17] International Ship and Port Facility Security code
[18] Customs-Trade Partnership Against Terrorism
[19] See https://cordis.europa.eu/programme/rcn/857_en.html
[20] See http://www.lisbon-treaty.org/wcm/the-lisbon-treaty.html

commerce and advanced communication tools. UCC aims, in particular, to complete the transition of customs to a paperless, integrated and fully electronic environment. The UCC establishes common rules and data requirements for customs pre-arrival and pre-departure declarations, notifications, applications and decisions.

Reflecting from past DTI innovation projects, framework program of EC is still considered as the appropriate provision for DTI innovation project financial needs and political background. The big topic "Cooperation: Security" was raised to develop technologies to protect citizens from threats such as terrorism, natural disasters and crime while paying attention to privacy and fundamental rights protection [CA-1]. CASSANDRA objectives can be seen as the alignment of this topic, in context of improvement of infrastructures security (examining and securing infrastructures in areas such as ICT, transport, energy and services in the financial and administrative domain), also intelligent surveillance and border security (technologies, equipment, tools and methods for protecting Europe's border controls such as land and coastal borders)

CORE

CORE was started by consolidating all the knowledge developed in the preceding projects in each supply chain sector (port, container, air, and post) [CO-1]. Focusing on implementation-driven R&D, CORE enables numerous demonstration of supply chain security (SCS) innovation with different partners, to test and observe the usability of those innovations in a large-scale demonstration. As discussed before, SAFE framework still provides as ‘soft' regulation to create a legitimate environment for SCS improvement. Furthermore, when CORE started, the UCC was already entered into force, but at that moment, only the Commission's empowerments took effect on that date. The other provisions of the Code became applicable from 1 May 2016 [GE-1, GE-2]. Under the UCC, information exchange between business (shippers, freight forwarders) and customs authorities, also between customs authorities must be based completely on electronic data-processing technologies by 2020. This enforcement can be seen as a major regulation that supports trade facilitation, reduce administrative burdens on cross-border procedures and ensure that harmonised requirements for trade flow apply throughout the EU.

The EU Framework program "Cooperation: Security" is still played as the important part in providing political background for CORE [CO-1]. Similar with CASSANDRA, CORE objectives can be seen as the alignment of this topic, in context of improvement of infrastructures security (examining and securing infrastructures in areas such as ICT, transport, energy and services in the financial and administrative domain), also intelligent surveillance and border security (technologies, equipment, tools and methods for protecting Europe's border controls such as land and coastal borders) [CO-1].

Additionally, a technological shift can be considered as the factor that can influence political movement. The rising of blockchain can be interpreted as a major technological shift that not only brings benefits to an economic domain, but also to politic, humanitarian, and scientific domain. In addition to its benefits, the coordination, record keeping, and transactions using blockchain are fundamental for forwarding progress in society. The blockchain can serve as public records repository for all documents, events, and assets. Along with the blockchain emergence, CORE developed one of their DTI by incorporating event

ledger, which can be perceived as blockchain technology application, to retrieve shipment events data and linking it to the KPI model of data pipeline demonstration[21] [CO-1, CO-8].

4.2.2. Construction of Networks

Construction of networks refers to resources mobilisation for starting up collective action in an institutional innovation process. To ensure top-level political support for innovation development network of actors plays the critical role in the innovation system. We use the notion level of actors[22] to explain multi-level actors that are involved in these projects. The levels of analysis are:

1. Level 1: The level where only several organisations from a particular category participate in a specific innovation project
2. Level 2: The level of all supply chain actors who are not participating in each project

We discovered that there is a dynamic mobilisation of a very complex network. The stakeholders are heterogeneous, and each of them possesses high power on DTI innovation system. Coalitions of partners occur to ensure that common goals (increasing supply chain visibility) are achieved, although initially, each actor share different interests and motivation. Given the scope of trade, corporate actors also engage in national and international associations, and interest groups. They do not only aim to build consensus among themselves, but also to ensure that their interests are taken care of in the political sphere. Concerning privacy issue, we anonymised the name of actors/organisations and included them in this discussion by referring to the abbreviation. The evolution of networks is attached in the appendix section.

ITAIDE

The ITAIDE consortium was initiated by an actor from a university that has interests in DTI development. Initially, he built networks of actors who participate in ITAIDE from his existing networks [IT-2]. He engaged a key person from a national tax administration (DT) who holds the important role to link the project with traders and EU-level legislators [IT-2, YT]. However, a conflict was rising along with the stakeholders' engagement [IT-2, FH]. Some actors found overlapped objectives of the DTI development project and their agendas when they were involved actively in mutual agreement. Specifically, one business actor was not sure if ITAIDE will be successfully conducted and produce a desirable outcome to address business interests [FI]. To solve this network management issue, knowledge brokers and boundary spanners arranged brainstorming and sense-making sessions, which resulted in 22 partners from different institutions, including business actor, agreeing to participate [IT-2].

In ITAIDE, knowledge brokers who also play the role of boundary spanners have an essential role in initiating and stabilising the network [IT-2, FI]. They are the key people that were very dedicated to ITAIDE, as representatives of the university, national tax administration, and IT Auditor of the national tax administration [IT-2, FI, YT]. Knowledge brokers contribute to create tacit understanding among society and increase awareness of other areas. However, knowledge brokers have to possess sufficient knowledge of working practices and culture to become trusted parties by complex constellations of

[21] Refer to CORE internal project deliverables
[22] Refer to a paper by Rukanova et al., 2007

multi-level actors and also to acquire legitimacy from them. In addition to knowledge brokers, operational manager emerged to keep the network together. These social capitals were critical to build consensus and motivate heterogeneous actors to commit to the innovation process.

In this consortium, representatives of international standardisation bodies, technology providers, Tax and Customs Administrations in the several Member States, user organisations, and research organisations have been included to facilitate innovation and diffusion. The overall project governance has been created to facilitate cooperation across the participating organisations with diverse goals and positions. In addition, representatives from WCO ad DG TAXUD were involved as the advisory board to provide feedback on ongoing innovation development [IT-12]. There are 22 participants of ITAIDE. As this project aimed to tests the concept like piggy-backing principle[23] which require shippers' involvement, networks of shippers here became essential [IT-12, YT]. The ITAIDE consortium consists of three government agencies (DT, DN, FN), four shippers (AR, HE, PC, UP), a bank (NB), a shipping line (SA), branch organisations (CL, PB), standardisation bodies (UE), five IT companies (IB, SP, RM, AV, WE) and five universities (VA, CB, UM, UD, UMA). Here we anonymised the detailed information of these institutions as the matter of confidentiality.

INTEGRITY

ITAIDE, INTEGRITY, CASSANDRA, and CORE are not continuous EU-funded projects. These projects can be seen as different collective action initiatives within DTI innovation system [FH]. They are the series of collective action efforts that bring DTI solutions to implementation. To understand innovation process, it is important to look at different collective action initiatives that contribute to the innovation development from one phase to later phases. By looking at the more extensive scale, failure or discontinuity of a single project will not directly be assumed as the failure. Instead, that can be the key to identify mechanisms to bring innovation to implementation.

INTEGRITY was started with the intention to improve supply chain visibility by paying attention to logistics perspectives [FH]. They aimed to create supply chain visibility (SCV) as a basis for securing intermodal container chains on the door-to-door basis, to minimise logistics costs for the chains [IN-1, IN-8]. The project's leader was a branch organisation who has interests on logistics-related research (IL) and based in Bremen, Germany [IN-8, YT]. Although the main interest of this project is the improvement of intermodal chains, knowledge developed in ITAIDE contributed as one of the inspiration for INTEGRITY [FH]. The reason might be because DT brought the vision developed by ITAIDE into 'other' network, as they were the key player in both ITAIDE and INTEGRITY [YT, FH].

Additionally, DT was very innovative, and they have a strong connection to numerous associations which consist of traders, freight forwarders, and DG TAXUD [YT]. Therefore, the INTEGRITY community was formed, helped by DT's existing networks. The vision was similar to ITAIDE, but INTEGRITY emphasised the intermodal door-to-door chains efficiency problem. The 'other' network here referred to actors that were directly involved in door-to-door logistics activities, such as freight forwarders, port operators, and terminal operators. Additionally, the networks were enlarged as there was a need to pay attention to

[23] Re-use of business transaction data

worldwide logistics chain. This network enlargement was implied by the participation of a port authority (YI) in this project to enable the pilot of SICIS[24] within trade lanes from China to Europe.

The governance model of INTEGRITY is a consortium, which is the same with ITAIDE networks governance. INTEGRITY consists of 17 participants, three freight forwarders, four terminal operators, two port authorities, two branch organizations, two shippers, an IT company, two government agencies, and a university. Actors comprising this consortium are all different from ITAIDE, except DT who also involve in both ITAIDE and INTEGRITY.

CASSANDRA

The urge to tests data pipeline in broader scale and diffuse the outcome was rising. Therefore, CASSANDRA was initiated to accommodate this urgency [FH]. The objective of this project is to integrate data pipeline introduced in INTEGRITY, along with the whole chain [CA-1]. To realise the objective, the involvement of the right stakeholders is necessary. Based on experience developed in INTEGRITY, terminal operators were not the right stakeholders to assist data pipeline development as they have insufficient links to actual buyers and sellers on the whole supply chain [FH]. Therefore, the community that was built in INTEGRITY and ITAIDE were merged and formed a joint force which participated in CASSANDRA and CORE, to enable knowledge exchange between the two projects participants and enlarge the networks [YT].

In comparison with INTEGRITY which focused on terminal operators' usability and ITAIDE which focused on initial concept development with shippers, the CASSANDRA project focused on developing the usability of data pipeline by freight forwarders [FH, YT] and intermediary parties such as port community system providers [FI]. It became essential to involve freight forwarders as they can provide better information and link to other actors in the whole supply chain [FH]. As the result of ITAIDE and INTEGRITY dissemination, the IT-enabled trade facilitation innovation received more attention [FH]. Numerous IT & data platform companies are joining such as Atos Spain and Descartes. Although no new actor categories are joining CASSANDRA, the number of participants was increasing. Four different freight forwarders, a standardisation body, eight IT companies, two universities, a terminal operator, a port authority, four government agencies, and five branch organizations joined CASSANDRA's consortium.

CORE

CORE was initiated to prove that data pipeline concept that has been developed in the preceding projects in a large-scale demonstration [YT]. To develop and conduct the large-scale demonstration, the role of shippers became more important than other actors, as they can provide more transaction data that are valuable for data pipeline development [FH].

Moreover, they are the potential actors who benefit data pipeline and become potential users as they may make their data accessible for cross-border procedures [FI]. Therefore, engaging more shippers was

[24] Shared Intermodal Container Information System

considered as one of a strategic way to mobilise data pipeline to adoption. However, it was not a smooth process to bring shippers onboard. It was difficult to engage individual companies for participating in CORE. Thus, the European Shippers Council (ESC) became the project leader, to influence shippers' participation in this project [FH].

CASSANDRA's massive dissemination contributed to increasing number of CORE participants. The networks are enlarged, involving legislative government as well as ranging IT & data platform companies such as SMT and SUN [CO-1, CO-6]. Most of them are the demonstrators for CORE pilot projects. On the other hand, some actors from CASSANDRA such as IB, MK, DT, HM, and BAP, remained in the CORE project and brought the vision developed in CASSANDRA to broader networks. The existing actors from preceding projects mobilised the knowledge about data pipeline from CASSANDRA to CORE, towards a bigger network of actors with the intention to raise awareness of data pipeline benefits and increase the possibility for more adoption. There are 71 participants of CORE. The consortium consist of seven freight forwarders, five shippers, 20 IT companies, three terminal operators, a shipping line, four universities, eight government agencies, 20 branch organizations, and three legislative governments. The differences in governance of these four projects are very limited as they are government-funded projects, and it is common for such project to be governed in the form of consortium[25].

4.2.3. Framing

Based on Hargrave and Van de Ven, framing is related to creation and manipulation of the meaning of issues. Now, we will discuss what the frames that shaped the perception of actors toward their involvement in DTI innovation system as project settings are. We focus our analysis regarding the framing of all projects related to the fundamental basis for actors' involvement in this innovation system.

ITAIDE

World Customs Organization (WCO) and EU's Customs Unions play the major role on problem background framing which served as a fundamental basis for actors' involvement in ITAIDE [IT-12]. As supra-national governance bodies, they both put the strong emphasis on simplifying Customs procedures. WCO released SAFE framework in 2005, in which the framework recognises the importance of international trade for economic prosperity and prevention of terrorist attacks that can harm the entire global economy. The framework was based on the establishment of co-operative arrangements between Customs and other government agencies in international trade, to enable the seamless transfer of trade data and ensure coordinated border management. Moreover, the framework also encourages Customs to Customs network arrangements to detect high-risk shipments. However, the SAFE framework can be seen only as a soft-law approach; it is not a binding legal instrument. To increase its legal power, the principle of the framework needs to be translated into specific national legislation [IT-12].

On the other hand, the problem is not the only issue that can be framed in the context of institutional innovation. The other example is the framing on outcomes of the proposed solutions. The solutions that

[25] Combination of entities which pooling their resources to achieve common objectives

will be offered by the end of the project are some concepts such as piggy-backing principle[26] and data pull vs data push[27] which offer ranging benefits [IT-7, IT-12, YT]. First, it provides the integrated mechanism for businesses to communicate with their other business partners, and also to report their transaction to authorities, rather than submitting the administrative documents to separate legislations [IT-7]. Second, the application of secured container lock allows better security control on goods movement. More into technical solutions, Service Oriented Architecture was proposed as the information exchange facilitation among supply chain partners and government. It is an IT innovation used as architecture to distribute business data about transactions stored in each supply chain partners' database. The other level of framing is the way to reach the outcome. To achieve the proposed solutions, the concepts should be tested in Living Labs[28] on EU level which covers four different domains: beer, paper, food, and drug [IT-12]. These Living Labs were conducted to validate the proposed solutions.

INTEGRITY

Reflecting from the ITAIDE application for this concept, we argue that problem framing was influenced by political background and project initiators/participants. The problem framing in INTEGRITY was not really deviated from the problem that was framed during ITAIDE project. As SAFE framework and MCC provide political background for INTEGRITY, security and inefficiency of supply chain issues were still perceived as problem background for INTEGRITY [IN-7, IN-8]. Also, there was additional problem framing that arise from the perspective of actors which are directly involved in logistics chain and ITAIDE participants. The proposed solutions from ITAIDE were only tested in limited stakeholders networks [FH]. As the results, the benefits were only perceived by a small number of stakeholders. There was a need to test it on global approach with a focus on logistics perspective, involving terminal operators and port authorities [IN-8, IN-9, FH]. It was expected that the awareness of broader supply chain stakeholders toward data pipeline could be increased so that the implementation phase can be reached sooner.

The main proposed solution is SICIS (Shared Intermodal Container Information Systems) which can be seen as initial data pipeline prototype [IN-1, IN-7, IN-8, FH, YT]. It contains the container data or links to the data providers such as port community systems, shipping lines, or port authorities, allowing fast and reliable data exchange. To achieve the desired outcome, SICIS had to be tested within the international level, combining some port authorities as key partners, which in this case Port of Yantian (China), Port of Felixstowe (UK), and Port of Rotterdam (NL) [IN-8]. This method was framed as it was strongly influenced by the framed problem and the fact that the EU-China lane is one of the busiest trade corridors [IN-8].

[26] Re-use business data for governmental purposes
[27] Pulling data from business organisations
[28] Collaborative platforms for development and real-life testing of innovation

CASSANDRA

Since 2005, the SAFE framework had been influencing the problem background of DTI innovation project [IT-12]. Such legislation was supported by Union Customs Code (UCC), which suggests that information exchange between business and customs authorities, also between customs must be based entirely on electronic data-processing technologies by 2020 [GE-1]. DTI became more important to enhance supply chain visibility and security as UCC was brought into force. Moreover, adoption issue and lack of clear benefits were perceived as problems by some participants who were involved in ITAIDE and INTEGRITY. The development of SICIS was limited as terminal operators do not have access to large transactions data [FH, YT]. The discovered benefits were limited and SICIS development still provides room for improvement. The blockages discovered in the preceding project contribute to new problem framing for the further project, as long as there is continuity of networks which can bring the knowledge developed in past project to later project.

The expected outcome of CASSANDRA is an integrated data pipeline along the chain and introduction of trusted trade lanes concept[29] [CA-1, CA-5]. To achieve the outcome, there has to be certain framed methodologies that were used by the partners. In CASSANDRA, the methods to reach the outcome focused on strong dissemination, technology development such as visualisation dashboards development, standardisation and trusted trade lanes concept, and also the demonstration on an international level (EU-US, EU-Africa) [CA-5, FH, YT]. The networks of actors combined in CASSANDRA contribute to complete dissemination coverage of all conferences related to customs innovation in Europe [FH, YT]. As a result, data pipeline ideas were included in WCO journal, which increased the attractiveness of data pipeline concept to other international supply chain actors.

