

Shipping Information Pipeline

An Information Infrastructure to Improve International Containerized Shipping

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SHIPPING INFORMATION PIPELINE: AN INFORMATION INFRASTRUCTURE TO IMPROVE INTERNATIONAL CONTAINERIZED SHIPPING

PhD Series 33-2017

Thomas Jensen

SHIPPING INFORMATION PIPELINE

AN INFORMATION INFRASTRUCTURE
TO IMPROVE INTERNATIONAL
CONTAINERIZED SHIPPING

Doctoral School of Business and Management

PhD Series 33.2017



COPENHAGEN BUSINESS SCHOOL
HANDELSHØJSKOLEN

Shipping Information Pipeline: An information infrastructure to improve international containerized shipping

Submitted for the completion of a Ph.D. degree 14th July 2017

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Preface

This thesis represents the written dissemination of my Industrial Ph.D.¹ study at Copenhagen Business School² in collaboration with Maersk³. I am honored to have received sponsorship from various organizations including Maersk, Danish government⁴, and European Union⁵.

I want to thank the many people that over the past four years have shared their valuable insights and knowledge, enabling me to complete this study. I am especially thankful to my professors Niels Bjørn-Andersen and Stefan Henningsson, to my co-authors particularly professor Ravi Vatrpu, and to my supervisor Henrik Hvid Jensen from Maersk.

¹ The abbreviation Ph.D. comes from Latin: Philosophiae Doctor which translates to Doctor of Philosophy.

² At Department of Digitalization (formerly Department of IT Management) and at Ph.D. School of Business and Management, Copenhagen Business School.

³ Employed by Maersk in Rederiet A.P. Møller A/S with reference to Chief Information Officer for Maersk Line and later for Maersk Transport and Logistic. In this thesis, Maersk is used to refer to the organization.

⁴ Acknowledging employment at Maersk and the support by Innovation Fund Denmark
<https://innovationsfonden.dk/en/application/erhvervsphd> under Industrial Ph.D. project number 1355-00075

⁵ Acknowledging the partial support by the European Union via the FP7 CORE grant agreement (N° 603993)

Abstract, English

This thesis applies theoretical perspectives from the Information Systems (IS) research field to propose how Information Technology (IT) can improve containerized shipping. This question is addressed by developing a set of design principles for an information infrastructure for sharing shipping information named the Shipping Information Pipeline (SIP).

Review of the literature revealed that IS research prescribed a set of meta-design principles, including digitalization and digital collaboration by implementation of Inter-Organizational Systems based on Electronic Data Interchange (EDI) messages, while contemporary research proposes Information Infrastructures (II) as a new IT artifact to be researched. Correspondingly, this thesis applies the concept of and design theory for II to improve containerized shipping.

Activity Theory has guided the analysis of containerized shipping, following avocados on their journey from the trees in Africa, to the retail shelves in Europe, revealing the plethora of organizations, activities and documents involved. The implication being that containerized shipping becomes inefficiently; costly, unreliably, and risky. These are posited as the major impediments to creating a more efficient shipping industry, and a number of critical issues are identified. These include that shipments depend on shipping information, that shipments often are delayed due to issues with documentation, that EDI messages account for only a minor part of the needed information, that multiple fragmented II are used throughout, and finally, that there is an unleashed potential for IT to support containerized shipping.

Based on the above, the SIP was designed, prototyped and evaluated which, through Internet-enabled collaboration on shipments, ameliorates the previously mentioned critical issues and major impediments. This is accomplished primarily through increased transparency into the containerized shipping process and through providing direct access to source information about the shipments. Based on the prototypes an accumulated set of design principles for the design of SIP are articulated. In the particular context of Internet-enabled II utilizing the World Wide Web, an extension of design theory is proposed through the formulation of an additional meta-design principle: share meta-information only and govern access to detailed information by the source. Finally, the practical implications of SIP are estimated, including how it facilitates more efficient containerized shipping and in turn sustainable international trade. The positive acknowledgements of SIP prototypes support how II designed in accordance with the developed set of design principles can be used to significantly improve containerized shipping.

Abstract, Danish

Denne afhandling anvender teoretiske perspektiver i forskningsfeltet Information Systems (IS) til at foreslå, hvordan informationsteknologier (IT) kan forbedre containertransport. Dette er adresseret ved at udvikle et sæt designprincipper for en informationsinfrastruktur til deling af forsendelsesinformation, under navnet Shipping Information Pipeline (SIP).

En gennemgang af litteraturen viser, at IS forskningslitteratur foreskriver digitalisering og digitalt samarbejde med Inter-Organisatoriske Systemer baseret på Electronic Data Interchange (EDI) meddelelser. På det seneste har IS forskere foreslået informationsinfrastrukturer (II) som et ny IT artefakt, der også kan anvendes til at accelerere den globale forsyningskæde for containertransport. Tilsvarende anvendes i denne afhandling konceptet og designteorien for II.

Activity Theory har guidet en analyse af containertransport, ved at følge avocadoernes rejse fra træer i Afrika til detailhylder i Europa, herved afsløres de mange organisationer, aktiviteter og dokumenter, der er involveret. Implikationen er, at containertransport er ineffektivt; bekosteligt, upålideligt og risikabelt. Disse er de største hindringer for at skabe en mere effektiv containertransport. Desuden er der identificeret en række kritiske udfordringer. Disse omfatter, at forsendelser er afhængig af forsendelsesinformation, at forsendelser ofte forsinkes på grund af problemer med dokumentation/information, at EDI-meddelelser kun udgør en mindre del af de nødvendige oplysninger, at flere fragmenterede II anvendes. Yderligere er identificeret et stort uforløst potentiale for IT til at understøtte containertransport.

Baseret på ovenstående blev SIP prototyper designet, udviklet og evalueret. SIP muliggør samarbejde om forsendelser via internettet og adresserer de nævnte kritiske udfordringer og forhindringer. Dette opnås primært ved, at SIP skaber transparens i containertransporten og relateret information samt ved, at SIP giver direkte adgang til kildeoplysninger om de enkelte forsendelser. Baseret på prototyperne er et akkumuleret sæt designprincipper for SIP artikuleret. I den særlige sammenhæng med internetbaseret II, der benytter World Wide Web, foreslås en udvidelse af designteori for II ved formulering af yderligere et meta-designprincip, som er: del kun meta-information og styr adgang til detaljeret information ved kilden. Endelig estimeres de praktiske konsekvenser af SIP, henimod mere effektiv containertransport og en mere bæredygtig international handel. De positive anerkendelser af SIP prototyperne understøtter, hvordan II designet i overensstemmelse med det udviklede sæt designprincipper kan bruges til at forbedre containertransport.

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1. Introduction

In the world history of technology after the industrial revolution the shipping industry has with the standardized container “propelled the globalization of the world economy”, similarly to the invention of the computer, Information Technology (IT) and later the Internet (Headrick, 2009). However, despite the fact that IT has revolutionized many aspects of global business, within containerized shipping many documents exist in a solely paper-based form. This observation, of a lack of IT proliferation within in the industry, leads to the main research question of this thesis: How can IT improve containerized shipping? To address the outlined research question, this thesis draws on the Information Systems (IS) research applied in the context of containerized shipping.

This research builds on a range of previous studies performed by, among others, the supervisors of this thesis. In particular, a project sponsored by the European Commission (EU) that focused on accelerating global supply chains with IT innovations (Tan, Bjorn-Andersen, Klein, & Rukanova, 2011). To continue this work, the researchers and their sponsors expressed a desire to involve a major shipping line. Maersk, agreed to co-sponsor this industrial research project focusing on the main research question. Consequently, the research is delimited to focus on containerized shipping.

1.1 The domain containerized shipping

The industry of containerized shipping originated in the late 1950's with the invention of the standard container. Containerized shipping is the activity of shipping goods from one place to another utilizing containers. A shipment includes one or more containers on the same journey. Note, that containerized shipping nearly always involves transportation both by land and by sea, but not by air due to standardized containers incompatibility with airplanes. Movement of goods through shipping involves supplementary modes of transport, for example trucks to move the goods on land, and container vessels to transport the goods at sea. Accordingly, there is an intermodal operation for the change of transport mode. Standardized containers ease intermodal operations through avoiding the manual loading and unloading of goods, instead leveraging dedicated equipment, such as cranes and dedicated transport equipment. Furthermore, the containers serve as storage facilities for the goods while they wait for next mode of transport. The standard container has revolutionized trade through gained efficiency and subsequent

lowered costs. Since its introduction, the use of this method of transport has grown. Today, containerized shipping accounts for approximately 80% of traded non-bulk goods⁶. Due to containerized shipping's reliance on transport by sea, utilizing container vessels, it is considered part of the maritime industry.

However, containerized shipping, as an industry, struggles with low reliability and inefficiency, resulting in high costs and high risks. Digitalization of processes through IT applications are increasingly drawn on to curb these issues and cope with increasing number of containers, however despite the success of many of these improvements and initiatives wide adaption remains to be seen. Alternatively, this research demonstrates a different designed IT solution for improving containerized shipping, an II called SIP. This leads to the main research question.

1.2 Research question

As previously mentioned the main research question for this research is:

How can Information Technology improve containerized shipping?

The research question is addressed through three main activities: 1) Reviewing the IS research literature to deduct recommendations and design principles. 2) Analyzing containerized shipping in practice. 3) Designing and evaluating prototypes of an IT solution named the Shipping Information Pipeline (SIP) and deriving inductive design principles.

Accordingly, the main research question is broken into three the sub research question, which each contribute to its answering:

- 1) What constitutes the current IS research knowledge about IT solutions supporting containerized shipping?
- 2) What is the current status quo and major impediments for containerized shipping which IT could ameliorate?
- 3) What design principles for an IT solution (Shipping Information Pipeline) could potentially lead to more effective containerized shipping?

⁶ International Chamber of Shipping estimates maritime shipping carries 90% of international trade, and containerized are estimated to account for at least 80% of non-bulk goods. The international maritime industry carries majority of traded goods, estimated by United Nations to be 99.9% by weight, 80% volume and 70% in value in 2012 (World Economic Situation and Prospects 2012 www.un.org/en/development/desa/policy/wesp/wesp_archive/2012wesp.pdf).

1.3 Structure of thesis

The first chapter of this thesis introduces the domain, research questions and overall structure of the thesis. The second chapter addresses the research design, including the methodology and the set of mixed methods that were utilized. Following this, the three sub research questions guide the structure of the third, fourth and fifth chapter. The third chapter, a literature review, provides the theoretical framework and deduced design principles for developing an IT solution for containerized shipping. The fourth chapter analyzes containerized shipping, identifying the major impediments and critical issues to more effective containerized shipping which could be improved by an IT solution. The fifth chapter provides inductive design principles for the SIP based on prototyping. In the sixth chapter the existing IS knowledge and how it is extended through this thesis, is addressed. This leads to a discussion and estimation of the practical implications of the designed IT solution towards improving containerized shipping. Finally, in the seventh chapter is concluded, answering the sub research questions and the main research question.

The appendixes include lists of abbreviations, references, data collection protocols, and list of research publications. Further, a set of selected research publications are included in print at the end of this dissertation.

1.4 Limitations

This research is limited primarily due to the available resources allocated for the research and the given conditions. For example, the research is grounded in the IS research community and accordingly, this research reports solely on the design of possible IT solution from the IS research perspective. Further, Maersk is focused on containerized shipping and accordingly, this research is delimited and does not include for example air cargo. Furthermore, being anchored within the IT organization of Maersk, this research only considers possible IT solutions, and it does not consider other initiatives potentially improving containerized shipping. Furthermore, this research is delimited to only consider the activities, actions and operations related to transport and logistics of containerized shipping, and not others such as the related financial transactions. Lastly, this thesis only reports analysis of containerized shipping utilizing one trade lane for perishables from East Africa to Europe, primarily due to existing relations to authorities. However multiple other trade lanes have been analyzed with

nearly same results but without being reported in this thesis, and further support comes from practitioners' acknowledgement of the results of this research.

1.5 Selected research publications

The research generated from this industrial Ph.D. has been published in a range of formats, both academic and non-academic publications.

The research is published in practitioner focused publications which for example can be seen in Maersk Post⁷ and through a number of short films^{8, 9 & 10}. Further, the research is reflected in a number of internal documents for Maersk and other companies, and in EU research projects.

However, it is the papers produced for academia which form the base of the thesis itself. In addition to this thesis, in collaboration with several co-authors a number of academic publications have been completed during my industrial Ph.D., which are listed in the Appendix.

In total 5 publications have been selected to be included in this dissertation. The outlets for the selected publications includes 1 Basket of Eight journal article, 1 book chapter, 2 international conference papers, and 1 working papers.

Table 1 provides a structural overview of the dissertation aligned within the proposed research questions, and listing the selected academic publications supporting specific chapters. Note, the selected publications are not written specifically to support a chapter, but they are written as individual publications, accordingly, they are supportive for more chapters than the one indicated.

⁷ <http://www.maerskpostdigital.com/h/i/84955128-may-2015-edition> p. 22-23 20062016

⁸ https://youtu.be/GBYgvHgh6X4?list=PLZbLY7ElgpWYWk4X3ts4_p27Z7YBv5VpR 28062016

⁹ https://youtu.be/p8yH4e-Aafk?list=PLZbLY7ElgpWYWk4X3ts4_p27Z7YBv5VpR 28062016

¹⁰ https://www.youtube.com/results?search_query=the+paper+trail+of+a+container 28062016

Struc- ture	Research question	Selected publications
Chapter 2: Research Design		Paper 1: Information Systems Action Research facilitates global trade utilizing modern IT. (Jensen, 2016a). <i>Paper at Copenhagen Business School.</i>
Chapter 3 Literature Review	Sub research question 1: What constitutes the current IS research knowledge about IT solutions supporting containerized shipping?	Paper 2: The Information Infrastructures Design Space: A Literature Review. (Henningsson, Rapti, & Jensen, 2017). <i>Research paper at 16th Business Informatics Research (BIR) conference.</i>
Chapter 4 Analysis of Containerized	Sub research question 2: What is the current status quo and the major impediments for containerized shipping which IT could ameliorate?	Paper 3: Ships & Roses: A Revelatory Case Study of Affordances in International Trade (Jensen & Vatrapu, 2015e). <i>Research paper at 23rd European Conference on Information Systems (ECIS) conference.</i>
Chapter 5: Design IT Solution	Sub research question 3: What design principles for an IT solution (SIP) could potentially lead to more effective containerized shipping?	Paper 4: Cloud Solutions for the Shipping Eco-System pose new opportunities (Jensen & Bjoern-Andersen, 2017) <i>Book chapter.</i>
Chapter 6-7: Discussion & Conclusion	Main research question: How can IT improve containerized shipping?	Paper 5: Avocados Crossing Borders: The Problem of Runaway Objects and the Solution of a Shipping Information Pipeline for Improving International Trade (Jensen, Vatrapu, & Bjoern-Andersen, 2017) <i>in Information Systems Journal.</i>

Table 1 Dissertation overview with the selected academic publications.

2. Research design

This chapter outlines the design for this research addressing the above main research question and sub-research questions. The research design includes, selection of methodology, of research methods, of case, of the unit of research, of research data and knowledge collection that correspond to thesis and theories (Creswell, 2013; Silverman, 2013). Table 2 provides an overview of the methodology, the methods and theories applied in this research.

Methodology		
Qualitative Methods - Engaged Scholarship		
Aim of Research Question	General Methods	IS specific Methods and Theories
Analysis to describe/explain and predict	Informed collaborative research, co-produce knowledge with stakeholder	Basics research techniques (Silverman, 2013) Activity Theory (Engeström, 1987)
Design	Design and evaluation research	Design theory within IS (Walls, Widmeyer, & El Sawy, 1992). Design theory for Information Infrastructures (Hanseth & Lyytinen, 2010) Design Science Research within IS (Hevner, March, Park, & Ram, 2004))
Intervene	Action/intervention research	Action Design Research (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011) Information Systems Action Research (Baskerville & Myers, 2015)

Table 2 Research design overview.

The research design is detailed below including research methodology, methods and theories, the two-folded unit of research (unit of analysis and unit of design), case of study and research data and knowledge collection.

2.1 Methodology

Traditionally research methods include either quantitative research following quantitative methodology, originally developed in the natural sciences, or qualitative research guided by qualitative methodology, developed in the social sciences to enable researchers to study social and cultural phenomena (Creswell, 2013; Silverman, 2013). The overall methodology selected for this research is qualitative methodology. In the following is given the considerations, the

philosophical assumptions, and the strategy of inquiry for this selection of qualitative methodology specifically the Engaged Scholarship (Van de Ven, 2007).

While the high number of container vessels, carrying millions of shipments could provide data for quantitative research, containerized shipping in the supply chain for international trade is complex with many unknown variables. Firstly, an understanding of the current situation is needed with elaborated details. Accordingly, qualitative research is more appropriate (Flyvbjerg, 2006). However, pure quantitative research would sacrifice insight into the social and institutional contexts, which is a key benefit of understanding socio-technical phenomenon (Kaplan, Maxwell, Anderson, Aydin, & Jay, 1994). Given the differences between qualitative and quantitative research methodology, both would be complementary in understanding containerized shipping for international trade. Purely qualitative research has inherent risks of bias, therefore international trade cost analysis, has been used to supplement, reducing this risk. Accordingly, this research, while is largely based on qualitative methodology but draws on quantitative elements, which contribute and guide the research.

Within the research field of IS the predominating research methodology is quantitative (Sarker, Xiao, & Beaulieu, 2013). According to Orlikowski and Baroudi (1991) quantitative methods aligned with positivistic philosophical assumption accounts for 96.8% of publications in four top IS related outlets in late 80's, above 90% included a research design based on single snapshots utilizing surveys, laboratory experiments or case study methods. Only 3.2% of these publications aligned with interpretive philosophical assumption including multiple snapshot, longitudinal or process traces utilizing mixed methods, field experiments or action research methods. Similarly, Chen and Hirschheim (2004) found 80% positivistic and 20% interpretive philosophical assumption in articles published during the 1990's in the top eight IS journals, and that "the overall percentages of quantitative, qualitative and mixed methods are 60%, 30% and 10% respectively". Furthermore, Sarker et al (2013) found the percentage of qualitative studies published in four of the top eight IS journals during the 2000's to be approximately 10%. This quantitative bias calls for increased publications of research using qualitative methodology. Presuming the utilizing of varied methods, produces novel outcomes, increased use of qualitative methods within business schools would create a more balanced portfolio of research. This research contributes to this balance through its reliance on methods based on qualitative methodology. This includes methods aimed to design solutions and to intervene within organizations in the ecosystem of containerized shipping.

Echoing Lee (2004) and in line with Emery et al (Bostrom & Heinen, 1977; Emery & Trist, 1960; Emery, 1959; Orlikowski & Scott, 2008; Trist, 1981) Sarker¹¹ argues that IS research always shall take a socio-technical perspective and to him studies that “do not account for the mutually and iteratively transformational interactions between the social system and the technological system... are not information systems research at all.” Sarker suggests approaching the socio-technical perspective as open systems with boundaries, multiple goals, multiple ways of reaching goals and of self-regulation; and consisting of technical, information and social components in a dynamic equilibrium of context, causality, mutual influence, inscription/design, contingency fit, and interpenetration. Building on this advice, the philosophical assumption underpinning this research is an interpretive socio-technical perspective, based on constructivism and pragmatism, aimed to find a practical IT solution to improve the efficiency of containerized shipping.

The research field of IS is typically performed in business schools. Within the qualitative methods used at business schools, one particularly relevant method is Engaged Scholarship, which is a form of inquiry where scholars involve practitioners and stakeholders to leverage their different perspectives and increase knowledge of a complex problem domain (Van de Ven, 2007). The relationship involves negotiation, mutual respect, and collaboration to produce a productive learning environment. In relation to the specific aims of an industrial Ph.D., Engaged Scholarship provides a relevant methodology as it bridges the gap between scholars at universities and practitioners and their situated knowledge of phenomena.

However, there are many ways to practice Engaged Scholarship depending on the aim of the research and accordingly, the methods selected for the research can vary depending on the sub research question in scope, which results in that the research design includes a set of mixed specific methods used for this research to address the main research question.

Analysis of a domain and design of the IT solution are very different research activities, and specific methods exist. Accordingly, specific methods and theories for each research activity has been selected for each of the sub research questions. Resulting in selection of a set of different research methods and theories. Accordingly, the research is guided by mixed methods.

¹¹ Lecture at Copenhagen Business School in 2015

The research strategy aligns the purpose of the research, expressed by the sub-research questions, with relevant method(s) as shown in Table 2. Accordingly, specific methods dedicated to literature reviews were selected addressing sub research question 1) to derive design guidance from IS literature. To describe and analyze containerized shipping addressing sub research question 2) certain methods and theories were selected as most appropriated to be informed, to collaborate and co-produce knowledge with practitioners. Other methods and theories are appropriated and were selected for design of IT solutions addressing research question 3). Further, to intervene and interact in the multiple organizational setting of containerized shipping other methods provided guidance. Furthermore, the research strategy also encompasses both theoretical and practice tactics regarding design by deducting principles from theory which is expressed by sub research question 1) as well as inducting them from practice which is expressed by the sub-research questions 3).

In the following are the specific methods presented.

2.2 Methods

Selection of methods reflect the “overall research strategy as methodology shapes which methods are relevant and how each method is used” (Silverman, 2013). Engaged Scholarship is an umbrella and covers both research of organizations and of specific artifacts, such as IT. As shown in Table 2, Engaged Scholarship proposes alternative approaches for studying organizational change depending on the organizational ontology – whether this is focused on artifacts or on process, and if epistemology is based on variance or process method (Van de Ven & Poole, 2005).

The specific approach for this research is: a narrative process study of containerized shipping in the supply chain for international trade, following a sequence of transaction events in organizations around shipments, and developing an IT artifact and engagement of both organizations’ and actors’ application of it. Engaged Scholarship views the process of organization change differently, depending on if unit of change is single or multiple entities/organizations, and if the mode of change is prescriptive or constructive; further in case of multiple organizations’ evolution with competitive change or dialectic with conflictual change (Van de Ven & Poole, 1995). This research benefits from Engaged Scholarship’s guidance and framing of the research methods as process and event, centered along the containerized supply chain, and from understanding organization change in containerized

shipping within the international trades multi-organizational setting, with its competitive environment fostering dynamics and continuously changes with its inherent conflicts and search for synthesis.

Methods of qualitative inquiry in Engaged Scholarship are categorized into 1) analysis to understand and predict a phenomenon 2) design and 3) on intervention within organization(s) (see the first column of Table 2). Examples of specific methods and theories utilized include: Activity Theory (AT) trying to understand the activities in the 'real' world; Design Theory (DT) prescribing design of IT artifacts; Design Science Research (DSR) focusing on creating artifacts to be applied in the 'real' world, balanced with knowledge production; and Action Research (AR) methods aiming for interventions to be taken.

Each of the contributory papers in this thesis applies a particular set of methods. For example, Paper 5 which initially contributed to a special issue of Information System Journal focusing on Activity Theory, the AT lens is applied. Similarly, Jensen and Vatrpu (2015b) uses the DSR method, to be published at the conference Design Science Research in Information Systems and Technology. Accordingly, each of the publications elaborate on their specific methods and theories. These diversities, applied throughout the collection of papers, is overall beneficial for research.

While the choice of methods and theories have been adapted appropriately for each of the various publication outlets, and to accommodate the sub-research questions, underpinning the research of this dissertation there are a set of basic research techniques (Silverman, 2013). For example, observations, interviews, focus groups, text analysis, and active participation in various activities, are considered relevant collection techniques within the qualitative research methodology. For interviews, open ended questions have been relied on to gain an understanding of impediments, barriers and issues in the domain, and to obtain feedback during presentation and demonstration of prototypes of the SIP.

As described above, multiple theories and methods have framed this research. Those theories and methods include: Literature review, Design Science Research (DSR) within IS research field, Action Research (AR), IS Action Research (IS-AR), Action Design Research (ADR), Design theory (DT) within IS research field, and Activity Theory (AT) in IS research field, which are presented below.

The literature review has been guided by Webster and Watson (2002) and Levy and Ellis (2006), who suggest that the literary contributions needed to build theoretical foundations are published within leading peer-reviewed journals, referred to as The Basket of Eight¹². Paper 2 shows a highly-detailed example of one-such literature review.

DSR method within IS aims to design, develop, and to evaluate the design of IT artifacts in relation to identified organizational problems (Hevner et al., 2004). DSR applies theoretical research knowledge to design solutions which address practical business needs. For example, applying IS research regarding information infrastructures, to information flows in the ecosystem of containerized shipping, and then in an iterative process design, develop, propose, and evaluate innovative solutions. Through publishing their knowledge researchers then contribute to the existing knowledge base. Within the IS field, DSR is relatively well established and continues to be enhanced through various publications (Gregor & Hevner, 2011, 2013; Hevner, 2007; Hevner et al., 2004; Peffers, Tuunanen, Gengler, Rossi, Hui, Virtanen, & Bragge, 2006). A specific variation includes the living lab method, which is considered to be a state-of-art research method (Niitamo, Kulkki, Eriksson, & Hribernik, 2006; Schuurman, 2015). This method studies innovation in complex real world experimental settings, involving partners such as organizations and institutions, encouraging a critical attitude, creative problem solving, and facilitating collaborative actions (Klievink & Lucassen, 2013). Living labs is the primary method used for the EU sponsored research projects related to this research, see Section 3.3 for details.

AR method was developed by Kurt Lewin as "comparative research on the conditions and effects of various forms of social action and research leading to social action" (Lewin, 1946). Since then, AR has evolved into a range of approaches as process consultation, action science, and action learning.

Current approaches to AR, largely in the sociological domain, seek to engage multiple organizations and improve democratic processes (Gunnarsson, Hansen, Nielsen, & Sriskandarajah, 2015) and further sustainability efforts (Hans Peter Hansen, 2016). Carrying out AR in organizations in which the researcher is part of can raise certain challenges and requires critical reflection on behalf of the researcher (Brannick & Coghlan, 2010). One of the main reflections stems from the purposeful intention to *create change* in an organizational

¹² <https://aisnet.org/?SeniorScholarBasket> 20170202

setting, which is inherent to AR. Empirical materials for Action Research are frequently collected through case studies, typically within a single organizational setting. For this research, we have limited the analysis to a case trade lane across multiple organizations.

IS-AR is advocated for being well suited for researching practice ((Avison, Lau, Myers, & Nielsen, 1999; Baskerville & Wood-Harper, 1996; Wood-Harper, 1985). The particular emphasis on observed action, as opposed to relying on practitioners to recount their memories, interpretations and reconstructions of activities (Avison et al., 1999), has been formative in revealing the differences between espoused and applied theory. This terminology originates from Argyris and Schön (1974; 1978), with a strong focus on theory in practice and theory of action with double-loop learning. Paper 4 is a tribute to David Avison.

Additionally, IS-AR represents several different variations (Baskerville & Myers, 2009) including, the Canonical Action Research method (Davison, Martinsons, & Kock, 2004; Davison, Martinsons, & Ou, 2012) and Design Ethnographies (Baskerville & Myers, 2015). The latter emphasis, drawing on thick descriptions, was particularly fruitful to this work to bridge the gap between espoused theory and actions in-use. Publications of IS-AR research is limited within major IS outlets, with only 1.6% of the publications in the top ten journals using this method (Mathiassen, Chiasson, & Germonprez, 2009). Paper 1 elaborates on this research's use and praise of the IS-AR method.

ADR is an evolution of the aforementioned methods combining DSR and AR into attempting to be where “Action Research Meets Design Research Theory” (Cole, Purao, Rossi, & Sein, 2005). There is a congruence of seven characteristics (concrete results of the study, knowledge produced, activities, the intent, and the nature of a study, the division of labor in a study, and generation, use and test of knowledge) shared between the AR and DSR, which means the research methods could be considered similar research approaches (Järvinen, 2007). However, ADR specifies the evolutionary development cycle with iterations of Build, Intervention and Evaluation (BIE) and learnings from the cycles are used to improve the design of the next version of the IT artifact (Sein et al., 2011).

DT within IS is a prescriptive theory for the design of IT artifacts, that covers both the design process and the designed IT artifact.

Further, IS design theory includes the following: “1) Meta-requirements 2) Meta-design 3) Kernel theories and 4) Testable design product hypothesis” (Walls et al., 1992). Meta-

requirements “describes a class of goals to which the (design) theory applies.” (ibid.). Meta-design “describes a class of (IT) artifacts hypothesized to meet the meta-requirements.” (ibid.). Wall et al reference the definition of design by Frieden (1975): “the use of scientific principles, technical information and imagination in the definition of a structure, machine or system to perform pre-specified functions with the maximum economy and efficiency”. Kernel theories are adapted from “theories from natural or social sciences governing design requirements” (ibid). Accordingly, the testable design product hypothesis is “used to test whether the meta-design satisfies the meta-requirements” (Walls et al., 1992). Further, Gregor and Jones (2007) find that “an IS design theory shows the principles inherent in the design of an IS artifact”. The design hypothesis part of a design theory can then be expressed as a number of key design principles for an IT solution which satisfies the requirements.

Design principles are one way to communicate the design of an IT artifact. “A design principle is a statement that prescribes what and how to build an artifact in order to achieve a predefined design goal” that “can be used in the practice of building purposeful IS artifacts” according to Chandra, Seidel, and Gregor (2015). In addition, Hevner and Chatterjee (2010) mention that “a principle can also be formed as a rule or a standard of conduct” which formalizes design principles. A design principle captures “knowledge about instances of a class of artifacts” (Sein et al., 2011) p. 39. In general, there are two sources of design principles: deducting them from theoretical knowledge, such as literature from the IS field, or to deriving them from practice, for example through experiential design through building, testing and evaluating IT artifacts (Yoo, 2010). Design principles, however, do not constitute testable hypotheses. The specific use of design theory in this context is elaborated further within the unit of design, Section 2.4.

AT is another theoretical approach drawn on in this dissertation, which forms the base of the analysis of the containerized shipping domain. AT originates in the Soviet Psychology of Vygotsky and colleagues (Roth & Lee, 2007; Vygotsky, 1930/1980, 1962). While originally, AT provided a holistic, materialistic and non-dualist conception of human activity, it was extended to systems modeling by Engeström (1987). Extant literature describes AT research in IS (Allen, Karanasios, & Slavova, 2011; Allen, Brown, Karanasios, & Norman, 2013; Hasan, Kazluaskas, & Crawford, 2010; Karanasios & Allen, 2013, 2014; Kuutti, 1991; Kuutti, 1996; Kuutti, 1999) and has predominantly focused on delineation (“Delineation is the very act of identifying the personal and geographical locus and limits of the activity”) of either the narrow phenomena of mediated interaction between a) the human actor and the world or b) the networked phenomena

of multiple, densely connected actors, directly interacting across system limits sharing a boundary object or network object (Engeström, 1999; Spinuzzi, 2011). This is what Engeström (1987) termed Third Generation AT (Engeström, 1999). Paper 5 contains elaborated descriptions of AT.

In particular AT has been highly relevant for the analysis of containerized shipping in the heterogeneous domain of international trade, where shipments traverse multiple national borders and organizational boundaries, obviously, the specific ones vary not only between trade lanes but also from shipment to shipment within a trade lane. Engeström (2008) proposes five principles of AT: 1) object orientation with mediation by tools, 2) multi-voiceness with mutual constitution of action and activity, 3) historicity (the historical actuality of persons and events, meaning the quality of being part of history as opposed to being a historical myth, legend, or fiction), 4) contradictions and deviations as source of change and development, and 5) possibility of expansive transformation. AT is drawn on in this work, to analyze the activity of containerized shipping, in particular investigating the transformation process with the outcome that avocados are moved from Kenya to the Netherlands and the concepts of knotwork of information communication involved and of lack of supporting mycorrhizae. Knot refers to rapidly pulsating, distributed, and partially improvised orchestration of collaborative performance between otherwise loosely connected actors (Engeström, 2009). Mycorrhizae represent relatively durable connections across activity systems (Engeström, 2007).

The aforementioned theories and methods have synergistic qualities with an industrial Ph.D. project, largely due to their emphasis on combining industrial practices with academic theories. The position of an industrial Ph.D. entails working both as a researcher and a practitioner, involving relevant people in each area to create valuable research and, in this research, innovative IT solutions. Table 3 provides a schematic overview of the research design, related to the research questions and the structure of this thesis. Outlined are the major research activities 1) Reviewing the IS research literature to deduct recommendations and design principles 2) analyzing containerized shipping in practice 3) designing and evaluating prototypes of an IT solution named Shipping Information Pipeline (SIP). The table indicates different numbering sequences for each of the major research activities and related chapter in this dissertation. Note, separate numbering identification is used for meta level and for detailed level.

Structure	Research question	Research Design with indication of numbering schemas applied		
Chapter 2: Research design		<u>Methodology:</u> Engaged Scholarship <u>Research activity:</u> Literature review <u>Analysis</u> <u>Design</u> <u>Methods:</u> Literature review Qualitative Action Design Research <u>Theories:</u> Activity Theory IS Design Theory		
Chapter 3 Literature review	Sub research question 1: What constitutes the current IS research knowledge about IT solutions supporting containerized shipping?	Literature review to deduct design principles from IS design theory: <u>Meta-design principles</u> <u>Detailed design principles for II</u> II 1.0 Digitalization .. I) Designing initially for usefulness II 2.0 IOS based on EDI II) Draw upon existing installed base II 3.0 Utilizing II III) Expand installed base by persuasive tactics IV) Make each IT capability simple V) Modularize		
Chapter 4 Analysis of containerized shipping	Sub research question 2: What is the status quo and the major impediments for containerized shipping which IT could ameliorate?	Analysis guided by qualitative methods and Activity Theory: Meta-requirements and feature requirements: <u>Major impediments</u> <u>Critical issues</u> A) International trade cost a) Plenty of paper documents B) Lead time and its uncertainty b) Actors rely on shipping information C) Security and risk concerns c) Information are stored in local IT systems d) Information is not up-to-date / missing e) Actors utilize multiple II f) Limited utilization of IOS based on EDI g) Communication pattern is bilateral h) Information is only exchanged locally		
Chapter 5: Design IT solution	Sub research question 3: What design principles for an IT solution (SIP) could potentially lead to more effective containerized shipping?	Design guided Action Design Research method and IS design theory: <u>Meta-design principles</u> <u>Detailed design principles</u> <u>SIP Prototypes</u> II 1.0 Digitalization .. I) No big brother #1 Data Pipeline II 2.0 Digital communication II) Integrate ones #2 Shared II II 3.0 Utilizing II III) One virtual pipeline #3 Dropbox II 4.0 Shared meta-info. only IV) No commercial #4 OneDrive and govern detailed V) Info direct from source #5 RCM info. by source VI) Event based #6 TLIP VII) Separate meta-info. #7 SVP Etc. Etc.		
Chapter 6-7: Discussion & Conclusion	Main research question: How can IT improve containerized shipping?	Verification and evaluation of research and results: Design process guide by the research methodology and methods e.g. ADR With Activity Theory as the kernel theory Meta-requirements/major impediments and requirements/critical issues Meta-design principles and design principles ----- Practices evaluation of prototypes and their design principles Reflection and discussions about theoretical contributions =====		

Table 3 Overview of the dissertation and research design.

2.3 Trade lane as focal case

The case study method, which relies on multiple data sources, and accommodates numerous more variables of interest as opposed to few, provides an ideal fit for international trade (Flyvbjerg, 2006). A case study approach enables the investigation of a contemporary phenomenon in depth and within its real-life context (Yin, 2009). Due to the complexity of the containerized supply chain for international trade, this research is limited to a single focal case, looking in-depth at one trade lane from East Africa to Europe, specifically in the domain of perishable goods. Avocados, as perishable goods, are sensitive to factors such as temperature and therefore their efficient transit bears higher risks than general cargo. Access to research about these types of sensitive goods is more readily available, as organizations involved in their handling are interested in generating research results which may mitigate these risks. This access is why the choice was made to focus on this specific trade lane. Additionally, some traders were eager to collaborate because they would like to complement their use of air carried goods with the option of sea carried goods at half the transport cost.

Researchers in the IS field suggest revelatory case studies, as an empirical inquiry, can potentially explain presumed causal links in real-life interventions, when relationships are too complex for survey or experimental research methods (Sarker, Sarker, Sahaym, & Bjørn-Andersen, 2012a). To capture the complexity of such a case study, an understanding of the details is needed; for example, knowledge of the practical impediments and critical issues that could possibly impact international trade cost, causing both long and variated lead-time, and raising risk and security concerns. Paper 3 elaborates on the challenges of revelatory case study research especially in a multi-organizational setting, leveraging the experiences of IS researchers.

Typically, case study research works with a single case organization. In contrast, this research focuses on containerized shipping for the complete trade lane, involving multiple organizations located on different continents. This multi-organizational analysis is feasible due to the specific focus on a single trade lane. Additionally, the multi-organizational nature of this research contributes to its general applicability (Firestone & Herriott, 1983) p.53 in (Yin, 2009)

2.4 Unit of analysis

The first unit of research being the unit of analysis for this research is the activity of containerized shipping for international trade. The analysis provides insights into the current practices of the industry, particularly the major impediments to a more effective containerized shipping which could be ameliorated through IT applications. For the unit of analysis, AT was selected as an analytical frame (Engeström, 1987). AT is particularly relevant for decomposing activities into actions and operations performed by organizations and their actors, and understanding their collaboration in relation to accomplishing a task and an outcome. Further, there is an alignment between so-called boundary objects in AT, and IS research objects, which assisted in clarifying the difference between the IOS based on EDI messages and the new design for SIP, described in further detail in Paper 5 and in the discussion in Chapter 6.

During the post-research reflection, the absence of an overarching governance or power structure innate to the AT framework was seen as especially relevant for this specific heterogeneous setting, with multiple organizations, nations and regions involved in containerized shipping in the supply chain for international trade. AT terminology is not used extensively in this thesis but it is elaborated in Paper 5. While AT provided insight, and understanding about the process of containerized shipping, it did not provide sufficient detail for the design of the IT artefact itself; accordingly, a more in-depth analysis of the impediments and related critical issues, which informed the design of the IT artefact are elaborated using IS design theory specifically design theory for II.

As previously mentioned, the unit of analysis is containerized shipping of shipments within the selected trade lane. To study this, specific shipments were selected in the selected trade lane and traced starting from farms in East Africa to the retail in Europe. Supporting this unit of analysis, each actor that was encountered during the research process was interviewed, focusing on her/his involvement in the shipment, their actions, operations, with whom they had communicated, and which information they had received, shared and stored, thereby revealing various parts of the ecosystem for containerized shipping.

Because the unit of analysis the physical container(s) of shipment move geographical location it becomes difficult to locate, and invisible for the actors unless they know where to locate it. However, for the shipments included in this research the location of the containers has been made more visible for the researcher since the container is tracked by a Global Positioning

System (GPS) device mounted on the container. Several actions and operations occur in geographically remote offices, further complicating the process, for example, the release of shipping instruction involves a service center in India.

The containers are sealed upon loading, accordingly, the goods (avocados) contained are invisible until the seals are broken, typically upon arrival at their destination. This means the international shipment vis a vis the refrigerated container(s) is invisible for the majority of actors, and only becomes “visible” through the related documents and information. Accordingly, the unit of analysis then becomes the physical shipment(s) of goods in containers and, more important, the related shipping information.

Due to the multi-organizational nature of the research, certain actors were difficult to gain access to, requiring approval from the organization they belonged to. Beyond this, the actors involved were not always stable and there was employee turnover due to certain firms hiring on a contract basis. For example, arranging a meeting at the port of Mombasa was arduous and lengthy. When the meeting finally took place, it was revealed that other authorities were involved which required an additional arrangement, and thus another trip was needed to capture the relevant data.

It is unique for this research to unravel containerized shipping by following the journey of goods in a trade lane from origin to destination. However, others have followed an international journey and revealed insights from different perspectives. For example, the story of Phileas Fogg’ eighty days’ journey around the globe (Verne, 1999). Similar to the technological invention of the container and innovation of this research, Jules Verne was inspired by the technological advancements of the 19th century which had opened the possibility of rapid circumnavigation which made a tourist-like around-the-world journey possible for the first time. Another example is Pietra Rivoli’s ‘Travels of a T-Shirt in the Global Economy’ (Rivoli, 2014) originally from 2005. Surprisingly, the T-shirt was a truly global entity, from the raw materials’ origin on the cotton fields of Texas, to the T-shirts production in the Far East, and finally its return to the USA to be bought for \$5 in 1999, resold years later in New York and meet its final resting place in Africa. By following the T-shirt’ travel Rivoli examined the markets, power, and politics of world trade. A final example is BBC News’ tracking the route of ‘The Box’. In 2008 the BBC News¹³ bolted a GPS transmitter to a container, following its

¹³ www.bbc.co.uk/thebox/28062016

travel 51,654 miles around the globe for over a year, while it carried a variety of goods. Firstly, it was filled with whiskey, then scales, and finally tins of cat food. Tracking the container allowed the BBC to tell the story of international trade and globalization, including the containers sitting forlornly for four months in the Japanese' port of Yokohama during the financial crisis. However, none of the above descriptions of international journeys describe the unit of analysis in a way which provides insight into the organizational and managerial issues of containerized shipping for international trade, and especially not the associated shipping information. This specific analysis of the unit of analysis is reported in Chapter 4 and in Paper 5 for fresh avocados, and in Paper 3 for fresh cut roses.

2.5 Unit of design

The unit of analysis being containerized shipping provides an understanding and insight into the critical issues and the major impediments which result in inefficiency. This has been used as requirements for developing the second unit of research - the unit of design - an IT artifact that can potentially ameliorate the major impediments to effective containerized shipping. The unit of design for this research is then the proposed IT artifact specifically an Information Infrastructures (II) following Tilson, Lyytinen, and Sørensen (2010b) named the SIP.

IS design theory in general (Gregor & Jones, 2007; Walls et al., 1992; Walls, Widmeyer, & El Sawy, 2004) and particularly IS design theory for II (Hanseth & Lyytinen, 2010) framed and guided the design efforts. Sub research question 1: 'What constitutes the current IS research knowledge about IT solutions supporting containerized shipping', is addressed through a literature review focused on deducting the IS community's design guidance (for the unit of design) including meta-design. Sub research question 2: 'What is the current status quo and major impediments for containerized shipping which IT could ameliorate?', is addressed through the analysis of the unit of analysis which to reveal the current status quo for containerized shipping and to identify impediments and critical issues which become respectively meta-requirements and detailed feature requirements for the unit of design. With those as input and with respectively the DSR and the ADR method for the design process and with AT as the kernel theory are addressed sub research question 3: What design principles for an IT solution (SIP) could potentially lead to more effective containerized shipping. Evaluation of prototypes of the unit of design verify the testable design hypothesis of design principles for

unit of design regarding how IT can improve the status quo in the domain. Table 3 provides an overview of the entirety of the research design related to the research questions.

For the design, multiple approaches have been used, which include both deductive and inductive design principles. The literature review was conducted deducting design principles from IS theory. Learning was gained and design principles was derived through iterative cycles of Build, Intervention and Evaluation (BIE). The accumulated set of inductive design principles for the unit of design evolved with the BIE cycles over time, based on the learnings and evaluation of the prototypes in practice. These are described as part of the design of the unit of design in Chapter 5 and in several of the selected papers specifically Paper 3, 4 and 5.

2.6 Research data and knowledge collection

Associated with the various methods outlined above are research data and knowledge collection. This includes general and participant observation, interviews, documents, and the researcher's impressions and reactions (Myers, 1997). Data collection methods for studying inter-organization communication involves difficulties in studying both private and public organizations that are involved inter-organizationally (Reimers, Johnston, Guo, Klein, Xie, & Li, 2013; Reimers, Johnston, & Klein, 2010a, 2012), particularly when their relations traverse borders with diversity in culture and language. A framework by Reimer, Johnson, and Klein (Reimers, Johnston, & Klein, 2010b) has provided inspiration to view IOS as constellations of aligned practices.

Data was collected about the shipments in the selected trade lane by simply beginning at the farm in Africa to 'jump' in and follow along with the goods, observing who relates, touches, moves and stops its trajectory. Due to the complexity of tracking shipments, GPS devices mounted on the containers were used to trace it. Further, this research was supported by, and depended completely on, local Maersk employees to arrange meetings with relevant actors for the selected shipments.

The research data has been collected over a period of more than three years through interviewing key actors and influencers in the involved organizations, visiting field sites, observing specific shipments, conducting interviews, focus groups, meetings, workshops and conferences. A list in appendix presents an overview of the empirical data collection. Paper 1, 3 and 5 includes examples of detail research data collection.

Data collection was carried out in Europe, East Africa, USA, and Far East; however, for the specific trade lane this was primarily Kenya in East Africa and the Netherlands in Europe. Some of the case study data has been collected and reported in connection with a report for the World Economic Forum¹⁴ (WEF, 2014). Practitioners and stakeholders have assisted in selecting the organizations for the research, in particular regarding fruit import to Europe via the Netherlands and similarly for the export from East Africa. While there are several hundred importers of fruit in the Netherlands they represent a great variation when examined in detail. Therefore, was selected a representative group of importers based on the recommendations of the respective trade associations. With regard to the selection of sites for visits, field observations, semi-structured interviews, and focus groups, we were assisted by the General Secretary of the Dutch association of fruit and vegetable importers, FrugiVenta¹⁵. Similarly, the non-profit organization for trade facilitation in East Africa Trade Mark East Africa (TMEA) assisted in selection and engagement of both private and public organizations in Kenya. Visits, meetings and interviews have been conducted with traders such as exporters and importers, and with other actors such as the authorities, the terminal operators, logistic service providers and consulting companies. Research data also consists of identified key documents (for example customs declaration) and identified key information for the logistic coordination (for example updated ETA).

Throughout the three-year process, data for more than fifty shipments in various trade lanes has been collected, including documents and GPS tracking, plus interviews with plenty of actors in organizations involved. However, as mentioned this thesis focuses on only one trade lane of avocados from Kenya. Another example is the trade lane for fresh cut roses which is described in Paper 3. In the selected trade lane twelve shipments of avocados were followed over a period of two and a half years, see appendix of Paper 5 for details of the shipments.

A significant challenge for this research was the lengthy time involved in identifying actors and arranging meetings with them, often involving several visits to countries to focus on new shipments. Throughout this process new organizations and documents were revealed presenting additional challenges. Beyond that, organizations have developed many of their processes over time, creating integration challenges with the organizations they partner with, despite the fact that many of these developed processes were intended to in fact generate improvement.

¹⁴ http://www3.weforum.org/docs/WEF_EnablingTradeReport_2014.pdf 28062016

¹⁵ <http://www.frugiventa.nl/> 28062016

Data collection, about the designed IT artifact in particular, has been obtained through its presentation at workshops and similar gatherings. Additionally, when meeting actors at various occasions, they have been presented with various versions of the prototypes to obtain feedback.

The research design described above guided the main three research activities. Next, in Chapter 3, the literature review to deduct design guidance from IS is outlined. Chapter 4 guided by AT analyzes the status quo, the major impediments and critical issues for containerized shipping. Finally, Chapter 5 guided by IS design theory and ADR describes the design of several prototypes of SIP following multiple Build, Intervention and Evaluation (BIE) cycles and derive an accumulated set of inductive design principles.

3. Literature review

This research is fundamentally anchored within the research field of Information Systems (IS). Accordingly, the following literature review solely includes research publications from the IS community. This literature review answers the first sub research question 1) What constitutes the current IS research knowledge about IT solutions supporting containerized shipping?

The review is structured as follows: firstly, IS research as a field investigating digitalization is introduced especially searching for dedicated literature within maritime IT for shipping. Secondly review of specific literature of Inter-Organizational Systems (IOS) is presented. Thirdly literature review of Information Infrastructures (II) is presented. Finally, the collected literature is synthesized, deducting a set of guiding design principles to inform the creation of an IT solution for improved efficiency of containerized shipping. The collected papers contain more elaboration on the literature review process, in particular Paper 2 contains details regarding the method used for a literature review for II with explicit examples in the paper's Appendix.

3.1 Information Systems research - digitalization

Digitalization of information combined with the application of innovative IT technologies has revolutionized our world. Research about this phenomenon comes from various disciplines, such as Computer Science and Engineering - primarily focusing on the technical challenges, and additionally from disciplines as Sociology and Operations Management, largely within Business Schools¹⁶. Within studies of technology at business schools there are many specialized research areas, one of these being the field of Information Systems (IS)¹⁷. This field is typically focused on bridging between formal business units and the IT. According to Allen Lee, the long-standing editor of a top IS journal, and awarded Association for Information Systems Fellow: "Research in the information systems field examines more than just the technological system, or just the social system, or even the two systems side by side; in addition, it investigates the phenomena that emerge when the two interact" (Lee, 2001) in (Hanseth, Aanestad, & Berg, 2004). A major part of the IS research contribution is by interacting between management of organizations and information technology, and thereby create, enhance and improve businesses.

¹⁶ Organized in a community: Academy of Management <http://www.aom.org/28062016>

¹⁷ Organized in the community The Association for Information Systems <http://www.aisnet.org> 28062016

Probably due to the tight link to business schools IS research tends to focus on information systems within organizational context and less on the in-between organizations. However, this research is primarily focused on information systems in between the multiple organizations involved in containerized shipping.

The maritime industry, in a large part, is unaddressed by the IS community. Guven (2015) reviewed the top publications within IS, ranging from 2005 until 2015, finding very few publications/proceedings regarding maritime IT and concludes that “the maritime industry has been ignored by the IS community”. This means the maritime industry in general is an under-researched phenomenon, and benefits from the investigation conducted in this thesis.

In the world history of technology the invention of the computer and subsequently IT and the Internet has revolutionized the world (Headrick, 2009). Within IS literature it was found that IS research prescribes digitalization for any industry which includes digitization of information, products and/or services and to share information digitally between organizations via Inter-Organizational System (IOS) based on standardized Electronic Data Exchange (EDI)¹⁸. The potential for digitalization to transform industries, providing competitive advantages for the enterprises that can master these transformations is widely recognized (MacCrory, Westerman, Alhammadi, & Brynjolfsson, 2014; Westerman, Bonnet, & McAfee, 2014). However, it has been questioned whether IT matter as competitive advantage for enterprises (Carr, 2003). Despite this, there is little doubt that digitalization has a huge potential to transform the maritime industry¹⁹ and public sector²⁰ that also are concerned with containerized shipping.

The need to leverage IOS is well understood and extensively researched within IS. The researched cases of IOS based on EDI, reports positive effects of IOS on organizational performance (Robey, Im, & Wareham, 2008). However, as the analysis described in next chapter will show, IOS based on EDI messages accounts for only a minor part of the information exchange within containerized shipping. Accordingly, II are looked to as

¹⁸ Based on the international EDI standard: United Nations/Electronic Data Interchange for Administration, Commerce and Transport (UN/EDIFACT) developed under United Nations.

¹⁹ As presented by Westerman at Maersk Line yearly management summit in January 2015. Further, Maersk promoting their digitalization strategy appointed a Digital Information Officer in 2016 at same level as the Chief Information Officer.

²⁰ One of European Commission's top ten priorities “Digital Single Market making EU's single market ‘go digital’” https://ec.europa.eu/commission/priorities/digital-single-market_en 20170425

supplementary to this. IOS based on EDI messages is an example of an II specifically a business sector II. Other types of II includes universal II as the Internet which pose new possibilities for IT solutions. This is a new and under-researched agenda that is emerging within the IS research field (Tilson, Lyytinen, & Sørensen, 2010a; Tilson et al., 2010b). In the following, IS research within IOS and II is elaborated, serving as the theoretical framework for this thesis.

3.2 Inter-Organizational Systems

Besides digitalization, digitized collaboration *between* organizations and their direct partner is an important element, especially IOS based on EDI messages. In more general terms, IOS are “information systems to span boundaries between countries, organizations and the relatively separate components of large, geographically dispersed corporations” (Gregor & Johnston, 2000). Applications of EDI include “supply chain management, electronic funds transfer, electronic forms, electronic messaging, and shared databases” (Schwens, Isidor, Bierwerth, & Kabst, 2011). Email, though widely used for the collaboration, is not considered because IOS focuses on system-to-system connection and not system-to-human. Paper 4 elaborates regarding IOS specifically.

Extant literature about the use of IT for collaboration across organizational boundaries is typically studied under the umbrella of IOS. A closer look at the IOS literature reveals that there are more than 25 theories (Madlberger & Roztock, 2008) with no single theory standing out predominantly. The majority of IOS research focuses on IOS based on EDI messages (Reimers, Johnston, & Klein, 2004) and generally “studies show positive effects of IOS on strategic and operational measures of performance” (Robey et al., 2008). The roots of successful IOS based on EDI messages began in Europe in the 1980’s according to Krcmar, Bjørn-Andersen, and O’Callaghan (1995).

Within international trade, there are both successful and unsuccessful IOS cases. For example, the benefits of IOS based on EDI are well documented for sea carried cargo with the successful TradeNet in Singapore (King & Konsynski, 1990b) and the failure of TradeLink in Hong Kong (King & Konsynski, 1990a). Similarly, within air cargo IOS was successful in Hong Kong, while failing at Schiphol Airport in Amsterdam (Christiaanse & Damsgaard, 2000; Damsgaard & Lyytinen, 1998). The cost of establishment, maintenance and change is relatively high for IOS within international trade (Henningsson & Bjørn-Andersen, 2009), especially compared to the cost of e-mails.

As pointed out by Henningsson (2014) the success of IOS requires standardization of the EDI messages. To facilitate understanding between the sending and the receiving organization EDI messages have to be standardized at a minimum among the communicating organizations, and ideally across a larger number of organizations. The UN/CEFACT²¹, a division of the United Nation (UN), provides standards for the IOS based on EDI messages. Further, WCO²² and GS1²³ provides standards and guidance for customs and for trade respectively. Figure 1 presents UN/CEFACT's simplified overview of international trade and the main roles of the organizations involved. The figure is adapted from the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT 2001). This research is limited to containerized shipping activity which is one of several options labeled as Transport in Figure 1.



Figure 1 Main actor roles and activities in international trade.

Based on the above literature review, it is concluded that IS researchers expect digitalization to transform industries, and in particular prescribe IOS based on EDI for collaboration between organizations. Similarly, within the maritime industry for trade and containerized shipping, there has been high level consensus to strive for digitalization and IOS solutions based on EDI for collaboration via digital communication with organizational partners. Despite the

²¹ The United Nations (UN) Economic Commission for Europe (UNECE) serves as the focal point for trade facilitation recommendations and electronic business standards, covering both commercial and government business processes that can foster growth in international trade and related services. A subsidiary is the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) mandated to develop a program of work of global relevance to achieve improved worldwide coordination and cooperation in these areas. www.unece.org/cefact/ 20161128

²² The World Customs Organization (WCO) has developed the WCO Data Model with a set of carefully combined data requirements that are mutually supportive and which will be updated on a regular basis to meet the procedural and legal needs of cross-border regulatory agencies. www.wcoomd.org Summary of WCO's Technology and Innovation Forum 2015 as an example of authorities focuses: https://www.eiseverywhere.com/file_uploads/ba0d23f53ac2acd5f7734f6af92b09cf_The_5th_WCO_TI_Forum_Reviewed.pdf?eb=252370 20161128

²³ GS1 is dedicated to the design and implementation of global standards and solutions to improve efficiency and visibility in supply and demand chain. www.gs1.org 20161125

predominance of IOS, a new field is emerging, and IS researchers are calling for new directions focusing on II, which is described in the following.

3.3 Information Infrastructures

Information infrastructures (II), such as the Internet, are different than traditional IT artifacts such as enterprise systems, due to their scale, scope and pervasiveness. Accordingly, II and their design call for a separate research agenda within IS which is presented in the following.

A literature review of II, conducted within the IS field's 'Basket of Eight Journals', revealed 32 publications in total. Paper 2 elaborates on the results of this literature review while the paper's appendix details the specific methods and techniques used. Additionally, a literature review outside the Basket of Eight journals has been performed, with the conclusion that II is discussed by researchers within Computer Science and by politicians, such former U.S. vice president Al Gore.

A few pioneers within the IS research community, namely Weil, King, Hanseth, Sorensen, Lyytinen²⁴, have pioneered the research of digital and information infrastructures. Outside the IS research field Gore stands out but also worth mentioning is Star. However despite these pioneering authors, "the IS (research) field has generally paid little attention to II" according to Tilson et al. (2010a) whom in January 2010 in their publication "Desperately seeking the Infrastructure in IS Research" "call for action to address the paucity of recent Information Systems (IS) research into the infrastructures that provide the foundation upon which all information systems builds". In December 2010 in the publication "Digital Infrastructures: The Missing IS Research Agenda" they claim digital infrastructures/II are missing on the IS research agenda, and set new directions for the IS field (Tilson et al., 2010b). One such author, Sørensen²⁵, revealed that the intent was to extend the four main research areas of IS: design of, implementation of, collaboration by and markets of information systems within an organizational context (Keynote speech by Peter Keen²⁶ at European Information System Conference 1998). Obviously, the call for research regarding II is influenced by the emerging

²⁴ Based on analysis from Google Scholars and Microsoft Academic searches using Harzing and Scopus tool 20151122.

²⁵ Interview of Carsten Sørensen 20160411

²⁶ <http://www.peterkeen.com/> 28062016

the Internet. Further, Weill and Woerner (2015) predict that II as platforms, as a promising option for the next-generation enterprise.

The definition adopted in this work comes from Hanseth and Lyytinen (2010) who define II as “a shared, open (and unbounded), heterogeneous, and evolving socio-technical system consisting of a set of IT capabilities and their users, operations, and design communities”. Similar definitions are provided by Bowker and Star (1999; 2016; Star, 2002; 2006; 1989; 1996) and Monteiro et al (1998; 1996; 2013; 2014).

While there are several types of II, in the following the review is limited to digital II, which are dedicated to serve information. Digitization, through converting information to digital form, is a prerequisite for utilizing II. Both digitization and II are key in the sociotechnical process of digital transformation - digitalization. Hanseth and Lyytinen (2004b) states that II “articulates a different concept of an IT artefact from the traditional definition of an information system.” They argue that “traditionally an IS is seen as an application –aka user tool-, which is developed to serve dedicated organizational tasks. In contrast, information infrastructure has no specific purpose or goal that justifies its existence, other than a very general idea of offering information related services to community.” Taking into account applications, platforms and IIs as three types of IT artifacts/systems IIs are composed of various infrastructures, platforms and applications and are controlled through distributed and emergent control structures (Hanseth & Lyytinen, 2010).

Hanseth and Lyytinen (2004b) divide II into three classes: corporate infrastructure, business sector infrastructure and universal service infrastructure. Corporate infrastructures are those for dedicated use within a single organization, who both pay for and govern its use. It is typically guarded by firewalls and/or utilize virtual private network connections. Business sector infrastructure is an industry-wide infrastructure, such as an IOS network based on EDI messages, where communication must comply with certain standards facilitated by the dedicated service providers that govern it. This use is typically paid for through a combination of a sign-up fee, yearly fee and/or a transaction fee. The Internet provides a prime example of universal service II, where the cost of use is either free or relatively low. These classes of II are instantiated through dedicated applications installed on the information systems that facilitates interaction, communication and monitoring.

Design theory for II presented by Hanseth and Lyytinen (2004b, 2010) is based on IS design theory by Walls et al. (1992) and includes both a kernel theory, and a set of refined properties. The design theory for II includes: 1) design goals 2) set of system features 3) kernel theory and 4) design principle (Hanseth & Lyytinen, 2004b, 2010). Design goals for IIs are firstly to “bootstrap the IT capability into an installed base so that it gains momentum (and secondly to) manage and allow for maximum II adaptability.” (ibid.). The set of system features are defined by “system of IT capabilities” (ibid.). The kernel theory for II, Complex Adaptive Systems or CAS theory, separately addresses the aforementioned bootstrapping problem and the adaptability problem. CAS suggests that initially an II designer should seek to attract a critical mass of users, and secondly enable “nonlinear growth by new combination of the installed base” (Holland, 1995).

Hanseth and Lyytinen (2010) propose six design properties and a set of five socio-technical design principles to guide the design of II. The design properties include four emergent: Shared, Open, Heterogeneous, and Evolving; and two structural properties: Organizing principle and Control. Of the five design principles for II, three design principles address bootstrapping: *I*) designing initially for usefulness *II*) draw upon existing installed base *III*) expand installed base by persuasive tactics; and two design principles address adaptability: *IV*) make each IT capability simple, and *V*) modularize the II using layering and gateways. These are regarded as deductive design principles aimed to guide design of II.

Hanseth and Aanestad (2003) provide additional advice for more successful bootstrapping of II including: i) improve and extend existing infrastructures/installed base ii) Harmonize the local message formats into more general standards iii) Make similar infrastructures for other areas. iv) Improve the solutions based on experience gained v) Strive for international standards. Both advice i) and iii) concern expanding the installed based, and are therefore similar to design principle *III*. Advice ii) and v) consider standardization and harmonization of data and messages, which are prerequisites for design principle *V*) modularization. Advice iv) regards improved usability solutions, similar to design principle *I*) initial usefulness.