CORE

Insufficient data pipeline implementation is the main problem framing for CORE [CO-8]. Although UCC as the underlying policy for DTI innovation development in the EU gives the political background for eCustoms innovation, data pipeline adoption has not reached ‘mass market' yet. Moreover, the efforts to develop data pipeline had been delivered since eight years ago. These two aspects lead to questions regarding data pipeline implementation. Some problems which caused the delay on data pipeline turning point are unclear benefits for some actors' business models and doubt on data pipeline capabilities when dealing with a large amount of data. Reflecting on the CASSANDRA project, freight forwarders have commercial interests which make them reluctant on applying the data pipeline idea in their business case [FH, YT]. They have competitive behaviour that makes it difficult to engage them to join CASSANDRA. Therefore there was still a problem on proving clear benefits of data pipeline to all actors' business models. Moreover, there was another discovered issue from the CASSANDRA project about data sources. To increase the likelihood of mass implementation by numerous supply chain actors, there was a need to test data pipeline with a large amount of data, to test the capability of data pipeline and ensure that it can be implemented worldwide. Activities in the CORE project were inspired by all the expertise developed in ITAIDE, INTEGRITY and CASSANDRA.

[29] Chain based supervision model, for instance validating data accuracy by multiple-eyes auditing principle of comparing the same data elements from different sources along the chain

The proposed solution of CORE is a ready-to-implement thick[30] or thin[31] data pipeline concept on international supply chain and further operationalisation of trusted trade lanes concept [CO-2, CO-8]. In Trusted Trade Lanes, it is not only important that a single company is in control, but it is also necessary to establish how the whole chain is in control. This concept can help to enhance the supply chain security and resilience as expected. To achieve this solution, data pipeline should be demonstrated in a large-scale demonstration for two purposes. The first purpose is to test the technology that has been developed in the preceding projects, whether it is ready or not for mass implementation, by incorporating several pilot projects and large-scale demonstration, allowing it to reap richer data sources from each demonstration [YT]. The second purpose is to increase the likelihood of potential users to adopt data pipeline idea for their business models, by providing the controlled environment in pilot projects to enable data pipeline trialability [YT].

4.2.4. Discontinuity

For all four projects, all the discontinuities are based on the agreement on the project proposal. All of them were agreed upfront that each project would be ended on a particular year [IT-1, IN-1, CA-1, CO-1, FH]. There were no sudden tragedies which halted the project within its agreed project duration. Nevertheless, some bottlenecks were rising within each project and disturbed the continuity of DTI innovation development.

ITAIDE

In ITAIDE, Living Labs solution could not be fully implemented although there were some interests for the adoption shown by several participants. At that time, the European Commission has initiated the development of a new information system solution the so-called Excise Movement and Control System[32] (EMCS). The system will need to be implemented by 27 member states and all businesses that were actively trading in excise goods in the EU. The outcome proposed by Living Labs could not comply with EMCS system. Therefore, different regulation was the major reason why the solution developed in ITAIDE could not be implemented [IT-6, IT-12, YT]. In the context of network, the consortium was lacking the role of many actors such as freight forwarders and port authorities. This project was ended in June 2010 [IT-1, IT-12].

INTEGRITY

This project was ended in October 2011 [IN-1]. Overall feedback on SICIS system was slightly positive. However, not all parties along the chain had the same interests when it comes to implementation [IN-7]. Moreover, there was the issue regarding data sources during the pilot of SICIS. SICIS relied on terminal data, container security device integrity data, vessel tracking data, and cargo data. To develop data pipeline, rich consignment cargo data should be fed into the system. However, the role of terminal operators was limited to extract right consignment information. Instead, freight forwarders or port

[30] Thick flow enables the actual information to be shared via the architecture

[31] Information shared via thin flow is limited to metadata and pointers to the information businesses intend to share

[32] For the same commercial transaction, businesses have to introduce several different systems to report to the separate authorities

community systems should take the lead of data pipeline pilot as they are in control of combined supply chain dataset [IN-7, FH]. Stated in the final report [IN-7], this issue was being addressed in CASSANDRA.

CASSANDRA

This project was ended in August 2014 [CA-1]. The project has provided tangible outcome such as data pipeline further specification, dashboards, and trusted trade lanes based on chain control models. However, to implement data pipeline requires implementing the right support policies and political background to keep stakeholders engaged in the realisation of data pipeline integration [CA-5]. Additionally, the role of shippers and ocean carriers in this project was somewhat limited [CA-5]. Shippers are usually the owners of the supply chain and the goods, and it was their decision to include particular trade lanes in the CASSANDRA demonstration. As a result, some trade lanes faced bottlenecks to reuse business data as the shippers were excluded from CASSANDRA consortium. Moreover, some actors were reluctant to share data, with commercial interests as the main reason. For instance, freight forwarders might have aimed to internalise data pipeline concept as part of their business model, to be able to supervise and control the chains [CA-5]. Stated in the final report [CA-5], some issues discovered at the end of CASSANDRA such as stakeholders' engagement will be addressed in CORE. The act of handling past project's issue serves as proof of DTI innovation development continuity.

CORE

CORE was scheduled to end in April 2018 [CO-1]. The project was ended with a final event which provides a meeting platform for all supply chain stakeholders to discuss the outcome of CORE [CO-1, CO-9]. There were a lot of positive responses of data pipeline concept from numerous stakeholders such as customs and shippers. However, full data pipeline implementation still becomes an issue although some companies (e.g., FL, IB, MK) have shown their concrete movement towards the implementation of data pipeline concept for their business models. It was discovered that data pipeline implementation is heavily influenced by business interests or private investments [CO-9]. Moreover, there are 71 participants in CORE. These stakeholders might possess diverging interests, and that can be the reason for the difficulty to convince the stakeholders regarding the further investments and implementation.

4.3. Functional Analysis

4.3.1. Entrepreneurial Activities

For this discussion, we expect entrepreneurial activities to be the decisions of industries to adopt data pipeline and integrate it into their business model, and risk takers that perform the innovative commercial experiments and exploiting business opportunities for a certain innovation. Table 10 describes the functions performance classification based on qualitative approach. We classified the function's performance according to its definition (see section 3.3.1).

Table 10: Entrepreneurial activities performance classification

Entrepreneurial Activities	minor	• stakeholders engagement on innovation development is limited • no complementing technologies (very limited)

	medium	• stakeholders engagement on innovation development is enlarged (more engagement from stakeholders with non-technical role) • some complementing technologies appear
	predominant	• many stakeholders with different role involve in innovation development (higher engagement from all stakeholders from technical and non-technical role from all over the world) • there are more complementing technologies

ITAIDE

The existence of entrepreneurs in the innovation system is of prime importance. ITAIDE was initiated by a University Professor in a National University. Having interests on cross-border trade and seeing opportunity for EU-funded research in that area, he keened on turning his idea into realisation. Realising that academic expertise is pre-requisite for credible proposal, he constructed academic partnerships with actors that he had already developed the relationship for a long time such as the key person from National Tax Administration (NTA). The proposal was about analysis related to cross-border trade and innovative solutions development within a living labs setting, composed of businesses, governmental agencies, universities and technology providers [IT-2].

From this storyline, we observe the key person from National University as the key role of an entrepreneur, who turned the potential of new knowledge and networks into concrete actions to generate and take advantage of business opportunities. Without him, innovation would not take place and ITAIDE as an innovation system would not exist. Additionally, NTA and technology provider showed their interests by actively joining the initial R&D phase of DTI. Technology providers showed their expertise in supply chain optimisation and tried to illustrate how they might use the secure container seal technology to help companies optimise its supply chain processes. NTA, on the other hand put very strong emphasis on issues like public-private partnership, AEO, and Single Window. Moreover, there were four pilot projects which involve shippers directly to test and experience value propositions of the DTI concept [IT-12]. These type of activities that were conducted by each actors regarding their involvement in ITAIDE can be mapped as entrepreneurial activities that are essential for well-performing innovation system.

At the end of ITAIDE, a beer company had shown their interests to adopt DTI concept developed during ITAIDE living labs. Due to legislation compliance issue, the implementation was not realised [IT-7, FH]. Although there were some entrepreneurs such as people from National University, NTA, and a beer company who had shown positive responses, innovation implementation was not realised as current EU legislation at that time was conflicting with the ITAIDE findings. Despite the fact that the implementation was blocked by regulation, this function is classified as medium level as stakeholder engagement toward the innovation project is not only limited to technology developers.

INTEGRITY

As there was strong growth in container transport and new security regulations (ISPS code), the urge to tackle intermodal container transport inefficiency and security issue with IT innovation was increasing [IN-7, IN-8]. Inspired by the ITAIDE project, the intention to test DTI in wider range of stakeholders

appeared and provided the basis of INTEGRITY entrepreneurship activities. The key person in DT holds the important role to bring the vision and knowledge developed in ITAIDE to INTEGRITY as they were involved in both projects [IT-12, IN-8, YT]. There was realisation during ITAIDE development that terminal operators should be involved in DTI concept testing, to prove that the value propositions of ITAIDE findings can be applied to wider stakeholders [FH]. INTEGRITY started with IL as the coordinator [IN-2, IN-7, IN-8]. Other partners are experts from different sectors, such as: customs authorities, port authorities, terminal operators, cargo owners, freight forwarders, university, as well as technology provider.

Discussion about exploitation opportunity between PCS in China and Europe via SICIS as data pipeline has started since April 2011 [IN-7]. This event implies one of the possible entrepreneurship activities functioning of INTEGRITY. There was a realisation on innovation implementation, but it was not taken into a wider scale, as current legislation did not comply with SICIS and terminal operators provided too few links to other supply chain actors [FH]. However, there were massive disseminations on INTEGRITY results. SICIS was presented in numerous scientific conferences worldwide such as Switzerland, Turkey, and the United States of America [IN-8, FH]. IL has access to the European Conference on ICT for Transport Logistics (ECITL) and other logistics-related conferences [FH]. These disseminations contributed heavily to attract worldwide attention to SICIS and data pipeline development projects. Moreover, there was the emergence of complementing technologies such as RFID, EDI, e-seals, radiation portals, and X-ray inspection [IN-8]. From these explanations, we argue that entrepreneurial activities function is getting stronger and remains a medium-level function in INTEGRITY, as the number of stakeholders involvement is not significantly increasing.

CASSANDRA

When CASSANDRA started, there were more interests shown by supply chain actors to participate in this project as the result of INTEGRITY dissemination [FH]. Again, DT played the role to link two different communities built in ITAIDE and INTEGRITY projects to collaborate together in CASSANDRA, with other supply chain actors such as port community systems providers and branch organizations. Additional stakeholder categories participating in the follow up project indicates the better entrepreneurial activities functioning. The more stakeholders' involvement with different role on DTI innovation development, the stronger entrepreneurial activities would be.

The merged communities shared the vision to develop data pipeline specification and customs dashboards, demonstrate it in living lab setting, and introduce chain based supervision as the basis for data pipeline concept [CA-5]. To enable large scale deployment, DTI innovation should be developed in technology, stakeholder engagement, knowledge agenda, and support policies [CA-5]. Although it seems that data pipeline still has to be improved in follow up project, the CASSANDRA dissemination successfully raised supply chain actors' awareness regarding the value of data pipeline as part of its outcome. The ideas were included in World Customs Organizations Journal and presented in numerous scientific conferences worldwide [CA-1, FH]. These disseminations supported the evolution of entrepreneurial activities function within DTI innovation development. Moreover, dashboards development to increase the usability of data pipeline concept [FH] also shows the emergence of

complementing technologies. Based on these reasons, we argue that the entrepreneurial activities function in CASSANDRA is getting stronger, indicated by the increasing number of stakeholders with different role who are involved in CASSANDRA (e.g., PCS providers, branch organizations).

CORE

This project was started to address the limitations discovered in CASSANDRA. One of the limitations is the role of shippers to assist with data sourcing issue [CA-5, FI, FH]. Involving a branch organization (ESC) who is very influential to engage shippers as the project lead was a successful way to attract other individual companies to participate in CORE. This is thanks to massive CASSANDRA's disseminations which contributed to the participation of 71 stakeholders with different roles [FH]. CORE mobilises active engagement and involvement of ranging supranational governmental bodies. Moreover, at the end of the project, some data pipeline concepts were taken into implementation by several companies. For instance, SE (freight forwarder) developed their pipeline configurations for their business model and is now working with a custom authority to realise the trusted trade lanes concept after the demonstration is completed [CO-9]. From this fact, we argue that the entrepreneurship activities function in CORE is the predominant function, comparing to its preceding projects as the implementation of the innovation is getting more concrete and actors with different role supporting the DTI development towards implementation. Nevertheless, the growing number of participants with different roles from one project to follow up projects also indicates the evolution of function towards more 'active' entrepreneurship activities. In context of complementing technologies, the blockchain technology in GTD [CO-9] can be mentioned as one of the example technology that supports data pipeline development besides visibility dashboards and containers smart seal.

4.3.2. Knowledge Development

This function incorporates 'learning by searching' and 'learning by doing'. Knowledge development not only includes the development of technological knowledge, but also covers other important aspects such as investments in R&D and other actors' contribution in knowledge transfer context. The table below shows the performance classification for knowledge development function.

Table 11: Knowledge development performance classification

Knowledge Development	minor	• there are limited groups of 'researchers' in R&D projects (regional level) • R&D budget is sufficient • there is little number of regional-scale pilot project
	medium	• multi-actors involved in R&D projects (national level) • R&D budget is sufficient and increasing • some pilot projects are done in national level
	predominant	• multi-actors involved in R&D projects (international level) • R&D budget is sufficient, increasing , and sourced from many actors • several pilot projects are done in international-scale

ITAIDE

Regarding R&D projects, the Living Labs concept is used as an innovation environment to develop and test DTI in real-life setting. The idea of Living Labs is presented as framework for studying and acting in living settings such as organisations, work spaces, and public environment. Here, users play a role as co-innovators [IT-3, IT-5, IT-12]. Inviting parties to engage in Living Labs will allow joint collaboration to create the desired outcome. ITAIDE Living Labs focused on four industries, namely pulp and paper, food (dairy products), excise[34] goods (beer), and pharmaceutical products (drugs). Given this type of R&D projects, innovation developments are put into living settings in order to create environment where the effects of designed solutions can be analysed, requirements can be solicited, and institutional supports can be mobilised.

Living Labs in ITAIDE developed the technology and tested key concepts such as the use of smart container seals, the reuse of business information for Customs purposes, pull data from the source via a service-oriented architecture and how system-based approach can be used when such information infrastructures are in place and a company can show that it is In-control of their operations. IB (with their Container Security Device called TREC), SA, DT, and HE developed initial ideas of how to use innovative IT and procedure redesign to address the public or private challenges for increased safety and security and trade facilitation [IT-12]. During this era, there was an intensive funding from the EU for this R&D project. Approximately, the European Union has invested 5 million euro for all requirements related to ITAIDE activities[35], and the rest of the project funds are covered by private parties [IT-1]. These explanations indicate that knowledge development function in ITAIDE is a predominant function as there were multi-actors involved in the living labs project who came from different countries, R&D funding from government and privates, and also several international-scale pilot projects.

INTEGRITY

R&D projects in INTEGRITY focused on developing SICIS. SICIS or Shared Intermodal Container Information System is a full-scale integration of IT systems along the chain, which enables the creation of shared container information system containing either the data itself or links to the data providers (shipping lines, port authorities) [IN-3, IN-8]. As part of system engineering, SICIS development started with user requirement analysis, to translate users' needs into functional requirements for the way SICIS need to function. The basic SICIS was firstly 'live' in September 2009 [IN-7]. Furthermore, it was tested in demonstration along the EU-China trade lanes which consists of container transportation between China mainland to a deep sea container terminal before it is then transported to a vessel and port of discharge in Europe. Demonstration has shown that SICIS provides value propositions to improve supply chain management and its visibility by integrating all actors in chain via SICIS' open platform. SICIS can be considered as initial prototype of data pipeline concept [YT].

[34] Tax levied on certain goods and commodities produced or sold within a country and on licenses granted for certain activities

[35] See https://cordis.europa.eu/project/rcn/79327_en.html

As this project is conducted under the EU framework program, public funding still holds important role on the whole R&D-related procurement [IN-1]. Private funding is also increasing into 40% of the total project budget (see Appendix H). With extensive technology development, international level demonstration, and increasing R&D funding, we argue that knowledge development function in INTEGRITY as DTI innovation system is getting stronger compared to ITAIDE, especially if we reflect on R&D funding.

CASSANDRA

In R&D context, CASSANDRA focused on three aspects which are technology building, data standardisation, and stakeholder analysis [FH]. CASSANDRA did not produce any new technology development. Instead, the data pipeline idea developed in INTEGRITY was re-configured in CASSANDRA. As part of technology building, CASSANDRA realised pipeline architecture within different living labs, and developed several data pipeline configurations based on the integration with different IT systems. These configurations were tested in global trade lanes: China-Europe, Europe-USA and Europe-Africa. CASSANDRA also developed range of dashboards that visualize data according to different stakeholders such as custom and business dashboards. In CASSANDRA, chain based supervision was introduced as the concept where actors in chain can supervise data and ensure its accuracy next to dual filing procedures which was intended to provide accurate data to ENS[36] protocol [CA-5]. Additionally CASSANDRA developed certain standardisation which dictates how stakeholders communicate with each other by means of the pipeline [CA-3, FH]. Stakeholder analysis as part of CASSANDRA R&D activities discuss how supply chain actors respond to data pipeline implementation. Comparing to its preceding projects, CASSANDRA R&D was rather non-technical. Instead, it focused on improving usability of data pipeline for customs officer and integrating the pipeline along supply chain in general [CA-1,YT].

Regarding R&D funding, total project budget reached around 15 million euro, partial business and government contribution [CA-1]. This amount is larger than ITAIDE and INTEGRITY project budget. Although there were lack of novel DTI innovation, increasing actors involvement and R&D budget contribute to stronger knowledge development functioning.