After the bootstrapping phase the adaption phase is initiated, during which a cultivation metaphor is proposed to provide guidance to grow the installed base and promote growth (Hanseth & Lyytinen, 2010). Such approaches include the creation of an ‘attractor’ (Braa, Macome, Mavimbe, Nhampossa, da Costa, Manave, & Sitói, 2001), adherence to specific

design principles which enable growth (Hanseth & Lyytinen, 2010), incremental functional deployment (Aanestad & Jensen, 2011), promotion of generative evolutionary mechanisms (Bygstad, 2010; Henfridsson & Bygstad, 2013; Zittrain, 2006) and the establishment of ‘killer apps’ (Eaton, Hallingby, Nesse, & Hanseth, 2014) for the active management of the growth of the installed base.

Regarding generative mechanisms, one analysis of II found that of forty cases, twenty-four of these could be classed as successful, largely owing to combining at least two of three generative mechanisms: Adoption, Innovation and Scaling (Henfridsson & Bygstad, 2013). Remarkably, nearly half (41%) of the studied cases were classified as unsuccessful. One of these successful cases involved the maritime industry specifically, and a shipping company who attempted to “develop an infrastructural information system to support the surveying of ships”, however experienced challenges related to scaling (Rolland & Monteiro, 2002). Accordingly, the degree of success can be questioned.

Returning to the empirical domain of this thesis, authorities follow recommendations and guidelines by United Nations (UN) and World Customs Organization (WCO) in the aim of establishing “a single window to enhance the efficient exchange of information between trade and government” (United Nations Centre for Trade Facilitation and Electronic Business, 2005; World Customs Organization, 2011) through the implementation of a Single Administrative Documents and a Single Window system for example in US²⁷. However, the implementation of these is challenging (Henningsson & Bjørn-Andersen, 2009; Henningsson & Hanseth, 2011; Henningsson & Henriksen, 2011). For example, in 2016 WEF reports: “Slow progress in implementing border reforms despite huge potential”²⁸.

Organizations within the trade ecosystem have begun researching the possibilities of II through the funding of several research projects that successfully demonstrated solutions. Examples include, the ITAIDE²⁹ project of five living labs, for example one was designed for beer trade, and the Casandra³⁰ living lab project which developed an II solution called Data Pipeline.

²⁷ E.g. U.S. federal agencies are directed 19th February 2014 to complete a Single Window system https://www.cbp.gov/sites/default/files/documents/singlewindow_infographic_3-4-14.pdf 20161012

²⁸ Press release on 30th November 2016 <http://www.tradefacilitation.org/slow-progress-in-implementing-border-reforms-despite-huge-potential.html> 20170107

²⁹ ITAIDE project http://cordis.europa.eu/project/rcn/79327_en.html

³⁰ <http://www.cassandra-project.eu> 20161128

The ITAIDE project³¹ specifically designed an II solution to be “the next generation information infrastructure for international trade” (Henningsson, Gal, Andersen, & Tan, 2011b). This was later named the ITAIDE II (I3) framework, and enabled end-to-end physical control for trusted traders, with an expected output of accelerating supply chains and increasing trade (Henningsson, Budel, Gal, & Tan, 2011a; Tan et al., 2011). The I3 framework leverages IT innovation, relying on the standardization of messages specified by the protocols of UN/CEFACT, GS1, and WCO for trade related content, and utilizes digital signatures and encryption.

However, neither of these projects moved beyond the living lab phase into working practice, the reasons for which remain unknown³². Paper 1 elaborates on these previous research projects. Note, the specific design behind these solutions was IOS based on standardized EDI messages.

3.4 Deductive meta-design principles

In summary, there is an absence of knowledge about how IT solutions may substantially support containerized shipping in the supply chain for international trade, a gap which bears investigation by IS scholars (Guyen, 2015). Notwithstanding, the more general IS research reviewed above is applicable to this domain.

In relation to sub research question 1, the preceding review allows for the deduction of three meta-design principles for an IT solution for containerized shipping such as SIP. They are listed below numbered with II to indicate their relation to II, and with 1.0 – 3.0 respectively.

II 1.0 IS research prescribes **digitalization** with digitization to transform any industry (MacCrory et al., 2014; Westerman et al., 2014).

II 2.0 IS research recommends **collaboration via digital communication by IOS based on EDI messages** (Robey et al., 2008). Particularly within containerized shipping this is supported King (King & Konsynski, 1990a, 1990b) reporting both successful and unsuccessful cases of IOS.

³² Interview of key stakeholders of those projects did not indicate explanations to the lack of adaption by practice.

II 3.0 IS research calls for increased investigation of utilization of II (Tilson et al., 2010b). Hanseth and Lyytinen (2010) specifically prescribe **design theory for II**, exemplified for the Internet. Within containerized shipping this is supported by Tan et al. (2011) with the I3 framework for accelerating global supply chains for trade using IT innovation.

However, in spite of these recommendations, containerized shipping remains inefficient, costly and risky, has relatively low reliability, lacks transparency and uses hundreds of documents and e-mails per shipment. Accordingly, this dissertation proposes a radical new design, which calls for an alternative to the current IOS based on EDI messages. Following the guidance regarding digitalization, digital communication utilizing II as meta-design principles is pursued for the proposed solution.

Although the three meta-design principles deducted from the IS literature are valuable and necessary, they are not wholly sufficient due to their lack of adaptation by practice. Accordingly, this research has carried out an in-depth analysis of the containerized shipping to reveal design requirements, which will be summarized in the next chapter. This is done to generate a radical new design of an II. This has been guided by the three meta-design principles mentioned above, but is augmented with a fourth meta-principle and with seventeen lower level design principles. This will be presented in chapter 5 and discussed in chapter 6.

4. Analysis of containerized shipping

This chapter addresses sub research question 2) What is the current status quo and major impediments for containerized shipping which IT could ameliorate? This question is two-fold seeking to uncover both: what is the status quo for containerized shipping? What major impediments to effective containerized shipping could IT ameliorate? The analysis is structured as follows: Firstly, the containerized shipping activity is described and decomposed. Secondly, the major impediments are revealed and analyzed. Thirdly, as a result of the analysis a set of critical issues are identified. Finally, is presented that there currently is an unleashed potential for IT solution like SIP to improve for containerized shipping. Elaborated analyses of containerized shipping with different focuses are included in Jensen et al (2014a) focusing on import of fruit, in Jensen et al (2014b) and Paper 5 focusing on a trade lane for fresh avocados, Paper 3 focusing on a trade lane of fresh cut roses.

In sum, the findings show that while the physical infrastructure dedicated to containers is efficient, containerized shipping overall is *inefficient*, due in a large part to administrative issues surrounding the trade. Further, the analysis reveals that the major impediments to a more effective trade, which are effectively three major non-tariff trade barriers, are related to a set of critical issues, which IT solutions could potentially ameliorate. The analysis overall reveals a fragmented II and identify an unleashed IT potential in containerized shipping.

4.1 Current status of containerized shipping

Typically, containerized shipping involves multiple legs utilizing different modes of transport. Particularly, the intermodal activity has benefited from the use of the standard container, enabling efficient shifts between these modes of transport. For example, after cargo is packed into containers, it is transported by truck to the port of origin where it is loaded onto a vessel. Weeks later, upon arrival at the port of destination, the cargo is loaded on a truck for transport to its final destination, where finally the cargo is unloaded from the container for further redistribution, and the container is ready for its next journey. Often cargo is stored between two transport legs, resulting in additional handling within the port area. Other modes of transport frequently used include train, barge and feeder vessels. The physical dimensions of the containers prevents them from being carried by plane. Furthermore, standard containers are rarely utilized if only one mode of transport is involved, or if other dedicated mean of transport

exists, such as tankers for bulk goods. Accordingly, containerized shipping generally includes minimum one leg of transport carried by sea, and multiple modes of transport which raise intermodal challenges. These intermodal challenges are somewhat mitigated through the efficient physical supply chain infrastructure, namely the standard container, and the dedicated equipment associated with its handling.

The physical infrastructures have evolved technologically towards greater efficiency. For example, the newest port terminals in Rotterdam have fully automated container handling³³ and large slow-steaming container vessels that can carry more than 20,000 containers³⁴. The journey of avocados from the farmer/exporter in Africa to the importer in Europe takes approximately 34 days, not including the additional days which are need to transport the goods to specific stores. Figure 2 illustrates this process. During these thirty-odd days, approximately half of the time is spent waiting, leading to the conclusion that containerized shipping is relatively inefficient. Further contributing to this ineffectiveness is the relatively low reliability of containerized shipping to actually fulfil the estimated time of arrival of shipments.

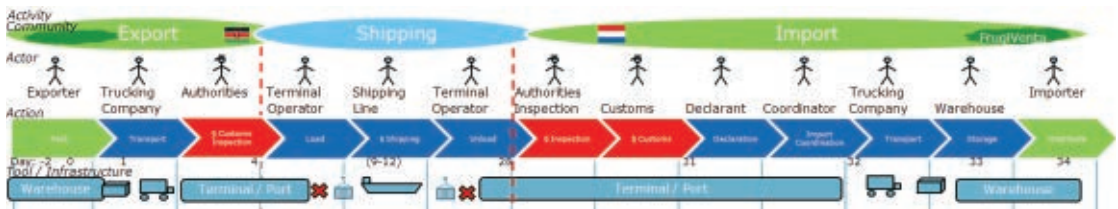


Figure 2 Physical supply chain for containerized shipping.

The analysis shows that a single shipment with one container containing fresh avocados has crossed national/regional borders at least **eight** times, and during that time has crossed the organizational boundaries of at least **ten** companies and **eleven** authorities. In total, at least **forty** actors, in more than **thirty** organizations in form of private companies and public organizations located in at least **seven** countries, are involved and perform actions related to the transport of fresh products from Kenya to EU. Each organization, as a standalone, is rather efficient in performing their action(s), with most having implemented tools such as dedicated equipment and IT systems to support their operations.

³³ APMT Maasvlakte II <https://dailyliftingmvii.com/en/http://www.apmterminals.com/operations/europe/maasvlakte> 20170401
³⁴ List of large container vessels https://en.wikipedia.org/wiki/List_of_largest_container_ships and example <http://www.maersk.com/en/hardware/triple-e> 20170401

These sheer number of actors and organizations involved in one shipment explains, in and of itself, the inefficiency of containerized shipping. Further, the number of actors and organizations involved raise concerns about security and risk. Therefore, it can be concluded that within containerized shipping the status quo is not only inefficiency, but also includes security concerns. This can largely be explained by the complex ecosystems, involving the chain of interlocked actors and organizations governed by different national and regional rules.

4.2 Major impediments to containerized shipping

Though the physical infrastructure enables efficient operations of containers, containerized shipping is struggling overall with unreliability and inefficiency, resulting in high costs and high risks. The major impediments to a more effective containerized shipping prohibit the flow of goods, affecting and preventing trade. Accordingly, these are often referred to as trade barriers. Traders experience plenty of challenges (WEF, 2013; WEF, 2011) which are not considered in this research, such as identifying a trading partner and obtaining a Letter of Credit, and the political trade barriers such as quotas and tariffs (Anderson, 2013). Instead, this research focuses only on the non-tariff trade barriers. Thus, in the context of this research the major impediments towards more effective trade can be grouped into three non-tariff trade barriers identified as:

A) International trade cost primarily cross border related administration cost.

B) Lead time and its uncertainty.

C) Security and risk concerns.

Each is discussed in detail in the following.

International trade cost presents a major barrier to trade. There are many estimates and methods for calculation of trade cost such as by the UNCTAD secretariat based on Wilmsmeier (2014) and the US National Bureau of Economic Research based on J. E. Anderson and E. Van Wincoop (2004). Trade cost is composed of the local cost of the goods at origin, the international trade cost, and the retail distribution cost, resulting in the retail cost price. As illustrated in Figure 3 the average retail cost approximately breaks down as follows³⁵: 1/3

³⁵ Recalculation of ad valorem tax equivalent from Anderson and Wincoop (2004) which is about 170% which breaks down into 55% local distribution costs and 74% international trade costs.

product cost at local export market, 1/3 international trade cost, and 1/3 retail distribution cost in imported country. This research focuses on the international trade cost which can be decomposed into 1/3 physical transportation cost and 2/3 accrued from administrative barriers that exist when crossing national borders (J. E. Anderson & E. Van Wincoop, 2004). Furthermore, the physical transportation cost can be split between transportation cost and time-dependent inventory carrying cost. For comparison, transportation cost for air cargo is approximately double the cost of sea cargo.



Figure 3 International trade cost breakdown.

The utilization of standardized containers in international trade has enabled efficient intermodal shifts between truck transport and sea transport (Levinson, 2010). Through the use of the standard container, the reduction of manual labor and increase in dedicated equipment used to load and unload goods, the cost of transporting of goods has plummeted. The physical transport cost/rate for sea cargo is volatile³⁶ and plunged to a low of \$ 400 per TEU container from Shanghai to Rotterdam in March 2016³⁷. Compared to general cargo, the international trade costs are higher for perishable goods such as avocados because they need to be refrigerated and monitored during transport. Furthermore, they require additional documentation and possible inspections regarding phytosanitary for agricultural goods. Influenced by reduced cost, the

³⁶ E.g. rate fluctuated between \$ 975 - \$ 1,256 per TEU container in January 2015 and dropped to \$ 466 per TEU container on 10th April 2015 from Shanghai to Europe www.bimco.org/Reports/Market_Analysis/2015/0414_ChinaExportBoxRates.aspx 28062016

³⁷ <https://www.flexport.com/blog/why-are-ocean-freight-rates-so-low/> 28062016

international trade³⁸ volume grew on average 5% per annum from 2000 to 2010³⁹. As this trade volume has grown administrative burden for the authorities has also grown, resulting in barriers experienced by traders and service providers.

Some of the significant administrative barriers for international trade include, authorities demanding the filing of import and export declarations, advanced manifests, special procedures and certificates for certain types of goods, scanning of containers, and several types of inspections. The administrative border crossing cost is carried both by the traders and by the authorities. Crossing international borders is costly and varies depending on country⁴⁰. The total annual world-wide cost due to administrative burdens was estimated in 2014 in the range of \$257 billion (United Nation ESCAP, 2014). The international trade cost for containerized shipping is relatively high, justified by the large number of organizations involved in one shipment. However, part of the transportation cost is indirect cost, which is related to lead time and its inherent uncertainty. Additionally, authorities report fraud and other illegal actions as being costly.

Lead time and its uncertainty regarding Estimated Time of Arrival (ETA), is a second major trade barrier (Hult & Lennung, 1980). For sea cargo, the reliability of containers arriving on time is relatively low, particularly when compared to air cargo, a major alternative means of transport for perishables as fruit. Reliability of container vessels arriving within +/- one day of estimated arrival is below 70%⁴¹ and commonly days of delay are experienced. If shipments

³⁸ International trade is trade between nations and includes trade across the globe. Trade originates with local exchange of ownership of goods and/or services to the benefit the ones involved. The option to trade encourages specializing in the goods or services which is possible to trade and attractive for others taking the transport or transforming cost into consideration. Due to practicalities and the cost involved trade has historical been with primarily neighbors.

³⁹ https://en.wikipedia.org/wiki/International_trade according to International Trade Centre part of World Trade Organization

⁴⁰ E.g. the cost to export and cost to import are estimated to be respectively: \$ 823 and \$ 915 per container from China to the Netherlands in 2015 in total \$ 1,738. Which is an increase of 22% from \$ 1,425 in 2011. <http://data.worldbank.org/indicator/IC.EXP.COST.CD> 28062016

⁴¹ The industry average reliability for vessel arrival on-time which is within +/- 1 day compared to estimated time of arrival promised two weeks prior was 67.8% for January 2015 and 69.2% for January 2017. The shipping line with lowest was 62.4% and best 77.6% based on 12,725 vessel arrivals with an average delay of 3-4 days for late vessels. However, cancelled or blank vessels are not included in the statistic. Additionally, the typically lead time for a container through a port is 3-5 days. Global top 18 liner carriers are ranked on reliability e.g., by SeaIntelligence www.seaintel.com 20170321

are rolled at transshipment port, or miss their planned transshipment⁴², delays can be weeks. For products like perishables, delays significantly impact the product quality eroding profits and increasing business risk.

Zooming in on the portion of the process where container goods move from the vessel to the importer reveals⁴³ that fruit importers experience inefficiency caused by days of lead time spent passing customs on route from the quay to the warehouse. Furthermore, there is a high variation in cost⁴⁴ of the lead time due to a lack of coordination among the involved actors. For those trying to coordinate actions within the supply chain, the physical shipment is generally out of sight (Carter, Rogers, & Choi, 2015). Accordingly, coordination and planning heavily depend on information about Actual Time of Arrival (ATA) and expected lead time for the release of goods, based on previous experiences, to calculate the next ETA.

This research reveals that containerized shipping is inefficient primarily due to a lack of adequate and timely information. Furthermore, all involved in the shipment of containers experience a substantial number of different administrative barriers. For example, one shipment was held back for days due to a missing original paper copy of the phytosanitary certificate. These kinds of delays create challenges for the onward delivery of goods, creating uncertainty when no information is provided about the delays or updated ETA. The relative low reliability and the related uncertainty confirms that containerized shipping is rather inefficient.

Notification about when goods have arrived in the port is also often a lengthy process, with containers often sitting in port for days unbeknownst to the relevant parties. Accordingly, importers and exporters create large buffers, which are often costly. It is estimated that at least 40% of the delays at the leading large ports are caused by administrative burdens, and that subsequently a 1% reduction in the time to clear customs would imply a reduction in maritime freight costs of about 0.05% (Wilmsmeier, Hoffmann, & Sanchez, 2006). Recent surveys⁴⁵

⁴² Transshipment is moving a container from one vessel to another vessel. Rolled shipment occur when a container does not get on the planned vessel. The number of rolled containers are an important indicator which means that the shipment remains at the port and wait for the next possible vessel instead of the original planned this results in a no-show as promised experience for the receiver. E.g. Maersk had in 2016 40% of containers rolled causing delays compared to original planned estimated time of arrival. 20170422

⁴³ Various interviews and focus group sessions e.g. 20140129

⁴⁴ For extended lead time beyond the upon agreed there typically is additional fees e.g. demurrage and detention costs.

⁴⁵ World Economic Forum's Global Enabling Trade Report
http://www3.weforum.org/docs/WEF_GETR_2016_report.pdf 20170117

reveal significant indirect cost caused by uncertainty and delays. In the case of avocados, the indirect cost accounts for between 22-43% of total costs for the exporters in Kenya. Furthermore, long lead time might impact the quality of the goods. Uncertainty makes it difficult to plan the next action in the containerized supply chain, such as retail distribution; a particularly challenging factor when delivery dates are crucial to the goods sales, as is the case with flowers delivered for Mother's Day. The situation is similar to the bull whip effect, creating variations in inventory due to uncertainty which results in inefficiency (Forrester, 1958). This kind of uncertainty makes trading relatively costly and risky, markedly so for perishables with limited shelf life.

Security risks are the major concern for the authorities responsible for risk assessments of containerized trade, for human health, for veterinary health and safety, for agricultural health and safety, and in particular for authorities and personnel with regard to dangerous goods. The volume of international trade has become a burden for many authorities as they simultaneously balance pressure to increase productivity and reduce cost. Furthermore, since the September 11th terror attack in the United States, many authorities have increased security levels for containerized shipping trade. New technologies such as scanners, IT solutions and improvement programs have been introduced to combat these risks. These programs are experienced by traders and service providers as new trade barriers, largely due to a lack of transparency from authorities regarding the initiatives.

It is not possible for authorities to monitor and physically inspect all cargo due to resource restrictions and only a small percentage of shipments are inspected physically. The majority of assessments made by authorities are based on information provided about the shipments. The quality of the information provided is unfortunately rather low, with around 50% being incorrect, faulty, inconsistent or simply missing⁴⁶. During the investigation of one marine accident involving a container vessel the declared container weight was compared with the actual weight, revealing many inaccuracies⁴⁷ which contributed to the failure of the vessel's structure.

⁴⁶ Estimate of senior customs officers.

⁴⁷ "The audit of the containers removed from MSC Napoli and the deadload calculated on departure, indicate that the declared weights of many of the containers carried by the vessel were inaccurate." (Branch, 2008 English Channel on 18 January 2007. 2008, MAIB Report).
<https://assets.publishing.service.gov.uk/media/547c703ced915d4c0d000087/NapoliReport.pdf> 20170509

Additionally, this information largely lacks details about the true consignee of the goods. For example, the authorities in Europe often do not know the name of the exporter as the freight forwarder is acceptable as declarant, despite the fact that they do not own the goods. Additionally, the contents of the shipment are accepted if the shipping line or freight forwarder declares that the shipment is “said to contain” fruit, though the declarant, perhaps located at a service center in India, has never seen neither the goods nor the container, and is fully relying on the shipping information provided. Note, this information is then used to calculate tariffs and create invoices.

4.3 Critical IT issues for a more effective containerized shipping

The three major impediments as described above effectively become barriers for trade; however, they are also symptoms, driven by a range of potentially solvable IT issues which prohibit effective containerized shipping. For example, the analysis of containerized shipments of avocados from the trees in Africa, to retail in the EU, reveals that plenty of actors in numerous organizations are involved in one shipment resulting in relatively high international trade cost, lead time uncertainty and risk and security concerns. As each of the organizations performs purposeful action(s) the analysis needed increased granularity at an operational and information/document level to identify further critical issues.

To a large extent, the number of organizations involved explains the international trade cost, lead time and the uncertainty of the lead time. However, the extended analysis reveals an expanded range of critical issues for containerized shipping. The most critical of these findings are reported in the following, listed in an order that reflects the highest IT potential to ameliorate to the lowest.

Through the theoretical lens of Activity Theory (AT) it became clear that while the physical infrastructure of standard containers is efficient, incorrect and missing shipping information in six out of ten shipments prohibited the movement of the container, resulting in supply chain inefficiency, relatively high uncertainty and low reliability.

This extended analysis also revealed that information is largely found on papers, which have to be approved and verified by official stamps and signatures. This is labeled issue (a) below. Very few of the involved actors can actually see the containerized shipment and thus completely depend on information about the shipment to perform their operation. This is described as issue (b) below. Each organization keep the information they have stored in an archive possible in an

IT system. However, no actors from outside the organization and not all actors within the organization have access to this information. This is referred to as issue (c). However, the information that the actors have if they have it are not up-to-date or are error prone for example the information about ETA for the shipment is provided by other actors but rarely communicated timely to other organizations, which is issue (d) that makes planning and coordination challenging; further, operations become reactive, combined with limited office hours tasks tend to pile up and getting done next day; this explains both the long lead time and its uncertainty, and the security concerns. Further, the analysis highlighted inefficient collaboration across organizational boundaries and national borders caused by actors using multiple communication channels representing a fragmented or missing II, see Jensen et al (2014a) and Paper 5. This is addressed as issue (e). Further the use of IOS and II are addressed as issue (f), (g) and(h).

In the following the main critical issues causing the major impediments within containerized shipping are expanded. Issue (a) is that a range of documents are required on paper⁴⁸. Furthermore, many documents are required in their original version with the correct stamp(s) and signature(s). For example, in nearly all countries a certificate of origin is required for import declaration, and for agricultural products a phytosanitary certificate is needed to clear authorities upon arrival. Digitized versions of these documents, such as an e-Phytosanitary certificate, are in general not accepted by importing authorities. The original paper documents do not travel with the container, but are sent by costly courier(s), typically by air since the documents are valuable and are processed after the containers departure and need to move quickly to catch up. The industries reliance on paper-based documents incurs additional costs, and sometimes delays.

One of the most challenging issues in containerized shipping is the lack of visibility of the shipment, as during its journey as it is remote to nearly all actors in the organizations involved. Accordingly, the shipment is only visible virtually through the information about it. This encompasses issue (b): Most actors rely on shipping information as they are remote to the physical containerized shipment. Thus, the actors mainly perform their operations based on the

⁴⁸ This is a known issue by U.S. Customs and Border Protection they state, “Today, traders must submit the same information to multiple agencies, multiple times through processes that are largely paper-based and manual.” 20170401

provided shipping information about the container. This makes coordination efforts challenging and increases risk and security concerns.

Furthermore, each organization needs different aspects of information about the container, which is not necessary relevant for other organizations. For example, the tax authority demands that the goods are declared as classified by a harmonized classification code⁴⁹. Due to this complexity, each actor ends up developing varied and unique information/documents, storing their information in a spread sheet, or in one or more information systems, on paper documents, and in emails, and/or highly specific systems, like the fee-based port community system⁵⁰. This results in issue (c): each organization holds information/documents in their ‘isolated’ information systems, which results in more than one hundred documents for one shipment⁵¹.

The magnitude of disparate documents results in issue (d): most of the documentation is not up-to-date, is error-prone or of poor quality, or simply missing, and real-time and reliable information is not available. This issue occurs primarily due to three reasons: each organization stores the information in one or more information systems within their control; the information is re-typed and copied and pasted between systems; and the information is communicated peer-to-peer in a chain along the supply chain. The result is that the actors lack real-time transparency and visibility about the physical container and its related information. For example, the fruit importers in EU report that they lack vital information about the fresh products in their shipments, while others in the shipping ecosystem hold this very information in their systems, see Jensen et al (2014a) for additional details. Another example, is that the authorities lack valid information, and often find inconsistent information in the various documents concerning the same shipment. Oftentimes the packing list, which is attached to the certificates, is produced before the container is packed, using ambiguous language such as “said to contain” on the Bill of Lading. These issues exacerbate the authorities many security concerns.

Additionally, issue (e): the actors use of multiple communication channels to exchange information and documents, stands out in contrast to the efficient physical infrastructure utilizing standard containers. Communication is typically between two actors (peer to peer)

⁴⁹ The Harmonized Commodity Description and Coding System by World Customs Organization <http://www.wcoomd.org/en/topics/nomenclature/overview/what-is-the-harmonized-system.aspx> 20170401

⁵⁰ Dutch port community system: Port Base used e.g. for the Port of Rotterdam www.portbase.com 20160609

⁵¹ Number of documents per organization involved in containerized shipping is in average six documents per shipment <https://shippingandfreightresource.com/documentation-involved-in-a-sea-freight-shipment/> 20170509

utilizing a mix of phone, e-mail, ordinary mail, courier, and electronic messages as EDI messages. This communication pattern is bilateral along the supply chain, involving time consuming iterations between multiple actors and prolonging lead time. One of the analyzed shipments revealed an example where the ETA information changed due to a storm, however this update was not communicated to all relevant actors, resulting in a truck arriving at the port two days before the shipment. For an illustration of the information flow and communication channels for a selected set of information and documents, see Figure 4 which in AT terminology illustrates both a small part of the knotwork involved in containerized shipping and the fragmented mycorrhizae. Accordingly, it is concluded that containerized shipping is lacking some efficient mycorrhizae and establishing an efficient mycorrhiza in form of a shared global information infrastructure could potential facilitate the knotwork improving the efficiency of containerized shipping, see Paper 5. The implicated actors have various working hours and may be located in different time zones, causing communication challenges on the weekend in particular. Additionally, the involved actors might be busy and therefore delayed in completing vital manual operations, setting off a cascade of issues when several actors need to coordinate, such as when importer, authorities, service providers as carrier and terminal operator have to be present for the physical inspection of goods.

Issue (f): is the limited use of IOS based on EDI messages. For illustration, the EDI messages are indicated with a lightning symbol in Figure 4. Following goods and their related information in the shipping lines, the terminals, the freight forwarders and authorities' systems, see Jensen (2016b) for details, revealed that the use of IOS based on EDI messages only accounts for few of the hundreds of documents/information required for shipping one container. Instead e-mails are used extensively, resulting in communication overload and a lack of coherent information, see Paper 3. The organizations using IOS based on EDI messages communicate a substantial number of messages. For example, Maersk communicates status changes and container moves for approximately three million containers through EDI messages, which results more than fifty events per shipment in Maersk's Global Event Management System, and several hundred updates per container in Maersk's internal container monitoring system each year.

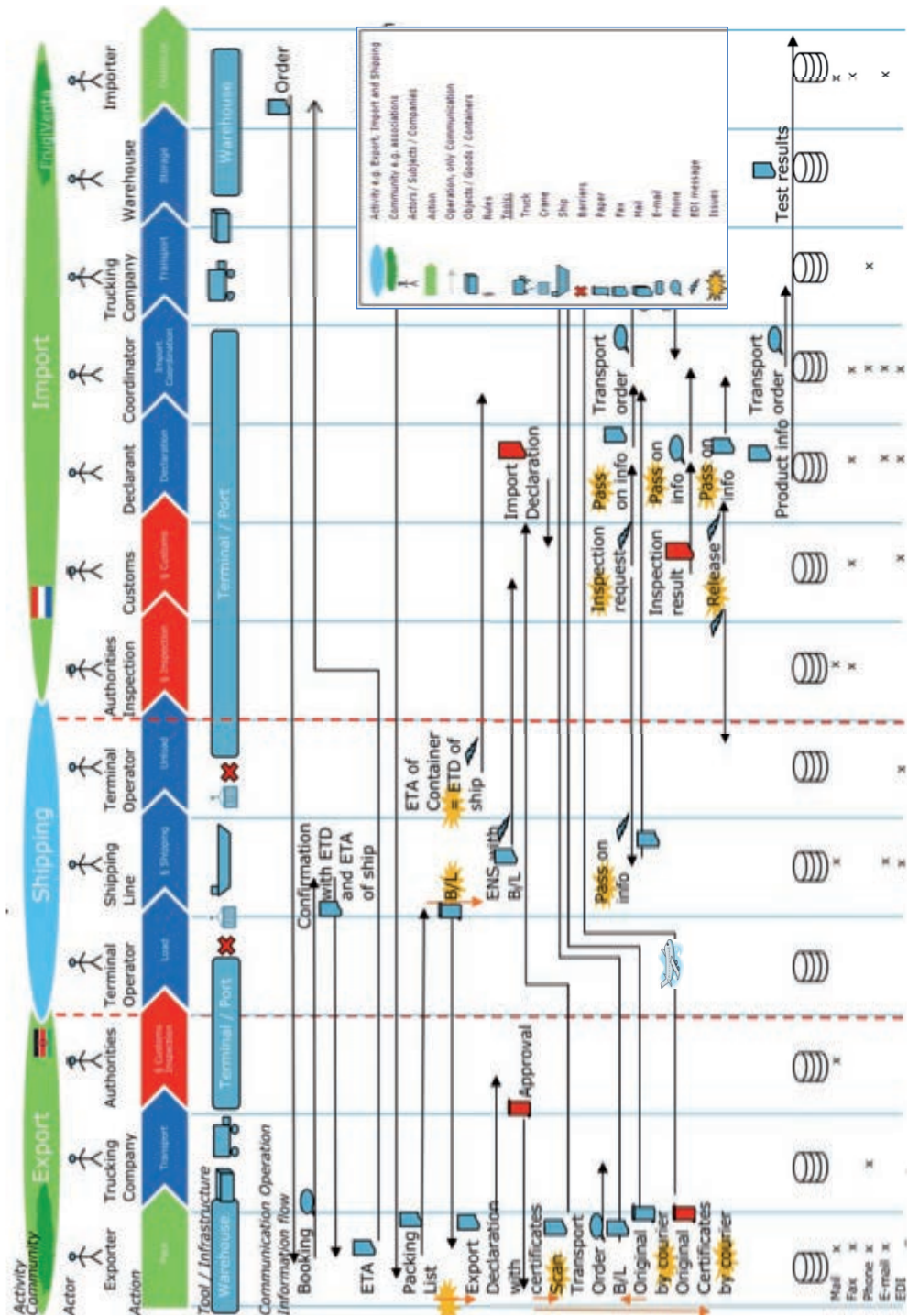


Figure 4 Knotwork for documents/information exchanged within containerized shipping.

Only a handful of organizations receive these outbound EDI messages, and many are often delayed due to business hours, geographical security issues, and batch protocols meaning communication is only done once daily⁵³. Out of the hundreds of documents for one shipment a maximum of ten are communicated as EDI messages. Primarily organizations with high volume transactions are utilizing EDI messages and, as previously mentioned, these are only bilaterally communicated. Instead of EDI messages, the actors utilize multiple channels for sharing information, e-mail being the preferred and phone including short text messages if urgent. Each actor has plenty of e-mails regarding shipments – one actor had over five hundred for a single shipment alone.

The IS community's recommendation to use IOS based on EDI messages (II 2.0) seems to be neglected for the majority. When EDI is utilized the communication is asynchronous, such as a batch job run once daily, or every second hour, which results in delayed event information and inaccurate indications of time/date. The analysis found large time/date deviations between reported event information and GPS information; the event information often reported that the container had gated in and out at the exact same time, suggesting that the time indication refers to the batch job of the EDI, rather than the time the gating actually occurred.

Issue (g): the current communication channels only facilitate bilateral information forwarding, in parallel asynchronous communication patterns of copy and paste, and peer-to-peer communication along the containerized supply chain. As the detailed analysis of the affordances of actors' communication operations reveals, this communication pattern does not provide provision for persistent and simultaneous exchange of information between multiple actors, see Paper 3 for details. Further, elaboration regarding communication patterns are provided in Paper 4 and discussed in Chapter 6.

Containerized shipping involves collaboration across different cultures, languages, technologies and across nations, regions and continents, see Jensen et al (2014a) and Paper 5. This leads to issue (h): information and document are not exchanged at global level but primarily at local level within one of three activity systems: exporter, importer and international shipping. This results in three disparate activity systems that are separated physically, geographically, temporally, and each governed by their own set of rules and procedures. They are only linked via physical infrastructures for fresh products in refrigerated containers, with

⁵³ Based on interview of senior experienced Maersk employee 20170503

little related information, of which includes Entry Summary Declaration (ENS) communicated by IOS based on EDI message, original certificates communicated by courier service, and bill of lading^{54&55} which is communicated by email or courier service. E-mail is used if a digital version is acceptable, documents are sent by courier service if the original version is required, and IOS based on EDI messages are used if the IOS is established. See Figure 5 for illustration of the three activity systems which are elaborated in Appendix of Paper 5.

However, compared to the total amount of shipping information, the shipping lines send very few EDI message (issue f). For example, ENS declaration is send as EDI message to the European regional authorities at first port called by the vessel and similarly is loading lists send as EDI message to terminal operators whereby the shipping industry connects the export and the import.

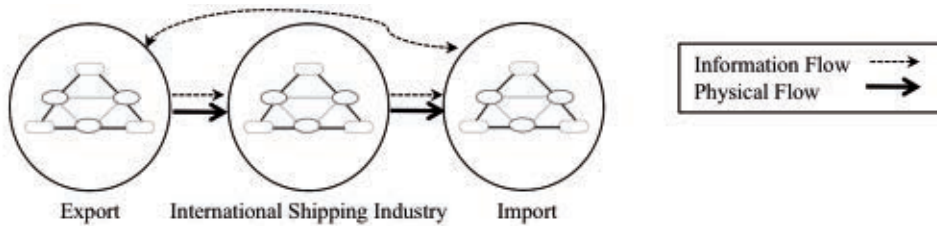


Figure 5 Three activity systems for containerized shipping.

Each activity system is governed by a unique set of rules which are separated by regional territories and national borders. This is confirmed by the fact that the IOS based on EDI messages in operation are local implementation for example of the port community systems (King & Konsynski, 1990a, 1990b). Thus, the findings indicate that the existing IOS based on EDI messages is limited in its use, and is not supporting end-to-end communication between the export and import entities in the supply chain for containerized shipping.

⁵⁴ 'Bills of lading' is defined by UN as "a receipt signed by or on behalf of the carrier and issued to the shipper acknowledging that goods, as describe in it, have been shipped in a particular vessel to a specified destination or have been received in the ship owner's custody for shipment."
http://unctad.org/en/PublicationsLibrary/c4isl6rev1_en.pdf 28062016 (United Nation, 1971)

⁵⁵ Various transport documents exist for various means of transport and countries/regions e.g. in EU the list includes: Bill of Lading (for sea), FIATA Bill of Lading; Road Waybill (CMR); Air Waybill (AWB); Rail Waybill (CIM); ATA Carnet; and TIR Carnet.
http://exporthelp.europa.eu/thdapp/taxes/show2Files.htm?dir=/requirements&reporterId1=EU&file1=ehir_eu_11_02v002/eu/main/gen_freidoc_eu_010_0612.htm&reporterLabel1=EU&label=Freight+documents&languageId=en

Accordingly, the more than forty actors in the ecosystem encounter numerous critical issues, particularly of an administrative nature. The analysis reveals the actors in the organizations involved experience major impediments, however, of these numerous issues, those that could be ameliorated through IT are non-tariff barriers for trade. The three major trade barriers are: international trade cost, lead time and its uncertainty, and increased security concerns.

Additionally, the analysis revealed a set of critical issues causing impediments for containerized shipping impacting the major trade barriers. Summarized the top eight critical issues are:

- (a) A range of documents are required on paper, many in original version(s) with official stamp(s) and signature(s).
- (b) Most actors have to rely on shipping information since they are located remotely from the physical containerized shipment.
- (c) Each organization holds information/documents about the container in their 'isolated' information systems, resulting in a magnitude of documents containing fragments of the shipping information.
- (d) Most documentation is not up-to-date, is of poor quality, or simply missing, and real-time and reliable information is not available.
- (e) The actors use multiple communication channels including: primarily phone and e-mails to exchange information and documents and couriers for original paper documents.
- (f) Organizations' use of IOS based on EDI messages is limited compared to other communication channels such as e-mail.
- (g) The current communication channels only facilitate bilateral information forwarding, through parallel asynchronous communication patterns of copy and paste and peer-to-peer communication along the containerized supply chain.
- (h) Information and documents are not exchanged at global/international level but primarily at local level within one of three activity systems: exporter, importer and international shipping.

Research shows that the border crossing related administration cost of international trade is double the cost of the physical transportation itself. Furthermore, shipping reliability is below 70%, leading to the conclusion that containerized shipping is both costly and extremely

inefficient. Furthermore, the analysis reveals that containerized shipping is not only inefficient but also involves intimidating risks. This can be explained through that the ecosystem for containerized shipping can be characterized as rather complex and interlocked with many actors across various loosely coupled organizations, which are bound by various rules and regulations across the different nations and regions involved.

Clearly the above critical issues negatively impact the uncertainty for the lead time and the international trade costs. Furthermore, this results in a situation with increased risks and security concerns where the shipment becomes a runaway object (in AT terminology) which is out of control, see Paper 5.

4.4 Unleashed IT potential for improving containerized shipping

Following IS design theory the aforementioned impediments form the meta-requirements to be addressed by the proposed IT solution. The major impediments for containerized shipping are: international trade cost, uncertainty in lead time and security risk concerns, which effectively are three major trade barriers. As previously mentioned these impediments are impacted by a range of critical issues, relating largely to the communication and exchange of documentation. Given that the core of these issues stems from a dependence on information, digital solutions could potentially improve efficiency but only if information is in digital form. Thus, designing an IT solution which addresses the critical issues could potentially ameliorate the impediments for more efficient containerized shipping.

The findings indicate that IOS based on EDI messages account only for a smaller part of the total communication related to containerized shipping. Further, the implemented IOS based on EDI messages are local either at regional, national or port level, see Jensen et al (2014b) and Jensen (2016b) for details. Accordingly, the existing infrastructure for sharing information is fragmented and grossly ineffective. In essence, they **lack a shared II**, see Jensen et al (2014a) and Paper 5. Compensating for the current fragmented II, a shared II can potentially ameliorate one of the root cause of the major impediments to effective containerized shipping. A shared II will complement the efficient physical infrastructure for containers.

Accordingly, it is concluded that there is an **unleashed IT potential for digitalization within containerized shipping**. See Jensen et al (2014b) and Paper 4 for elaborations. A prerequisite to unleash this potential is the digitization of all information, and the development of a state of the

art integrated II to exchange information between the actors and their information systems in real time. While currently many documents exist in digitized versions, they are stored in local IT systems and only accessible to the actors of the organization. Beyond that authorities require original paper documents with specific stamps and documentation to ensure trust. Accordingly, trust becomes a key challenge when prescribing digitization to transform businesses.

This research is not the first to draw the conclusion that IT has an unleashed potential to improve the current situation within shipping, many within the IS community have recommended IOS based on EDI messages to exchange digitized information in inter-organizational settings (Christiaanse & Damsgaard, 2000; Damsgaard, 1998; Damsgaard & Lyytinen, 1998; King & Konsynski, 1990a, 1990b; Robey et al., 2008; Tan et al., 2011). Further, research into the leading Dutch transport and logistic industry drew similar conclusions; the main findings of this research can be summarized in the following: “logistics one of the strongest pillars in the Dutch economy...The future looks bright but if we wish to maintain a leading-edge we will need to work even more closely together. In the field of data exchange in particular there is still a lot to be done.... A lot of data are already being exchanged. But through a host of difference solutions. As a result, we are missing opportunities to build connections and work together more.”⁵⁶

In summary, physical infrastructures for containerized shipping was found being efficient; however, overall containerized shipping is inefficient because of the many revealed critical issues related to shipping documentation/information which containerized shipping depends on. Thus in regards to sub research question 2, the status quo of containerized shipping can be said to be ineffective with three major impediments. Within these are a range of critical issues which could be ameliorated by IT. Furthermore, there is an unleashed IT potential for digitalization in the ecosystem for containerized shipping, largely owing to a fragmented II for the actors' exchange of shipping information. Based on this it is hypothesized that digitalization, including digitization of information/documents and enhanced collaboration via a shared II, constitutes an IT-based solution that will significantly facilitate efficiency, by ameliorating the critical issues and the major impediments for containerized shipping. The design of an IT artifact, in the form of a shared II for shipping information (within containerized shipping), is described in the following chapter.

⁵⁶ iShare project <https://www.ishare-project.org/en> video: <https://youtu.be/O9u6ZmGIQAc> 20161121

5. Design of IT solution: Shipping Information Pipeline

This chapter addresses sub research question 3): What design principles of an IT solution (SIP) could potentially lead to more effective containerized shipping? In light of the meta-design principles identified in Chapter 3, combined with the findings of the above analysis in Chapter 4, an IT artifact has been designed that potentially can ameliorate the critical issues addressing impediments to a more efficient containerized shipping. The proposed design is an IT solution named the Shipping Information Pipeline (SIP) that is described in this chapter with a set of inductive design principles.

The structure of this chapter is as follows: Firstly, the three meta-design principles recommended by the literature and an additional fourth meta-design principle is summarized. Secondly, the initial design of the SIP is presented, followed by an outline of the subsequent iterations of 13 prototypes are reported. Finally, the learnings from the interventions of these prototypes are summarized as a set of inductively obtained design principles.

5.1 Meta-design principles

The literature review identified three meta-design principles which guide the design. These, in short, are digitization of documents, collaboration via digital communication by IOS using EDI messages, and the use of II. The empirical analysis, however, revealed that practice follows only the first two meta-design principles. This presents a disjuncture, as research proposes following the third meta-design principle and specifically using the I3 framework to accelerating global supply chains (Tan et al., 2011). The initial design was guided by all three meta-design principles. However, through the BIE cycles of the prototyping of SIP seventeen detailed design principles were revealed. Through subsequent discussions the importance of one of these design principles became apparent and therefore included as a fourth meta-design principle.

For II solutions utilizing the Internet and its WWW are there four meta-design principles:

- II 1.0 Digitalization with digitization of information and documents.
- II 2.0 Collaboration by digital communication.
- II 3.0 Utilization of II.
- II 4.0 Sharing meta-information only and governing access to detailed information.

In the following the relation between these four meta-design principles and the design of SIP is expanded.

In general, it was found that there is plenty of paper involved in international trade, preventing digital collaboration via digital communication which causes impediments impacting effectiveness. This leads to confirmation of the **first meta-design principle (II 1.0): digitalization** of information and documents/papers, as recommended by the IS community (MacCrory et al., 2014), which became a pre-assumption for the inductive design of the SIP.

Digitization of all information for containerized trade is a prerequisite to the use of a shared digital II which potentially eliminates dependency on multiple other communication channels. However, the digitization could also result in several different formats for the information and documents intended to be shared. Accordingly, the design does not demand a specific format for the digitized information; beyond the information being in a digital form that is compatible with standard web browsers for viewing. Compatible examples uncovered during the analysis include: web pages, documents in Adobe pdf format, spreadsheets (XLXS format), images (JPEG, PNG), and EDI/XML messages, which all can be handled by standard browsers. Handwritten notes or signed documents can be challenging; however, it is proposed that these documents are either scanned or captured through photograph.

In order to make the SIP effective, it is recommended that authorities in the importing country be willing to accept digital version of these documents, such as the previously mentioned example of e-Phytosanitary, which the Dutch customs currently does not do, even when equipped with digital signatures and encryption. Digitization of documents and information enables piggy backing, reducing the workload of re-keying information, creating efficiency, and preventing data-entry errors and improving the quality of the information (Tan et al., 2011).

The second meta-design principle is (II 2.0): Collaboration by digital communication complementing existing communication channels. Digitized information enables collaboration through digital communication. Currently IOS communicates using digital EDI messages which are successfully implemented in port communities meaning that containerized trade to a large extent depends on IOS based on EDI messages. However, IOS based on EDI messages is only used for few of the hundreds of documents and information exchanged in the ecosystem for shipping, see Paper 3.

Furthermore, the IOS based on EDI are currently only scoped for, and thus successful in, local implementations. The relative cost of these IOS messages based on EDI is relative high (Henningsson & Bjørn-Andersen, 2009; Henningsson & Henriksen, 2011). For example, the cost of adding one EDI communication between a private company and authorities is estimated to be 100,000 EUR. This was confirmed during interviews with the CIO of Maersk, who reported EDI communication as one of the major costs for the shipping line's IT budget. Another example of escalating costs related to EDI, can be seen in an attempt to address the problem of overweight containers causing serious accidents, through the addition of an EDI field detailing estimated weight of containers⁵⁷. This has involved multiple organizations in the ecosystem, and the total cost is estimated to escalate into double-digit millions in USD⁵⁸.

The poor quality of information received by authorities could be mitigated through a data pipeline, obtaining data/information directly from the source (Hesketh, 2009). The concept of data pipeline (Hesketh, 2010), has been developed and has been successfully demonstrated in several research projects such as ITAIDE (Tan et al., 2011), however, it has not been adapted by practice. An explanation of this could be found in the concepts suggestion to send EDI messages directly from the importer to the exporter, which is costly.

The solution proposed in this research is using the Internet for digital collaboration which is far less costly. This is a substitute for the plethora of bi-lateral communication and utilizing the Internet provides opportunities to scale collaboration and sharing of information across multiple organizations worldwide.

This leads to **the third meta-design principle (II 3.0): Utilize shared Information Infrastructure**, specifically for the SIP it was chosen to be based on the Internet. As the analysis revealed, currently actors use multiple communication channels forming fragmented II, and they lack a common II for sharing shipping information. Utilizing the Internet as basis for the shared II is beneficial for two primary reasons: global reach and extremely low cost. The coverage of the Internet is nearly global, however lacking on many of the large oceans. Thus, since Internet coverage is fine in ports, it will be known when a shipment was loaded onboard a vessel and when unloaded, accordingly, and while onboard all needed is the GPS position of the vessel which is public available. Accordingly, the lack of Internet coverage on the oceans

⁵⁷ Verified Gross Weight project https://www.mplusb.de/SMDGwgV3/docs/PDF/EDI_Weighing_MSC-Le-Navi_SMDG_Discussion.pdf 20170509

⁵⁸ Estimate by project manager for eVGM project at Maersk. 20170501

is not an issue. Furthermore, some of Maersk's refrigerated containers have a device which provides GPS position both on land via GMS communication, and at sea via vessels' satellite communication capabilities.

The proposed design for the SIP is in line with **the fourth meta-design principle (II 4.0): sharing through publishing meta-information only**. The fourth meta-principle is one of the major contributions of this thesis. This principle prescribes against sending all detailed information, such as with EDI message, and instead recommends sharing only the referential meta-information, informing receivers that the detailed information is available without including it.

This design principle crystalized during the development and coding of the initial prototypes, and was further solidified during reflections after development, leading to the recommendation that it candidates to be included as a meta-design principle. The concept of sharing only referential information was, in part, inspired by the design of the world wide web (Berners-Lee & Fischetti, 1999). Note, that the governance of the detailed information is performed by the source and only sharing meta-information and references utilizing the Internet. The information source can thus select the location of the storage of the detailed information, and access for others can be enabled using a server or web/html page. Furthermore, the source needs only publish meta-information with referential information, which could include an URI/URL⁵⁹ pointing to where to find the detailed information at the source.

Because the information resides solely under the governance of the source there is a limited need for standardization. This is in contrast to EDI messages, where standardization of the detailed information into data sets is required, as seen with the UN/CEFACT ISO standards. To facilitate collaboration there is however, an absolute requirement of aligning ID's and other meta-data which become meta-information (for the detailed shipping information) which SIP has to govern. The concept is different from current practices of IOS based on EDI messages and from the data pipeline concept of Heijman & Hesketh (2009) due to the fact that SIP does not send standardized information via a pipeline, but instead only sends referential information with links to the source. Instead of the sender pushing the full detailed information as with EDI message, detailed information is published at origin and only referential information with meta

⁵⁹ URI Uniform Resource Identifier is the Uniform Resource Locator (URL), frequently referred to informally as a web address. See https://en.wikipedia.org/wiki/Uniform_resource_identifier

information such as container ID and event time, location and publisher are published. See Paper 4 and Chapter 6 for elaborated details.

The II 4.0 meta-design principle enables collaboration which differs from the longstanding recommendation of IS scholars to collaborate between organizations using the IOS concept for exchanging detailed standardized data using EDI messages. This fourth meta-design principle does not conflict with the recommendation, but should rather be considered as complementary.

The current practice of exchanging detailed data as EDI messages provides opportunities for automation at the receiving organization. With the application of the meta-design principle (II 4.0) similar automation at the receiving end requires a different approach, where the detailed information has to be fetched by receiving organization using the provided URI/URL. Additionally, the publishing organization's systems could offer an API service to ease the consumption of the detailed information.

Organizations might be reluctant to share information though only the limited meta information about shipping information is shared and the detailed shipping information/documents are not shared initially but governed by the source. Accordingly, encryption and other methods to secure and protect information could be relevant to increase willingness to share.

The fourth meta-design principle (II 4.0) changes the affordances performed by the actors involved in containerized shipping, see Paper 3 for details. The actor, or a system on behalf of the organization, can publish referential information for a shipping event. Furthermore, the actor can search within and/or subscribe to published information. Beyond this, detailed information can be accessed by following the referential link. This communication pattern is different from the current bilateral communication pattern along the supply chain, since information about an event can be shared to many actors simultaneously, and the actors can select which information about events to search and subscribe for. This is discussed further in Paper 4 and in Chapter 6.

From the analysis, it was learned that most of the operations performed by actors are based on visual checks of the information/documents, and that detailed information is not re-used digitally nor entered into an IT system. The typically primary operation is to change status for the shipment or container which triggers the subsequent operation. Accordingly, some actors do retype or copy and paste an ID related to the shipment before the status is changed. This issue is mitigated through design principle (II 4.0), as every authorized actor can get the

URI/URL and thereby simply click on the link to access the detailed information if authorized. However, this requires different affordances performed by the actors who have to change working procedure. For example, authority officers need to open the URI/URL to view the information, this is a change relative to their current way of working, and may not be accepted by all, see Paper 3 for further details. This will have to be tested and evaluated in a dialogue with the various authorities. Of note is that Dutch Customs has in fact piloted an option for multiple filing, called NLBB52 Notification of additional information⁶⁰. This is an option to upload an URI/URL linking to additional information for a B/L or container ID, which is in line with the design principle (II 4.0).

5.2 The initial design

The initial design concept of the SIP was to complement the physical supply chain for containerized shipping with an information infrastructure utilizing the Internet. This was in line with an idea of a data pipeline, connecting authorities in EU to source data in China, which assumes documents and information being digitized. This idea of a data pipeline was developed by two officers from respectively Dutch customs and UK customs during a visit to China⁶¹. The data pipeline idea described: “A web-based, seamless, electronic data ‘pipeline’...to link the seller/consignor and the buyer/consignee and the interested economic operators in between. Real-time, accurate data must be assured from the beginning, updated as the goods move, and shared in a risk based, layered approach” (Hesketh, 2009). Furthermore, the implementation should be based on EDI messages and EPICS standards (Hesketh, 2010; Hu, Tan, & Heijmann, 2016; Klievink, Van Stijn, Hesketh, Aldewereld, Overbeek, Heijmann, & Tan, 2012b; Tan et al., 2011). Jensen (2015b) elaborates about the history of the Data Pipeline.

The ITAIDE project specified the data pipeline by the I3 framework as “a platform for control of shipments and information transparency in international supply chains.” (Tan et al., 2011). Subsequently the data pipeline was developed in several EU funded research projects and instantiated and demonstrated in four living labs for: beer, paper, food and drug (ibid.).

⁶⁰ Presentation by Wout Hofman at the “8th European Conference on ICT for Transport Logistics” October 2015 http://www.coreproject.eu/media/1176/presentations-on-core_ecitl_2015.pdf

⁶¹ Interview 2012

The history of the SIP began in 2013, with a series of dialogues with researchers knowledgeable about the concept of data pipeline for international trade. The idea of the SIP started in the IT department of Maersk, who after a dialogue with researchers, decided to engage in an ongoing research project demonstrating the Data Pipeline idea⁶² focused on demonstrating possible solutions facilitating international trade and increasing security.

As result of discussions with above inventors, a range of researchers and practitioners it was decided to start with similar vision and to design an alternative solution. This vision was discussed with various stakeholders including sponsoring EU officers, inventors, and the management of Maersk Line (CEO, CFO, and CIO), who were all supportive and encouraged work towards a concrete design, creating “an Internet for shipping information”. This has also recently been adapted into the CORE research as deliverable of a dedicated work package: to develop on a large scale the “Internet of Shipping” (CORE internal Document of Work 2016-10-19 page 107).

An outcome of a series and workshops with practitioners revealed a set of recurrent themes which were formulated into design principles.

- I. No big brother (no central database).
- II. Integrate once and connect to everyone.
- III. One virtual pipeline built by many physical pipelines.
- IV. No facilitation of commercial agreements.

These principles became the starting point for all subsequent prototypes. While the data pipeline concept was presented during these discussions, the three deductive meta-design principles described earlier were not included in the discussion since they were taken for granted. The rationale behind each of the four initial *inductive* design principles are overall as follows.

The first design principle (I) addresses the commercial and highly competitive situation within both containerized shipping and international trade. In such a situation, organizations have little desire to share information with others, unless compelled by legal regulation. Further, the culture of the authorities operating in the industry is to share information on a ‘need to know’ basis only. For example authorities demand the carriers (which are fewer in number than the shippers) to provide the packing list even carriers do not know since they might not own the

⁶² E.g. Cassandra-project.eu see videos: <https://youtu.be/tdIMTYdxn5c> and <https://youtu.be/jqdGvjzUVNA?list=UUY4zPTedIJNZBjA0GRdtmqA> and COREproject.eu see video <https://youtu.be/JkVOtM-q8jM>

container nor did they pack the container, instead they state “said to contain” or “Freight at all” based on a requested packing list from the shipper whom is assumed to request it from the source e.g. the consolidation center or warehouse, but to prepare the documents and get approvals in advance this is done prior to the container being packed and accordingly, this information often differ from what was actual packed. Accordingly, if the SIP collects large amounts of information about business operations then many organizations could be reluctant to adopt SIP. To prevent this the SIP, by design, ensures no ‘big brother’ is watching. Such a solution precludes a central database for information storage, leading to a solution with multiple databases and instances.

The second design principle (II) prescribes that this multiplicity should occur behind the scenes and not be prohibitive in users connecting. This is similar to the Internet, which is used as the underlying II for the SIP. Accordingly, the use of the SIP is easier when an actor or organization is integrated and the SIP can be used to access shipping information about any shipment. These users need to have tools to manage the information relevant to the shipments they are involved in. Further, they need to be authenticated to obtain specific information.

The results are one virtual pipeline, which is built of multiple pipelines. This is the third design principle (III). In this case while several providers offer pipelines, for the actors using them it appears to be a single pipeline. Similar to how both Internet users and mobile phone users can seamlessly connect even if they are on different physical infrastructures. This is possible through various established elements including standard protocols and roaming agreements.

Lastly the fourth design principle (IV) is to focus solely on the operational part of containerized shipping, excluding the commercial parts, which organizations are reluctant to share given the competitive situation and the culture of the authorities. Additionally, this design principle supports the separation of the IT solution from other existing solution such as handling quotes and bookings⁶³.

Figure 6 below schematically illustrates the design concept of the SIP creating efficient mycorrhizae for containerized shipping. In the shared II all documents are digitalized and stored under governance by the source who also provide remote access to authenticated actors via a shared link and associated meta-information.

⁶³ For example, solutions provided by INTTRA www.inttra.com 20161203

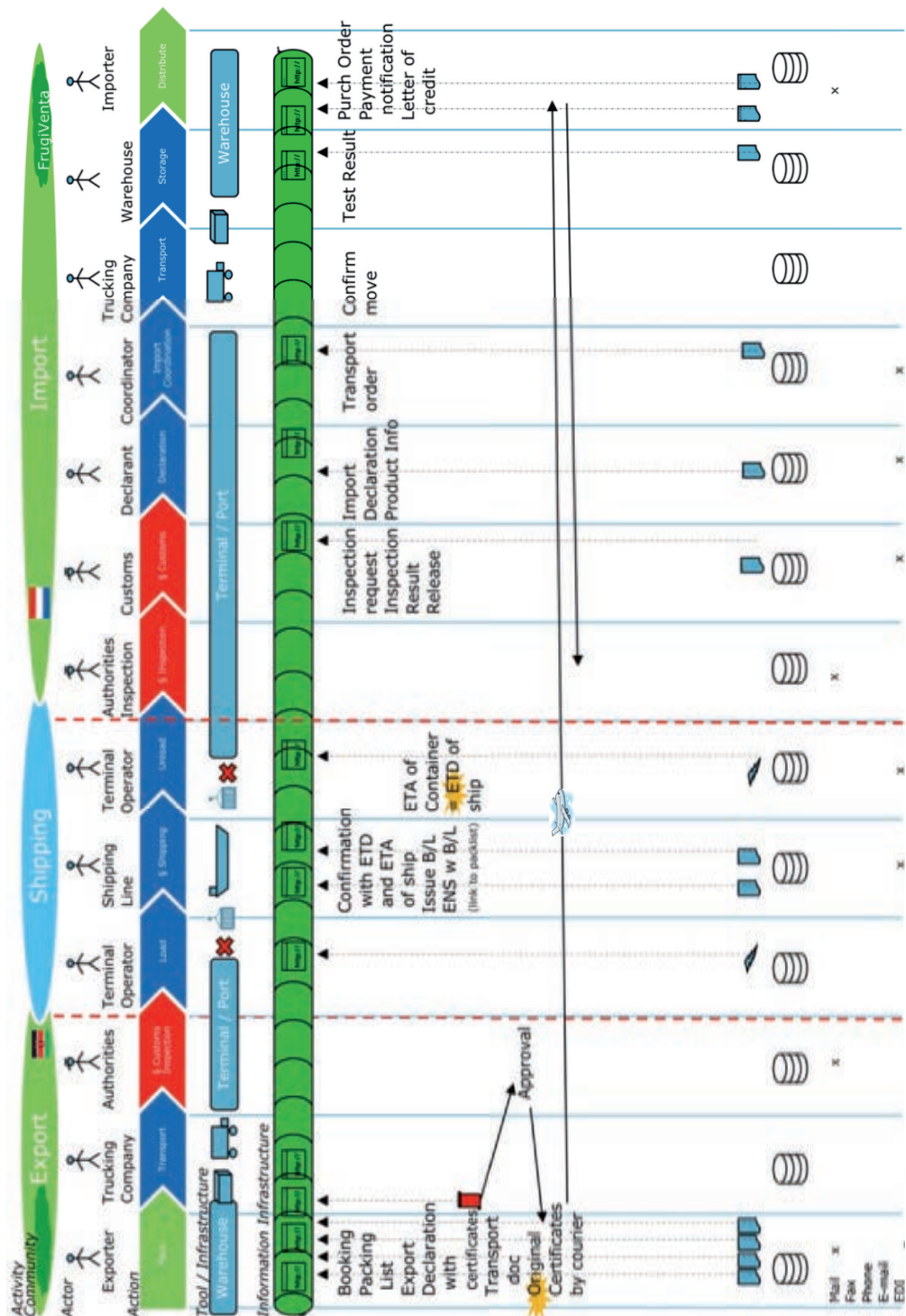


Figure 6 Shipping Information Pipeline concept - mycorrhizae for containerized shipping.

The only exception that is not facilitated by the SIP is the phytosanitary certificate (marked with red icon in Figure 6). This is due to the authorities continued requirement of the original paper document's presence during import, indicating a lack of trust of the e-phytosanitary certificate. The vision, design concept and schematic for the SIP has been largely the same through its various developments. In the following a range of the developments and delivered prototypes are described.