CORE

In CORE, the data pipeline concept was tested in a large scale demonstration and integrating it with the demonstrators' current business models. It consists of 23 work packages and 10 demonstrations with shippers and port authorities [CO-1]. Implementation-driven R&D were undertaken to develop capabilities and solutions developed in reference projects (ITAIDE, INTEGRITY, and CASSANDRA) that could deliver sustainable progress in supply chain security across the EU and global scale. Again, same with CASSANDRA, there is no significant and novel technological innovation which is produced in this project. R&D activities of CORE focused on incremental innovation such as authorization of data access, also on proof-of-concept that data pipeline can be applied and bring value propositions along different type of supply chain (sea container transporting, air cargo, etc.) and ranging stakeholders (technology providers, shippers, etc). Each demonstrator developed the data pipeline concept and applied it based

[36] Entry Summary Declaration

on their business models during the demonstration. For instance, Demonstrator Felixstowe created a seamless data pipeline concept to capture reliable, accurate, and complete data regarding UK trade lanes with China and Australia to enhance supply chain security [CO-1, CO-9].

The total project budget which reached around 50 million euro indicates tremendous amount of R&D funding [CO-1]. As this project aims to present the applicability of data pipeline concept implementation in many demonstrations, the required project budget is larger than previous projects. Although there was no significant and novel technological innovation, massive R&D investments from both public and private entities, and numerous global-level demonstrations can be considered as proof that CORE performs very strong knowledge development function.

4.3.3. Knowledge Diffusion

In this section, the discussion will be emphasised on the project's dissemination. The development of knowledge is diffused throughout the network. Learning at system level takes place, which greatly enhances technology development and diffusion not only within the system, but also to a wider audience. The performance classification is shown by Table 12.

Table 12: Knowledge diffusion performance classification

Knowledge diffusion	minor	•dissemination activities (workshops, conferences) are only conducted to limited number of actors in a national level • project documents are not accessible by public
	medium	• dissemination activities are conducted to actors in international level • limited number of project documents are accessible by public
	predominant	• more frequent dissemination activities in global level • there are more project documents accessible

ITAIDE

This function can be mapped by seeing workshops, conferences, and publications that are related to DTI R&D project in ITAIDE. A book titled *Accelerating Global Supply Chains with IT Innovation* is produced as the result of joint learning and collaboration of actors in ITAIDE R&D projects. It consists of 16 studies ranging from Living Labs concept, ITAIDE information infrastructure framework, IT, interoperability tools, standardised data models, process redesign methods and network collaboration models [IT-12]. Actors in the ITAIDE consortium actively published working and research papers that elucidates Living Labs' results into numerous conferences related to IT governance, such as the European Conference of Innovation System (ECIS), Bled conference, Enterprise Information System (EIS) conference, Research Symposium on Emerging Electronic Markets (RSEEM) conference, International Conference on Electronic Government, and Americas Conference on Information Systems which were unfolded from 2006 to 2010 [IT-2, IT-3, IT-4, IT-5, IT-6]. In addition, a movie regarding the ITAIDE concept was released to the public as part of dissemination. Involvement of UNECE and TAXUD as partner of ITAIDE contributed to project results dissemination [YT]. However, despite all the dissemination efforts, the circle of audiences was rather small [FH], and the available website does not provide any project

documents. From the explanation above, we argue that knowledge diffusion function in ITAIDE is classified as medium-level function.

INTEGRITY

In INTEGRITY, documents regarding project description and outcome are accessible via website [IN-1]. It consists of project deliverables and newsletters. Additionally, INTEGRITY dissemination was highly influenced by the role of ISL as project coordinator as they have strong connection to committees of logistic-related conferences [FH, YT]. Also, thanks to UNECE, WTO, and DG TAXUD by providing international dissemination platform (workshops and conferences) for INTEGRITY results, mainly regarding data pipeline idea [FH, YT]. With their supports, the circle of audiences was enlarged. INTEGRITY results were presented in the annual European Conference on ICT for Transport Logistics (ECITL), World Customs Forum 2010 in Turkey, EVO - Customs Supply Chain Conference 2010, International Symposium on Logistics in Malaysia, and WCO IT Conference in USA [IN-1]. These disseminations enabled more extensive knowledge transfer between INTEGRITY's project coordinator to legislators in different levels. The function of knowledge diffusion in INTEGRITY became a predominant function, stronger than ITAIDE, due to easy-to-access project documents and a larger circle of dissemination audiences.

CASSANDRA

CASSANDRA reaps the benefits from extensive dissemination during the INTEGRITY project. Awareness and interests from supply chain stakeholders are increased, resulting in ranging stakeholders involved in CASSANDRA as participants [FH]. Additionally, the CASSANDRA consortium consists of some active ITAIDE and INTEGRITY participants, with other intermediary parties such as port community system providers, or other branch organizations. The advantage was derived from the merge of two communities, combining actors in logistic-chain and IT-related trade facilitation [YT]. Combining these communities, CASSANDRA got a complete coverage of all IT-enabled trade facilitation network of actors in Europe. Hence, stronger networks for disseminating the knowledge are constructed. Again, with the role of ISL, UNECE, WTO, and DG TAXUD, project outcomes were disseminated worldwide. In addition, the ground-breaking outcome of CASSANDRA was also reviewed in WCO journal [FH, YT]. Project deliverables and newsletters are accessible online via project's website besides online academic journals [CA-1, CA-2, CA-3, CA-4, CA-5]. With the role of greater communities that successfully assisted CASSANDRA dissemination activities, we argue that knowledge diffusion function in CASSANDRA is getting stronger and remains a predominant function.

CORE

As influenced by CASSANDRA's active dissemination, many stakeholders put a lot of attention toward CORE. For instance, Interpol and numerous security systems have shown their interests by joining CORE, and with that the networks built for CORE dissemination are enlarged [CO-1, YT]. Additionally, DG TAXUD and DTCA also played an important role to diffuse knowledge regarding CORE project to all European Customs Administration. They were actively organising dissemination activities of CORE, such as European Customs Administration workshops and CORE presentation [YT]. CORE website provides

updated demonstration results, in the form of reports, project deliverables, newsletters and a video that explains supply chain visibility issue along with CORE solutions [CO-1]. Several academic journals are published as part of the CORE knowledge diffusion functioning, such as a paper regarding DTI anatomy and Shipping Information Pipeline [CO-2, CO-3]. These papers serve as theoretical basis for CORE solutions.

CORE results were also presented in numerous conferences such as the European Conference on ICT for Transport Logistics and International Conference on Dynamics in Logistics [CO-1]. At the end of the project, a final event was held as one of their important dissemination activities, to integrate all CORE results into a comprehensive one-day presentation. The efforts to disseminate the outcomes seem comparable with CASSANDRA efforts, relied heavily on frequent presentation on numerous conferences, newsletters, academic journals, and project deliverables. However, we argue that knowledge diffusion function is getting stronger in CORE as the effect of large networks of actors constructed within CORE.

4.3.4. Guidance of the Search

Guidance of the search is a matter of market or government influence, and also resulted from interactive and cumulative process of exchange ideas, notions, and expectations between actors in innovation system. This function can be fulfilled by a variety of system components such as industry, government and/or market. Supporting regulation and dissemination activities can also be the example of guidance of the search as it supports positive expectations building from stakeholders within the system. Table 13 shows how we classify the guidance of the search function.

Table 13: Guidance of the search performance classification

Guidance of the search	minor	• there is supporting environment for developing the innovation (funding and strategy plan) • dissemination activities to raise positive expectations are very limited • in the end very limited positive expectations appear
	medium	• increasing supporting environment for developing the innovation (funding and strategy plan) • more active dissemination activities to raise positive expectations • in the end, more stakeholders give positive expectations
	predominant	• high supports to adopt the innovation (funding and regulation) • global level dissemination activities to raise positive expectations • in the end, more stakeholders give positive expectations and start to adopt the innovation

ITAIDE

The Multi-Annual Strategic Plan of EU which aims to create European electronic environment in area of Customs and indirect taxation appears as the major background of ITAIDE initiative. It was perceived as a plan for developing and implementing DTI and eCustoms systems in the EU. MASP has no legal power, but it provides basis for planning and implementation of Electronic Customs Decision regarding paperless environment for Customs and trade[37]. It does not explain into details on how to structure global supply chains but pays specific attention to structure and exchange declarations of import and export between governments [IT-12]. This high level planning granted a certain degree of legitimacy

[37] See http://europa.eu/legislation_summaries/customs/111019b_en.htm

regarding DTI development and stimulates resources allocation for DTI development. Additionally, MCC also provided guidance of the search regarding electronic environment governance for customs and trade as explained in section 4.2.1. These two strategic regulations were also supported by SAFE Framework by WCO, as explained also in section 4.2.1. MASP, MCC, and SAFE Framework can be mapped as targets set by governments regarding the specific use of DTI.

During ITAIDE era, to raise expectations among actors, project members from National Universities actively published journals and articles to Information Systems Journals and conferences that related to eGovernance [IT-3, IT-4, IT-5]. These publications have one thing in common, which is strong emphasis on problems that are related to customs, which may hamper inefficiency and security of international supply chains. In addition, the role of DTI as solution for the problem is always mentioned in those articles, which from this, we argue that there is strong emphasis on positive aspects of DTI that can stimulate positive expectations from potential users. The interest that was shown by a beer company to adopt ITAIDE solutions is an example of positive expectation towards DTI. However, EU's EMCS system could not comply with the ITAIDE solution and it serves as negative expectation, which weakens the function [IT-7, FH]. From these explanations, we argue that this function is scored as a medium-level function as there was negative expectation from the EU which halted the implementation.

INTEGRITY

There were no significant changes regarding the set of target by governments that provide guidance of the search for DTI innovation from ITAIDE to INTEGRITY. SAFE framework, MASP, and MCC still hold the role to legislate trade simplification for improving supply chain visibility and security [IN-7, IN-8]. In contrast, INTEGRITY'S extensive dissemination activities because of ISL's strong connection to numerous conferences organizers and SICIS testing were very supportive to raise positive expectations from supply chain stakeholders and even from demonstrators [FH]. As explained in section 4.3.3, all the efforts that were given to diffuse the outcome of INTEGRITY resulted in higher interests from supply chain stakeholders when CASSANDRA was initiated. The circle of audiences was rather extended. Although legislation was still blocking the implementation of SICIS [FH], this function was reinforced by active disseminations conducted by project participants. Moreover, funding support is increased, and in the end, demonstrators of SICIS adopted the system although it was not really taken into wider scale [FH]. From these explanations, we argue that guidance of the search became a predominant function.

CASSANDRA

The initiation of CASSANDRA was still influenced by MCC, MASP, and SAFE framework. However, in 2013, Union Customs Code (UCC) entered into force [GE-1]. This regulation forces central clearance concept and paperless mechanism for information exchange between customs and business. UCC serves as a supporting regulation that strengthened the guidance of the search function within DTI innovation system [FI]. Taking advantage of INTEGRITY's dissemination activities, the number of CASSANDRA participants are increasing [FH]. Many actors expected data pipeline to be the concrete solutions for trade simplification. Additionally, the demonstration of data pipeline concept was tested in other trade lanes as well such as EU-US and EU-Africa, implying that there was positive expectation for

CASSANDRA's solution to be implemented in a global level [CA-1]. Dissemination activities which benefits from expanded networks between key actors from ITAIDE and INTEGRITY holds important role to increase positive expectations from supply chain stakeholders in global level. Hence, there was higher attention for CORE as many stakeholders acknowledge that CORE would be the follow up project to test data pipeline in larger scale. Nevertheless, there were some negative expectations toward data pipeline concept, as some actors were reluctant to share their commercial data [CA-5]. However, this issue would then be addressed in CORE, as CASSANDRA's follow up project. In brief, we argue that guidance of the search function remains as a predominant function despite the minor emergence of negative expectation, as the dissemination activities of CASSANDRA's outcome were very active and UCC had emerged.

CORE

In CORE, UCC still provides the legitimate environment for DTI to be adopted, as it regulates paperless environment within customs and trade as part of UCC provisions by 2020 [GE-1]. Innovation projects were not strong enough to dictate legislation change, but it helped to influence EU legislators' way of thinking regarding trade simplification and operationalise all EU vision regarding supply chain visibility and security [FH, YT]. Massive amount of project budget, 71 participants from all around the world, and 10 demonstrations indicates rising expectations for DTI to be successfully implemented in large scale chains. A lot of private and public funds are spent as there are positive expectations from the EU, national customs, and businesses that data pipeline will reach its turning point into implementation in CORE. With active roles of a government body and DT to diffuse knowledge regarding CORE project to numerous European Customs Administration, many other national customs administration have shown their interests towards data pipeline. The CORE website which provides updated demonstration results, project deliverables, newsletters and a video that explains supply chain visibility issue along with CORE solutions, also contributes as a tool to raise public awareness [CO-1]. In the final event, many stakeholders who are not directly demonstrators and project members such as DO (shipper) and SW (customs administration) have shown their positive expectations toward data pipeline [CO-9]. They want data pipeline to be implemented and will look forward to any innovation project related to data pipeline. From the explanation above, we argue that the guidance of the search function is getting stronger in CORE and remains as a predominant function.

4.3.5. Market Formation

This function is fulfilled by creating a protected space for new technologies: temporary niche markets for specific applications of a technology. In such an environment, Stakeholders can develop their understanding about the new technology and expectations can be developed. Another possibility is to create a (temporary) competitive advantage by favorable tax regimes of legislation changes that support the adoption of new technology.

Table 14: Market formation performance classification

Market formation	minor	• there is emergence of temporary niche market • current legislation is still conflicting with technology adoption

	medium	• temporary niche markets level is enlarged (linking actors from different level and different categories) • the regulation that support technology adoption starts to appear
	predominant	• numerous large temporary niche markets • there is regulation that supports technology adoption, followed by real innovation adoption

ITAIDE

Living Labs creation can be considered as niche market formation. As the main R&D strategy of the ITAIDE project, it shaped expectation and needs for potential technology users, such as public and private actors. It allows potential users of the technology to actively participate in R&D project as co-innovators and collaborate to create a desired outcome of such technological innovation [IT-12]. In ITAIDE, Living Labs provide an ideal environment for shippers to realise the benefits of piggy-backing principle, data pull concept, and other ITAIDE solutions. It represents concrete real-life settings in which DTI (TREC device and AEO system) is used, demonstrated, observed, and refined further. During the process of Living Labs method in ITAIDE, potential technology users participate in this research by implementing new technology for their business process and customs procedures as a whole. These 'created' niche markets which allow DTI to take over incumbent customs system.

In ITAIDE context, DTI as the new technological innovation is imposed by the government to increase safety, security, and efficiency of international supply chains. It is a top down approach, where government is imposing eCustoms systems to businesses. Inspired by SAFE framework, MASP provides guidance for eCustoms implementation within EU Member States and it can be described as environmental standards for DTI to be implemented by potential users [IT-12]. Modernised Customs Code was modified to provide legal basis for the AEO concept and Customs rules to achieve paperless environment for international trade [IT-12]. MASP and MCC played role as government standards to create the market for DTI. However, EU's EMCS system halts DTI solutions developed by ITAIDE to be used by living labs demonstrators [FH]. In this project, market formation is a minor function due to conflicting regulation although living labs methodology was really effective to create niche market.

INTEGRITY

The market for INTEGRITY's DTI solutions focused on stakeholders with strong logistics role such as port authorities and terminal operators [FH]. There was a need to test DTI in wider scale, to see how it can bring value propositions to other parties within the supply chain. In INTEGRITY, niche market was created when SICIS was brought to demonstration. The demonstration involved port authorities from Yantian, Rotterdam, and Felixstowe, Hutchison Port as terminal operators. SICIS tracked more than 5400 containers along logistics chain from China to Europe, enabled terminal operators to track container shipping information with container security device (CSD) [IN-7]. Again, as the government standards to support the innovation, MASP and MCC still played a role to create the market although SICIS was still conflicting with the current legislation [FH]. Not so different with ITAIDE market formation function, lack of government regulation compliance still blocks the market creation for INTEGRITY's solution. Therefore, this function remains a minor function although niche market level is enlarged.

CASSANDRA

Data pipeline demonstrations in CASSANDRA took place in a wider level of trade lanes, such as EU-Africa and EU-USA [CA-1]. Participation from port community system providers and freight forwarders indicate a growing number of project members and demonstrators. There are three living labs to test data pipeline and chain based supervision such as EU-China, EU-Africa, and EU-USA, which implies that living labs demonstrators scope are bigger [CA-1, CA-5]. Hence, the niche market creation was evolved. Regarding the regulation, there were no strong regulations that forced data pipeline to be implemented [FH, YT]. However, UCC which was forced in 2013 provides such a supportive legislation basis for electronic declaration submission procedures and Import Control System 2.0 that would benefit from data pipeline tested in CASSANDRA [FI, YT]. Therefore, we argue that in CASSANDRA, the market formation function is getting stronger and this function serves as a medium-level function.

CORE

CORE is an implementation driven R&D project for developing IT innovation to improve supply chain visibility. Thus, it is not questionable if there are numerous demonstrations including large scale demonstration between IB and MK, demonstrator Felixstowe that tests data pipeline in UK trade lanes with China and Australia, and demonstrator Schiphol that tests data pipeline concept to air cargo supply chains [CO-1]. Each demonstration implies temporary niche market for DTI, and as the demonstration scope is enlarged and demonstration numbers are increasing, the temporary niche markets are significantly evolved. By the end of the project, some demonstrators kept implementing the tested CORE solution for their business models [CO-9, YT]. Some other stakeholders who are not directly participants of CORE also show their positive expectations towards the data pipeline implementation [CO-9, YT]. Moreover, the UCC provision deadline by 2020 [GE-1] enforces DTI innovation that can support supply chain visibility and better data quality, as all trade declaration should be submitted electronically based on UCC. UCC also released regulation article regarding pilot testing which enables an innovative project that might not comply with the current legislation to be tested [GE-1, YT]. From the explanations above, we argue that CORE has a very strong market formation function compared to its preceding projects.