5.3 Design, intervention and evaluation of prototypes

To address the aforementioned major impediments and critical issues several prototypes have successfully been built, demonstrated and tested, and evaluated. The development of the SIP has been an iterative process alternating between build, intervention and evaluation (the BIE cycle), with the analysis that has been iterative as well. The development process has spanned three years, starting as a concept and simple implementation over a range of prototypes, to the current state of development with increased number of features and technologies for example blockchain technology. Development continues guided by the same set of design principles, however adjustments are expected as the design is exposed to new challenges and/or opportunities.

Each of the prototypes are part of the BIE cycles performed during the iterations of solution development. See Figure 7 for an illustration of the individual prototypes/solutions, and of the BIE cycles, both indicated with a number, Data pipeline #1, Shared Information Pipeline #2, and so forth. The BIE cycles are also indicated as 1st, 2nd, and so on. The figure also shows the categorization of the type of intervention and evaluation, either formative artificial or summative naturalistic.

The Data Pipeline #1 is described in a previous Section 5.2 and has been presented at various conferences, such as the UN⁶⁴.

⁶⁴ E.g. presented by Vice-Chair for the Committee on Trade Division, UN Economic Commission for Europe Professor Tan at the UNCEFACT's Global Trade Facilitation Conference in Geneva on December 2011 https://www.unece.org/fileadmin/DAM/trade/Trade_Facilitation_Forum/ConferenceProgramme.pdf and https://www.unece.org/fileadmin/DAM/trade/Trade_Facilitation_Forum/ConferencePPTs/D01_01AM_YaoHuaTan.pdf

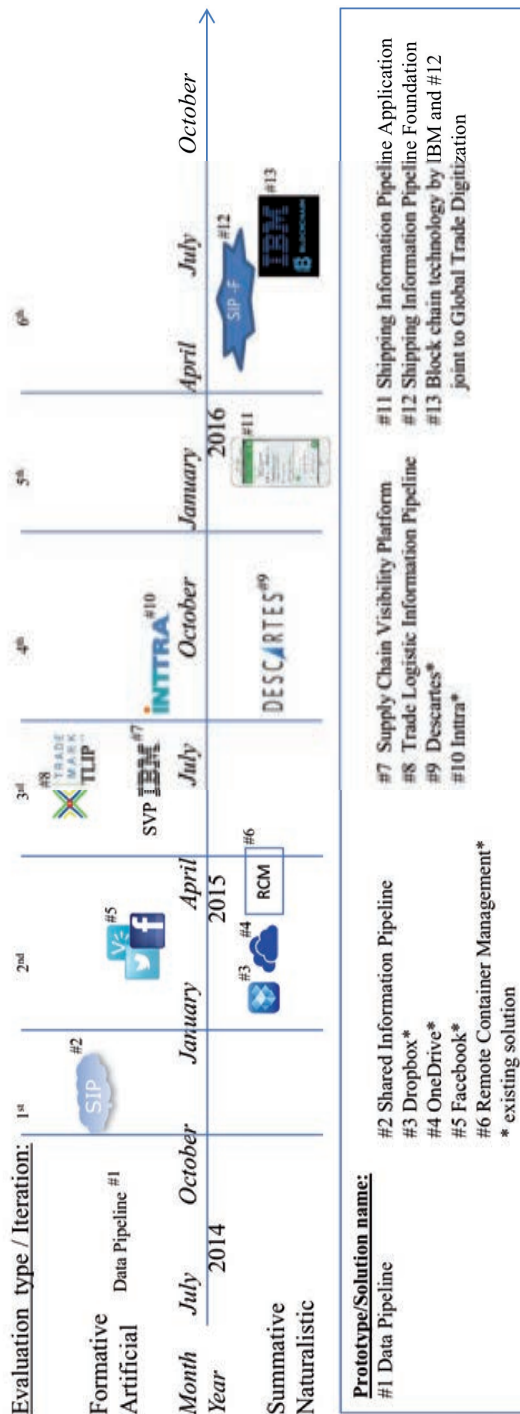


Figure 7 Prototypes of Shipping Information Pipeline.

To understand the problems and possibilities in detail, an initial analysis of a specific trade lane, of avocados from Kenya to Europe, was performed, including recording events and collecting exchanged documents, as described in the previous chapter. After designing the initial dedicated solution - Shared Information Pipeline #2 - it became apparent that the required resources were greater than what was available, and the next iteration utilized existing solutions.

The analysis of the specific avocado trade lane revealed that the main element of collaboration is the exchange of documents/information including information about shipping events. There are some obvious pre-existing solutions such as Dropbox for documents and Facebook for events. Accordingly, in the 2nd BIE cycle a range of prototypes were built/setup building on available solutions, tried out on real shipments, and finally evaluated with the decision to continue or discontinue.

The evaluation of the solution based on Dropbox #3 revealed practical issues with managing and governing access rights across multiple organizations. This was in a large part due to Dropbox granting access through individual's email addresses, which is not readily accessible with multiple organizations, and the many actors involved. A similar solution from Microsoft, OneDrive #4, was then trialed, which provides additional features for managing and governing access rights at an organizational level. However, the results were not favorable, as administration across multiple organizations was rather challenging.

Similarly, standard solutions grouped as Social Media #5, including Facebook, Twitter and Yammer, were used to prototype but failed to deliver useful solutions for sharing information about specific shipments. Other existing solutions specific to the shipping industry with an installed base were evaluated but found incapable of supporting sharing diverse kinds of documents without undergoing costly modification. Combined it became apparent that drawing on an existing solution was not feasible, and the second iteration cycle was ended.

At this point the IT department of Maersk initiated a third iteration cycle through engagement with potential IT vendors⁶⁵ to develop the initial design of a dedicated solution. This resulted in collaboration with a range of both internal for example the Remote Container Management

⁶⁵ Additional solutions include <http://shipstr.com>, <https://freight.uber.com>, <https://logistics.amazon.com/>, <https://www.freightos.com>, <https://www.flexport.com/>, and <https://www.kontainers.com/>

(RCM) #6 and external organizations specifically IBM, TMEA⁶⁶, GS1⁶⁷, Intrtra⁶⁸, and Descartes⁶⁹. These collaborations produced varied solutions, of which the most notable are mentioned in the following. The Supply Chain Visibility Platform (SVP) #7 was sponsored by a venture capital fund of IBM and built to comply with the industrial standard EPICS of GS1. TMEA obtained funding for developing the Transport and Logistic Information Pipeline (TLIP) #8 dedicated for East Africa Community.

The engagement with both Descartes and Intrtra was extended and is considered a fourth iteration which happened in parallel, and overlapped with the third iteration. Both Descartes #9 and Intrtra #10 are existing solutions which they consider to enhance to support the SIP concept, through leveraging their existing installed base of organizations involved in containerized shipping. This engagement resulted in positive responses, and with the funding of specific solution development, for example the Customs Dashboard, and with the enhancement of existing solutions. However, these developments were lengthy and in many cases, did not live up to the required expectations.

The fifth iteration involved the creation of a mobile SIP application. The SIP application #11 was successfully presented to the management team of Maersk in spring 2016, leading to the CIO seeking internal funding in connection with the launch of a new digitalization strategy. This resulted in funding, and the development of the next version of SIP named SIP Foundation #12. Furthermore, this development in summer 2016 became part of a collaboration with IBM Research's blockchain technology initiative, forming the Global Trade Digitization (GTD) #13 with equal funding from the two organizations.

As described above the development of the SIP solution has been through several iterative BIE cycles and resulted in various named prototypes. The major iterations beyond the Data Pipeline

⁶⁶ Trade and Markets East Africa is an East African not-for profit Company Limited by Guarantee established in 2010 to support the growth of trade - both regional and international - in East Africa.
<https://www.trademarka.com> 20161125

⁶⁷ GS1 is dedicated to the design and implementation of global standards and solutions to improve efficiency and visibility in supply and demand chain. www.gs1.org 20161125

⁶⁸ INTTRA is the electronic transaction platform and information provider at the center of the ocean shipping industry. www.intrtra.com 20161125

⁶⁹ Descartes - The Global Leader in Uniting Logistics-intensive Businesses in Commerce with their Logistics Technology Platform fuses the Global Logistics Network — the world's most extensive logistics network covering multiple transportation modes. www.descartes.com 20161125

#1, which was developed from 2006 to spring 2014⁷⁰ are: The 1st iteration with initial solution developments in 2014. The 2nd iteration with the testing of the use of standard solutions in the first half of 2015. The 3rd and 4th iterations with external engagement resulting in the development of new solutions and enhancement of existing solutions in 2015. The 5th iteration in early 2016 with the development of the SIP mobile application, which resulted in onward funding. Finally, the 6th iteration of the GTD solution jointly developed by Maersk and IBM in second half of 2016. This resulted in double digit million USD funding for 2017 by both IBM and Maersk top management; however, the organizational and legal set up for this joint venture is yet to be determined.

Besides the development in the BIE iterations several additional activities have taken place in parallel, involving identifying and elaborating the conceptual idea, the business benefits and the associated business model, determining and engaging major stakeholders, and addressing issues regarding potential use, barriers and obstacles (Betz & Henningsson, 2016; Jensen & Vatrpu, 2015a; Lindberg & Göteborg, 2016).

The individual prototypes are described in more details in dedicated documents. Data Pipeline #1 in Tan et al. (2011); Remote Container Management #6 in (Kinra, Mukkamala, and Vatrpu, 2017) and (Lindberg & Göteborg, 2016); Supply Chain Visibility Platform #7 in internal “SVP Functional System Documentation” and “SVP Core Web-Service SOAP Interface Control”, both from 2015; and Transport Logistic Information Pipeline #8 in internal project document. SIP Foundation #12 is described in an internal document “Shipping Information Pipeline - Greenfield Product Conceptualization Workshop (Week of 9th May 2016)”. Some of the first ten prototypes are shortly described by Jensen and Vatrpu (2015a) and in Appendix are examples of user experiences. Furthermore, the SIP mobile application #11 and SIP-F #12 in first version are described in Paper 5 with some few illustrations of user experiences of those prototypes of SIP. Additionally, SIP-F #12 in second version and GTD #13 are shortly described and illustrated with user experience from the pilot phase in a video⁷¹.

⁷⁰ Data pipeline was one the innovations demonstrated in the ITAIDE project (January 2006-December 2010) and subsequent projects.

⁷¹ IBM and Maersk Demo: Cross-Border Supply Chain Solution on blockchain. Demo of how IBM and Maersk are digitizing and simplifying global trade to create trust and transparency in the supply chain using blockchain technology--a distributed, permissioned platform accessible by the supply chain ecosystem designed to exchange events data and handle document workflows. The example shows how shipping flows can create trust and security in a digitized workflow while improving efficiencies of global supply chains. <https://m.youtube.com/watch?v=tdhpYQCWnCw>

5.4 Accumulated inductive design principles

Each prototype and its intervention in practices has provided vital learning. The design iterations of build, intervention and evaluation, and the associated learnings are summarized in Table 4. The main evaluation criteria have been if the solutions were found successful to be useful and beneficial by the actors and importantly if sponsoring for continuation of the next iteration of development was granted. Additionally, a number of design principles were derived, which also are listed. In total, there are seventeen design principles, including the initial four referenced in previous sections. Features, such as the capability to take a picture by mobile device, and capture the container ID through optical character recognition, are not considered design principles.

The prototypes provided valuable insight into what works and what does not work within containerized shipping. Based on the use and evaluation of the various prototypes we learned about desirable and undesirable features, which led to additional requirements and new design principles, fostering new innovative designs. Accordingly, the BIE cycles have enabled an accumulation of knowledge and experience across the multiple organizations involved in the developments. However, to a large extent the prototypes were developed by different people in different organizations, accordingly, the learnings were not always shared, or systematically recorded. The most important design principles, such as the initial four design principles (I-IV), were always included when introducing the SIP idea to new developers. In excess to the previously mentioned four inductive design principles (I-IV), thirteen others have been derived and adapted based on the experience from the development and the evaluation of prototypes.

The fifth design principle, to obtain information directly from the source (V), was learned from the initial data pipeline. This replaces the current practiced communication pattern of peer-to-peer communication along the supply chain which was identified in the analysis. An example of benefits obtained by design principle (V) can be seen in the following. Often information, such as the planned packing list, is attached to other documents. For documents that need to be approved by authorities the actors will often send them well in advance since this may take some time to process and obtain approval. However, the final packing list is only known at a later point in time, when the container is stuffed. Accordingly, the approved packing list are not consistent with the final packing list based on the stuffing. This is prevented when obtaining the information directly from the source.

Name of prototype /solution	Design of Build	Intervention and Evaluation	Learning	Inductive design principles
Initial discussions	N/A	Similar to the Internet	Many different “languages” and interpretations among the stakeholders from the multiple organizations. Pre-assumption regarding digitization of information.	I) No big brother (no central database). II) Integrate once and connect to everyone III) One virtual pipeline built by many physical pipelines. IV) No facilitation of commercial agreements.
#1 Data Pipeline	Data directly from source communicated via data pipeline in form of EDI messages	Successful demonstrations. Obtained substantial onward funding. However, not adopted by practice.	IOS based on EDI messages is cumbersome to standardized and costly to implement. Piggy backing principle is promising.	V) Information directly from source.
#2 Shared Information Infrastructure	Cloud solution instantiated on Microsoft Azure.	Unsuccessful.	Events along the supply chain connects the shipment in container(s). Organizations are reluctant to share information/documents.	VI) Event based. VII) Separate document store at source and publish meta-information with reference to source.
#3 Dropbox	Standard cloud solution for collaboration especially regarding documents.	Successful demonstrations. However, impractical and cumbersome to administrate access rights.	Ease of collaboration around documents. However, e-mails of actors are not efficient for authentication among multiple organizations.	VIII) Seamless authentication for seamless collaboration. Governance of access and ease of access is important and challenging; access has to be part of normal work on internal systems.
#4 OneDrive	Standard cloud solution based on Share Point by Microsoft for sharing files. Integrated with e-mail and calendar account.	Successful demonstrations. However, impractical and cumbersome to administrate access rights.	Complex set up of administration of access for multiple organizations.	Separate user name and password will be an administrative burden.
#5 Facebook and other social media solutions	Existing cloud social media solutions for interacting with other actors e.g. sharing events or opinions. Instantiated by dedicated account per shipment/container.	Successful demonstrations. However, impractical to use since the solutions are designed for other social interactions.	Facebook is sharing events but not built for sharing documentation. Public and subscribe increase ease use of solution. Dedicated solution is need.	IX) Publish and subscribe.
#6 Remote Container Monitor System	Internet of Things solution for container monitoring devices. Separate dedicated II. Central monitoring solution governed by Maersk.	Successful demonstrations of condition and geographical location of 350,000 containers. However, legal and political issues prolong adaption.	Track and trace of containers and their condition provides visibility into the physical shipment. Thousands of events for a shipment are overwhelming.	X) Configurable to filter relevant events.

Name of prototype /solution	Design of Build	Intervention and Evaluation	Learning	Inductive design principles
#7 Trade Logistics Information Pipeline	Based on the vision of SIP.	Successful consensus among multiple key organizations in East Africa. Obtained substantial funding.	Multiple organizations involvement is challenging. Political alliances are key to engage key organizations.	XI) Political engagement is important.
#8 Supply Chain Visibility Platform	Event based with central repository. Based on GS1 standard for RFID events of physical goods and extended for documents.	Unsuccessful demonstration.	Mandatory standards make practical use too cumbersome. Minimize mandatory standards. However, as minimum standardization of identifiers is needed for collaborators to align and filter information.	XII) Minimize required mandatory standards. XIII) Identifier alignment.
#9 Descartes	Connectivity service for xx,000 partners based on EDI messages.	Successful demonstration of integration to Dutch Customs' Dashboard. Used in pilot project by US Customs, Border and Protection.	Existing connectivity for collaboration is based on EDI messages. Events of EDI messages need to be included via Application Program Interfaces (APIs).	XIV) Complement existing solutions via Application Program Interfaces (APIs).
#10 INTTRA	Connectivity service based on EDI messages, specialized for containerized shipping. Focused on commercial.	Unsuccessful. On hold.	Arm length to competing solutions.	IV) No commercial transactions.
#11 Mobile Shipping Information Pipeline Application	Designed for research of shipments capturing and publishing events with associated status and links to information/documents.	Successful demonstrations. Resulted in onward funding for #12.	User experiences get complex for actors across multiple organizations. Mistrust regarding if information/documentation is unchanged.	XVI) Configurable user experience to enhance ease of use.
#12 Shipping Information Pipeline Foundation developed by IBM for Maersk	Tracking ID solution with central repository, however also possible distributed repositories. Role specific user interface.	Successful demonstration piloting. Obtained additional funding from EU. Obtained onward double digit million USD onward funding from Maersk.	Tracking ID relation to multiple identifiers challenging. Too simple with four partner roles.	XV) Hash for proofing.
#13 Global Trade Digitization with IBM Research's Blockchain technology	Joint solution with #12. Blockchain technology with hyper ledger and smart contracts.	Successful demonstration piloting. Obtained onward double digit million USD onward funding from IBM.	Two very different user experiences for the joint solutions. Blockchain technology attracts plenty of interest.	XVII) Blockchain technology to increase trust.

Table 4 Design principles derived from prototypes.

The most important information to share between actors is regarding completed and planned events, enabling actors to move forward with their own operations. Accordingly, an actor can publish and share information about an event including a reference URL to more detailed information. Thereby the detailed information/document can be stored separately under separate governance. Further, by providing event based (VI) information about shipments the actors are informed and can look up the detailed information directly from the source. The event information includes both physical container events, such as gate-out, and administrative events, such as container sealed and packing list available.

During the development process, a list of event types was developed and maintained named Event Ledger to categorize events. Previous research projects provided a starting point⁷² for relevant shipping events, such as consignment completion point, which is the event when the container is stuffed and sealed. At present the event ledger includes more than one hundred event types, and will likely evolve over time. Insight into which event information is relevant for each specific actor and organizations bears further investigation. Previous experience from other similar projects is that the type of events will vary depending on geography and time⁷³.

Another large learning was the need to separate detailed information and meta-information including a referencing link (VII). This could be potentially supported by document collaboration solutions. However, neither document sharing solutions as Dropbox, nor social media as Facebook succeeded as solution for sharing shipping information. This was primarily due to two reasons: Firstly, both systems have been designed for other purposes with little flexibility. Secondly, their authentication is based on actors' e-mail. From this the importance of seamless authentication for collaboration (VIII) was learned. Further, from Facebook the power of publish and subscribe⁷⁴ (IX) was learned and adapted the design principle.

The pilot of the Remote Container Management solution, based IoT devices mounted on each container producing thousands of events per shipment, provided insights into the need to be able to configure and filter for relevant events (X). This applies for the nearly one hundred

⁷² Cassandra Living Lab White Paper May 2014 DASC methodology: Data Analysis for SCs

⁷³ Lyytinen's presentation at Innovative Information Infrastructure Conference in Oslo in 2014 and article forthcoming

⁷⁴ Example of publish and subscribe pattern https://msdn.microsoft.com/en-us/library/ff649664.aspx#despublishsubscribe_securityconsiderations 20170509

events per shipment created and collected in internal systems within one organization, for example by Maersk' Global Event Management System.

From the engagement with multiple public organizations in East Africa establishing Trade Logistic Information Pipeline, the importance of political engagement (XI) became clear. This is described in Jensen (2015c) and (2016b). IBM developed the Supply Chain Visibility Platform based on the EPICS industry standard of GS1 and the learning encouraged to minimize mandatory standards (XII). However, there is a need to, at the minimum, standardize identifiers (Eriksson & Ågerfalk, 2010), and to find a balance between standardization of all information interchanged and alignment of identifiers (XIII) is essential for collaboration. This is especially important for identifiers like shared IDs, such as containers' BIC number, and standard time and location for events⁷⁵. However, alignment through a common tracking ID, as implemented in solution #12, introduces additional manual alignment work with multiple organizations' identifiers⁷⁶. While the identifier for containers are globally unique and standardized by BIC⁷⁷, the identifiers of organizations and of shipments are not standardized.

Of the two mentioned IT vendors, INTTRA and Descartes, both with existing solutions and a large installed base, one has enhanced their existing solution #9 to interface with both solution #8 and #12 via Application Program Interfaces (API), and the other vendor has put collaboration on hold, but is actively lobbying for opportunities. From this it was learned that providing API (XIV) was fruitful to complementing existing solutions.

During an evaluation by several actors using the mobile SIP Application #11 authorities requested features that ensured documents had not been modified. Accordingly, it was proposed that a "fingerprint" in form of a hash for proofing (XV) of documents should be included as part of the meta information to validate that the document has not been changed since publication. Additionally, was identified the need for configurable user experience to enhance ease of use (XVI), such as with dedicated user experiences for a trucker and for an inspector. Furthermore, the affordances to be performed by the actors has been analyzed, as outlined in Paper 3, finding that the SIP requires a change in working procedures. This is evident in the

⁷⁵ E.g. "United Nations Code for Trade and Transport Locations" with country location codes <https://www.unece.org/cefact/locode/welcome.html> and https://www.unece.org/cefact/codesfortrade/codes_index.html 20170509

⁷⁶ Example, Japan Post offers tracking id solution for international shipments.

⁷⁷ BIC number is a kind of license plate number for containers coordinated by Bureau International des Containers et du Transport Intermodal <https://www.bic-code.org> 20170401

case of the authorities, who instead of receiving pushed information, have to click on an URL link associated with the shipment to get access to the detailed information. However, they gain improved information at their fingertips, in comparison with today's situation. Accordingly, the authorities are delighted to try out the new way of working. This could mean that instead of the standard phrase "as said to contain" goods could be declared with the phrase "click (the URL) to see what the shipper packed".

To increase the trust among authorities, and with private organizations, the SIP-F was enhanced with blockchain technology (XVII), utilizing hyper ledger and smart contracts to address authentication, distributed control and federation among multiple distributed instances of SIP. The joint solution is named the Global Trade Digitization solution (GTD). IBM and Maersk publicly announced they will be live with the GTD solution, for a network of organizations involved shipping 10-15 million containers, by end of 2017⁷⁸.

⁷⁸ GTD announcements;

20170208 Maersk Annual Magazine 2017: Charting a new direction -a supplement to the A.P. Møller -

Maersk A/S Annual Report 2016.SIP is at the top in the article "Welcome to the future" page 16

<http://www.maersk.com/en/the-maersk-group/about-us/publications/group-annual-magazine/2016/pdf-and-zmag-download>

20170227 live broadcast of Maersk CCO Vincent Clerk talking at TPM 2017 Conference in Long Beach, CA today at 3.30 pm PST on "Maersk's New Direction: What it means for customers and the industry"

<https://www.linkedin.com/feed/update/urn:li:activity:6242045445347119104/>

20170228 Lloyd List publish that Maersk digital breakthrough has massive cost saving potential

<https://www.lloydlist.com/ll/sector/containers/article550783.ece>

20170228 PRNewswire publish that Maersk and IBM Unveil First Industry-Wide Cross-Border Supply Chain Solution on Blockchain

<http://www.prnewswire.com/news-releases/maersk-and-ibm-unveil-first-industry-wide-cross-border-supply-chain-solution-on-blockchain-300418039.html>

20170303 Maersk News states that CCO: Serving our customers for the next 100 years. "The 2017

Transpacific Maritime Conference (TPM) was held this week in Long Beach, California. The event positioned Vincent Clerc and the North American and Asia Pacific teams to reconnect with customers as the transpacific contracting season kicks off."

<https://imaersk.maersk.bridgeit.dk/News/ViewNewsArticle/?articleId=1065599>

20170303 Shippingwatch: This is how Maersk Line will digitize its fleet Container: Maersk Line annually earmarks a double-digit million-dollar figure to roll out a digital strategy for its fleet, says Niels Bruus, the carrier's head of future solutions for fleet management and technology. All Maersk Line's vessels are expected to be digitally linked by 2018

<http://shippingwatch.com/secure/carriers/Container/article9405681.ece>

20170304 New York Times: Blockchain: A Better Way to Track Pork Chops, Bonds, Bad Peanut Butter

[https://www.nytimes.com/2017/03/04/business/dealbook/blockchain-ibm-](https://www.nytimes.com/2017/03/04/business/dealbook/blockchain-ibm-bitcoin.html?rref=collection%2Fsectioncollection%2Ftechnology&action=click&contentCollection=technology®ion=stream&module=stream_unit&version=latest&contentPlacement=6&pgtype=sectionfront&_r=0)

[bitcoin.html?rref=collection%2Fsectioncollection%2Ftechnology&action=click&contentCollection=technology®ion=stream&module=stream_unit&version=latest&contentPlacement=6&pgtype=sectionfront&_r=0](https://www.nytimes.com/2017/03/04/business/dealbook/blockchain-ibm-bitcoin.html?rref=collection%2Fsectioncollection%2Ftechnology&action=click&contentCollection=technology®ion=stream&module=stream_unit&version=latest&contentPlacement=6&pgtype=sectionfront&_r=0)

20170305 Forbes: IBM And Maersk Apply Blockchain To Container Shipping.

Overall, three of thirteen prototypes obtain substantial onward funding, while the other prototypes have been discontinued or put on hold. It is estimated that because the SIP, by design, addresses the top critical issues, it will enable significant improvement in the situation of inefficient containerized shipping.

How the design principles described above in Table 4 address the in Chapter 4 identified critical issues affecting the major impediments is summarized in the following with reference their listing in respectively Alphabetic and Roman numbers.

Regarding critical issue (a), that certificates still are demanded on original paper with the right stamp(s) and signature(s). The importing authorities are hesitant to accept electronic version though that the documents reside at the source in the exporting country (V and VII) and that digital “fingerprints” (XV) are provided to prove that the version is unchanged. The application of blockchain technology (XVII) seems promising in this perspective.

Regarding critical issue (b), that actors can only “see” the container through information, the SIP enables visibility and transparency into selected shipping events (VI, X and XVI) through providing up-to-date shipping information in a seamless way (II and III), enabling the coordination among the multiple organizations involved.

Regarding critical issue (c), that each organization holds several documents about the container in their “isolated” information systems, SIP respects the source governance of the detailed documents (I and V) and also provide easy access via the URL link (VII) if the actor is authenticated (VIII).

<https://www.forbes.com/sites/tomgroenfeldt/2017/03/05/ibm-and-maersk-apply-blockchain-to-container-shipping/#29e288293f05>

20170305 Yahoo Finance: Maersk and IBM aim to get 10 million shipping containers onto global supply blockchain by year-end

<https://uk.finance.yahoo.com/news/maersk-ibm-aim-10-million-031144388.html>

20170306 Maersk News: Universe One of trade's biggest barriers <http://news.apmoller.net/Pages/20170306-Maersk-and-IBM-target-one-of-trades-biggest-barriers.aspx>

20170305 IBM: Maersk and IBM Unveil First Industry-Wide Cross-Border Supply Chain Solution on Blockchain

<http://www-03.ibm.com/press/us/en/pressrelease/51712.wss>

20170305 YouTube: IBM and Maersk Demo: Cross-Border Supply Chain Solution on Blockchain

<https://youtu.be/dcdYatMCGQ>

Port Technology 20170306 Watch: IBM-Maersk Unite on Global Blockchain Initiative (include video)

https://www.porttechnology.org/news/watch_blockchain_digitizing_global_logistics

Critical issue (d) addresses that information and documents are not up-to-date, and are error-prone or of poor quality. The SIP provides near-real-time meta-information about availability of detailed shipping information to be obtained directly from the source (V). This will break the current chain of peer-to-peer communication which is critical issue (g) and will make trustworthy and reliable shipping information available.

Regarding critical issue (e), that multiple communication channels are in use today; the SIP will utilize the Internet to communicate digital shipping information globally and become the one shared information infrastructure (II and III) which provides one source of reliable shipping information.

Regarding the critical issue (f) of the limited use of IOS based on EDI messages, the SIP will offer a complementing solution (XIV). However, the IOS can also publish (IX) shipping events (VI) whenever sending an EDI message of interest to be shared. Further the SIP by utilizing the global Internet, minimizes required standardization (XII), and by using only a few harmonized and globally standardized IDs (XIII) effectively enables collaboration across boundaries and borders and directly between the three activity systems identified as critical issue (h), of primarily local IOS being successful.

The increased transparency provided by the SIP will enable actors in the various organizations to coordinate their operations and actions, reducing uncertainty about lead time and moving towards improved efficiency. Further, the SIP enables the communication of changes in planned actions, which will alert other actors and organizations in the supply chain, prompting proactive action on their behalf. Information, such as ETA, can be used to re-plan the subsequent operations upon container arrival. Further, increased transparency into near real-time shipping information, including information about the organizations themselves, and easy access to detailed information about specific shipments, will reduce the authorities' security concerns (C), and enable them to target only suspect shipments. The above, will impact the uncertainty of the lead time (B) significantly. This combined with the elimination of data-entry redundancies that are facilitated through piggy backing, is estimated to significantly reduce international trade cost (A). Overall, it is estimated that the SIP will significantly enable containerized shipping to be both more efficient and to be more secure – perhaps to the extent of revolutionizing containerized shipping like the standard container did.

The next major phase includes the organizations and its actors building trust and ensuring no big brother (I and IV), and perhaps changing some working procedures (IX and X) is next and possible requires political involvement (XI) before any conclusions can be made.

In sum, the Shipping Information Pipeline (SIP) has been designed as a shared II, utilizing the WWW and the Internet to complement the physical supply chain for containerized shipping. This design addressees the critical issues, and ameliorates the three major impediments towards more effective containerized shipping for international trade. This research has led to the theoretical insight of a new fourth meta-design principle for designing II utilizing the World Wide Web of the Internet, and in total seventeen inductive key design principles.

6. Discussion

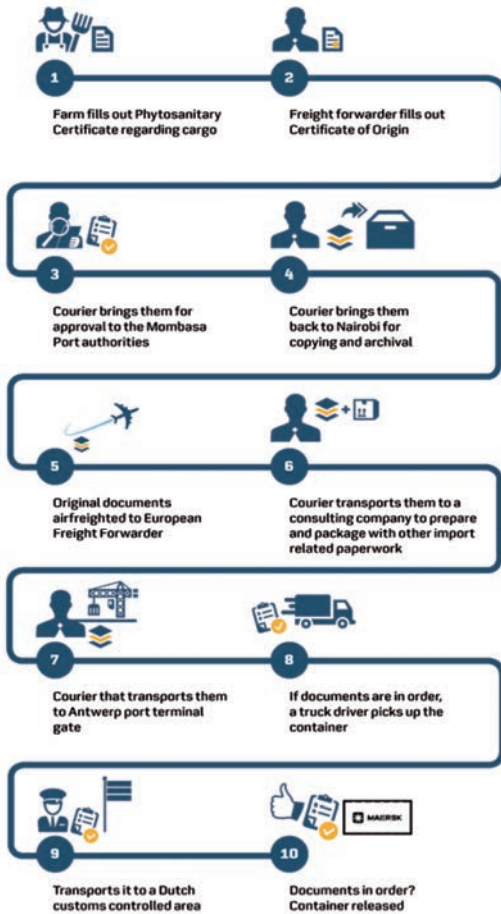
This chapter will discuss the overall research design, reflecting on both theoretical and practical implications. Firstly, is discussed how the design of SIP both differs from the current thinking regarding IOS based on EDI messages, and complements the existing design guidance. Secondly, is discussed why the fourth meta-design principle can be leveraged to meta level, and how this can be considered an extension to the existing design guidance of the IS community. Thirdly, is discussed the value of AT methods in IS research, specifically regarding II. Based on this advice is proposed to the IS community, to incorporate or possibly to give precedence to AT for elaborated understanding of II. Fourthly, is shared reflections regarding the chosen research design, including methodology and mixed methods. Finally, is discussed the practical implication of the design of SIP and suggested that the SIP poses new opportunities for the ecosystem for containerized shipping. The discussion is based on the previous chapters and the selected papers included in the appendix.