4.3.6. Resources Mobilisation

Technology development requires financial resources, either from internal or external funds (e.g., public funding or private investments). The required financial resources are influenced by the objectives of the innovation project, whether it focuses on developing specific technological innovation or conducting pilot projects. Table 15 presents the classification for resources mobilisation's performance.

In the early stage of innovation development, public investment is important to provide trialability and neutrality for the innovation development process [YT]. It is common that private businesses are reluctant to invest when they do not really know what the perceived benefits are for their business cases. Neutrality is also important to ensure that the innovation project is not only focusing on particular actors' interests. Therefore, public investments are needed in such innovation project which consists of multi-level actors from business and governments.

In common, funds for a government-funded innovation project are made available as if the project's proposal is approved. In these analysed cases, DT involvement was very contributive to increase the likelihood of project proposal's to be accepted by the European Commission. DT has strong connection with a supranational government body and together they share ambition regarding IT innovation in trade facilitation. DT was also very active in engaging other customs administration from other countries, academic actors, and traders to innovate with DTI [YT]. With these networks, a very high approval rate for eCustoms related innovation projects' proposal was obtained as DT connected so many networks which consist of the most innovative stakeholders in Europe.

Table 15: Resources mobilisation performance classification

Resources mobilisation	minor	R&D funding is available for technological innovation development
	medium	R&D funding is available for both technological innovation development and pilot project/niche experiments
	predominant	R&D funding is available for both technological innovation development and pilot project/niche experiments, and sourced from multi-actors (both public and private)

ITAIDE

For the ITAIDE project, entrepreneurial efforts lead to a signed research contract with European Commission, which ensured partial financing of the project (the rest of the funding was contributed by partners). Total project cost is approximately 7.5 million euro, including 5.8 million euro of EU contribution [IT-1]. The actors involved to develop the technology were rather limited, as it was only focused on shippers and neglected stakeholders with strong logistical role such as freight forwarders and terminal operators [IT-12, FH]. This argument can be considered as the reason of limited private funding sources for this project. Overall, the resources mobilisation function of ITAIDE was scored as a pre-dominant function as there was sufficient budget to conduct the technical R&D and pilot projects which was sourced from both public and private entities.

INTEGRITY

In INTEGRITY, European Commission agreed to finance the project under the 7th Framework Program with Transport topic. They spent an approximate budget of 6.5 million euro, out of the total budget which is 10 million euro [IN-1]. The resources mobilisation's function of INTEGRITY was classified as a predominant function as there was sufficient budget from private and governments to conduct the technological development and pilot projects. However, the total project budget is increasing and reach 10 million euro, with 60% of the budget sourced from the EU. The increasing budget in INTEGRITY may represent more ambitious aims in such innovation project, more extensive R&D activities, and more active dissemination events.

CASSANDRA

The European Commission agreed to finance the project under the 7th Framework Program with Security topic. The approximate EC spending is 10 million euro, out of a total budget needed around 15 million euro [CA-1]. Demonstration level as part of R&D within CASSANDRA was enlarged to USA and Africa besides remaining involving the EU-China trade lanes. Hence, the financial resources needed were also increasing. The resources mobilisation function remains a predominant function as the funds are made available for the R&D activities, dissemination events, and pilot projects. However this function is getting stronger gradually as the project budget is increasing.

CORE

CORE is a large scale eCustoms innovation related project which requires almost 50 million euro as the total project costs. The European Commission agreed to finance the project at around 30 million euro, while private investments contribute for the rest of the costs [CO-1]. The focus on CORE is large scale demonstrations, implementation driven R&D, which are expected to bring DTI to real implementation. Thus, it is understandable if CORE required massive project funding due to its objectives. Financial resources, especially from governments, were crucial to stimulate the businesses actors to invest on DTI, as it provides trialability value for DTI innovation [YT]. However, DTI is a business driven innovation and the implementation depends on private investments to adopt such IT innovation within their business models. To reach a turning point phase for such DTI innovation, extensive funding from businesses are needed [CO-9, FH]. Although not reaching massive adoption phase yet, many companies are interested to adopt pipeline configurations on their business models by the end of the CORE project [YT]. Resources mobilisation function remains scored as a predominant function in CORE as there were sufficient funds made available for both technological development and experiments.

4.3.7. Advocacy Coalitions

To develop such innovation process, a new technology has to become part of an incumbent regime. Advocacy coalitions can function as a catalyst of technology adoption. Their efforts can help to put the innovation to agenda, lobby for resources, favorable tax regimes and legislation change. By doing so, legitimacy for a new technological trajectory can be created. If successful, advocacy coalitions will grow in size and influence the legitimation of particular innovation adoption.

Table 16: Advocacy coalitions performance classification

Advocacy coalitions	minor	• coalitions activities just limited on R&D projects without efforts to create legitimacy of innovation trajectory
	medium	• coalitions grow in size, influence potential users to involve in innovation development, other technology providers to complement the technologies, and legislators to create the legitimacy of an innovation trajectory
	predominant	• coalitions grow in size influence directly legislation changes

ITAIDE

In ITAIDE, the function of advocacy coalition can be explained as follows. In Beer Living Lab, HE and DT were very positive to implement the ITAIDE solution. Even DT also has the same intention to implement it not only for HE, but all sellers of excise goods in The Netherlands [YT]. However, the coalition in ITAIDE

was not sufficiently strong to lobby the legislators for implementing the ITAIDE solutions directly. The outcome could not comply with EU's EMCS system that was established with top-down approach [IT-4, IT-7]. On the other hand, the coalition positively influenced other stakeholders which are not project members of ITAIDE to develop and complement the technology. DT has strong networking with many traders, freight forwarders and other customs administration [YT]. ITAIDE results triggered other actors, mainly from DT existing networks, to develop complementing technology for ITAIDE solutions [FH, YT]. As a result, the other actors agreed to develop DTI further in other follow up project. For example, the European Commission agreed to fund ITAIDE and INTEGRITY. Although no legislation changes and EU EMCS system was conflicting with the innovation outcome, coalition can give pressure to other actors to develop the technology (done in INTEGRITY project) and influence legislators' innovation agenda to create the legitimacy of innovation trajectory (CASSANDRA emergence as follow-up project). Hence, we argue that the advocacy coalition function is fulfilled and serves as a medium-level function.

INTEGRITY

The INTEGRITY consortium represents advocacy coalition within DTI innovation system in project setting. Their role also was not strong enough to change legislation. Nevertheless, the coalition still inspired other stakeholders to participate in follow-up projects and complement DTI with other technology such as CSD and dashboards developed in CASSANDRA [IN-7, CA-5, FH]. The coalition also successfully inspired the European Commission to fund and participate in the follow-up project, CASSANDRA [CA-1, YT]. In comparison with ITAIDE coalition, INTEGRITY coalition function is stronger because IL, the project coordinator, held an important role to access numerous dissemination platform and conferences [FH]. They were very dedicated to disseminate the results of INTEGRITY to a wider audience. With all dissemination efforts, they indirectly gave pressure to other actors to develop DTI and implement it to their business models. As the results of active dissemination, there were more interests from many actors to participate in CASSANDRA. These phenomena show that INTEGRITY coalition gives stronger effect as it influenced heavily more actors from PCS providers and branch organizations to join CASSANDRA, and also legislators to support CASSANDRA project with funding and UCC provisions. However, it remains serving as a medium-level function as the coalition was not strong enough to bring legislation changes.

CASSANDRA

Still, the CASSANDRA consortium did not have sufficient power to change any current legislation. Additionally, the CASSANDRA coalition was a bit disturbed with the fact that freight forwarders were not really interested with DTI developed in CASSANDRA as it can be the threat to their business models [FH, YT]. Nevertheless, the coalition still inspired other stakeholders to complement DTI with other technology and implement it within their business models in pilot setting [CO-1, FH, YT]. As the financial spending from EC and numbers of project member were increasing significantly in CASSANDRA's follow up project (CORE), we argue that the advocacy coalition function of CASSANDRA performed stronger than its preceding projects. Coalition was getting stronger as communities that were built in ITAIDE and INTEGRITY were combined into CASSANDRA's consortium [YT]. There were extensive dissemination on the knowledge developed in ITAIDE, INTEGRITY, and CASSANDRA [FH,YT]. With all dissemination efforts,

they indirectly gave pressure to other actors to take part in a project which focuses on DTI implementation. As the results of active dissemination, higher interests from other actors to join CORE were obtained.

CORE

Even in an implementation-driven R&D project like CORE, innovation projects have little impacts to legislation changes [FH, YT]. Data pipeline concept that has been developed through ITAIDE, INTEGRITY, CASSANDRA, and CORE is going much further than UCC. There are no direct suggestions within UCC to adopt a certain technology to realise paperless environment of customs [YT]. All of the projects consortium were not strong enough to change UCC as EC uses a top-down approach to regulate trade facilitation mechanisms for all member states. Solution from innovation projects can be seen as bottom-up approach [IT-4, IT-7]. It means that the initiative to develop the innovative concept emerged from collaboration between businesses, government representatives and technology providers where the parties saw each other as equal.

However, all outcomes produced in eCustoms related projects influenced the European Commission's way of thinking regarding how they arrange innovation agenda [FH]. Gradually, since ITAIDE started in 2006 until 2018, Customs Code evolved into Union Customs Code and supply chain security issue was brought to legislation in 2009, introducing Entry Summary Declaration, and Import-Export Control System [FH]. Moreover, innovation projects help to realise the operational level of European Commission's vision on trade simplification with IT innovation [YT]. It helps to demonstrate how DTI can be used to support international supply chain visibility and security.

Comparing to all coalitions that existed in the preceding projects, we argue that CORE's coalition is the strongest for the following reasons. Although great numbers of project participants do not guarantee the active participation from each member, there are so many project participants who hold an important role as demonstrators and eventually show their interests to implementing tested solutions on their business cases [CO-9, YT]. For example, a pipeline configuration that developed in large scale demonstration of CORE by IB and MK attracts not only those actors to implement data pipeline concept to their business models, but also other companies [YT]. It is reasonable if the pipeline configuration became successful, knowing that the idea behind data pipeline concept has been developed for 13 years, since ITAIDE was started. Additionally, the coalition agreed to demonstrate other complementing technologies' implementation such as smart containers and container scanning [CO-6]. At the end of the project, many stakeholders who are not project members show their interests for data pipeline realisation within their business models [CO-9]. Despite so many actors in CORE that should be convinced, the coalition in CORE was very influential to bring DTI into adoption.

4.3.8. Functions Fulfilment

To sum up the functional analysis part, functions performance classification is arranged as shown in the Table 17.

Table 17: Evaluation of innovation system function

Functions	Initiation phase	Development phase		Implementation phase
	ITAIDE	INTEGRITY	CASANDRA	CORE
Entrepreneurial activities	medium	medium	medium	predominant
Knowledge development	predominant	predominant	predominant	predominant
Knowledge diffusion	medium	predominant	predominant	predominant
Guidance of the search	medium	predominant	predominant	predominant
Market formation	minor	minor	medium	predominant
Resources mobilisation	predominant	predominant	predominant	predominant
Advocacy coalitions	medium	medium	medium	medium

In ITAIDE, market formation functions are classified as minor functions, as they provide large room for improvement remembering weak adoption rate of DTI concept at that time. In contrast, extensive knowledge development by Living Labs supported the strong functioning of knowledge development. Living Labs provided very technical environment for R&D activities in ITAIDE. Entrepreneurial activities, knowledge diffusion, guidance of the search, and advocacy coalition functions were sufficiently fulfilled as stakeholders with technical and non-technical role joined the project, and the dissemination activities in ITAIDE influenced other stakeholders to participate in the follow-up project. Funding resources were also adequate to run the project according to its objectives.

In INTEGRITY, the small-scale adoption of SICIS in the end of the project and the increasing awareness of logistics-related business players towards SICIS show that entrepreneurial activities function is getting stronger. However, as legislation compliance still blocked a wider scale implementation, market formation remains as a minor function within the project. Knowledge development function and resources mobilisation are still perceived as the predominant functions as there were extensive SICIS pilot projects and bigger R&D funds. Worldwide approach had been taken, indicating that massive dissemination activities conducted during INTEGRITY project represent stronger knowledge diffusion, guidance of the search, and advocacy coalitions. Nonetheless, coalitions are not strong enough to dictate legislation changes.

CASSANDRA has very strong knowledge development, knowledge diffusion and guidance of the search functions. The funds were also sufficient for CASSANDRA's R&D objectives. The dissemination conducted in CASSANDRA was even stronger as the network of actors in CASSANDRA was enlarged and CASSANDRA results were published in WCO journal. With all the efforts in INTEGRITY and CASSANDRA, higher interests from ranging actors to join the follow-up project were obtained. Positive expectations were rising and DTI remains on the EU innovation agenda. In addition, knowledge developed in CASSANDRA is getting stronger by enabling users' dashboards improvement and a wider scale of pilot projects. By the end of the project, entrepreneurial activities and market formation functions are reinforced due to massive dissemination effect, transition from MCC to UCC, and increasing number of project funding.

CORE's demonstrations served as substantial knowledge development functioning. The global level data pipeline testing which involved numerous stakeholders indicates how strong this function is. Furthermore, stronger dissemination activities and UCC implementation provisions contributed to strong knowledge diffusion, guidance of the search and successful advocacy coalition. By the end of CORE, some demonstrators remain implementing the DTI concept that is being tested within their business models. This phenomenon implies higher adoption rate of DTI which reinforce entrepreneurial activities, market formation, and resources mobilisation functions. Therefore, we argue that entrepreneurial activities, market formation, resources mobilisation are very important functions that need to be reinforced in implementation phase. In CORE, all the functions became stronger, even the strongest than all functions working in preceding projects.

4.4. Blockages

In this research, blockages refer to the factors which negatively affect the innovation process continuity. According to proposed framework, we focused to identify blockages based on the combination of 'blockages' concerning collective action process, which is defined as blocking factors that contribute to discontinuity or failure of collective action, and 'weakening indicators' concerning FIS theory, which is defined as the factors that prevent functions to be fulfilled and developed. We generated these blockages based on the identified problems in innovation process by looking at both structural and functional analyses. Issues that were identified from reviewed documents and interviewees' opinion were coded and categorized as some specific blockages categories.

Blockages derived from structural analysis are the issue related to collective action process. Although not all of the four projects experienced it, these are the identified blockages from structural analysis in general: *missing actors to support innovation development*, *diverging interests*, and *governance.* On the other hand, we identified five general weakening indicators that hamper DTI innovation system functioning, which are: *lack of direct legislation support*, *immature technology*, *lack of right stakeholders' involvement, lack of shared interests and clear perceived benefits,* and *lack of public and private investments.*

ITAIDE

From the structural analysis, we identified missing actors' participation as the issue in collective action process. The collective action's shared goal is achieving supply chain visibility with IT innovation. In ITAIDE, a project participant realised that wider network should be constructed and other actors (logistics-related actors) should be included, to enable the innovation development. On the other hand, we identified weakening indicators for each function as shown in Table 18. 'Missing actors to support development' and 'lack of right stakeholders' involvement' can be justified as identical issues. Hence, this analysis had shown that some blockages identified in structural analysis can also be considered as weakening indicators of innovation systems' functions.

Table 18: ITAIDE's blockages

Structural	Functional	
Blockages	**Function**	**Weakening indicators**
Missing actors to support development	Entrepreneurial activities	Lack of direct legislation support, lack of shared interests and perceived benefits, lack of right stakeholders' involvement, lack of public and private investments
	Knowledge development	Lack of right stakeholders' involvement
	Knowledge diffusion	Lack of right stakeholders' involvement
	Guidance of the search	Lack of shared interests and perceived benefits
	Market formation	Immature technology, lack of direct legislation support, lack of shared interests and perceived benefits, lack of right stakeholders' involvement, lack of public and private investments
	Resources mobilisation	Lack of public and private investments
	Advocacy coalitions	Lack of direct legislation support

INTEGRITY

From the structural analysis, we identified that missing actors' participation still appear as the issue in collective action process. Due to technological development issue, freight forwarders and intermediary parties should be included in the DTI innovation development. Wider network should be constructed to enable the innovation development. On the other hand, we identified weakening indicators for each function as shown in Table 19. Again, 'missing actors to support development' can also be considered as weakening indicators of innovation systems' functions. However, in INTEGRITY, the extensive dissemination activities reinforced knowledge diffusion and guidance of the search function. The weakening indicators are slightly removed because of the dissemination activities conducted in INTEGRITY.

Table 19: INTEGRITY's blockages

Structural	Functional	
Blockages	**Function**	**Weakening indicators**
Missing actors to support development	Entrepreneurial activities	Lack of direct legislation support, lack of shared interests and perceived benefits, lack of right stakeholders' involvement, lack of public and private investments
	Knowledge development	Lack of right stakeholders' involvement

	Market formation	Immature technology, lack of direct legislation support, lack of shared interests and perceived benefits, lack of right stakeholders' involvement, lack of public and private investments
	Resources mobilisation	Lack of public and private investments
	Advocacy coalitions	Lack of direct legislation support

CASSANDRA

Although new categories of actors had join INTEGRITY and more actors joined CASSANDRA, it was still missing shippers involvement, in order to enhance the technological development issue. Furthermore, the reluctant attitude shown by freight forwarders and other parties to share their data in the pipeline appears as diverging interest issue. We identified weakening indicators for each function as shown in Table 20. Next to stakeholders' participation, diverging interests issue can also be justified as 'lack of shared interests' issue. This similarity then explains the possibility of collective action-related issues in contributing as factors that disturb innovation system functions. In CASSANDRA, immature technology issue is handled as we argued that the configurations of data pipeline architectures in several pilots, standardisation, and business and customs dashboards have been developed and tested. Based on its activities, we argued that CASSANDRA contributes to increase the maturity of data pipeline concept as they were focused on usability, such as pipeline interface and visual dashboards.

Table 20: CASSANDRA's blockages

Structural	Functional	
Blockages	**Function**	**Weakening indicators**
Missing actors to support development	Entrepreneurial activities	Lack of direct legislation support, lack of shared interests and perceived benefits, lack of right stakeholders' involvement, lack of public and private investments
	Knowledge development	Lack of right stakeholders' involvement
Diverging interests	Market formation	Lack of direct legislation support, lack of shared interests and perceived benefits, lack of right stakeholders' involvement, lack of public and private investments
	Resources mobilisation	Lack of public and private investments
	Advocacy coalitions	Lack of direct legislation support

CORE

Identified blockages from the structural analysis in CORE no longer includes the missing actor issue. The 71 participants comprise ranging stakeholders' categories. Most of the project participants are

fascinated with data pipeline. At the same time, they also realised that data pipeline implementation requires significant business investments, and not all stakeholders have the same level of interests regarding the supply chain improvement when it also involves some costs that should be spent. These stakeholders might possess different interests and it contributes to disturb the collective action process. Hence, the implementation of data pipeline can be delayed. The large number of CORE project participants creates difficulty for sense-making process to convince actors who have different interests. This phenomenon indicates the governance issue. Looking at the functional analysis, we discovered that stakeholders' participation issue can be addressed in CORE. Shippers are involved, demonstrations are conducted and involve numerous stakeholders from different categories. Hence the remaining weakening indicators are legislation support, investments, and shared interests. Different from diverging interests which can be assumed as lack of shared interests, governance issue is not relevant to explain any weakening indicators in CORE.

Table 21: CORE's blockages

Structural	Functional	
Blockages	**Function**	**Weakening indicators**
Diverging interests	Entrepreneurial activities	Lack of direct legislation support, lack of public and private investments, lack of shared interests and perceived benefits
	Market formation	Lack of direct legislation support, lack of public and private investments, lack of shared interests and perceived benefits
Governance issue	Resources mobilisation	Lack of public and private investments
	Advocacy coalitions	Lack of direct legislation support

4.5. Unblocking Strategy

Changes in network and framing influence the continuity of the innovation project. The changes are usually constructed based on the intention and strategy to keep developing the technological innovation, and to handle discovered issues during the current project in the follow-up project. Discovered issues that hamper the continuity of DTI innovation process can be justified as the blockages. From reviewed texts and interviews, we identified the connection between changes in structure of innovation system with collective action model approach and how they were actually being used to improve the functions of DTI innovation system from one project to another. Thus, the term for this linkage is "unblocking strategy". We identified such unblocking strategies concerning collective action process which can also be used to address weakening indicators: *re-configuration of networks* and *re-framing*. We did not identify *re-governance* (see section 3.4.2) for these projects as these cases represent government-funded projects. They are commonly governed as consortium, to allow actors from different categories to pool their resources and join the project, in order to achieve a shared goal.

ITAIDE to INTEGRITY (initiation to development phase)

1. Re-configuration of networks
   By involving logistic actors, the ITAIDE concept can be refined and tested in a setting that focuses on container transport, reducing the issue regarding immature technology. Wider actors receiving the knowledge about data pipeline concept will reduce the issue of shared interests lacking as bigger communities can influence other actors' way of thinking. Additionally, lack of stakeholders' involvement will also be reduced. Last, wider actors may provide additional investments for innovation development. Hence, it helps to address lack of investments issue. In relation to Table 18 and 19, these weakening indicators are reduced and then functions which were disturbed by these indicators can be reinforced.
2. Re-framing
   Framing allows changes in focus of technological development, with the intention to refine the operationalisation of DTI concept. It also influences wider stakeholders (such as terminal operators, branch organisations) to pay more attention on DTI innovation development. Thus it helps to reduce lack of shared interests and stakeholders' involvement issue. Re-framing also triggers the European Commission to keep funding the follow-up project (INTEGRITY) and private actors who are the project members of INTEGRITY to invest.

INTEGRITY to CASSANDRA (development to development phase)

1. Re-configuration of networks
   By involving more freight forwarders and combining communities constructed in ITAIDE and INTEGRITY, all the knowledge, expertise, and role of project members can be used to refine the immature technology. It allows global level demonstration of data pipeline and dashboards improvement. These R&D activities will then reduce the issue of lack of shared interests and perceived benefits. Merging two different communities in CASSANDRA can address the issue regarding stakeholders' involvement and increase the likelihood of additional investments for the follow-up project.
2. Re-framing
   Problem re-framing was very essential to refine the immature technology. In CASSANDRA, the intention to improve the usability and integrate data pipeline along the supply chain can be linked to immature technology issue reduction. The idea of testing data pipeline in a wider scale also helps to address lack of shared interests and clear perceived benefits as pilots aim to make clear the value propositions of data pipeline for all actors in chain. By re-framing the problem and solutions, many stakeholders from freight forwarders, IT companies, and branch organisations joined the consortium and assisted the technology development and dissemination. This can be assumed as the linkage between re-framing and stakeholders' involvement and investments issue reduction

CASSANDRA to CORE (development to implementation phase)

1. Re-configuration of networks
   Involving ESC as the project lead allows numerous of shippers/cargo owners to join the demonstration. Stakeholders' involvement issue was reduced as networks of actors in CORE are

immensely enlarged. Many stakeholders participate in CORE to realize data pipeline large scale demonstrations. The demonstrations will help to clarify perceived benefits that are provided by data pipeline concept. Furthermore, enlarging the network of actors into global level and involving them in demonstration will influence the European Commission and some demonstrators to provide investments as part of the CORE project budget.

2. Re-framing

   Data pipeline implementation for improving supply chain security and visibility appears as re-framed problem and large-scale data pipeline concept demonstrations serves as the way to address the problem. This problem and R&D concept attracted many stakeholders from all around the world to take part in CORE, such as numerous IT companies, branch organisations, and shippers. Issues regarding stakeholders' involvement can be addressed by this mechanism. The framed R&D concept will lead to increase the value propositions of data pipeline. Hence, it can reduce issue regarding shared interests and perceived benefits. Re-framed problem and concept does not only attract many stakeholders to join, but also to spend their budget on developing DTI as they have commercial interests on implementing data pipeline concept to their business models.

This page is intentionally left blank

5. DISCUSSION AND FINDINGS

After applying the conceptual framework to the cases, some findings are identified. In this chapter, the discussion will not be as detailed as the discussion in the case analysis chapter. Instead, major critical findings that explain the applicability of conceptual framework and enrich body of knowledge used in this research are highlighted.

5.1. Structural Analysis

When cases are applied to structural analysis based on collective action model, we identified the occurred changes regarding the political condition, actors, and framing from the initiation to implementation phase. The changes in political opportunity are influential to the continuity of innovation process. For instance, when UCC entered into force, the expectations to implement the data pipeline solutions are rising as data pipeline is perceived as a highly supporting concept to create paperless environment for customs and trade. Those expectations were then translated into the participation of some actors in the data pipeline project. The actors may enter the DTI project as a result of political opportunity, while some actors may join the project because of the boundary spanners' active role and framing contests. For example, CASSANDRA consortium was built as a result of boundary spanners that communicate all the knowledge developed in ITAIDE and INTEGRITY extensively to both communities. Based on those reasons, the structure of innovation system is changing from one phase to another. Regarding the discontinuity, all the cases are ended on the agreed time as they are government-funded projects, and bottlenecks within the project are discovered and reviewed by the end of the project. There are no significant conflicts that stopped the project in the middle of the project's duration.

5.2. Functional Analysis

Each innovation project was analysed with a functional approach, to see whether the project can perform the necessary functions for an innovation system to mobilise the innovation process. Traditional FIS approach does not value functions of innovation system qualitatively. It focuses on describing innovation events pattern which comprises the functions fulfilment. Scheme of analysis by Bergek et al. (2008) explains how FIS can be used by innovation system analysts to analyse the function of innovation system both in quantitative and qualitative approach. However, the study does not elucidate functions' performance classification. Hence, the challenge appears when it comes to establish decision rules for functions' performance classification, as we want to discover functions' performance over time but no theories have described the functions scoring yet. We translated the definition of each function into such performance classifications. The cases had shown that all functions were always fulfilled in all projects although some functions are categorized as minor in the beginning, while others may be categorized as predominant functions.

ITAIDE represents the innovation system in the initiation phase. In ITAIDE, extensive R&D activities by Living Labs serve as a strong functioning of knowledge development. Living Labs provides such technical environment for R&D activities in ITAIDE. The other functions in this phase were sufficiently fulfilled although some of them performed weakly. It is essential for DTI innovation system to perform all

functions so the innovation process can be mobilised. However, in the initiation phase, the knowledge development function needs to be strong, to ensure the extensive advancement of technological development before it reaches critical mass.

INTEGRITY and CASSANDRA represent innovation system in the development phase. Such efforts that need to be done in this phase are refinement of technological innovation, demonstration, and dissemination activities. We observed that some functions are extremely stronger, namely knowledge diffusion and guidance of the search. Knowledge development remains strong as the R&D activities still focus on usability improvement. These functions need to be strong since the development phase focuses on the efforts to transform innovation idea to reality.

CORE represents innovation system in the implementation phase. In this phase, the innovation should already be adopted to market. A study by Hekkert et al. (2007) explained that the pattern of innovation system functions over the years should present a continuous build up, in order to gain critical mass. The findings of our research also support their theory. Eventually, all of the functions need to be stronger than all the functions working in the previous phases. By the end of CORE, many demonstrators remain implementing the DTI concept that is being tested in the pilot projects of CORE. This phenomenon implies higher adoption rate of DTI which reinforces entrepreneurial activities, market formation, and resources mobilisation functions. Therefore, we argue that the entrepreneurial activities, market formation, and resources mobilisation are very important functions that need to be strengthened for the implementation phase.

5.3. Blockages

This concept is proposed as the combination of blockages derived from structural analysis, which are the issues related to collective action process, and weakening indicators of innovation system functions. The combination of two analyses to derive blockages information gives richer insights about what can be improved in an innovation system. Looking only at a single analysis may provide limited insights, especially if one only looks at the structural analysis. Functional analysis gives more knowledge on the aspects that can be improved in an innovation system, in order to reach shared objectives. We also discovered that blockages of collective action process can contribute as the weakening indicators of innovation system functions in the same time. This phenomenon appears as some weakened functions are a manifestation of problems in innovation system's structure, such as *lack of shared interests* weakening indicators which can be described as *diverging interests* of collective action blockage.

From the analysed cases, the identified blockages from structural analysis in general are: *missing actors to support innovation development*, *diverging interests*, and *governance.* Next to that, weakening indicators of innovation system functions were identified: *lack of direct legislation support*, *immature technology*, *lack of right stakeholders' involvement, lack of shared interests and clear perceived benefits,* and *lack of public and private investments.* These blockages did not only disrupt the minor functions, but also weakened the predominant functions. For instance, in ITAIDE, knowledge development function strongly performed, but still it is damaged by the stakeholders' involvement issue. Knowledge development function was the strongest function in ITAIDE compared to the other function as it

represents extensive and technical R&D activities within the project. However, the function would perform better if wider stakeholders are involved in ITAIDE R&D activities.

5.4. Unblocking Strategy

Looking at two analyses, we discovered that the unblocking strategy which is based on 'unblocking mechanisms' by Rukanova et al. (2017): *re-configuration of networks*, *re-framing*, and *re-governance*, is not only capable to address the blockages derived from structural analysis. Instead, it helps to reduce or even remove the weakening indicators of an innovation system function. As mentioned in previous section, the explanation on why those unblocking strategies are able to help to remove weakening indicators relies on the fact that some weakened functions are manifestation of structural issues. For example, weakening indicators such as lack of right stakeholders' involvement are removed in CORE as the re-configuration of network and re-framing brought the necessary actors in the consortium until they cooperated and refined the usability of technology.

However, the issue regarding direct legislation support cannot be addressed only by those unblocking strategies in these empiric cases. From one project to another, the re-configuration of networks and re-framing were most of the time not that effective to address the "lack of direct legislation support" issue. This phenomenon shows that some weakening indicators may not always be addressed by this 'collective action process-based' unblocking strategy. The indicators that cannot be addressed by this unblocking strategy serve as one of the problem backgrounds for further innovation project. Moreover, they are not merely blocking the whole innovation process if the weakening indicators are not addressed. Based on the explanation mentioned before, we argue that the proposed conceptual framework (SFA) appears as a novel theoretical lens that can be used as an analytical tool to understand innovation process by looking at innovation system perspective.

This page is intentionally left blank

6. CONCLUSION

This chapter recapitulates the essential parts of the research. The discussion is divided into four sections. First, the research question is revisited and discussed in the conclusion section below. Second, the research contribution is presented to conclude the research's added value. Third, the research limitations and recommendations for future research are presented. Fourth, we also reflect on the research execution, which might be helpful as lessons that can be learned for future research.

6.1. Conclusion

The primary purpose of this research is to fill the gap in our knowledge of innovation process management in the international trade domain by introducing a framework that can be used to understand digital trade infrastructures innovation process by looking at innovation system functions and its structural changes. Furthermore, structural-functional analysis (SFA) framework can be used as a tool to generate strategy of innovation process management regarding how to bring the innovation specifically, the digital trade infrastructures, to implementation.

The main research question is:

***"*How does structural and functional analysis contribute to explain blockages and unblocking strategies of digital trade infrastructures innovation process from initiation to implementation phase?"**

The structural analysis explains how actors enter an innovation system, construction of networks and changes of institutional setting. The blockages identified from the structural analysis are rather limited as they explain issues that are discovered in a discontinuity of collective action process, such as the stakeholders' participation issues. On the other hand, the functional analysis explains how the innovation system achieves its goal. To successfully mobilise the innovation process from initiation to implementation phase, the innovation system has to perform all functions. The blockages identified from functional analysis are the indicators that weakened the innovation system to perform its functions, such as lack of investments and immature technology.

Some weakened functions may be caused by issues in collective action or innovation system's structure. Therefore, unblocking strategy based on collective action model can help to reduce weakening indicators of the innovation system functions, hence strengthen the functions of innovation system in the next phase. For instance, in one project, a weakening indicator, namely lack of stakeholders' involvement, was addressed by *re-configuration of networks* and *re-framing.* Lack of stakeholders' involvement is the example of a weakening indicator which is linked to the collective action issue. As the effect of those unblocking strategies, the other stakeholders from different categories are interested to join the innovation system. The involvement of more stakeholders allows higher investment and positive expectations on the innovation process, thus functions such as resources mobilisation and guidance of the search are reinforced.

It was found that the combination of these analyses provides richer explanation on issues that block the innovation process. This study helps to understand what issues that limit the innovation system structure and weaken the functions of innovation system. Furthermore, unblocking strategy which represents efforts that can be done by actors within an innovation system to handle blockages based on structural analysis can also be used to address the indicators that weakened the functions. This unblocking strategy helps to strengthen weak functions in the later phase of the innovation process. However, some weakening indicators may not always be addressed by this unblocking strategy. The indicators that cannot be addressed by this unblocking strategy serve as one of the problem backgrounds for further innovation projects and they are not merely blocking the whole innovation process. Overall, this study is capable to present a theoretical lens to identify blockages and unblocking strategy of DTI innovation process by looking at the innovation system's structural and functional characteristics.

In brief, the thesis result is rephrased as follows: "*A framework which is built on the combination of analyses concerning structural changes and functional performance of an innovation system is capable to provide richer explanation on issues that limit an innovation system to further develop the DI innovation, a strategy that can be done to mobilise the innovation process, and the DI innovation process itself*".