6.1 Shipping Information Pipeline pose a radical new design

Compared to the current recommendation by the IS community, which is to facilitate collaboration through IOS based on EDI messages, the design of SIP is radically different. Figure 8 illustrates the change in communication patterns for containerized shipping, exemplifying specifically the phytosanitary certificate used to export avocados from Kenya to the EU.

On the left of Figure 8 the current sequential communication flow is shown, including couriers by air and by car which happen in parallel to the physical containerized supply chain. Note, the certificate is additionally communicated by e-mails following the same communication pattern. Further, IOS based on EDI messages follows the current pattern along the supply chain, however, primarily within one nation or region but not internationally as the analysis revealed.

Current:
Communication flow along supply chain



Future:
Communication via shared II



Figure 8 Communication patterns. On the right side the publish and subscribe communication pattern utilizing the SIP following the fourth meta-design principle (II 4.0) is shown.

On the right part of Figure 8 is illustrated the SIP communication pattern of sharing meta-information about shipping events and documents by publishing them. Further, is illustrated that information can be received by the actors either by subscription or on request. It should be stressed that the SIP is not the only channel of communication. Rather, it is complementary to the existing communication like e-mail and EDI message. Further, it is suggested that organizations consider sharing meta-information about their current communication whenever possible, either with an URL to the detailed information of the message or with the detailed information included in the message.

The table below compares the traditional, the IOS based on EDI message (Krcmar et al., 1995; Robey et al., 2008; Tang, Rai, & Wareham, 2011) and the SIP methods for information exchange between multiple organizations.

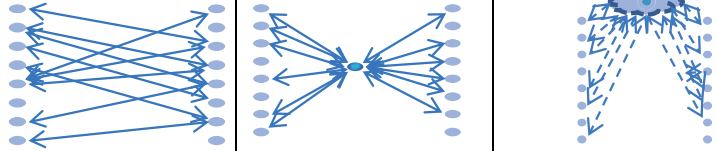
Characteristics	Type of information exchange		
	Traditional	Inter-Organizational Systems	Shipping Information Pipeline/Cloud
Media	Mix of paper based, telex, fax, phone, e-mail, etc.	Electronic Data Interchange messages	Digital information about events
Level of formalization	Non-formalized (Except standards regarding the communication)	Formalized data (Based on ISO UN/EDIFACT standards)	Formalized meta-data / information (ID and events) and links to document / webpage or web-service
Communication pattern	Peer-to-peer communication	System-to-system communication via service provider	System-to-systems communication via cloud for meta-information and direct communication for detailed information
Legend			
Private / public access to data / information	Private communication between persons in organizations	Private communication between organizations' systems	Public for some events (public available today) and private (encrypted) for other events
Price / Cost	Ordinary mail and courier are expensive Electronic is less expensive	Prices initially similar to ordinary mail. Set up and changes / maintenance costly	Premium ⁷⁹ model Basic service is free of charge and additional services can be charged

Table 5 Type of information interchange

The traditional information exchange is a mix of physical documents, e-mails, fax, etc. as revealed on the analysis following the above mentioned current communication pattern of bilateral communication between actors. The explanation is probably historical following the communication patterns for physical documents which have been inherited for digital communication including for telex, fax, e-mail and EDI messages.

⁷⁹ Premium model combines Free of charge services and possibility for charged premium services as for instance used by LinkedIn.

With IOS information is exchanged between organizations and their systems utilizing EDI messages. The communication pattern is similar to the current traditional, except that for most EDI messages an EDI broker facilitates the exchange. During the literature review it was revealed that the success of IOS based on EDI messages is only locally and not overwhelming, which was strengthened during the analysis uncovering that collaboration via IOS based on EDI message is inadequate for addressing many of the challenges. The main reasons are that IOS based on EDI is costly, inflexible and only covers a minor part of the information involved in containerized shipping. E -mails and other modern communication channels, which are nearly free of charge, and already subscribed to by many actors, outperform the relatively expensive EDI message, see Paper 3 for details. Accordingly, this research questioned the longstanding recommendation by the IS community to focus on digital collaboration via IOS based on communication of EDI messages as the only recommendation. As discussed above, is proposed a radical different but complementary solution.

The design of SIP uses the cloud for sharing meta-information about the availability of the detailed shipping information (for example that a packing list for a container is created with an URL pointing to the detailed information), which enables access to the detailed information directly from the organization originally creating it (for example the detailed packing list for a container). In essence, this provides an opportunity for re-engineering of containerized shipping for international trade. To pursue such re-engineering opportunities, a new course is needed; one in which a new mindset and knowledge are required, both for the private companies and for the authorities involved. If the opportunities are pursued, it will enable a re-engineering of the overall ecosystem eliminating the need for a number of traditional intermediaries, and enabling the creation of new types of specialized intermediaries.

The design of SIP is a theoretical contribution offering a new approach to collaboration among multiple organizations utilizing digital communication following a different communication flow pattern than traditionally. For historical reasons the traditional communication is based on the physical documents and does not take advantage of information being in digital form. IOS based on EDI messages and e-mails to a large extent replaces the traditional communication pattern and does not leverage the potential of digitalization. The innovation consists in establishing the new but complementary communication pattern of only publishing meta-data instead of focusing on IOS based on EDI messages designed to communicate the complete detailed information. For a more elaborated discussion see Paper 4.

6.2 Meta-design principles for design theory for Information Infrastructures

As described in previous Chapter 5, one of the key finding is to extend the three existing meta design principles from the IS literature with an additional meta-design principle. The additional meta-design principle II 4.0 is a continuation of the II 1.0, II 2.0, and II 3.0 and thereby becomes the next step in the design theory.

The three meta-design principles identified in the IS literature:

- II 1.0 **digitization,**
- II 2.0 **collaborate by digital communication**
- II 3.0 **via II**

The fourth meta-design principle:

- II 4.0 **sharing through publishing meta-information only** and governing access to detailed information.

The II 4.0 is a critical meta-design principle for an II that utilizes the Internet and particularly the potential of the WWW but thereby it also frames the architecture and inherent patterns and hierarchies (Henfridsson, Mathiassen, & Svahn, 2014). The main reason being that the communication pattern of publishing without a known receiver is possible utilizing WWW. This is fundamentally different from traditional peer-to-peer communication, where the receiver is identified as the recipient.

The meta-design principles support various communication patterns. First of all, meta-design principle II 1.0 digitization, in this case information specifically shipping information, enables the II to facilitate collaboration. Secondly, meta-design principle II 2.0 regarding collaboration by digital communication, in the case of IOS based on EDI messages facilitates the push of information in the form of data sets to specific receivers. Additionally, meta-design principle II 3.0, regarding utilizing II facilitates push of information to unknown receivers such as posts on a blog or webpage. Additionally, meta-design principle II 4.0 facilitates a combination of both push and pull, where the meta-information is pushed and the detailed information pulled, under governance of the source. There is a continuation in the meta-design principles adding new communication patterns, as illustrated in table 6.

Meta-design principle	Communication pattern			
	Enabler	Push to known receiver	Push to known and <u>unknown</u> receiver(s)	Push to known and <u>unknown</u> receiver(s) and pull by known receiver
II 1.0 Digitization	X			
II 2.0 Collaboration via digital communication e.g. IOS based on EDI messages	X	X		
II 3.0 Utilizing II	X	X	X	
II 4.0 Sharing meta-information only and governing access to detailed information	X	X	X	X

Table 6 Communication patterns of meta-design principles

The background for the fourth meta-design principle, which is one of the main contributions of this thesis, is that the three deductively derived meta-design principles found during the literature review, are necessary but not sufficient. The primary reason for this being that organizations are reluctant to share information for competitive reasons related to asymmetry in the value gained from sharing information. However, sharing of information is necessary in order to collaborate and to achieve overall optimization. Accordingly, the fourth meta-design principle was identified and formulated. This principle ensures all detailed information is kept in its original form at the source, where it can be governed and released only for actors representing organizations who have a legal demand for it. Access to information is controlled through sharing limited meta-information and governing access to the detailed information content from the source. Furthermore, the source can choose to make the information publicly available.

Evidence from the many actors suggest that the principles of publishing only limited meta-information (with referential information) will increase the willingness to share information, since they can govern the access to the detailed information content. Keeping information at the source also guaranties the authenticity and validity of the information. In order to increase trust, an electronic “fingerprint” of documents and blockchain technology have been implemented, and are in the process of being enhanced.

Though the Internet is a prime example of II, the fourth meta-design principle is not mentioned in the design theory of II (Hanseth & Lyytinen, 2010). The design theory of II, on the other hand, does not specify the communication patterns specifically, but rather provides examples, such as industry networks based on standard EDI messages. One possible explanation for this omission might be that one primary source of the research was an interview with Robert Kahn, who is an original developer, and sponsor of Internet protocols (ibid). Their focus was thus on the Internet overall, and not specifically the WWW, although it is referenced as a web service invented by Berners-Lee “to meet information sharing needs among high energy physicists” (ibid).

In the same publication, e-mailing is identified as a prime example of an IT capability utilizing standard protocols and gateways of II. In an earlier publication, while not focused at the special characteristic of WWW as an element in developing II, the WWW is mentioned in a foot note as an IT capability utilizing the Internet. In this foot note it is explained that “naturally when most Internet users talk about using Internet they do not actually think about using the Internet service infrastructure per se but specific IT capabilities, which rely on it like WWW, IM, e-mail or blogs” (Hanseth & Lyytinen, 2004b).

Note, that the Internet and the WWW are two different things. Further, it is acknowledged that there are two dominating IT capabilities utilizing the Internet: using WWW and sending/receiving individualized communication like e-mails. However, as illustrated in Table 5, communication utilizing the WWW is a very different from communicating via e-mail. In everyday language, the Internet and the WWW are used synonymously. Because the universal WWW builds on the Internet with its global coverage and is nearly free of charge, the WWW becomes a key enabler to scale an II solution like SIP simply by building on the WWW on the Internet. Similar it is predictable that plenty of other II can benefit from building on the WWW, especially if designed in accordance with those design principles. Accordingly, the fourth meta-design principle makes a crucial difference and without this the shared II will not be able to scale rapidly.

Whether the fourth meta-design principle should be classified as a meta-design principle or as a low-level design-principle could be questioned. However, two arguments justifying its place as a meta-design principle: Firstly, the new meta-design principle represents a radical innovation with a communication pattern that involve sharing by publishing a limited amount

of information initially and later sharing detailed information to those interested and authorized. Secondly, the governance for the SIP is split into a combination of universal but coordinated - for the shared meta-information, and local governance for the detailed information - governed by the source.

In this respect, it is worth noting that the meta-design principles II 1.0, II 2.0 and II 3.0 are fundamentally building on the notion of either centralized governance for corporate and business sector II for example Norwegian banks (governing access by Bank ID) (Eaton et al., 2014), Visa (Markus & Bui, 2012), SWIFT (Scott & Zachariadis, 2010, 2012; Scott & Zachariadis, 2017) according to analysis of architectural control points within II for payments (Henningsson, Hedman, & Andersson, 2013) or minimal governance for universal II like the Internet (Hanseth & Lyytinen, 2010). II involve the paradoxes of change and control in II (Tilson, Sorensen, & Lyytinen, 2011, 2012a, 2012b) for example within mobile operating systems. Another prime example being the development of the two major mobile operating systems, iOS and Android, and the subsequent development of ecosystems of apps in which “stakeholders illustrate the control paradox as varying control arrangements have both hindered and fueled generativity” (de Reuver, Sorensen, & Basole, 2016). But also partner ecosystems delegating governance rights for example Microsoft’s partner ecosystem (Wareham, Fox, & Cano Giner, 2014; Wareham, Fox, & Cano Giner, 2012) and Apple’s ecosystem (Eaton, Elaluf-Calderwood, Sorensen, & Yoo, 2015).

Governance involves balancing the governing institutional logics, standards, and digital technology (Henningsson et al., 2013; Orlikowski & Scott, 2008), and the paradox of control present the opposing logics of digital platforms simultaneously being governed through both centralized and distributed control (Tilson et al., 2010a, 2010b; Tilson et al., 2011, 2012a, 2012b). Further, there are two concepts of balancing the tensions in an ecosystem, the contradictory concept of duality of governance and the complementary concept of dualism in governance (Wareham et al., 2014; Wareham et al., 2012).

The governance model of the II 4.0 meta-design principle is different from the above by publishing meta-information without any governance except what is demanded by the Internet and the WWW and to leaving the governance of access to detailed information to the local sources. The II 4.0 addresses the paradox by a dual governance structure that separates into minimal governance for publishing of meta-information and distributed governance for sharing

of detailed information. This is in line with the complementary concept of dualism in governance described by Wareham et al aiming for positive effects which is expected to positively impact willingness to share and the scaling possibilities. This is a radical innovation which in itself justify that this design-principle is classified as a meta-design principle II 4.0.

Largely, the current knowledge of successful governance is based on success stories of the past, and “our current thinking of successful governance is limited and primarily drawn from success stories.” (de Reuver et al., 2016). Accordingly, the IS research has not yet turned the knowledge into design guiding principles. This research contributes to the above by the formulating of the fourth meta-design principle based on dual governance structure.

Paper 2 review the IS literature regarding II, finding and analyzing forty-three diverse cases of II, and propose that within the class of II artefacts, there are important differences in both the problems addressed and the II solutions designed to address these problems. The divergence in the design space is represented by: design situation and design resolution. Design situation refers to the relevant dimensions of the context in which an II can be employed, while design resolution covers configurability in a given design situation. Thus, the II design space refers to the combined possibility to match situation and resolution dimensions. For example, in a situation with relatively heterogeneous stakeholders the resolution dimension ‘flexibility’ (for example in regard to governance) needs to accommodate this heterogeneity to facilitate adaption. Accordingly, it is argued that the concepts for II artifacts should be reconsidered and a multi-dimensional framework for characterization of II is proposed. This is supported and exemplified by findings of this research and the need for an additional meta-design principle.

6.3 Activity Theory for IS research regarding Information Infrastructures

Activity Theory has been applied to holistically describe, analyze and understand the containerized shipping activity in the international trade ecosystem with focus on physical objects and their related information. It was revealed that shipping information in digital format or on paper are the primary source of information for the majority of the actors, since the physical container(s) of the shipment are outside their visible horizon. Further, this information is stored in the internal systems of each individual organization, typically using their proprietary formats, which is the reason why most actors lack up-to-date and proper information.

AT focus on the transformation process and the outcome for example shipping of avocados in container(s) to arrive at the importer's warehouse. Additionally, AT provides a framework with six dimensions (actor, object, community, tool, rules, and division of work) and a structure (of activity, action and operation) for decomposing of activities into activity systems (being separate communities separated by governing rules), further, at an inter-organizational level into actions (associated to the organizational level primarily influence by division of work) and further into operations at the level of the actors (utilizing tools).

This kind of AT based analysis helped to identify and understand the structure of involved organization's action, and of the operations of the individual actors, for which the IT solution was intended to improve the performance, the transformation and the outcome. The focus was on the actors' communication operation between organizations since this is intended to be facilitated by the II.

Compared to other system-analysis theories, which often assumes the power structure or governance model as given, it was found that the absence of this in AT is especially relevant for these heterogeneous settings with multiple organizations and nations. AT provides explicit guidance about rules and governance, while allowing the possibility of analyzing several different governance structures.

AT helped to clearly spot the driving activity of containerized shipping in the ecosystem with the container/shipment and related information/documents as the object(s). AT, further specifies actors, communities, rules, division of work and tools in play, and guides the breakdown of shipping activity into actions and operations. The focus on communication operations was fruitful in revealing and articulating the boundary objects used by the actors in their collaboration. Furthermore, insight into the (lack of) exchange of boundary objects assisted in identifying three separate activity systems for export, import and international shipping, separated by borders, see Figure 5 for illustration, and Jensen et al (2014a) and Paper 5 for elaboration.

In this case by focusing on the communication operations of actions the underlying knotworking was discovered, and thereby the fragmented/missing mycorrhizae, see Figure 4 and 6 for illustration and Paper 5 for elaborations. Additionally, AT concepts helped to articulate how the SIP, through the mycorrhizae of a shared II, facilitates transparency into delineation and historicity of containerized shipping. Delineation, is identifying the person (or the

device/container) and geographical locus of the operation of the activity. Historicity, is capturing historical authenticity of information about persons and events for containers and related documents which for example is recorded on the blockchain.

Furthermore, as the analysis was repeated several times revealing an ever-increasing number of communication operations and boundary objects AT helped to identify and to articulate the knotwork resulting from the collaboration efforts of the multiple organizations for containerized shipping. Further, AT assisted to articulate the possible solution of mycorrhizae, which is used as an AT analogy for the shared II, see Paper 5 for details.

Furthermore, AT guided to characterize the shipment as a runaway object (Engeström, 2008) yielding further insight. In a runaway world (Giddens, 2002) AT has helped to better understand why actions, knotwork and fragmented mycorrhizae becomes problematic. As an example, the authorities' server security concerns about the contents of a container is fueled by the faulty shipping information they receive. Another example is traders, who due to the uncertainty of shipment's estimated time of arrival, have high risks, particularly if deliveries are associated with marketing campaigns, or if the goods shipped are perishables like avocados.

Furthermore, during the discussions AT helped to realize the alignment of AT methods movement's different boundary objects and the associated research object of IS, this is explained in further in Paper 5. May be AT can assist other IS researchers with an elaborated understanding of ecosystems for II and the associated challenges. AT characterizes the heterogeneous and multiple organizational setting, consisting of sparsely connected actors indirectly interacting across multiple national borders and organizational boundaries, governed by different sets of rules and regulations.

Additionally, AT explicitly focuses on shared elements within an ecosystem, and on the relation to other systems, which are conceived as being separated by time, geography, government, culture, linguistics, literacy, and, to some extent, even technical capabilities. AT's ability to view the relations and structures of the systems, is specifically relevant within an international, heterogeneous setting with multiple organizations in the ecosystem.

However, AT did not support the detailed analysis of operations, which is needed when developing concrete IT solutions. Accordingly, the theory of affordances (Gibson, 1979; R. K. Vatrapu, 2010) was applied to further decompose and characterize the individual actors' communication operations, which enrich and clarify what and how the designed IT could

support the actors in their operations, see Paper 3 for details. Those insights enabled to crystalize and detail some of the key design principles for the design.

In summary, AT was used as the kernel theory especially the concepts for example of knotwork and mycorrhizae for respectively describing the problem for containerized shipping and the possible solution to be designed. It was found that AT provides a better understanding of the design space because AT articulate insights which have been useful for the design of shared II. Further, was identified an alignment of the AT methods' boundary objects and the IS research' objects which in itself is a contribution to the IS research knowledge.

It is humbly suggested that other IS researchers might benefit from internalizing AT in order to obtain a more in depth understanding of the complexity and challenges of II in heterogeneous settings and multi-organizational domains.

AT helped to articulate how the design and facilitation of shared II contributes as mycorrhizae to facilitate digitalized collaboration among heterogeneous organizations in an international ecosystem, specifically in the domain of containerized shipping. Note, the design is challenging when the domain is characterized by loosely-coupled actors and multiple organizations, in dynamically changing indirect relations, across the boundaries and borders of nations, regions, languages, cultures, which are separated by time, geographical location and, to some extent technology.

Shared II enables and facilitates reduction of the runaway effect of containerized shipping in Giddens' runaway world. Other IS researcher might in their research of II benefit similarly by using AT as the kernel theory.

6.4 Reflections on research design

The reflection on research design includes research methodology, research methods and units of research.

This research has been guided by Engaged Scholarship, especially it has encouraged the involvement with multiple stakeholders from a broad range of organizations including other researchers, practitioners and influencers leveraging their different perspectives to learn about the complexity in the domain. The research design, utilized several methods depending on the focus of the research activity: literature review, analysis of domain, or design of IT solution.

However, this research has consistently adhered to fundamental scientific principles of keeping records of all the interactions.

This demands certain skills of the researcher, including mutual respect of different cultures, collaboration, and negotiation to enable an environment where insights are shared, to progress learning and facilitate research activities. This has involved engagement in certain streams of initiatives where research was if not appreciated then at a minimum accepted and supported. Given the research purpose and vision, the Engaged Scholarship methodology, and having a number of 'agoras' for collaboration, practitioners seemed to have been engaged and open for discussion, which is uncharacteristic to this competitive ecosystem. Examples of such neutral agoras include the research projects sponsored by EU where both practitioners and researchers are engaged. This included the relevant part of the Maersk with their involvement in the CORE project.

There are other initiatives within the ecosystem trying to establish and organize collaboration among the multiple organizations and improve the current situation, most of which success seems to prolong. The increased competitive environment in the ecosystem since the drop of shipping rates in 2008 provides one explanation. Another reason is that authorities cannot be seen to favor any single organization, or constellation of organizations. Accordingly, engagement in joint research projects can be a fruitful ground for achieving substantial breakthroughs. While previous research projects have developed what seemed to be excellent IT solutions, there is a low level of implementation and adoption of these results, see Paper I and VI for details. Accordingly, this research chose to pursue an alternative design strategy for the II compared to the existing design, which is guided by IOS based on EDI messages.

The research methods used varied depending on the engagement settings and the unit of research. For this research in general, basic research techniques of Webster and Watson (2002), Silverman (2013), Van de Ven (2007) were followed. Further, this research was inspired by Sarker et al. (2012a), Yin (2009) and Flyvbjerg (2006) to conduct a revelatory case study per trade lane, which can be considered an empirical inquiry that can potentially help to explain and understand presumed causal links in real-life interventions that are too complex for other research methods. Further, this research has been presented, separately discussed, and obtained highly valuable guidance for this research by Watson, Silverman, van de Veen and Sarker in person.

This research has been guided by various theories and methods. For the literature review and analysis have been primarily guided by Webster and Watson (2002) and Levy and Ellis (2006), see Paper 2. For the initial analysis of the EU import side of the domain we were guided by senior researchers in the Cassandra project, see for example Jensen et al (2014b). The analysis of the international domain of containerized shipping were predominantly guided by AT and in the later subsequent re-analysis by the reviewers of, for example Jensen et al (2014a) and particularly for Paper 5. The design was guided by IS design theory especially for II and more specifically by the DSR method in the initial research, while for the later stages the ADR method was used. ADR was specifically relevant, because of the BIE cycles' intervention. In spite of the relative success with the ADR approach, it was learned that it is challenging to kick start development of an II given the international and multi organizational settings. Accordingly, prior to the design, this research was guided by AR, especially IS-AR, to engage practitioners and sponsors for the design efforts.

A key methodological concern has been the possible bias of the researcher stemming from being employed in one of the organizations while performing research (Brannick & Coghlan, 2010). However, for this research it has in fact been an advantage, particularly in gaining access to a number of agoras, which would have not been accessible otherwise. IS-AR was particularly helpful in facilitating the use of modern IT to jump-start actions engaging multiple organizations' collaboration, in order to facilitate engagement across organizational boundaries, national borders and cultures. It was found that the shared vision of improving containerized shipping, through lowering trade barriers to enable trade, supported the engagement of the heterogeneous multiple organizations involved.

Further, it was found that the research became a neutral ground for practitioners to engage and interact with other practitioners, even within the competitive environment in the ecosystem of containerized shipping for international trade. Additionally, it was found that especially IS researchers possess the capabilities to contribute their competencies within IT, attracting practitioners both from private and public organizations. This thesis demonstrates that IS-AR can produce excellent outcomes and can potentially give significant impact both within the IS research field and in the world of practice, specifically for containerized shipping for international trade. The reflection regarding IS-AR method is elaborated in Paper 1.

Following IS-AR various organizations were engaged, trying to link the solution to existing initiatives and projects where possible. Kick starting projects is however challenging in the multi-organizational setting of containerized shipping. The main reason being that none of the organizations see the SIP as their prime responsibility, and for many, it can be difficult to identify a large enough potential benefit compared to alternative improvement projects. This can diminish the possibilities of funding, and jeopardize otherwise positive outcomes. To compensate, this research engaged and ran several project streams in parallel trying to kick start/bootstrap the SIP, hoping that at least one would be successful, which several of them were.

More than twenty initiatives/project streams have been attended or initiated with relation to the SIP. To be invited to be introduced or to participate are a first and important step. Within this research the capacity was limited and it was initially not possible to start own project streams, however, this research initiated a work package within the CORE project (project stream 1 in Figure 9). The projects were funded from various sources in the multi-organizational setting for containerized shipping for international trade. Figure 9 illustrates eight of these project streams, with the names of the IT solution highlighted in bold. The details of the eight project streams are not described in this chapter, however, further descriptions are in the Paper 1 and in Jensen (2015c) and (2016b). These papers include empirical details on the selected project streams, the research methods used and the results.

For several of the project streams, the SIP IT solution was given a dedicated name, for example ‘Internet for Shipping Information’, ‘Supply Chain Visibility Platform (SVP)’ and ‘Transport and Logistic Information Platform (TLIP)’. It is worth mentioning that the TLIP project engaged multiple organizations in workshops to reach consensus on continuing with the project, which are described in more details in Jensen (2015c) and (2016b).

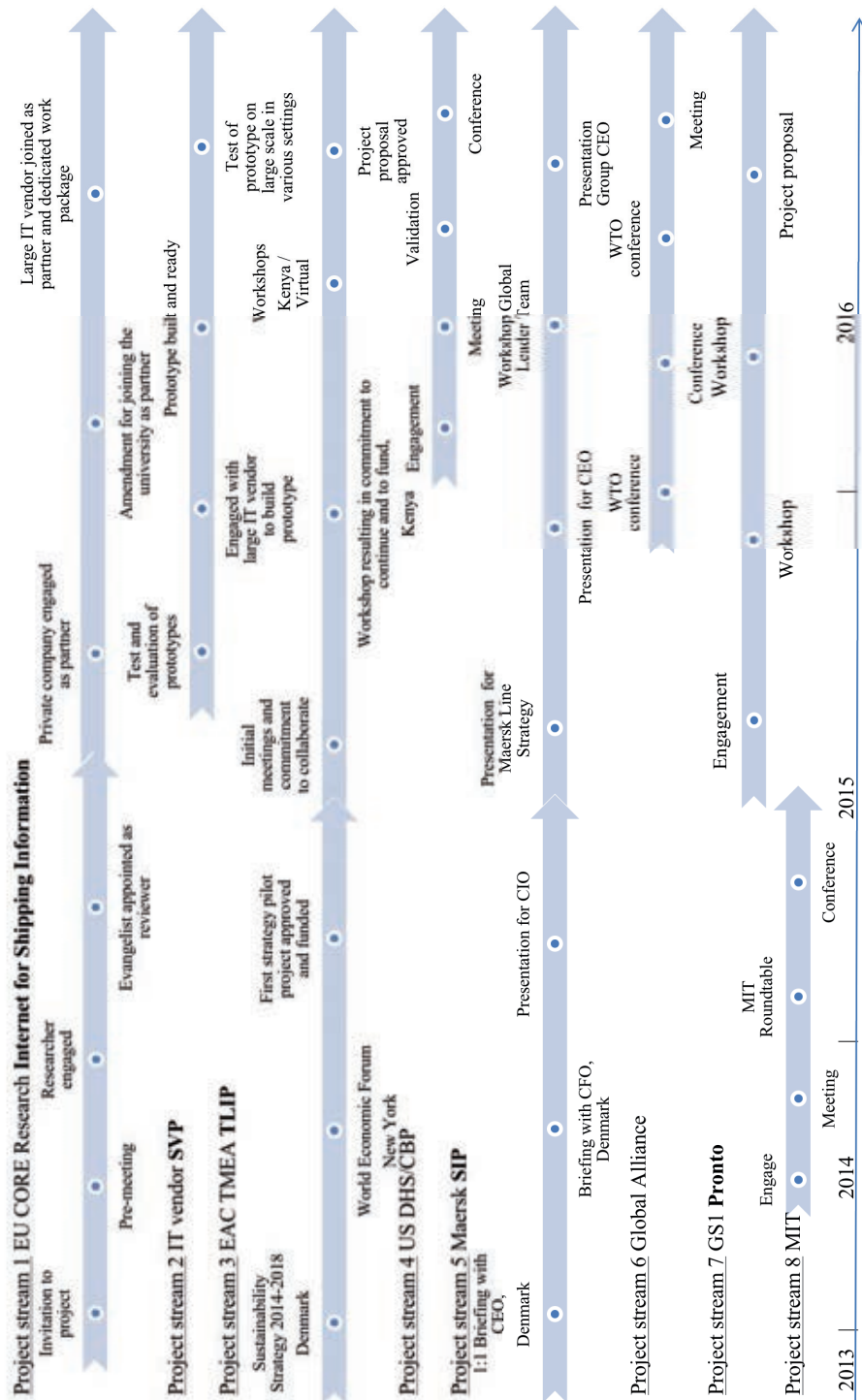


Figure 9 Project streams.

The first three of the project streams are described in more details in Paper 1. Especially three characteristics stand out: a) IS-AR researchers have IT competences which enable them to reframe the used IS theory from IOS to II, b) IS-AR project becomes a neutral ground, or an agora, where representatives from public, NGO and even competing private organizations meet and the researchers are accepted and sometimes even acknowledged and welcomed, c) IS-AR allowed the engagement in action oriented activities, such as trying and evaluating prototypes of IT solutions. Within this research IS-AR is praised as guiding this research in the many project streams within the complex multi-organizational ecosystem for international containerized shipping.

Another key learning from this research is the benefit of applying the IS-AR approach within a multi-organization project. In such a context, IS-AR allowed the researchers to understand the interactions and the many hand-overs in a much better way than if only the process was studied from the point of view of a single organization. Potentially other researchers researching II could similarly benefit from IS-AR.