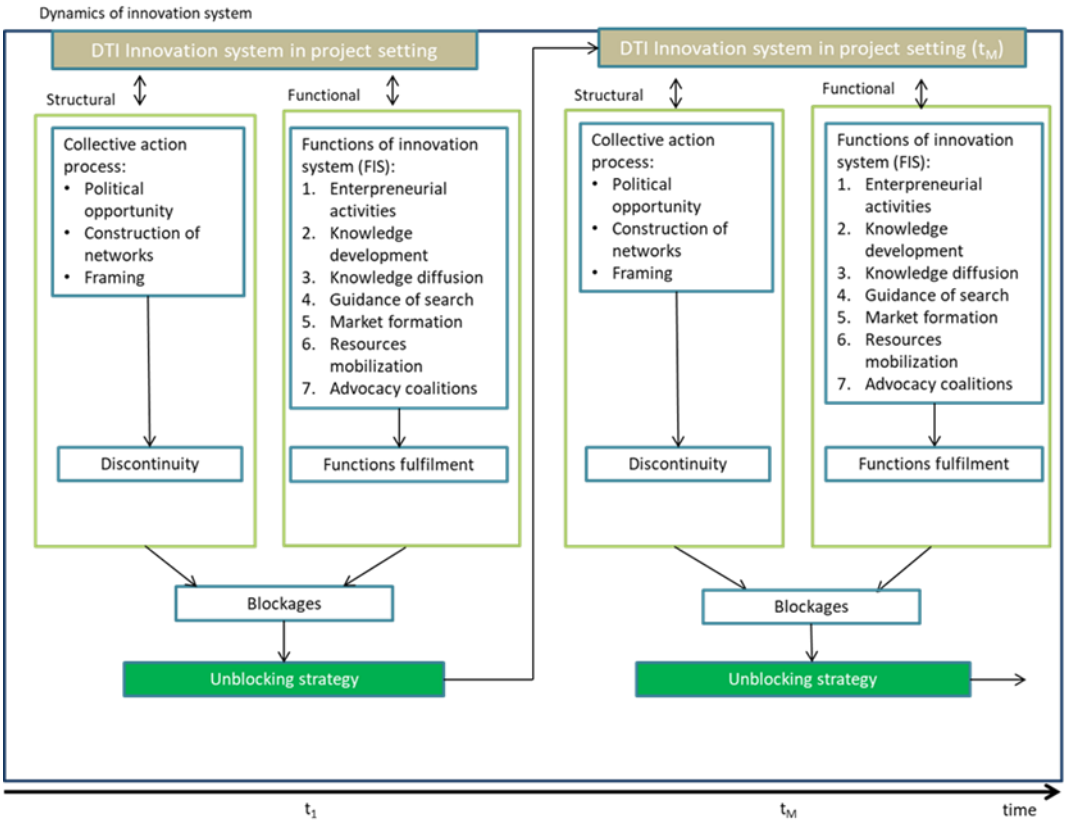


Figure 12: Structural-Functional Analysis (SFA) Framework

6.2. Research Contributions

In this section, the research contributions are presented to show that the research has made the expected academic and practical contributions discussed in the previous chapter.

6.2.1. Academic Contributions

1) Fill the knowledge gap

This study introduced a conceptual framework named the structural-functional analysis (SFA) framework as a novel invention that can bridge the literature gap. This is done by providing the theoretical lens which discusses activities and events that happened in DTI innovation system to a detailed breakdown of its structural changes or functional changes, remembering that those events contribute to bring DTI innovation to later phases.

2) Add to the body of knowledge of the research domain

First, this study adds to the body of knowledge in innovation process management (Rogers, 1995; Van de Ven et al., 1999), as it explains how innovation system activities/events/characteristics can determine the movement of innovation phase (initiation, development, and implementation). It combines collective action model of institutional innovation (Hargrave and Van de Ven, 2006; Rukanova et al., 2017) and functions of innovation system theory (Hekkert et al., 2007; Bergek et al., 2010) as the foundation to identify blockages and unblocking mechanisms of the innovation process. This framework serves as additional concept that can be used to understand digital trade infrastructures innovation process from one phase to later phases by looking at the dynamics of innovation system which consist of both functional and structural evolutions.

This study also extends the knowledge regarding digital trade infrastructures (DTI) (Klievink et al., 2012; Jensen & Vatrapu, 2015; Rukanova et al., 2017). Adding collective action model, functions of innovation system and innovation process to DTI body knowledge enhance the concept with immense insights regarding DTI innovation management. Existing studies have ignored what 'happens' in such DTI initiatives, and the mechanisms to mobilise DI innovation. Instead, they only focused on discussing the anatomy of DTI, by looking in-depth at the process, governance, type, and architecture. On the other hand, this framework offers detailed explanation on how activities within DTI development evolve and influence the continuity of DTI innovation development.

Next, this study enriches the body of knowledge in collective action model of institutional innovation, especially in DI environment (Hargrave and Van de Ven, 2006; Rukanova et al., 2007, Rukanova et al., 2017). Adding functions of innovation system from Hekkert et al., (2007) (as functional analysis of innovation system) to this knowledge extends the applicability of collective action model in addressing issues and blockages in innovation system. Traditionally, the collective action model only explains the process from framing to the collective action process. With additional insight from the innovation system functions, collective action model can be used to explain the mechanisms to address indicators that weaken functions of innovation system. Therefore, there is the extension of collective action model

by connecting the steps of collective action process to weakening indicators that appear in such innovation system.

Lastly, this framework contributes to enrich the functions of innovation system (FIS) theory by making a connection between the functions of innovation system, blockages that weaken the function, and the strategy to tackle the blockages based on collective action model. Existing studies of FIS (Hekkert et al., 2007) focus only on explaining cumulative events that occur in innovation system, that serve as a fulfilment of certain functions in innovation system. The applicability of this concept is limited on explaining the changes of innovation system functions within a certain time period, but it does not explain the blocking factors for weak functions and particular mechanisms to reinforce the functions (which in this research we call it as the 'unblocking mechanisms'). Bergek et al. (2008) extended FIS theory by creating an innovation system analysis scheme. However, the study has neglected the process of collective action as part of an innovation system. The study focuses on general TIS analysis, while SFA framework focuses on DI as the specific knowledge field. Collective action process is very important for DI innovation process as DI is characterised as an open, shared, heterogeneous, and evolving information technology system. The SFA framework adds the urge of analysing weakening indicators that weaken the system and applying collective action process to address the blocking mechanisms in order to mobilise the digital innovation, getting it closer to adoption.

3) As a new foundation for other research

In this research, international trade domain serves as the main field of research due to the research background discussed in Chapter 1. However, the result of this research also contributes to the enrichment of digital infrastructures (DI) knowledge. It is possible to apply this framework to explain the dynamics of digital infrastructures innovation system for other fields which are characterised by highly-regulated environment and multi-level actors such as the Energy and Healthcare fields.

6.2.2. Practical Contributions

1) As a tool for practitioners to understand the dynamics of technological innovation process

This framework enables practitioners (e.g., business and policy makers) to understand the success and failure of a technological innovation as it incorporates FIS that traditionally aims to discover the dynamics of innovation system. It assists stakeholders to understand what functions serve as underperforming functions and what functions serve as predominant ones. Additionally, collective action model as a basis for structural analysis helps to recognize stakeholders' engagement and collective action efforts within the innovation system that occurred over a period of time. The innovation trajectories that can be explained by the application of this framework are not limited to international trade domain, but it can be applied to other domains characterised by highly-regulated environment and multi-level actors such as Energy sector.

2) As a tool for practitioners to identify the mechanisms to mobilise innovation to market

This framework helps to identify what can possibly go wrong in an innovation system, both regarding weak functions and structural issues. These 'wrong' issues may contribute to slow-moving innovation process toward implementation. The blocking factors which appear and weaken the system functions can be addressed by the unblocking strategy based on the collective action model and FIS approach. Before deciding on what unblocking strategy that has to be conducted, blockages should be thoroughly identified. As explained in Chapter 5, although some blockages may not be handled by the unblocking strategy with collective action model and FIS approach, innovation can still be mobilised as long as there is continuity of vision, networks, funding, and process.

6.2.3. Actionable Recommendations

The SFA framework can be used by innovation system analysts or project coordinators to ensure that the innovation project is going towards the desirable direction. Analysts can review the structural aspects of an innovation system such as political issues, what frames that are emerged, and construction of the network along the innovation projects. While they are reviewing innovation system structural changes, innovation system functioning should also be assessed, to know whether an innovation system is capable to achieve their objectives or not. Logically, the issues that disturb system's structure and functioning will be discovered as those analyses are conducted. If the aim of the framework application is to understand the innovation process, then further analysis can be done to identify whether any unblocking strategies are emerged and able to reinforce system's function in the later phase. On the other hand, if the aim of the application is to identify the mechanisms to mobilise innovation, then the identified issues from those analyses can be further discussed by project coordinators, so that the blockages can be removed in the future by such innovation policy or any other efforts such as sense-making and framing. Hence, the innovation process can be smoothened.

6.2.4. Contributions to the Management of Technology

Management of Technology program's graduates are expected to execute a research which related to technology utilisation by the commercial stakeholders to develop their business and improve outcome such as profitability and customer satisfaction. In this research, DI utilisation in the trade domain can be perceived as such technology utilisation. This report explains the understanding of most stakeholders within the innovation system to utilise data pipeline as the possible technology advancement to improve supply chain visibility. In addition, this study elucidates the mechanism to identify the issues which hamper the adoption of such technological innovation. Knowledge concerning the issues that hamper technological innovation development and possible strategy to address the issues are very important for technology management field.

The project members can be assumed as the actors who manage DI technology so that it can be beneficial for the whole supply chain. This study is able to help project members with problems identification related technology innovation development. Moreover, it also contributes to enrich the management of technology-related knowledge by demonstrating a framework application to understand deeper DI innovation process from system's perspective. It reports an extension to the knowledge regarding innovation process management, not only from business actors' perspective, but

also from governments' perspective, as DI is a shared technology that provides benefits for both public and private parties. It offers novel way for technology managers, project coordinators, and governments to understand the process of innovation development by looking at organisations and institutions that comprise the innovation system.

6.3. Research Limitations and Future Recommendations

6.3.1. Research Limitations

First, the case study done in this research is only concerned on data pipeline as digital trade infrastructures innovation. Hence, the findings in this study might be limited to generalise other DTI, such as single window and national community hubs. In reality, DTI knowledge field is not only limited to data pipeline concept. However, due to time constrain and the intention to derive in-depth understanding, we conducted this single case study of data pipeline innovation process. Second, the discussion limits the scope of innovation system into project setting. In reality, innovation system is way more complex. However, to define the research scope, we focused on discussing the innovation project setting as the innovation system. Third, this framework only focuses on digital innovation in the international trade domain from the experience of the European Union. There might be other experiences on digital innovation process in other domains, such as Energy or Healthcare, and also from different regions or governments bodies.

There are also some potential biases that appear in this research.

First, the role of the author as a project participant could possibly create data collection bias. The role of the author in one of the project as an observer would not influence the collected data. Nevertheless, this condition allows project documents, both confidential and public documents, to be accessible for the author. Thus, the availability of the documents may be different for other researchers. Second, most of the reviewed documents are part of project deliverables and they might include biased information concerning the project. Some project documents may only inform the successful outcome and hide the unexpected outcome which may also occur. Third, the two supervisors of this research held double role as both key informants and supervisors. Bias may appear as the supervisors have stake at the projects. As a result, data provision and connection to the other interviewees were made available slightly immediate than if the supervisors were not the key informants.

Next, participant selection bias may appear in this research as we only involved limited interviewees in our data collection method. We aimed to involve participants that can help us provide necessary information to support the research objectives. However, we selected the interviewees based on extensive discussion between author and key informants of one of the project. Bias might appear in this process as both the author and key informants depended on their network and knowledge regarding proposed interviewees. There are various stakeholders that joined the projects but there are very limited actors that we assume have relevant knowledge and play an active role on all the four projects. Therefore, there were only three interviewees that we involved to provide richer information. Last, the interview process might have difficulties in retrospective sense-making as we demanded information regarding past events which were occurred around 12 years ago.

The biases can lead to false conclusions. To minimise these biases, we incorporated project documents which available online, besides project deliverables. In addition, we did not rely heavily on project documents to provide data, but also from interviewees' personal opinion. Thus, we were able to dig personal experience of project participants, whether they satisfied with the projects or not. However, double role, participant selection, and retrospective sense-making biases were difficult to minimise. Possible informants who have relevant knowledge regarding the relation between the observed projects and have available time within planned schedule to support the research are very limited.

6.3.2. Further Recommendations

To address the limitations, further research is suggested to be able to improve the conceptual framework based on empirical study to other DTI innovation, and also to increase generalisability of the research to wider practice not only to the data pipeline innovation. Moreover, it is suggested that the observed innovation system in further research can incorporate all networks, institutions, and regulations that provide the innovation system and not limited to project setting. Hence, the complexities are increased and richer understanding of dynamic environment of innovation system can be obtained. If possible, unblocking strategy concept can be extended and incorporate different perspectives, outside of the innovation system analysis and collective action model.

Lastly, it is suggested to apply this framework to other domains that are also characterised by highly-regulated environment, such as Energy and Healthcare. Thus, the framework can also be used as a tool to manage digital innovation process mobilisation in wider domains. Concerning biases, adding more interviewees and selecting them on a basis of randomisation that align with the study aims can help decrease dependency towards project documents. It provides additional data sources which support higher validity of the findings. This recommendation can also prevent biases such as data collection and participant selection biases to emerge.

6.4. Reflection towards Research Execution

The journey of my research execution started in fall 2017. I found that my interest in innovation management of international supply chain domain is aligned with the project of Prof. Yao-Hua Tan and Dr. Boriana Rukanova regarding IT innovation development to enhance safe and secure trade lanes. Extensive contacts with Dr. Rukanova have allowed me to sharpen the direction of my final research. Approximately four months before my research project officially started, the time was spent to read the literatures, in order to identify research gaps and regularly consult the immediate findings from the literature review. Eventually I found my research focus based on reviewing some literatures and the guidance from Dr. Rukanova.

As time passes by, a research proposal had to be prepared. The preparation had started since three months before the project was started as I took the course of master thesis preparation. Within these months, I struggled to complete the proposal as I had to present the problem background, proposed idea for the research, and provided realistic planning. This was not an easy task, but it was necessary to sharpen the research execution. Once the proposal was done, the project started in February 2018 as planned.

“Don’t be trapped by dogma—which is living with the results of other people’s thinking. Don’t let the noise of others’ opinions drown out your own inner voice. And most important, have the courage to follow your heart and intuition.” – *Steve Jobs*

Sometimes I feel like I made more significant progress compared to some people, while sometimes I also feel that I am progressing slowly compared to some other people. This insecurity haunted me and made me doubt my own capability. I was paying attention too much on how others conduct their research project and kept comparing my progress to theirs. Hence, I decided to be a bit more individualistic and to only focus on my own research planning. Being an individualist means working alone in my own room or a silent room at the library. To ensure life balance, I still spend my spare time during weekend by doing social and sport activities.

“And when your journey seems too hard, and when you run into a chorus of cynics who tell you that you’re being foolish to keep believing or that you can’t do something, or that you should just give up, or you should just settle—you might say to yourself a little phrase that I’ve found handy these last eight years: Yes, we can.” – *Barack Obama*

The actual research execution was a bit delayed as data collection activities also depended on other parties’ availability time. As a result, the period for data analysis execution was shortened. While waiting for the scheduled interviews, I started to write the report and some parts in the last chapter. Once the interview data were gathered, the part of report that should be finished was only around two chapters as the results of parallel works between data collection and draft writing, so the time to work on writing the report after data collection and analysis can be shortened.

The last round of completing the research project appeared as the most challenging period for me. The boredom often disturbed me from progressing on my research project. Sometimes I felt like I am not confident enough to finalise this research as I underestimated my own capability for random reasons. Yet, when I found myself in such condition, I tried to lift my mood to work on the report and convinced myself that I am capable to finalise this research, similar to the quote from Barack Obama, saying “Yes. We can.”

REFERENCES

Antovski, L., & Gusev, M. (2003). 'M-payments', in information technology interfaces. *Proceedings of the 25th International Conference ITI 2003*, (pp. 95-100).

Arsyida, T. (2017). *Trade and compliance cost model in international supply chain.* Delft: Master Thesis TU Delft.

Bergek, A., Jacobsson, S., & Hekkert, M. (2010). Functionality of innovation systems as a rationale for and guide to innovation policy. *RIDE/IMIT Working Paper*.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation system: a scheme of analysis. *Research policy 37*, 407-429.

Bianco, W., & Bates, R. (1990). Cooperation by design: leadership, structure, and collective dillemas. *Americal Political Science Review 84 (1)*, 133-147.

Brandenburger, A., & Nalebuff, B. (1997). *Co-opetition.* Strawberry Hills Australia: Currency.

Campbell, J. (2002). Where do we stand? Common mechanisms in organizations and social movement research. *Social Movements and Organization Theory Conference.* Ann Arbor.

De Reuver, M., Verschuur, E., Nikayin, F., Cerpa, N., & Bouwman, H. (2015). Collective action for mobile payment platforms: A case study on collaboration issues between banks and telecom operators. *Electronic Commerce Research and Applications 14 (5)*, 331-344.

Edquist, C. (2001). Innovation systems and innovation policy: the state of the art. *Nelson-Winter Conference.* Aalborg: DRUID.

Edwards, P., Jackson, S., Bowker, G., & Knobel, C. (2007). *Understanding infrastructure: Dynamics, tensions, and design. Report, History and Theory of Infrastructure: Lessons for New Scientific Cyberinfrastructure workshop.* University of Michigan,Ann Arbor.

Eisenhardt, K. (1989). Building Theories from Case Study Research. *The Academy of Management Review, 14(4)*, 532-550.

Elaluf-Calderwood, S., Eaton, B., Herzhoff, J., & Sorensen, C. (2011). Mobile platforms as convergent systems - analysing control points and tussles with emergent socio-technical discourses.

EU CORE project . (2015). *EU CORE project*. Retrieved from EU CORE project: http://www.coreproject.eu/

European Commission. (2018). *REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL.* Brussels: European Commisision.

Freeman, C. (1987). *Technology Policy and Economic Performance: Lessons from Japan.* London: Pinter Publishers Ltd.

Frößler, F., Rukanova, B., Higgins, S., Klein, S., & Tan, Y. (2007). Inter-Organisational Network Formation and Sense-Making: Initiation and Management of Public Collaboration. *20th Bled eConference eMergence: Merging and Emerging Technologies, Processes and Institutions.* Bled.

Galetta, A. (2013). *Mastering the semi-structured interview and beyond - From Research Design to Analysis and Publication.* London: New York University Press.

Hanseth, O., & Lyytinen, K. (2010). Design theory for dynamic complexity in information infrastructures: the case of building internet. *Journal of information technology 25(1)*, 1-19.

Hargrave, T., & Van de Ven, A. (2006). A collective action model of institutional innovation. . *Academy of Management Review 31 (4)*, 864-888.

Hayes, N. (2000). Work-arounds and boundary crossing in a high tech optronics company: The role of co-operative workflow technologies . *Computer Supported Cooperative Work 9 (3/4)*, 435-455.

Heckathorn, D. (1993). Collective action and group heterogeneity: voluntary provision versus selective incentives. *Am. Sociol. Rev. 58 (3)*, 329-350.

Hekkert, M., Suurs, R., Negro, S., Kuhlmann, S., & Smits, R. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological forecasting and social change 74*, 413-432.

Henfridsson, O., Mathiassen, L., & Syahn, F. (2014). Managing technological change in the digital age: the role of architectural frames. *Journal of Informaton Technology 29(1)*, 27-43.

Jensen, T. (2015). *Can the cloud lift global trade?* Retrieved from Maersk: http://www.maersk.com/en/the-maersk-group/about-us/publications/maersk-post/2015-2/can-the-cloud-lift-global-trade

Jensen, T., & Vatrapu, R. (2015). Ships & roses: a revelatory case study of affordances in international trade. *23rd European Conference on Information Systems (ECIS).*

Klein Woolthuis, R., Lankhuizen, M., & Gilsing, V. (2005). A system failure framework for innovation policy design. *Technovation Vol 25*, 609-619.

Klein, S., & Schellhammer, S. (2011). Developing IOIS as collective action: A cross country comparison in health care sector. *System Sciences (HICSS)*.

Klievink, B., van Stijn, E., Hesketh, D., Aldewereld, H., Overbeek, S., Heijmann, F., & Tan, Y. (2012). Enhancing Visibility in International Supply Chains: The Data Pipeline Concept. *International Journal of Electronic Government Research, 8(4)*, 14-33.

Maimbo, H., & Pervan, G. (2005). Designing a Case Study Protocol for Application in IS research. *Pacific Asia Conference of Innovation System*, 106.

Minstrom, M., & Vergari, S. (1996). Advocacy Coalitions, Policy Entrepreneurship, and Policy Change. *Policy Studies Journal Vol. 4 no. 3*, 420-434.

Monge, P., Fulk, J., Kalman, M., Flanagin, A., Parnassa, C., & Rumsey, S. (1998). Production of collective action in alliance-based interorganizational communication and information system . *Organizational Science 9 (3)*, 411-413.

Monteiro, E., Pollock, N., & Williams, R. (2014). Innovation in information infrastructures: Introduction to the special issue. *Journal of the association for information systems 15 (4)*, 1-3.

Negro , S., Hekkert, M., & Smits, R. (2007). Explaining the failure of the Dutch innovation system for biomass digestion-a functional analysis. *Energy policy 35*, 925-938.

Nijdam , M., Romochkina, I., & van Oosterhout, M. (2012). *Cassandra Stakeholder Analysis-update.* European Commission.

Nikayin, F., de Reuver, M., & Itälä, T. (2013). Collective action for a common service platform for independent living services. *International journal of medical information 82*, 922-939.

Olson, M. (1965). *The Logic of Collective Action.* Cambridge: Harvard University Press.

Ortt, R. (2010). Understanding the Pre-diffusion phases. *Journal of Product Innovation Management*, 5-18.

Pettigrew, A. (1990). Longitudinal field research on change: theory and practice. *Organization science Vol 1 no. 3*, 267-292.

Pohlmann, M., Gebhardt, C., & Etzkowitz, H. (2005). The Development of Innovation Systems and the Art of Innovation Management—Strategy, Control and the Culture of Innovation. *Technology Analysis and Strategic Management*.

Rogers, E. (1995). *Diffusion of Innovation.* New York: The Free Press.

Rukanova , B., Henningsson, S., Tan, Y., & Henrikssen, H. (2017). The Anatomy of Digital Trade Infrastructures. *BIR Conference Proceedings 2017, Lecture Notes of Business Information Processing.* Springer.

Rukanova, B., De Reuver, M., Henningsson, S., Nikayin, F., & Tan, Y. (2017). Overcoming blockages to collective innovation in digital infrastructures: the case of mobile payment. *25th European Conference on Information Systems*, 1-14.

Rukanova, B., Henningsson, S., Henriksen, H., & Tan, Y. (2018). Digital Trade Infrastructures: A Framework for Analysis. *Complex Systems Informatics and Modeling Quarterly 80(14)*, 1-21.

Rukanova, B., Henrikssen, H., Von Raesfeld, A., Van Stijn, E., & Tan, Y. (2007). A collective action perspective on technological innovation in business/government networks. *Proceedings of the European Conference on Information Systems*, (p. 194).

Sabatier, P. (1988). An advocacy coalition framework of policy change and the role of policy-oriented learning therein. *Policy Sciences 21*, 129-168.

Sagar, A., & Holdren, J. (2002). Assessing the global energy innovation system: some key issues. *Energy Policy 30 (6)*, 465-469.

Silverman, D. (2005). *Doing qualitative research: a practical handbook.* London: SAGE Publications Ltd.

Sørensen, C. (2012). *Digital Platform and Infastructure Innovation.* Tokyo: Nikkan Kogyo Shimbun.

Suurs, R., & Hekkert, M. (2009). Cumulative causation in the formation of a technologial innovation system: the case of biofuels in the Netherlands. *Technological forecasting & social change 76*, 1003-1020.

Tan, Y., Bjørn Andersen, N., Klein, S., & Rukanova, B. (2011). *Accelerating Global Supply Chains with IT-innovation.* Berlin: Springer.

Tilson, D., Lyytinen, K., & Sørensen, C. (2010). DigitalInfrastructures: The Missing IS Research Agenda. *Information Systems Research*, 1-12.

UNECE. (2005). *Recommendation and Guidelines on establishin a Single Window.* Geneva: United Nations.

Van de Ven, A., Polley, D., Garud, R., & Venkataraman, S. (1999). *The Innovation Journey.* New York: Oxford University Press.

van Engelenburg, S., Janssen, M., Klievink, B., & Tan, Y. (2017). Comparing a Shipping Information Pipeline with a Thick Flow and a Thin Flow. *Electronic Goovernment: 16th IFIP WG 8.5 International Conference, EGOV 2017.* St. Petersburg.

van Stijn, E., Hesketh, D., Tan, Y., Klievink, B., Overbeek, S., Heijmann, F., . . . Butterly, T. (2011). The Data Pipeline. *Global Trade Facilitation Conference 2011 Connecting International Trade Single Windows and Supply Chains in the Next Decade* (pp. 1-26). European Commission.

Verschuren, P., & Doorewaard, H. (2010). *Designing a research project.* The Hague: Eleven international publishing.

Walsham, G. (1993). *Interpreting information systems in organizations.* Chichester: Wiley.

Webster, J., & Watson, R. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quarterly, Vol. 26, No. 2* , 13-23.

Yin, R. (1994). *Case study research.* Thousand Oaks, CA: SAGE Publication Inc.

Yoo, Y., Lyytinen, K., & Yang, H. (2005). The Role of Standards in Innovation and Diffusion of Broadband Mobile Services: The case of South Korea. *Journal of Strategic Information*, 323-353.

Appendices

Appendix A: Sources of collected data with code lists

Table 22: Documents list

Projects	Documents code	Documents name	Authors	Documents categories
ITAIDE	IT-1	ITAIDE project	CORDIS-EU	website pages
	IT-2	Inter-Organisational Network Formation and Sense-Making: Initiation and Management of Public-Private Collaboration	Frossler et al.	academic journals
	IT-3	Moving an eInnovation from a Living Lab to the Real World: Politically Savvy Framing in ITAIDE's Beer Living Lab	Van Stijn et al.	academic journals
	IT-4	A Collective action perspective on technological innovation in business/government networks	Rukanova et al.	academic journals
	IT-5	Analyzing Living Labs as part of the complete innovation development process	Jessurun et al.	academic journals
	IT-6	The First (Beer) Living Lab: Learning to Sustain Network Collaboration for Digital Innovation	Frossler et al.	academic journals
	IT-7	Bringing IS Innovation in a highly-regulated environment: a collective action perspective	Rukanova et al.	academic journals
	IT-8	Understanding the influence of multiple levels of governments on the development of inter-organizational systems	Rukanova et al.	academic journals
	IT-9	Beer Living Lab Report on redesign of administrative processes D5.1:2	ITAIDE consortium	project deliverables
	IT-10	Beer Living Lab – Final Report D5.1:5	ITAIDE consortium	project deliverables
	IT-11	Beer Living Lab Report on Initial Site Survey and Problem Definition D5.1:1.	ITAIDE consortium	project deliverables
	IT-12	Accelerating Global Supply Chains with IT-innovation	Tan et al.	book
INTEGRITY	IN-1	Integrity website	INTEGRITY consortium	website pages
	IN-2	Newsletter 1	INTEGRITY consortium	newsletter

	IN-3	Newsletter 2	INTEGRITY consortium	newsletter
	IN-4	Newsletter 3	INTEGRITY consortium	newsletter
	IN-5	Newsletter 4	INTEGRITY consortium	newsletter
	IN-6	Newsletter 5	INTEGRITY consortium	newsletter
	IN-7	Final report	INTEGRITY consortium	project deliverables
	IN-8	Project description	INTEGRITY consortium	project deliverables
CASSANDRA	CA-1	Cassandra website	CASSANDRA consortium	website pages
	CA-2	Seamless electronic data and logistics pipelines shift focus from import declarations to start of commercial transaction	Hesketh	academic journals
	CA-3	A Web-Based Data Pipeline for Compliance in International Trade	Overbeek et al.	academic journals
	CA-4	Stakeholder Analysis	CASSANDRA consortium	project deliverables
	CA-5	Final report	CASSANDRA consortium	project deliverables
CORE	CO-1	CORE website	CORE consortium	website pages
	CO-2	The anatomy of digital infrastructures	Rukanova et al.	academic journals
	CO-3	Comparing a Shipping Information Pipeline with a Thick Flow and a Thin Flow	Van Engelenburg et al.	academic journals
	CO-4	Coordinated Border Management through Digital Trade Infrastructures and Trans-national Government Cooperation: The FloraHolland case	Rukanova et al.	academic journals
	CO-5	Understanding transnational information systems with supranational governance: A multi-level conflict management perspective	Rukanova et al.	academic journals
	CO-6	Newsletter	CORE consortium	newsletter
	CO-7	Newsletter 2	CORE consortium	newsletter
	CO-8	Application and refinement of Public-Private Governance Model (PPGM)	CORE consortium	project deliverables
	CO-9	Final event notes	author	field notes
GENERAL	GE-1	Report from the commission to the European parliament and the council on the implementation of the Union Customs Code and on the exercise of the power to adopt delegated acts pursuant to Article 284 thereunder	EC	report

	GE-2	Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Regulation (EU) No 952/2013 to prolong the transitional use of means other than the electronic data-processing techniques provided for in the Union Customs Code	EC	proposal

Table 23: List of interviewees

Interviewee code	Interviewee category	Organizations	Position of the interviewee
YT	University	TU Delft	ICT department researcher
FH	Government organizations	DTCA (Dutch Tax and Customs administration)	Director National Trade Facilitation
FI	Government organizations	Dutch Ministry of Finance	IT auditor

Appendix B: Interview protocol

The interview protocol for the projects' participants

Project: Master Thesis TU Delft student "Identifying Blockages and Unblocking Mechanisms for Digital Trade Infrastructures Innovation Process"

Date: _____
Time: _____
Location: _____
Interviewer : Siti Arna Arifah Arman
Interviewee: _____

Approximate length of the interview: 1-1.5 hours

The interview's question list

I. Information about the interviewee:

Note**:** *Approximate length of this interview session is 5 minutes*

- How long have you been working in international supply chain field?
- Are you currently still involved in an EU-funded project related to international supply chain?
- If yes, what is your current role in that project?
- In which projects among ITAIDE, INTEGRITY, CASSANDRA, and CORE have you actively participated?
- What were your roles and/or responsibility on those projects?

II. Structural and functional analysis-related questions

Note: *Approximate length for this session is 35 minutes. These questions will be applied to all of innovation projects.*

Structural analysis

- How was the evolution of regulatory environment for IT innovation in customs and trade?
- Are there any powerful regulations which support IT innovation in trade facilitation which emerges during the process?
- How was the initiation of these projects? (e.g., *the participants engagement, consensus building, proposal signing*)
- Based on my initial analysis, I noticed that numbers and roles of participants for these projects change over time, can you explain about the ideas behind stakeholders' engagement which evolve accordingly through these projects? (e.g., *existing networks, continuity of vision*)

- Was there any issue regarding stakeholder engagement? If yes, what was the cause of those issues? (e.g., *rejection*)
- What was the main focus of this project? (e.g., *concept, objectives, technology that has to be developed*)

Functional analysis

- Can you explain about the differences of major R&D activities in these projects?
- From your experience, how was the dissemination of these projects' outcome? (e.g., *publications, how many articles*)
- Did the outcome lead to major regulation changes?
- Do you think that there were numerous emerging users or potential market after the project was finished?
- (*Showing proportion of EU-private funding*) How is your opinion regarding financial and human resources of these projects?
- How was the coalition of project's participants? (e.g., *all participants shared the same principle*)
- Was there any issue related to actors' conflicts during the project?
- Related to functions of innovation system theory, it suggests that innovation initiatives perform certain functions to make sure that it can reach commercialization. I discovered that all those 4 projects performed all the functions but I want to know your opinion, which function is the strongest and the weakest for each project? Can you explain the reasons of your arguments?

III. Blocking and unblocking mechanisms-related questions

Note: *First, interviewer will explain shortly the conceptual model of the research for 5-8 minutes. Approximate length of this interview is 12 minutes.*

Blocking and unblocking mechanisms

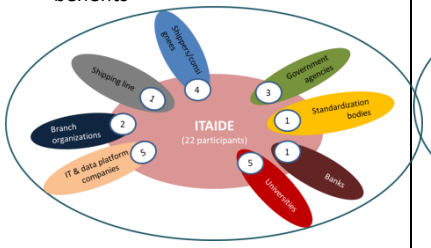
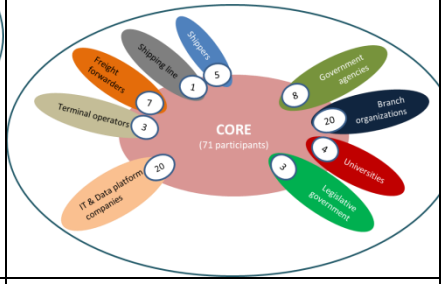
- How was the ending of each project? (e.g., *agreed upfront, conflicts*)
- What were the bottlenecks for each of projects?
- Do you think these bottlenecks influence the performance of project's functioning?
- Do you think that the bottlenecks which emerged in each project are tackled in later projects? (e.g, *refining the technology, engaging wider stakeholders*)
- What is your general impression about this conceptual model? Do you have additional comments on this?