The unit of research in this research was two-folded, it was useful to distinguish between *the units of analysis*, looking at the current empirical situation, and what has been called *the unit of design* (the SIP).

The unit of analysis has been containerized shipping of shipments. This research is one of very few that have chosen to investigate the ecosystem of international containerized shipping by following goods, such as avocados, from origin to destination across borders. Tying this research to the avocado has provided a unique opportunity to follow the sequential flow of the fruit, and at the same time investigate the information provided, demanded and used by the multiple actors in the many organizations involved.

The results of the analysis are consistent with the experience of the industry's senior practitioners, finding that containerized shipping is relatively inefficient. Further, was confirmed the hypothesis of this research that there is an unleashed IT potential within the domain and that IT is a solution to pursue for improving the situation. There are plenty of suggestions for possible solutions to address this, however, the analysis was directed towards finding critical issues that became the input for designing an IT artifact.

The second unit of research, the unit of design, being an IT artifact has been relevant for the design task of determining the SIP artifact. This involved additional groups of practitioners, IT

vendors and a range of international organizations focusing on trade facilitation. In this context, the unit of design was extended through leveraging competences of the IS community to guide the design. In design theory terms, the kernel theory and applied scientific principle have resulted in positive evaluations. Especially, the BIE cycles, which are an integrated part of the ADR, have been successful, which justifies the claim that this research have been able to demonstrate the possibility of ameliorating the major impediments in containerized shipping, including the key critical issues for the actors and their organizations.

The SIP has demonstrated promising results toward improving the situation in containerized shipping. Several initiatives are sponsored to continue pursuing and enhancing the SIP to engage a larger part of the ecosystem for containerized shipping. Accordingly, these developments support the hypothesis that IT solutions can improve containerized shipping, especially following the design principles of SIP.

Of course, the results are only indicative and they need to be augmented by research of implementation and scaling of SIP to cover many more trade lanes and a wider variety of actors. This is the scope of the additional working package of the CORE research project, see Figure 9. However, as discussed in the next section and in the last section in Chapter 7 the conclusion is that there is widespread industry acknowledgement of and support for the SIP, and the design thesis shows advantages compared both to the current traditional approach, and to the designs which are based on EDI messages, see Paper 3.

This research is done in a multiple organizational setting which in itself is challenging. In the post reflection of the research design it was realized that the use of mixed methods, including IS-AR and ADR, and theories, such as AT and IS design theory, increased the ability to reach results. Particularly, as Paper 1 describes, IS-AR guided engagement within the complex multiple organizational ecosystem for international containerized shipping, and as Jensen et al (2014a) and Paper 5 describe the used of AT for both the unit of analysis in the heterogeneous domain for containerized shipping and for the unit of design the IT artifact of SIP.

Utilizing mixed methods also inherently creates tensions and risk of deviating focus. However, since the individual method was primarily used for one of the research activities for which it is dedicated for example ADR and DT for the design of SIP and accordingly, the tensions have been minimal. Further, the Engaged Scholarship methodology has been an umbrella facilitating consistency of the research.

6.5 Estimated impact

In this final section, is presented a summary of the estimated impact of SIP at four different organizational levels: actor level (individuals in any of the organizations), organizational level (private companies such as traders, service providers, IT vendors, and public organizations including authorities), country/region level and global society level. Further, the willingness to engage and fund prototyping and testing of the SIP is taken as a positive evaluation of the design of SIP.

The **individual actor** in the many organizations expressed that they would like to utilize the SIP to gain insight into events in the international containerized shipping supply chain, which is part and parcel of their work. For them SIP is a huge improvement, as of today none of the actors have transparency into containerized shipping, and requesting information is time consuming and cumbersome. Additionally, the SIP provides up to date and valid information to a much higher degree than currently, where information is often missing, out of date and of poor quality. Accordingly, when asked as part of the evaluation of SIP, all actors found the service provided useful, especially when the physical flow does not go as planned.

On an **organizational level**, the private organizations involved are the traders, as well as a variety of service providers, from trucking companies to clearing consulting companies. The traders foresee that the SIP creates the possibility of more efficient logistical coordination, which substantially will lower the risk. This could impact the international trade cost in downward direction, increasing the attractiveness of trade, and the wiliness to partake in it. The international trade cost can be split in a physical transportation cost and an administrative cost, which respectively are 8% and 20% of total retail cost. The SIP addresses primarily the administrative border related cost, which is the costliest part of international trade cost.

The service providers include major shipping lines, who foresee the main benefit being increased trade volume, resulting from lowered trade barriers and costs, and increased international trade, particularly for first movers. The public organizations have been very active in supporting the different prototypes and they foresee potential improvements in the area of inspections, security and health. Through the SIP, the authorities will have the opportunity of getting information directly from the source, whereby the quality of the information will increase substantially compared to today. More reliable information will enable the authorities to improve their risk assessments and it will provide them with a higher degree of accuracy in

calculating tariffs. However, the stated benefits do not come without trade-offs. Authorities will have to modify their ways of working, requiring them to pull information instead of information being pushed to them. Especially Paper 4 outlines how SIP offers new opportunities for improving security and reliability in the work of authorities.

IT vendor organizations could benefit from offering IT solutions, including cloud-based platforms that facilitate information exchange for international trade. Many have been positively engaged in collaborating regarding the SIP, but so far none of them have seen a business opportunity, which they want to pursue. One major vendor IBM has been involved in a series of workshops detailing the architectural design of the SIP, and has invested in building prototypes. However, IBM is struggling to find an attractive business model as a trusted third-party solution provider, and is instead trying to establish a joint venture with Maersk. At this point in time, the details are unclear, but both remain prepared to fund the further development and operations of the SIP. Governing of the SIP is a challenging task, involving a diversified group of organizations in developing and creating a viable business model, which while beneficial to all, largely lacks a clear business opportunity for any one specific actor. In the absence of a joint effort by a larger consortium, it is likely that a major actor, who controls a substantial part of different key process might see an advantage in establishing the II and offer/demand it to be used by its network of collaboration partners.

On the **country level** the impact of reducing the administrative barriers are estimated to have a significant impact on trade volume, which affects the economy positively. The World Economic Forum (WEF) estimates that an improvement by lowering trade barriers to half-way regional best practice, on average will result in a globally increased Gross Domestic Product (GDP) by 3% (WEF, 2013). Such improvements are important especially for developing countries such as in East Africa (Sub Sahara), where a similar estimate predicts improved trade lanes could increase GDP by 12% if halfway of global best practice is achieved. An analysis of the impact for Kenya estimates that more than 40,000 new jobs⁸⁰ will be created for export primarily of flowers and fruit like avocados if trade barriers are lowered by SIP.

At the **regional level**, the European Union has a clear interest in the SIP, since EU is actively involved in and is funding the research project⁸¹ which is testing the SIP prototype. The EU

⁸⁰ Estimate presented at workshop for EAC representatives in Nairobi 20150415.

⁸¹ CORE research project <http://www.COREproject.eu> (May 2014 – April 2018) 20161128

sponsors aim to improve the security for containers imported to the EU and to ease trade between the US and EU. Further, for the first piloted trade lane between East Africa and Europe, several association of importers, authorities and representatives for EAC expressed positive expectations about the SIP and committed to be actively involved in pilot projects lead by Trade Mark East Africa⁸², see Jensen (2015c) and (2016b) for elaboration.

At **global society level**, WEF estimates that by lowering trade barriers through introducing solutions like the SIP, international trade volume will increase and thereby fuel economic growth (Hanouz, Geiger, & Doherty, 2014; Headrick, 2009; United Nation ESCAP, 2014; WEF, 2013).

“Estimates suggest that an ambitious improvement in two key components of supply chain barriers, (border administration and transport/communications infrastructure), between all countries raising their performance halfway to global best practice, would lead to an increase of approximately US\$ 2.6 trillion (4.7%) in global GDP and US\$ 1.6 trillion (14.5%) in global exports. For comparison, the gains to be obtained from a complete worldwide tariff elimination amount to no more than US\$ 400 billion (0.7%) in global GDP and US\$ 1.1 trillion (10.1%) in global exports” (WEF, 2013).

Accordingly, implementing solutions like SIP potentially provides a much larger positive improvement in international trade than removing all tariffs. In other words, improved information infrastructures are the most potent vehicles to enabling efficient and effective trade for a society. Additionally, this contributes to the global sustainable agenda, see Jensen (2015c) and (2016b).

In summary, SIP can potentially contribute significantly to enabling trade and fueling growth in the global economy. WEF estimates that increased trade, utilizing sea-carried containers and modern IT in the form of a shared II such as SIP could reduce international trade cost by 5-20%, increase trade volume by 10%-15% impacting GDP by 3%-5% (WEF, 2013). It would also reduce CO2 emissions from 560g for air cargo to 3g per ton of goods, see Jensen (2015c), fostering sustainable development in the world and contributing to the attainment of the 17 sustainable development goals of the UN⁸³. As evidence of the external interest in this research,

⁸² Trade and Markets East Africa is an East African not-for profit Company Limited by Guarantee established in 2010 to support the growth of trade in East Africa.

⁸³ <http://www.un.org/sustainabledevelopment/> 20170413

the findings have been selected to be presented and discussed at World Trade Organization conferences on several occasions⁸⁴, see Appendix in Jensen (2015c) for illustrations. United Nations General Secretary, Ban Ki-Moon in the report ‘Mobilizing Sustainable Transport for Development’ (2016)⁸⁵ mentioned the SIP as the example of IT solutions that support mobilizing sustainable transport for containerized shipping, and he estimated that “improvements in border administration, transport and communication infrastructure could increase global GDP by US\$2.6 trillion”. No one could hope for a better endorsement of this research than this statement of social responsibility and sustainability.

⁸⁴ E.g. at the World Trade Organization Conference 2015.

⁸⁵ <https://sustainabledevelopment.un.org/topics/sustainabletransport/highleveladvisorygroup>

7. Conclusion

The research concludes in this chapter by addressing the main research question. This is done by firstly summarizing the completed research. Secondly, by reporting the analysis of design recommendations from the IS literature, which are relevant for the maritime industry. Thirdly, by summarizing the findings of the current status quo and of the three major impediments to a more efficient containerized shipping from the analysis of one trade lane. Fourthly, by presenting the design of an IT solution including design guidance and derived design principles based on evaluation by practices. Finally, by summarizing the discussion of the main theoretical implications and the practical implications, with relevance and value to society in general and to the actors and organizations in the maritime industry in particular.

7.1 Completed research

The research has aimed at answering the main research question:

How can Information Technology improve containerized shipping?

This main research question has been addressed through three sub research questions, which were guided by the research design. Specifically, the research has been guided by Engaged Scholarship as an overall methodology for the three main research activities that are reported in this dissertation:

- 1) A literature review within IS research field to extract the current design guidance for possible IT solution that potentially could improve containerized shipping. Based on thorough IS literature reviews guided by Webster and Watson (2002), it was found that research focusing on maritime industry is lacking, however, a deductive analysis was conducted identifying three generally applicable meta-design principles for designing IT artefacts in large ecosystems like the maritime sector. IS design theory, particularly for II, was identified and has guided this research. Further, the research design guiding entirety of the research is the outcome of reviewing possible research methodologies, methods, and techniques.
- 2) An analysis of containerized shipping to reveal the hidden world of shipping and its status quo. Through analyzing a selected case – one trade lane within the ecosystem for containerized shipping, three major impediments and eight critical issues were

identified, all of which IT might ameliorate. These became the requirements for the design. Activity Theory has guided the analysis.

- 3) Based on the results of the above two research activities, an IT solution was designed and prototyped, inductively extracting design guidance. The SIP solution has been guided and tested using multiple methods, primarily Information Systems Action Research (IS-AR) and Action Design Research (ADR) including 6 Build, Intervention, and Evaluate cycles. Activity Theory (AT) has been the kernel theory. In total 13 prototypes were evaluated and 17 design principles extracted. The main evaluation criteria have been if the solutions were found to be useful for the actors in the maritime sector and whether it was possible to obtain funding for continuation of the development.

Answering the main research question, this research found that IT solutions designed according to the design principles of SIP can significantly facilitate the digitalization of collaboration among multiple organizations. Furthermore, it can potentially support actors to ameliorate the critical issues and reduce the major impediments to improve containerized shipping. Although the physical operations of containerized shipping are rather efficient, overall the industry suffers from inefficiencies primarily due to administration, which to a large extent depend on shipping information, this becomes barrier for trade when crossing borders and boundaries.

Digitalization in accordance with the principles behind SIP will enable shared II. This will become akin to an Internet for shipping information with nearly global coverage. This can potentially facilitate collaboration among the organizations through creating real-time transparency into shipping events. This, in turn, will potentially improve efficiency, increase reliability, reduce administrative international trade cost and not least, it will go a long way towards reducing the security concerns of containerized shipping.

Based on the above described research the key theoretical contribution, should be emphasized as this is where insight is added to the current body of scientific knowledge. The IS literature suggests three theoretical meta-design principles. Based on this research it is proposed to extend the IS design theory with a fourth additional but complementary meta-design principle for designing II's, suggesting that the II should utilize the fundamental design principles of both the Internet and WWW. Acknowledging, that further research is needed to validate the proposal

of the fourth meta-design principle Paper 2 provides rudimentary support to the claim that different design situations requires design of different II solutions.

This research is documented through a large number of publications (working papers, conference papers, book chapters, journal articles and this thesis). In the appendix is a full list of the publications and further, 5 selected publications are included in print in appendix. The publications included in appendix cover the analysis of containerized shipping, the design of the SIP and the design recommendations for designing II.

The research is also presented in publications and at a broad range of conferences and business meetings both for academia and for practice. The research was positively received at conferences, and a best paper award was obtained for one of the conference papers. Further, one of the papers has been published in the Information Systems Journal, which is one of the high ranked journals in the IS community's Basket of Eight.

7.2 Results of literature review of current design recommendations

Sub research question 1) What constitutes the current IS research knowledge about IT solutions supporting containerized shipping? Here it was found that the current IS research knowledge has a breadth of advice for individual organizations, but has little in terms of specific guidance for the maritime shipping ecosystem. Three general recommendations were found applicable in an industry the maritime industry. The IS literature recommends:

II 1.0 Digitalization.

II 2.0 Digital collaboration by digital communication via IOS based on EDI messages.

II 3.0 To utilize shared II for digital collaboration.

The first two recommendations have been around for decades, guiding practices within containerized shipping, but the third recommendation is relatively recently introduced as a recommendation, specifically the I3 framework to accelerating global supply chains (Tan et al., 2011) which includes containerized shipping.

The analysis of containerized shipping has confirmed the relevance of all three meta-design principles, and they have guided the development of a II for sharing shipping information.

7.3 Results of analysis of current practices for containerized shipping

Sub research question is 2) What is the current status quo and major impediments for containerized shipping which IT could ameliorate? Here the study has been delimited to those impediments, which IT could either partially or completely ameliorate.

In the analysis, containerized shipping was found to be very inefficient, mainly due to critical issues with information content and availability. This is due to the fact that more than thirty organizations are involved in a single shipment, utilizing hundreds of documents and information. Despite the physical infrastructure provides productivity and efficiency, the fragmented or missing II, which is absolutely critical for supporting the collaboration around all the physical shipping activities, results in an overall ineffectiveness. This results in that the physical assets are not properly utilized and there is a general waste of resources.

Examples of critical issues include paper documents required in original version with stamps and signatures, missing documents delaying shipments, incorrect information in documents, and time indications being grossly inaccurate. Further, the analysis shows that the recommendation by IS researchers to use IOS based on EDI messages has only been implemented to a limited degree, and it covers only a minor part of the communication necessary for handling containerized shipping. Furthermore, phone, text messages and e-mails are extensively needed for collaboration in the absence of the necessary IT-solutions, like the proposed SIP.

Based on the extensive empirical analysis, the eight most important critical issue, which IT could ameliorate, were identified. These eight critical issues cause three major impediments that effectively become non-tariff trade barriers. Accordingly, it is apt to conclude that there is an unleashed IT potential and a need for alternative IT solutions.

7.4 Design guidance for Shipping Information Pipeline

Sub research question is 3) What design principles for an IT solution (SIP) could potentially lead to more effective containerized shipping? As mentioned above, the solution has been guided by the recommendations in the IS literature, which can be summarized into the three meta-design principles of digitalization (II 1.0), collaboration using digital communication (II 2.0) utilizing a shared II (II 3.0) for shipping information. However, it was found that these are necessary, but not sufficient recommendations. In particular, it became clear that the II

recommendations were both partially deficient and not detailed enough to solve the challenges in the maritime ecosystem. This was evident during the implementation of the first prototypes. Accordingly, the prototypes were improved through a trial and error process constantly trying to fail fast and to learn. In this process, and through the developments in related pilot projects, it became clear that a fourth meta- design principle was necessary in order to design an effective SIP that could deliver the results, and gain support from key stakeholders and influencers.

This research identified one new meta-design principle and seventeen inductive design principles during the BIE cycles of the 13 prototypes. The meta-design principle, which in the conceptual framework becomes the fourth meta-design principle, is one of the key contributions of this research. It is formulated in the following way, and it is worth noting that it is an II version 4.0 which is consistent with terminology applied in industry, using a concept like ‘Industry 4.0’:

II 4.0 Sharing meta-information only and governing access to detailed information.

This is a critical meta-design principle, when the II utilizes the Internet and the WWW, and it is at the same level as the first three II meta-design principles. The reason being that it is radically different to the traditional IOS based on EDI/XML messages. Information is not pushed to the next actor or trading partner in the value chain, instead all information is left at the source and access is provided only on request from those who have a legitimate claim. It should be noted that this design is utilizing the design principles behind the Internet and particularly the WWW, defined by Berners-Lee (1999)⁸⁶, creating an enormous flexibility and adaptability which facilitates scalability due to their global coverage.

Next to this fourth meta-design principle, seventeen more detailed design principles have been identified through the empirical studies. These represent different types of principles from individual Human Computer Interaction (HCI) type principles, to principles mainly relevant on the society level. They were all found relevant in the context of the maritime ecosystem, but it is clear that further research is needed to establish the validity of all seventeen principles and their relative importance.

⁸⁶ Tim Berners-Lee was recognized for the invention of WWW by getting the ‘Millennium Technology award by Finish Research Council and he was awarded A.M. Turing Award in 2016 <http://amturing.acm.org/> 20170522

7.5 Theoretical contribution

In this section, the four major theoretical contributions are briefly summarized:

1. At least for the last decade there is a lack of publications by IS scholars focusing on the maritime industry (Güven, 2015). Within the European Conference on IS in 2016 and in 2017, the topic of this research was not covered by any of the papers presented at the maritime track. The analysis of current status for containerized shipping in the maritime industry revealed many deficiencies and a huge potential for improvement with proper IT solutions. However, these could not be ameliorated through existing IS principles following IOS based on EDI messages, mainly due to the heterogeneity of the needs of the many stakeholders and their unwillingness, for competitive reasons, to exchange information broadly. The design of a shared II for improving containerized shipping is a radical new design for collaboration via digital communication. This point is further elaborated in Section 6.1 and in Paper 4, which contributes to the discourse within maritime IT by exemplifying how cloud solutions for shipping pose new opportunities for reengineering the ecosystem for containerized shipping which has not been published before.
2. The definition of an additional fourth theoretical meta-design principle for the design of II when utilizing the Internet and WWW, see Section 6.2 and 7.4 for elaboration. This principle is based on only sharing minimal meta-information about the availability of the full detailed information, but leaving the detailed information to be governed at the source. In this way, only actors of organizations, who have a legitimate reason to request the information, will be granted access. This is a contribution to the IS design theory for II with this additional meta-design principle complementing the existing IS design theory for II. Further, Paper 2 proposes to reconsider the current design space of existing and proposed II.
3. The use of Activity Theory (AT) for analysis of a multiple organizational setting to provide input for the design of IT solutions especially II. Although AT has been used extensively within individual organizations, the primary focus was on production processes, and has not been used for analysis of shipping for trade, involving a full ecosystem like the maritime sector. The use of AT for the analysis contributed with a case which identifies the shipments as a runaway object. According to Spinuzzi (2011),

only one case of a runaway object has been documented so far in the literature, a case within a health care organization. All in all, AT compared to other system theories provides terminology and insights especially relevant for analysis of complex ecosystems which are particularly useful for design of II supporting collaboration within ecosystems. For a more detailed discussion of the use of AT in such a context, see Section 6.3, Jensen et al (2014a) and Paper 5, where AT is used as the prime theory for the analysis and the design, which represents a contribution.

4. In retrospect, it was found that Information System Action Research (IS-AR) method provides a further contribution. There is no doubt that IS-AR has supported the ability to engage actors and sponsors, as discussed in Section 6.4, and has contributed to the research results. IS-AR has been valuable in guiding the research within the complex multi-organizational ecosystem for international containerized shipping. Potentially, other researchers investigating infrastructures as II, could benefit from IS-AR. There are very few examples of IS-AR within multi-organizational settings, for example the work of Braa, Monteiro, and Sahay (2004) is noteworthy. The contribution of this research, which especially is detailed in Paper 1, is an additional example of IS-AR research in a multi-organizational setting, specifically the international ecosystem for containerized shipping.

In summary, this research has provided theoretical contributions which can inspire other IS researchers especially in three areas: x) by sharing the insights and benefits of the use of AT for research of II within inter-organizational settings, especially the alignment of IS research objects to AT's boundary objects specifically II, see Paper 5 for details, and y) by sharing the experience regarding how IS-AR method can enable particular IS researchers (in this case industrial researchers) to engage and facilitate multi organizational collaboration through agoras of research projects, see Paper 1 and Jensen (2015c) and (2016b) for elaboration, and z) by demonstrating the value of the fourth meta-design principle and the proposed framework of design spaces for II, see Paper 2, which hopefully will revitalize the discourse regarding design theory for II especially shared global II's building on the Internet and WWW.

Above these theoretical contributions, based on the positive evaluations and the acknowledgement by key influencers and stakeholders, it is estimated that the radical new design guidance will improve the status quo for containerized shipping, this is elaborated in

several of the selected papers and discussed in last section of Chapter 6. Further, the acknowledgement of SIP is elaborated in the next section.

7.6 Acknowledgement of Shipping Information Pipeline

The design of SIP enables visibility outside the current visible horizon of actors in the supply chain through providing access to source information (unabridged, undistorted and with the original high quality) about shipments. This goes a long way towards addressing the major impediments for a more efficient containerized shipping: trade barriers, uncertainty and risk. If that can be achieved, it will dramatically impact trade cost, security and sustainability, and it will substantially lower the trade barriers, increase trade and fuel GDP growth.

The design of SIP addresses key challenges in the real world of containerized shipping. Practice evaluations of the 13 prototypes of the SIP show promising results towards improving efficiency, lowering barriers and reducing risk in the complex ecosystem for international trade. Practitioners' acknowledgement of the analysis of status quo and of the design on how IT can ameliorate impediments and improve containerized shipping is important evaluation of this research.

The practical implications of SIP are estimated to significantly impact our global society benefiting organizations and society at large. In the previous chapter, was presented and discussed the practical implications of SIP for various levels ranging from actors using the SIP, from organizations deciding to implement and possibly sponsor the SIP, and to country, region and global level. Those were based on numerous presentations of the SIP to the aforementioned stakeholders and on estimations by communities like the World Economic Forum. In the following is discussed how, and to what extent, various specific stakeholders believe SIP can support a more effective containerized shipping. SIP is relevant for nearly all stakeholders in the ecosystem despite their varying goals, background and nationality.

Both the analysis and the design/solution of this research have been presented at various events for various audiences of practice. including:

- Maersk, including chairman of the board, CEOs, CFO and Strategy Officer, and CIOs.
- Technology providers e.g. IBM, Microsoft, INTTRA, Ericsson, etc.
- A number of authorities and ministries, e.g. Dutch Customs, Department MOVE for Mobility and Transport in European Union, Department TAXUD for Taxation and

Customs Union in European Union, U.S. Department of Homeland Security, and U.S. Customs and Border Protection, and various departments of authorities in East Africa.

- A number of international fora e.g. at conferences for Intermodal, WEF, WTO, and UN.
- Standardization organizations such as GS1.

The evaluation by the Chairman of the board at Maersk on 31th March 2017 was specifically encouraging: “Your analysis is spot on, how to take next step, I need to go back to discuss.” Along similar lines, the EU officers sponsoring the CORE research project request to demonstrate the SIP on a large scale.

In conclusion, it is worth mentioning as a sign of acknowledgement that since the identification of the fourth meta-principle and the seventeen detailed design principles, a number of stakeholders have adapted the SIP principles in developing their own solutions.

Several organizations are substantially funding the onward development and journey of SIP. For instance:

- (1) Trade Mark East Africa has got support for their version of SIP prototype #7 named Transport Logistic Information Pipeline (TLIP),
- (2) Maersk and IBM are aiming to form a joint consortium pushing next version of SIP prototype #13 named Global Trade Digitalization (GTD),
- (3) The CORE research project funded by the EU has been extraordinary adding an additional work packages in order to pilot the SIP prototype #12 re-named to Internet for Shipping on a large scale firstly for trade corridors between EU and US to facilitate and ease trade and secondly between EAC and EU.

Authorities in EU, USA and EAC, and with Maersk as the leading shipping line, are engaged in order to support toward productive versions of SIP to be implemented in this large-scale pilot project.

- (4) Finally, the researcher has been invited, and continue to get invitations, to engage in new initiatives, corporations and constellations organized or initiated by organizations like the World Shippers Forum, European Shippers’ Council, and a newly established Transport and Cargo Facilitation Association.

The sentiment of all of these activities is that there seems to be agreement about the status quo for the containerized shipping, based on the analysis of avocados crossing borders, and that IT can improve the situation in containerized shipping and that SIP offers a promising design.

This is reflected in the support for continuation of the research with several implementations. However, while the mentioned organizations show interests, each one of them has their own

agenda and set of prerequisites as a starting point, affecting the focus and content of the discussions. For example, the UN related organizations, and many national authorities, are largely concerned with how SIP contributes to a more sustainable world. Private organizations focus first and foremost on their own business and on creating business for themselves, in an ecosystem characterized by substantial information asymmetry, and where many see the potential for inter-organizational reengineering disrupting their existing business models. This raises a number of implementation issues, which are hard to mitigate.

Despite these diverse agendas, this research has been presented and obtained positive feedback at numerous events, and is additionally published extensively outside academia. Additionally, the results of this research are documented in a number of videos, which have been presented at the main track of various conferences, such as at the WTO conferences. Furthermore, the importance of this research is reiterated through the United Nations General Secretary explicitly naming the SIP as an example of a solution for containerized shipping in his final UN report announced⁸⁷ at UN headquarters in New York on 28th of October 2016 aimed to mobilize sustainable transport for development of our global society.

The SIP design principles can potentially contribute to transforming the containerized shipping. The prospective impact could be similar to that of the standard container, which revolutionized the physical infrastructure for shipping (Levinson, 2010). The time is ripe for a similar groundbreaking revolution in the administrative, non-physical infrastructure, which is responsible for the lion's share of the total costs of containerized shipping. Here the SIP provides immense potential for improved effectiveness for containerized shipping, of the global economy and for the attainment of a more sustainable world.

Additional domains find themselves in similar situations as containerized shipping increasingly international eco-systems of multiple heterogeneous organizations. These domains could potentially improve through similar dedicated and shared global II. However, despite these similarities additional research investigating the design space for each domain probably could be inspired by the findings of this thesis.