IV. Closure

- Thank you to interviewee
- Reassure confidentiality
- Ask permission to follow-up

Appendix C: Initial conceptual framework application

Table 24: Initial conceptual framework application

		ITAIDE	INTEGRITY	CASSANDRA	CORE
Structural Analysis	**Political opportunity**	• Terrorism attack , 9/11 tragedy • Multi-Annual Strategic Plan (MASP) 2003 • SAFE Framework by WCO • Rising of Public-Private Partnership (PPP) approach • Modernized Customs Code by DG TAXUD • FP6-IST Framework Programme of EU	• SAFE Framework by WCO • Modernized Customs Code by DG TAXUD • New security regulations (ISPS, EU-COM 2003-0229, 2004-0076, US CSI, US C-TPAT) • FP7-Transport Framework Programme of EU	• Preceding projects co-funded by EU (ITAIDE & INTEGRITY) • SAFE framework by WCO • Transition to Union Customs Code by DG TAXUD • FP7-Security Framework Programme of EU	• Preceding projects co-funded by EU (ITAIDE, INTEGRITY & CASSANDRA) • SAFE framework by WCO • Union Customs Code by DG TAXUD • Blockchain emergence • FP7-Security Framework Programme of EU
	Construction of networks	• 22 participants • **Stakeholders categories**: Government agencies, standardisation bodies, banks, universities, IT & data platform companies, branch organizations, shipping line, and shippers • Focus on **shippers**' usability and benefits 	• 17 participants • **new actors**: freight forwarders, port authorities, and terminal operators • DT remain here from ITAIDE as participant • Focus on **terminal operators** and **port authorities** usability and benefits 	• 26 participants • **new actors**: no specific categories, number of partners are increasing • Actors from ITAIDE project and INTEGRITY project were partially merged in CASSANDRA, such as IB and MK • DT, SE, BAP, IL, HM, and ERM here from INTEGRITY as participants. • Focus on **freight forwarders** usability 	• 71 participants • **new actors**: more branch organizations in security domain, more universities even from US, more shippers, more freight forwarders from across EU, interpol (international security agency) • DT, SE, IL, HM, IB remain here from CASSANDRA as participants • IB and MK remain in the networks since ITAIDE, CASSANDRA, and CORE • Focus on **large scale demonstration** and improve **shippers**' usability 
	Framing	• Problem: need to increase security and efficiency of supply chain according to SAFE framework • Proposed solutions: piggybacking principle (re-use business data for government control purposes) and data pull vs data push (pull data from business), service oriented approach	• Problem: DTI concept was tested in limited stakeholders networks and not yet covering the applicability in worldwide logistics perspective • Proposed solutions: SICIS • Way to reach outcome: SICIS pilot along EU-China trade lanes, international level initiative	• Problem: data pipeline still need improvement as the sources of data were limited in preceding projects and the awareness of data pipeline needs to be increased for both business and authorities • Proposed solution: integrated data pipeline and trusted trade lanes concept • Way to reach outcome: massive	• Problem: data pipeline upscaling issue • Proposed solution: thick and thin data pipeline and further operationalization of the Trusted Trade Lanes • Way to reach outcome: large scale demonstration on global level

		• Way to reach outcome: 4 Living Labs within EU initiative		dissemination, technology development, pilot projects on international level (EU-US, EU-China, EU-Africa)	
	Discontinuity	• Discontinuity was agreed upfront that the project would end in 2010 • Main bottleneck: No adequate legislation coverage for Living Labs solution	• Discontinuity was agreed upfront that the project would end in 2011 • Main bottleneck: terminal operators unable to provide original consignment information while project has to be stopped	• Discontinuity was agreed upfront that the project would end in 2014 • Main bottleneck: lack of shippers role and willingness of actors to share data	• Discontinuity was agreed upfront that the project would end in 2018
Functional Analysis	**Entrepreneurial activities(F1)**	• This project was initiated by an actor from university, who became knowledge brokers and framed other actors during brainstorming sessions to participate on this project • This project was initiated due to commercial needs of one individual company, the adoption of ITAIDE solutions by a beer company was not realized due to conflicting regulation issue	• Inspired by ideas developed in ITAIDE, ISL as the project coordinator invited actors from different role to join the project • This project was initiated due to need for testing DTI concept in wider scale, the market for this innovation is growing • An individual company adopt the innovation but it was not taken into wider scale due conflicting regulation issue	• Network of actors that built in preceding projects was merged, thus there were some actors that brought vision from preceding projects • This project was initiated to test DTI with freight forwarders as the main lead and to disseminate data pipeline concept, as the number of testing were growing, the market also evolved	• With the vision brought by actors in preceding projects, this project was initiated to test data pipeline concept in large-scale demonstration with shippers as the lead of the project • ESC as the project lead influenced individual shippers to participate actively in pilot projects • More shippers participate actively in data pipeline pilot • Most of data pipeline pilot were successfully demonstrated and will soon to be adopted by some companies (e.g., GTD from IB and MK)
	Knowledge development(F2)	• 4 Living Labs (Beer, food, drugs, and pulp and paper) • Technical R&D activities involving many actors in international level • R&D budget is sourced from both governments and privates • Dissemination circle reaches international level	• SICIS architecture development • SICIS demonstration from port in China-Europe-UK • R&D budget is sourced from both governments and privates • Dissemination circle reaches international level, with contribution from ISL, the dissemination circle is enlarged • Multi actors are involved in R&D projects (port authorities, terminal operators)	• 3 Living Labs to test Global Data Pipeline • Testing piggy-back concept, re-use validated packing list data for customs purpose • Piloting optional dual-filing in Customs Dashboard, to gives Dutch customs access to all additional data from real source • Development of DTI was rather incremental, increasing usability and authorization • R&D budget is sourced from both governments and privates, increasing • Dissemination circle reaches international level, with contribution from merged communities the dissemination circle is enlarged	• 23 Working Packages consists of requirement analysis • 10 demonstration with shippers and port operators • Large scale demo with IB and MK • Development of thick and thin data pipeline • R&D budget is sourced from both governments and privates (massive funding 50 million euro) • Dissemination circle reaches global level as the effect of resources mobilisation (both funding and ranging stakeholders) , the dissemination circle is enlarged •
	Knowledge diffusion(F3)	• A book consists of 16 studies was published, with title "Accelerating Global Supply Chains with IT innovation' • Almost 50 papers were released	• INTEGRITY representatives presented the works on around 25 conferences and workshops worldwide • Press releases, newsletters, project information are accessible online	• Data pipeline ideas were presented at key conferences held by WCO and published WCO journal • This project aimed to disseminate data pipeline concept, and the dissemination	• CORE concepts are presented in more than 50 conferences worldwide, and CORE partners held numerous workshops such as The Core project - Building The Internet for Logistics

		during ITAIDE era and submitted to numerous conferences such as ECIS, EIS, RSEEM, ACIS, etc. • ITAIDE movie • Circle of audiences is limited • Project documents are very limited		coverage level was reaching World Customs Organization-level • Press releases and project documents are accessible online	• CORE movie • Project documents are accessible online
	Guidance of the search(F4)	• EU's MASP as the basis for eCustoms development • Approximately more than 50 articles were published with strong emphasis on DTI as solution for trade issue • Modernized customs code with AEO approach • ITAIDE movie • EMCS system developed by EC halt the implementation of Beer LL solution	• EU's MASP as the basis for eCustoms development • Modernized customs code with AEO approach • Extensive participations from INTEGRITY consortium on numerous conferences related to ICT and transport logistics unfolded from 2008-2011, resulting in many parties raised positive expectations and interested in joining CASSANDRA • Global level dissemination, supported by IL	• Transition to Union Customs Code • Extensive dissemination from CASSANDRA consortium on numerous key international trade conference unfolded from 2011-2014, resulting in many parties raised positive expectations and interested in joining CORE • Global level dissemination, supported by merged communities from ITAIDE and INTEGRITY • Freight forwarders' negative expectations appear due to data sharing issue	• Massive funding from both government and privates, shows positive expectations from both parties • Transition to Union Customs Code • Extensive participations from CORE consortium on numerous conferences, publications, and work packages, to increase positive expectations for all potential user • CORE movie • Global level dissemination, supported by 71 CORE participants
	Market formation (F5)	• Living Labs as temporary niche markets to raise awareness of DTI to potential users • EMCS developed by EU was not comply with Beer LL solution, market formation was blocked	• Real demonstration of SICIS as temporary niche market to raise awareness of DTI to terminal operators • An individual company adopt the innovation but it was not taken into wider scale	• 3 Living Labs for data pipeline pilot project as temporary niche market • UCC emerges and brings supporting environment for data pipeline implementation • Standardisation and users' dashboards are improved	• 10 demonstrators and large-scale demo as temporary niche markets • Some demonstration ended up with concrete adoption of DTI (e.g., GTD developed by IB and MK) • UCC emerges and brings supporting environment for data pipeline implementation
	Resource mobilisation(F6)	• **Financial**: 5.8 million euro from EU, 1.8 million euro from other actors, in total almost 7.6 million. Public funding plays bigger role, 76% of total financial costs	• **Financial**: total cost approximately 10.8 million, EU contribute 6.5million , the rests are co-funded by business. EU contribution is decreasing into 60%.	• **Financial**: total cost approximately 15 million euro, with EU Contribution approximately 10 million euro. Contribution of EU rising to 67%.	• **Financial**: total budget approximately 50 million euro. Comparing to preceding projects, EU contribution for this project is the lowest, below 60%. There are quite significant investments from private funding.
	Advocacy coalitions(F7)	• Pressure on actors in power to change and complementing the technology started to grow as the results of Living Labs • EU EMCS application hampering the technology adoption • Coalitions in this project was not sufficiently strong to lobby the legislators for the implementation issue, but enough to attract EU to fund the program and influence EU way of thinking	• Coalitions in this project was not sufficiently strong to lobby the legislators for the implementation issue, but enough to attract EU to fund the program and influence EU way of thinking • They were not grow in size that much, but they reach stakeholders from different categories to start give pressure on complementing the technology (e.g., terminal operators)	• Freight forwarders was not really in favor with DTI as it can be a threat to their business model • Coalitions grow in size, combining actors from both ITAIDE and CASSANDRA • Coalitions in this project was not sufficiently strong to lobby the legislators for the implementation issue, but enough to attract EU to fund the program and influence EU way of thinking	• UCC provides indirect support for data pipeline implementation • Coalitions grow in size significantly and the range of stakeholders categories getting wider, but was not that strong enough to change current legislation on EU level • More stakeholders are in favor of data pipeline implementation, leads to pressure to complementing the technology (e.g., IB and MK on GTD implementation)
	Weakened	• Lack of direct legislation	• Lack of direct legislation support	• Lack of direct legislation support	• Lack of direct legislation support

	indicators	support • Immature technology • Lack of right stakeholders' involvement • Lack of shared interests and clear perceived benefits • Lack of public and private investments	• Immature technology • Lack of right stakeholders' involvement • Lack of shared interests and clear perceived benefits • Lack of public and private investments	• Lack of right stakeholders' involvement • Lack of shared interests and clear perceived benefits • Lack of public and private investments	• Lack of public and private investments • Lack of shared interests and perceived benefits
Unblocking strategy		**1. Re-configuration of networks** (involve terminal operators) to handle blockages such as immature technology, lack of shared interests & clear perceived benefits, lack of right stakeholders' involvement and lack of public and private investments issues **2. Re-framing** (more into supply chain optimization) to handle blockages such as immature technology, lack of shared interests & clear perceived benefits, lack of right stakeholders' involvement and lack of public and private investments	1. **Reframing** to mobilize SICIS into data pipeline development. Technological development focuses on improving the usability for potential users such as customs and freight forwarders. This mechanism can be used to address immature technology, lack of shared interests & clear perceived benefits, lack of right stakeholders' involvement and lack of public and private investments issues 2. **Reconfiguration of network** to proceed with demonstration and develop SICIS as data pipeline, adding PCS, freight forwarders, and branch organizations .	**1. Reframing** to test data pipeline in numerous large scale demonstrations , can be used to address issues such as lack of shared interests & clear perceived benefits, lack of right stakeholders' involvement and lack of public and private investments **2. Re-construct of network** by involve shippers as project lead and more actors in DTI innovation system. This mechanism can be used to address issues such as lack of shared interests & clear perceived benefits, and lack of public and private investments	*(Project is still ongoing)*
Innovation phase		Initiation	Development	Development	Implementation

Appendix D: Networks construction

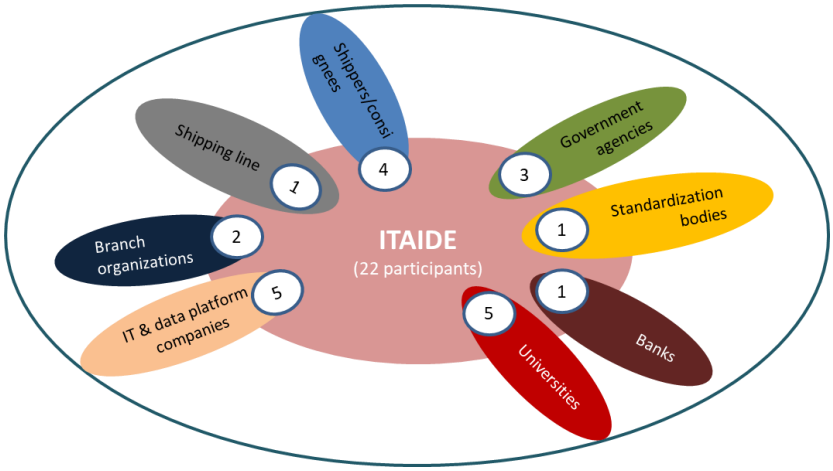


Figure 13: ITAIDE network

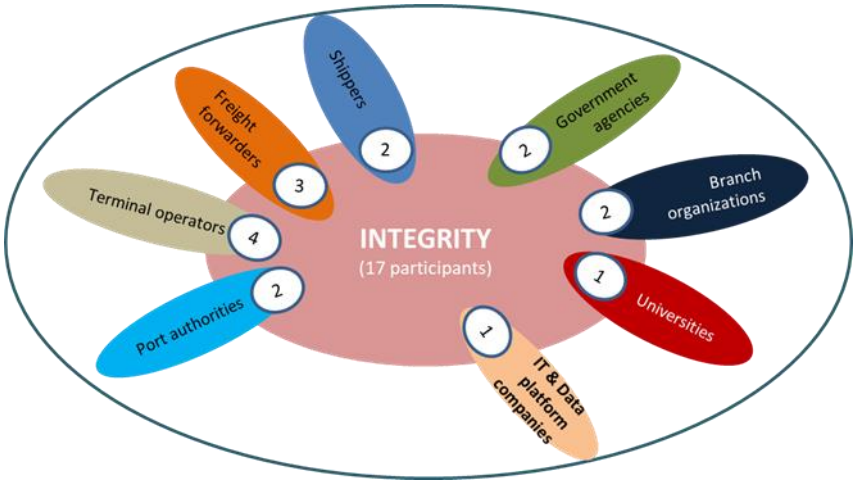


Figure 14: INTEGRITY network

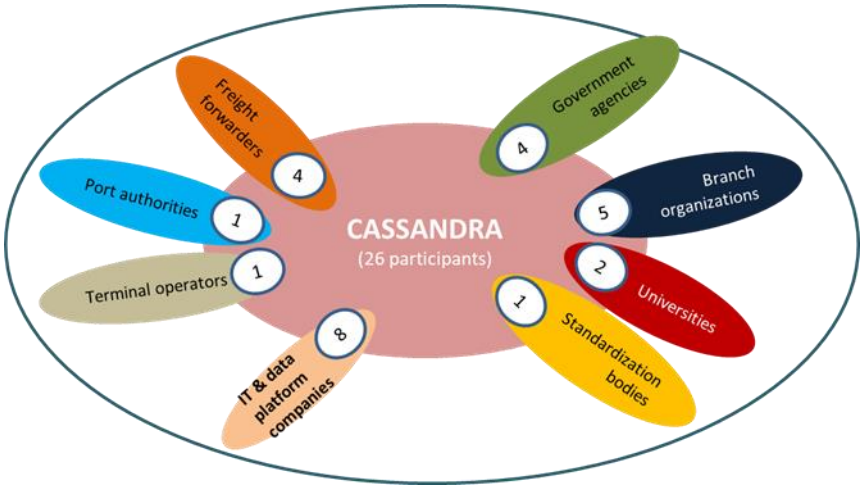


Figure 15: CASSANDRA network

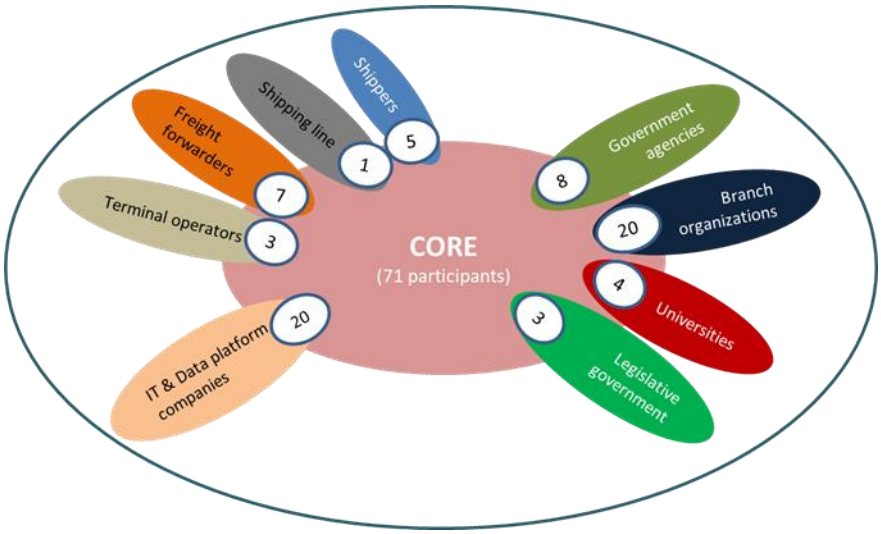


Figure 16: CORE network

Appendix E: Total project budget

Table 25: Total project budget

	ITAIDE	INTEGRITY	CASSANDRA	CORE
total costs (€)	7.556.458	10.816.220	14.720.517	48.862.256
EU contribution (€)	5.799.981	6.499.956	9.958.749	29.254.828
private contribution (€)	1.756.477	4.316.264	4.761.768	19.607.428
EU contribution (%)	77	60	68	60
private contribution (%)	23	40	32	40

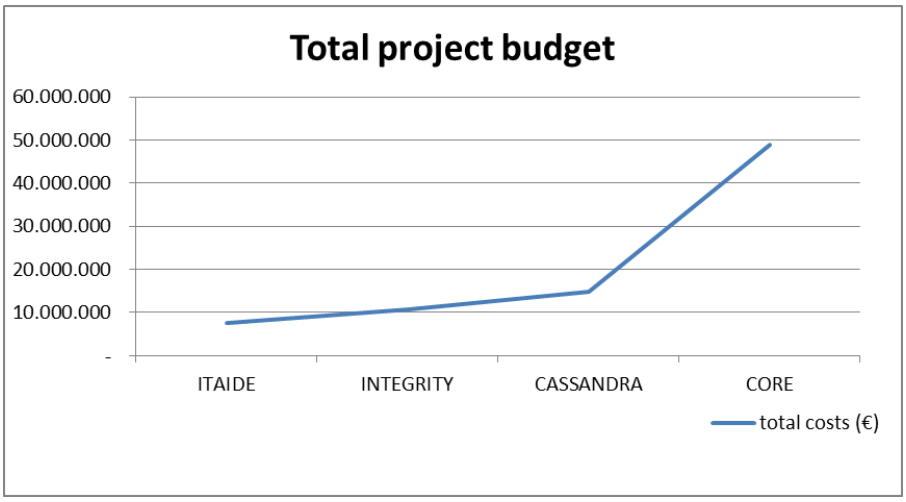


Figure 17: Graph of project budget changes