⁸⁷ Press release by UN <https://sustainabledevelopment.un.org/?page=view&nr=1118&type=230&menu=2059>

List of abbreviations

ADR	Action Design Research
API	Application Program Interface
AR	Action Research
AT	Activity Theory
ATA	Actual Time of Arrival
BIE	Build, Intervention, and Evaluation
CAS	Complex Adaptive Systems theory
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CIO	Chief Information Officer
CORE	Project for Consistently Optimized Resilient Ecosystem
DI	Digital Infrastructures
DSR	Design Science Research
EAC	East African Community
EDI	Electronic Data Interchange
EPCIS	Electronic Product Code Information Service
ETA	Estimated Time of Arrival
EU	European Union
GDP	Gross Domestic Product
GS1	Global Standards 1
GTD	Project for Global Trade Digitization
I3	ITAIDE II framework
II	Information Infrastructures
ISI	Internet for Shipping Information
IOS	Inter-Organizational Systems
IS	Information Systems
IS-AR	Information System Action Research
ITAIDE	research project for IT for Analysis and Intelligent Design of e-Government
IT	Information Technology
RCM	Remote Container Management
SIP	Shipping Information Pipeline
SVP	Supply Chain Visibility Platform
TLIP	Transport and Logistic Information Pipeline
TMEA	Trade Mark East Africa
UN	United Nation
UN/CEFACT	United Nations Centre for Trade Facilitation and Electronic Business
US	United States
WCO	World Customs Organization
WEF	World Economic Forum
WTO	World Trade Organization
WWW	World Wide Web

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List of selected research events for data and knowledge collection

Date and Location	Event	Participants	Focus
2013-07-02 The Netherlands	Meeting and site visits	Maersk and AMPT, plus Dutch Customs and TU Delfts	Container terminal and customs at Port of Rotterdam
2013-09-01 Kenya	Interview and observation / site visit (by colleague)	Farmer of avocado Exporter1201	Export of fruits
2013-10-04 The Netherlands	Meeting and site visits	Fruit Import Organization and service providers including shipping line, terminal operator, freight forwarder and consultants	Import of fruit
2013-10-20 Denmark	Meeting	Academics	Discuss CORE II research program
2013-10-29 Denmark	Interview	Maersk Line CIO	IT transformation
2013-11-26 Denmark	Presentation	Maersk Line CFO and Strategy Officer	Strategy and transformation
2013-11-26 Denmark	Presentation	Maersk Line CEO	Maersk Line Strategy
2013-11-27	Meeting	Maersk Line CFO and Strategy Officer	Present and discuss idea of SIP
2013-11-28 Denmark	Meeting	Maersk Line CEO	Present and discuss idea of SIP
2013-12-13_16 Italy	ICIS Conference	Academics	IS research
2014-01-27_31 The Netherlands	Focus group	3 representatives from authorities and 3 from private service provider	Shipping Line, Terminal, and Dutch customs authorities,
2014-01-28_30 The Netherlands	Interviews and observations / site visits	3 Logistic Manager, Fruit importers	Import of fruits to EU
2014-01-29 The Netherlands Den Haag	Focus group	Director and 8 logistic experts from 8 fruit importers	Association of fruit importers
2014-01-30 Terminal, Port of Rotterdam	Interview and observation / site visit	3 representatives from private service providers company and 3 advisors from special service providers	Import of fruit
2014-05-05	Meeting	Traders, authorities and researchers	Analysis
2014-05-22_27 USA	DESRIST Conference	Academics	Present research paper
2014-05-26_27 Nairobi, Kenya	Interview	Logistic Forwarder Service Provider	Export of fruit
2014-05-28 Nairobi, Kenya	Meeting and interview	Customer Relationship Manager Shipping Line	Export of fruit
2014-05-29	Interview, meeting	Logistic Manager (and partner /	Export of fruit

Date and Location	Event	Participants	Focus
Nairobi, Kenya	and observation / site visit	owner) Exporter	
2014-06-01_03 Slovenia	Bled Conference	Academics	Present research paper
2014-06-04 Delft, The Netherlands	Meeting / presentations	Traders, authorities and researchers	Introduction to traders' business
2014-06-05 The Netherlands	Conference	CORE Research	Kick off
2014-06-06 Naaldwijk, The Netherlands	Site visit and meeting	Traders and researchers	Follow the logistic flow
2014-04-30 Denmark	Meeting	Researchers	Logistic of automotive industry
2014-08-15_20 Japan	CABS Conference	Academics	Present research paper
2014-07-08	Shipment from Kenya to Holland	Shipment in containers	Collect communication, information and documents plus container monitoring data
2014-09-08_9 Sosterberg, The Netherlands	Meeting	Traders, authorities and researchers	Actors involved
2014-10-14_17 Norway	III Conference	Academics	Present research paper
2014-10-29 Italy	Workshop	CORE researchers	Containers
2014-11-13_19 Delft, The Netherlands	Meeting	Traders, authorities and researchers	Actors involved
2014-11-18 Aalsmeer, The Netherlands	Site visit	Traders, authorities and researchers	Follow inspection by authorities
2014-11-18 Aalsmeer, The Netherlands	Workshop	Traders, authorities and researchers	Understand objectives of key actors
2014-11-19 Aalsmeer, The Netherlands	Workshop	Trader informant	Analysis of communication by trader
2014-12-03 Denmark	Meeting	Maersk Line CFO and CIO	IT innovation
2014-12-10	Virtual meetings	Trader informant	Validation of findings
2015-01-08 The Netherlands	Workshop	Traders, authorities and researchers	Analysis
2015-01-20 Denmark	Site visit at Maersk Container Industry and AMPT, Århus	CORE researchers	Containers

Date and Location	Event	Participants	Focus
2015-01-21_28	Virtual meetings	Traders	Analysis
2015-02-06	Virtual conference	Traders	Logistics
2015-02-09	Virtual conference	Dutch Customs	Logistics
2015-03-02_05 The Netherlands	Workshop	Traders, authorities and researchers	Validate findings
2015-03-10_13 Polan	CISR Workshop	Academics	MIT research
2015-04-12_22 Kenya	Site visits and meetings plus workshop	Fifteen authorities, exporters, freight forwarders, terminal operators, etc.	Paper trail of container for export of perishables
2015-04-27 The Netherlands	Site visits and meeting	Traders and Dutch Customs	Logistics
2015-05-06 Norway	Meeting	Academics	Present and discuss research paper
2015-05-18 The Netherlands	Site visit	Traders, Freight forwarders	Shipment/container
2015-05-20 Ireland	DESRIST Conference	Academics	Present and discuss research paper
2015-05-25_30 Germany	ECIS Conference	Academics	Present research paper
2015-05-31_06-05 USA	Site visit	CORE researchers and Department of Homeland and Security	Composite containers
2015-06-24 The Netherlands	Workshop	CORE researchers	Coordination
2015-06-25 The Netherlands	Site visit	Dutch Customs Freight Forwarder	Analysis and validate findings
2015-07-03_08 Singapore	PACIS Conference	Academics	Discuss PSA research paper
2015-09-21 Denmark	Presentation	Maersk CFO and Strategy Officer	Potential economic impact of SIP
2015-09-22	Virtual conference	Traders	Analysis
2015-10-13 UK	III Conference	Academics	Present research paper
2015-10-14	WITNESS Conference	Academics	Present research paper
2015-10-26_29 The Netherlands	Conference Site visit and meetings	Practitioners World Customs Organization Dutch Customs Port of Rotterdam	Analysis and validate findings
2015-10-28 The Netherlands	Meeting	EU TAXUD	Present and validate findings
2015-11-29_31 The Netherlands	Conference	Practitioners Fruit importers	Present and validate findings
2015-12-08 Denmark	Conference	Practitioners	Verify findings

Date and Location	Event	Participants	Focus
2015-12-10	Virtual conference	Traders	Verify findings
2016-01-28 Denmark	Presentation	Maersk CFO and Strategy Officer	Validate interest
2016-01-21	Virtual conference	Traders	Verify findings including solution
2016-02-08 UK	Meeting	Academics	Present research paper
2016-02-17 The Netherlands	Virtual workshop	Traders, authorities and researchers	Validate findings including solution
2016-02-23_26 The Netherlands	Site visit Workshop	Practitioners Fruit importers	Validate findings including solution
2016-03-07_16 Kenya	Site visits and meetings	Fifteen authorities, exporters, freight forwarders, terminal operators, etc.	Verify findings for paper trail of container for export of perishables including solution
2016-04-12_15 UK	Presentation and meeting	Maersk Line Management Board	Present and verify findings including solution
2016-05-27 The Netherlands	Workshop	Traders, authorities and researchers	Validate findings including solution
2016-06-06_09 UK	Presentation and meeting	Maersk Line Group CEO	Present and verify findings including solution
2016-06-08_11 USA	Presentation and workshop	Large IT vendor research	Present and verify findings including solution
2016-06-21 The Netherlands	Workshop	Traders, authorities and researchers	Validate findings
2016-08-31_09-03 The Netherlands	Site visit and meetings	Traders, authorities and researchers	Validate findings including solution
2016-09-12_16 USA	Presentation and workshop	Large IT vendor research	Present and verify business model for solution
2016-10-10 Denmark	Meeting	Maersk CEO	New strategy and digitization
2016-11-24 The Netherlands	Site visit and meetings	Traders, authorities and researchers	Validate findings including solution
2016-12-20 USA	Presentation and workshop	Large IT vendor research	Plan brake through pilot including solution
2017-01-30 The Netherlands and France	Site visit and meetings	Trader's Logistic Center and freight forwarder	Analysis, validate findings including solution
2017-02-08 Poland	Site visit and meetings	Trader's Logistic Center	Validate findings including solution
20170331 Denmark	Meeting	Chairman of Maersk	Present and discuss findings and SIP

Table 7 Selected research events for data and knowledge collection.

List of academic publications

Year	Author(s)	Title	Outlet
2014	Thomas Jensen, Yao-Hua Tan and Niels Bjørn-Andersen	Unleashing the IT potential in the complex digital business ecosystem of international trade: The case of fresh fruit import to European Union.	27th Bled eConference in Slovenia. Published in AIS Electronic Library.
2014	Thomas Jensen, Niels Bjørn-Andersen and Ravi Vatrupu	Avocados crossing borders: the missing common information infrastructure for international trade.	Collaboration Across Boundaries: Culture, Distance & Technology (CABS) in Japan. Published in ACM Digital Library.
2014	Arjan Knol, Thomas Jensen, Yao-Hua Tan and Niels Bjørn-Andersen	Design Guidelines for Adoption of an Electronic Data Pipeline Information Infrastructure in the Global Supply Chain Over Sea.	Innovation in Information Infrastructures Workshop (III) in Norway.
2014	Arjan Knol, Thomas Jensen, Yao-hua Tan, and Niels Bjørn-Andersen	Unleashing the ICT potential in the complex digital business ecosystem of international trade: The case of fresh fruit import to European Union.	European Conference on ICT for Transport Logistics (ECITL) in Germany.
2015 Paper 3	Thomas Jensen and Ravi Vatrupu	Ships & Roses: A Revelatory Case Study of Affordances in International Trade.	European Conference on Information Systems (ECIS) in Germany. Published in Balsa Poznan.
2015	Thomas Jensen	Key Design Properties for Shipping Information Pipeline.	Workshop on I20159 IT-Enabled Resilient, Seamless, and Secure Global Supply Chains (WITNESS) in Netherlands. Published by Springer.
2015	Thomas Jensen and Ravi Vatrupu	Shipping Information Pipeline: Initial Design Principles.	Design Science Research in Information Systems and Technology (DESIST) in Ireland. Cork Open Research Archive
2015	Thomas Jensen	Sustainability through improving information infrastructures: A Revelatory Case Study of International Shipping.	Proceedings of SIG GlobDev 2015 Pre-ECIS Workshop, in Germany.
2015	Thomas Jensen	Bootstrapping a Shared Information Infrastructure Lowering the Administrative Barriers for International Trade.	Innovation in Information Infrastructures Workshop (III) in UK.
2015	Thomas Jensen	Information Systems Action Research Lifts Global Trade utilizing IT.	Mini Information Systems Research in Scandinavia Conference (mini IRIS) in Denmark.
2015	Thomas Jensen and Niels Bjørn-Andersen	How the CIO got freedom to navigate – the case of IT Transformation in Maersk Line.	SIM competition.
2015	Thomas Jensen and Niels Bjørn-Andersen	Cloud solutions for the shipping ecosystem pose new CIO opportunities.	SIM competition.
2015	Thomas Jensen and Ravi Vatrupu	Key Design Principles of Shared Information Infrastructure for Solving the Problems of Administrative	Department of ITM, Copenhagen Business School

Year	Author(s)	Title	Outlet
		Barriers and Information Invisibility in the Shipping Industry.	
2016 Paper 1	Thomas Jensen	Information Systems Action Research facilitates Global Trade utilizing IT.	Department of ITM, Copenhagen Business School.
2016	Thomas Jensen and Niels Bjørn-Andersen	How the CIO got freedom to navigate – the case of IT Transformation in Maersk Line.	Chapter in book: Cases on IT leadership: CIO Challenges for Innovation and Keeping the Lights on. Edited by Niels Bjørn-Andersen. Published by Samfundslitteratur.
2016	Thomas Jensen	A revelatory case study of how North's sustainability strategy enables South's sustainable development in improving communication link for East African and European trade.	Department of ITM, Copenhagen Business School.
2016	Charikleia Rapti, Stefan Henningsson, and Thomas Jensen	In Search for Divergence: A Literature Review of the Information Infrastructure Design Space.	Department of ITM, Copenhagen Business School.
2016	Stefan Henningsson, Boriana Rukanova, Yao-Hua Tan and Thomas Jensen	Architectural innovation of distributed information infrastructures.	Submitted for Journal of the Association for Information Systems (JAIS).
2017 Paper 5	Thomas Jensen, Ravi Vatrapi and Niels Bjørn-Andersen	Avocados Crossing Borders: The Problem of Runaway Objects and the Solution of a Shipping Information Pipeline for Improving International Trade.	Information Systems Journal (ISJ).
2017 Paper 2	Stefan Henningsson, Charikleia Rapti and Thomas Jensen	The Information Infrastructures Design Space: A Literature Review.	Business Informatics Research (BIR) Conference in Denmark.
2017 Paper 4	Thomas Jensen and Niels Bjoern-Andersen	Cloud Solutions for the Shipping Ecosystem pose new opportunities.	Article in book: Information systems, development approaches and qualitative research: a tribute to David Avison. Edited by Guy Fitzgerald and Julien Malaurent. Contributions by Published by ESSEC Publishing, Paris, France.

Table 8 Academic publications.

Paper 1 Information systems action research facilitates global trade
utilizing modern IT

Information Systems Action Research facilitates Global Trade utilizing Modern IT

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Abstract

This paper reports on how the Information Systems Action Research (ISAR) facilitates utilizing modern IT to jump-start actions engaging multiple organizations' collaboration across boundaries, national borders and cultures towards facilitating global trade. The supply chain domain of international trade is characterized by multiple organizations collaborating. The research becomes a neutral ground for practitioners to engage and interact with other practitioners, even with competitors. Additional Information Systems (IS) researchers contribute with competencies within IT, attracting practitioners both from private and especially public organizations. Although previous research has successfully demonstrated the possibilities of a shared data or information pipeline, it has not been adopted in practice within the supply chain for global trade. This paper demonstrates that ISAR can produce remarkable outcomes and can potentially give significant impact both on the IS research field and the world of practice, specifically in the supply chain for international trade.

Keywords: Action Research, Information Systems, International trade, Inter-organizational systems, Information infrastructures, Information Systems Action Research

1 Introduction

The containerized supply chain for international trade carried by sea is efficient due to the utilization of standardized containers [3] and specialized assets, e.g., newly developed energy efficient container vessels resulting in relatively low cost and low environmental foot print. Further, both public organizations and individual private companies seem quite efficient due to, respectively, demanding budget reduction for public organizations and the competition among private companies. In any case, there are some administrative trade barriers, that is, the documentation/ information is handled in an old fashioned way and the associated burden is not only relatively high but also costly and risky [4], since the most contentious issues and challenges are not within the individual organizations but between organizations.

The supply chain for international trade is characterized by an ecosystem where multiple organizations need to collaborate and coordinate their efforts across organizational boundaries, national borders and cultural differentia [5]. To initiate any change and improvements within this ecosystem is not easy, and even though initiatives have been supported, none has been adopted in practice, neither by private nor by public organizations. This has long been recognized and research projects have been initiated, by, for e.g., regions such as the European Union (EU) addressing these challenges and demonstrating possible solutions. Unfortunately, none of these demonstrated solutions has successfully been adopted in the ecosystem.

Information Systems Action Research (ISAR) - within the Information Systems (IS) research field - succeeds when other methods did not, thus facilitating global trade toward utilization of modern IT in the ecosystem. International trade is characterized by involving multiple organizations and is governed by different sets of rules in the countries and regions that the goods cross. Inter-organizational information systems [1] support international trade; accordingly, Inter-Organizational Systems (IOS) [1] need to operate across national borders and organizational boundaries [6, 7]. Based on Electronic Data Interchange (EDI) [2] messages, IOS have successfully been adopted by organizations collaborating [8] within international trade [9], but they cover only a fraction of the communication needed [10]. Both public institutions and private companies are calling for collective action in private-public collaboration [11, 12]. A range of research within international trade has been successful in providing guidance towards standardization and in demonstrating IT solutions supporting improved collaboration locally.

Attempts to build and implement IOS for international trade, however, have not been able to scale internationally. Numerous explanations have been offered, for example, that no consensus could be obtained due to the competitive environment among the organizations involved. The research methods used have been primarily qualitative methods combined with demonstration of possibilities. Despite the evaluations being positive, none of the organizations has picked up and initiated implementation afterwards. ISAR offers an alternative aimed at utilizing IT as a crank shaft for actions towards improvements and, accordingly, could be a more successful method.

The aim of this research is to jump-start collaboration not within one organization but among multiple organizations involved in the supply chain for international trade, initially for selected trade lanes but with the overall aim of contributing toward enabling sustainable growth by facilitating increased collaboration in global trade by utilizing modern IT in the form of shared Information Infrastructures (II) for shipping information (Author 2016 forthcoming). Previous research has successfully demonstrated the possibilities of shared data pipeline, but such data sharing has not been adopted in practice within the supply chain for global trade. This research addresses the challenge in at least three novel ways: 1) the conceptual framing is changed from IOS [1] based on EDI messages to II framing; 2) involvement of both private and public organizations in both exporting and importing countries / regions; and 3) active engagement of collaborative partners in a range of parallel and interacting projects facilitated by a team of action researchers utilizing the Action Research (AR) approach.

This paper reports on how the ISAR facilitate a shift in the IS theory used by the involved organizations from traditional IOS to II theory in three project streams has enabled increased collaboration towards bootstrapping a shared II that the involved organizations choose to support and fund. The expected business impacts are that shared II will lower trade barriers, and this lowering is estimated to increase trade boosting growth in the countries involved. Accordingly, this research contributes to the IS knowledge by providing an example of how ISAR deployment enhances public-private collaboration around an IT artifact in the setting of the supply chain for international trade.

The rest of the paper is organized as follows. First, the domain of the supply chain for international trade, its issues and challenges are introduced as background. Second, the related theories used are described to frame the research. Third, the AR and the ISAR methodologies and considerations are detailed for the three revelatory project streams, including the action

researcher's role and data collection. Fourth, the empirical results are reported and key results highlighted. Last, the interpretation of the empirical results is outlined and discussed, with reflection on theoretical considerations for IS theory, potential implications for practice and methodological implications for the ISAR, underlining study limitations and possibilities for future research.

2 International Trade

As background knowledge, the international trade domain is briefly described. International trade plays an important role in the economic growth, social welfare and human development of countries. The containerized supply chain carried by sea accounts for approximately 90% of the international trade and is characterized by involving multiple organizations that are governed by different sets of rules in the countries and regions crossed [5]. Information systems supporting international trade similarly need to operate across national borders and organizational boundaries, involving not only interactions across national borders but also communications across diverse linguistic and cultural contexts.

A multitude of research projects and results exist within international trade but only few involve information technology, since the majority of research is within politics, economics, management and administration, sociology, ethnographic, etc. Recent research has revealed and demonstrated the potential benefits for organizations involved in international trade by utilizing IOS based on EDI messages for collaboration across organizational boundaries, for example, the projects: ITAIDE⁸⁸ [13], Integrity⁸⁹, or Cassandra⁹⁰. Based on the literature review, it can be seen that research documents the significant benefits and provides guidance regarding standardizations and IT solutions, which has been successfully demonstrated.

Despite the evaluations being positive, none of the organizations has picked up and initiated implementation afterwards to improve the situation. There are various explanations offered, for example, that no consensus could be obtained due to the competitive environment among the organizations involved and that the solution was not able to scale. The research methods used were primarily qualitative methods, some possibly combined with a demonstration or some involving both practitioners and researchers. The challenge for this research is to demonstrate

⁸⁸ www.itaide.org

⁸⁹ www.integrity-supplychain.eu/

⁹⁰ www.cassandra-project.eu

how ISAR offers an alternative and more successful method in AR terms, since collaborative organizations support, engage and fund the research as a first step towards improvement in the operational level of the supply chain for international trade.

Information Technology (IT) and IS research could play an important role in addressing the above challenges related to information in the supply chain for international trade. In other words, there could potentially be a large efficiency gain by utilizing modern IT towards a more effective sharing of information and documents within the international trade supply chain. Given the lack of adoption of the solutions proposed by previous research and given the setting of multiple organizations being governed by different sets of legal rules, this research proposes taking a new route following ISAR. That said, it is clearly beyond the scope of this paper to deal with all of the critical issues in international cross border trade, and the scope of this paper shall be limited to addressing the following:.

Situated in the domain of the containerized supply chain for international trade carried by sea, this paper reports how ISAR can facilitate collaboration among multiple international organizations towards bootstrapping utilization of modern IT to enable global trade.

The approach taken to this research is to carve out and focus on selected projects structured around the modern IT involved. This calls on different related theories presented in the following section.

3 Related research

The theory related to this research is primarily regarding information exchange for collaboration and integration of operations among international organizations dealing with IOS theory and II theory.

3.1 Inter-Organizational Systems Theory

In the well-researched IOS field [1], the dominant IT artefact for efficiency gains in the supply chain for international trade is the utilization of IOS. IOS are defined as “information systems to span boundaries between countries, organizations and the relatively separate components of large, geographically dispersed corporations” [14]. IOS can bring “significant competitive advantages” [15] and serve an essential role to facilitate integration and develop unique processes across the supply chain [16]. Extant literature on the utilization of IT for collaboration across organizational boundaries and national borders is primarily focused on IOS. The extant

literature on IOS employs more than 25 theories [17] and no single theory stands out as being predominant. A majority of research regarding IOS is focused on EDI [18], and the majority of the described IOS successfully utilize EDI [8].

Within the IS the benefits of facilitating IOS [8] based on EDI are well documented for international trade [6, 7, 19], but it is also known that the cost of change regarding the IOS is relatively high [20]. The earlier mentioned recent studies sponsored by EU continue to utilize IOS based on EDI messages as their proposal for modern IT solutions. In practice, the EDI based IOS are utilized among some fragmented and national/regional parts of the supply chain for international trade, characterized primarily with high transaction volumes, for example, communication between the shipping lines, terminal operators, or port authorities [10].

Based on the literature review, it is observed that within the IOS research, the use of e-mail does not seem to have been considered a means of communication for IOS. In contrast, the empirical data analysis of the researched trade lanes for international trade reveals e-mails as being the predominant means of communication in practice (Ibid). One of the proposed modern IT solutions in the research aims to provide a more beneficial, and a less costly, solution than do EDI message based IOS and also to have a true global coverage for the end-to-end supply chain for international trade.

3.2 Information Infrastructures

IOS are also characterized as one type of II [21]. Infrastructure refers to the basic physical (and organizational) structures needed for facilitation and operation of a society and necessary for an economy to function [22]. The term typically refers to the technical structures that support a society, such as roads, bridges, water supply, sewers, electrical grids, telecommunications, and so forth, and can be defined as "the physical components of interrelated systems providing commodities and services essential to enable, sustain, or enhance societal living conditions" [23]. Infrastructures are characterized by nodes and means of connection as a basis for activities, and they are constantly evolving. As pointed out by Carr [24], infrastructures are characterized by being broadly shared and becoming part of the general business infrastructure.

Three classes of II are: universal service infrastructure, business sector infrastructure and corporate infrastructure [25]. The Internet is a prime example of universal service information infrastructure. An example of the business sector infrastructure is the industry-wide EDI messages [2] where not only does the communication have to comply to certain standards and

be facilitated by dedicated service providers but the utilization is also charged typically by a combination of a signup fee, yearly fee and a transaction fee. The corporate infrastructure is dedicated for usage by an organization (and optionally also accessed by their business partners) and will typically be guarded by firewalls and / or a virtual private network. Taking into account applications, platforms and IIs as three types of IT systems, "IIs are recursively composed of other infrastructures, platforms, applications and IT capabilities and controlled by emergent, distributed and episodic forms of control." [25]. Platforms and applications are often combined with restricted access and lock-in effects. The IOS based on EDI messages are categorized as platforms [17].

4 Methodology

AR and ISAR are introduced followed by description of the roles of the researchers and practitioners, project streams as revelatory AR studies and data collection for this research.

4.1 Action Research

AR is considered to be exceptional when compared to more traditional research methods for three major reasons: 1) it focuses on actions in the organization(s) addressing improvements regarding the issues and challenges in the domain and simultaneously zeros in on performing research; 2) it involves a set of iterative activities in a cyclical process [26] and 3) it opens to the political world of the domain. Traditional research methods, both quantitative and qualitative methods, have the objective of the research to model, measure, observe and/or reveal insights from the "real" world and possibly intend to predict something, but the researcher is detached and needs to limit the interference with the object of the study. AR is particularly relevant because the initiators' and sponsors' intentions are to create improvements for international trade. AR differs in these respects, since the researcher engages in the object of the study, namely, the organization(s), the purpose of which it may be to reach as well as to influence actions. In general terms, AR can be understood as a diverse set of strategies or family of practices in which researchers can engage collaboratively with practitioners, often in groups, to facilitate action processes that are stakeholder-focused, participatory and aim to generate outcomes that are more effective and socially fairer.

Kurt Lewin coined the term 'action research' in 1946 as "a comparative research on the conditions and effects of various forms of social action and research leading to social action"

[27]. Since then, AR has evolved into a range of approaches as process consultation [28], action science, action learning and so on. Lately AR in sociology engages multiple organizations politically aiming for democracy [29] and sustainability [30] at society level. Carrying out AR in organizations in which the researcher is part of can raise some challenges and require critical reflection of the researcher(s) [31].

4.2 Information Systems Action Research

ISAR is an umbrella term for a range of methods that have been prevalent since coined at conferences in mid 80's [32] and are well described and discussed within the IS research community. Even so, the number of publications that reference utilizing ISAR is limited in leading IS journals. This could indicate that the use of ISAR is limited or it could suggest that the leading journals tend not to publish research based on ISAR. In any case, ISAR has benefitted from exemplary cases of research contributions that are of interest to both academia and practitioners. The IS research field is generally seen to be academically founded in Business Schools; accordingly, researchers aim for outcomes that are relevant and useful for practice.

The IS research field has benefitted from ISAR publications demonstrating how researchers have made a difference to the world. ISAR is well documented and covers, according to Baskerville and Wood-Harper [33] and Davidson-et al [26], at least ten to twelve different forms: Canonical Action Research [34-36], Information Systems Prototyping [37, 38], Soft Systems [39], Action Science [40-42], Participatory Action Research [43], Participant Observation using diaries [44], Action Learning, Multiview, ETHICS, Clinical Field Work and Process Consultation, Reflective Systems Development [45]. From the late 90's to beginning 00's, ISAR has become popular and has aimed to make research relevant to practitioners [46, 47]. Since the emergence of Engaged Scholarship [48, 49] in 2007, ISAR has been associated under that umbrella. Van de Ven [50] argues that engaged scholarship is a method where researchers involve others and leverage their different perspectives to learn about a complex problem domain and that there are any ways to engaged scholarship. Engaged scholarship is an umbrella term covering both organizations and artifacts, e.g., design of an IT artifact.

Due to its roots, AR focuses on organizational change and not especially on IT artifacts. ISAR can, but does not necessarily, involve IT artifacts. The IT artifact is the focus of several research methods within the IS research field, explicitly the design of the IT artifact. Design Science

(DS) within IS is a specific method focused on IT artifacts as a unit of analysis [51]. Based on a comparative analysis of DS within IS and ISAR [52], a new method has emerged: Action Design Research (ADR). ADR focuses on build, intervention and evaluation (BIE cycle) of an IT artifact [2] that “emerges from interaction with the organizational context even when its initial design is guided by the researchers’ intent” [53]. ADR was the result of a case study within one organization [54] “published as AR with a design orientation” [53]. DS and AR share many of the same characteristics, e.g., engagement between practitioner(s) and researcher(s) to produce and evaluate an outcome for practice [55], but the unit of analysis is different, respectively, IT artifact related to a problem context and action related to organizational change in a difficult social setting.

Design Ethnography in Information Systems (DEIS) is another attempt to combine DS and AR, focusing on design of IT artifacts during fieldwork and centering on revealing “social and cultural values present in design practice” that “seeks its validity in richly detailed, ‘thick’ descriptions” [56, 57]. The temporal mode of theorizing is fundamentally different for DS including ADR and AR including DEIS: DS being nomothetic oriented towards objective scientific explanations, [56] and AR idiographic oriented towards human subjective insights [57, 58].

There are research utilizing ISAR in a network of multiple organizations in the health care sector in a number of developing countries and derive a version of AR named Network of actions, where “local action research interventions need to be conceptualized and approached as but one element in a larger network of action in order to ensure sustainability.” [59].

4.3 The roles of researchers and practitioners

The action researcher initiating this research is an industrial Ph.D. student (the author) sponsored by a private company⁹¹ and associated to two universities⁹². The industrial Ph.D. program is three years and funded by the government⁹³, the purpose is to place the researcher in both practice and research. In the private company, the industrial researcher became part of a small team of “evangelists” focusing on technology and innovation organized within the IT department

⁹¹ A large shipping company active as service provider in containerized global trade carried by container vessels at sea

⁹² Primarily, Copenhagen Business School and secondly, Technical University, Delfts

⁹³ Except for the salary which is paid by the private company

The first action of the researcher in relation to the first stream of EU funded projects was to gain support to engage practitioners from the private company to act as reviewers of a large, ongoing, EU funded research project (Cassandra mentioned earlier). The project management team of the EU funded project happily included in the review committee the practitioner (one of the evangelists) from the private company.

Second, the researcher tried to create organizational commitment to engage the private company in an upcoming large (m€ 48) EU funded research project (CORE⁹⁴). After some legal considerations, the private company became a partner (one of 70+ partners) with budget for travel, offering 50% refund of time in several of the over twenty work packages.

Third, approximately 1½ year into the project the researcher's associated primary university succeeded in joining as a partner in the research project (the secondary university was a partner from the start of the project).

Fourth, the researcher and team got their own work packages, including allocated funding. The objective was to get a large IT vendor as partner in the EU funded research project, which would enable testing of the solution developed in the third project stream on a large scale with thousands of containers. The actions in relation to the large research project are described as project stream one in the subsequent sections.

In parallel with the above project stream, other organizations were engaged, one of those being the owners of the private company, involving additional organizations which here are grouped in a second stream of projects. Initially, the evangelists supported by the researcher engaged in collaboration with a work group in a World Economic Forum resulting in a range of reports focusing on trade barriers and enabling trade. The owner organization of the private company had (and still has) a corporate sustainability strategy with the realization plan, including pilot projects that would later be able to scale; the research was the first approved pilot project provided with both support and funding (m\$ 1). Part of the pilot project was to engage with trade facilitating communities, e.g., in East Africa. This led to a number of workshops in East Africa with various public authorities and associations, and presentations at the World Trade Organization conferences, followed by both organizational and political commitments as well as substantial funding (m\$ 22) for moving forward.

Another set of activities by the researcher and the team was to build prototypes of the IT artifact which early on was named the Shipping Information Pipeline. These activities are grouped into

⁹⁴ www.core-eu.org 20151015

a third stream of projects. Initially, the existing standard solutions and applications were tried out, but unfortunately, none was found to be useful enough for the collaboration for the documentation and information related to the supply chain for international trade; instead, a prototype was built which neither performed as required (for detailed evaluation see author 2016 forthcoming). At a certain point, the team realized that additional IT capabilities were needed to realize the IT artifact with a reasonable set of features and with the possibility to scale globally.

There are limited IT vendors capable of deploying on a global scale; one was contacted to engage but without any funding in place. It was quite a struggle to gain support but later some funding (m\$ 1) was granted to build a prototype. In order to take the next step after the development of the prototype, the IT vendor required additional commitment and funding; the researcher and the IT evangelist convinced the stakeholders in the organizations participating in a project (CORE) in the first project stream to engage the IT vendor as partner in the project as solution provider with its own budget allocation.

4.4 Project streams

The grouping of parallel projects into streams is similar to case study methods, which enable the researcher to carve out a manageable part of the complex practice with multiple organizations and multiple activities and projects towards more rigorous results. The method employed is inspired by methods regarding revelatory case studies with the purpose to investigate international trade to address the research problem. The method is especially relevant to the research problem, since in international trade there are many more variables of interest than there are data points; therefore, the results of the research relies on multiple sources of evidence with data convergence. A revelatory case study [60] could potentially help to explain presumed phenomena in real-life interventions that are too complex for the survey or experimental research methods. The activities in the project streams are regarded as revelatory ISAR studies since the researcher(s) have the “opportunity to observe and analyze a phenomenon previously inaccessible to social science inquiry” [61]. The individual study is designed so that multiple actors can contribute to the empirical data. “The evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as being more robust [62]” [63]; further, the research results will be more generally applicable. Of course, this remains to be verified by subsequent empirical research.

Three ISAR studies / streams of projects were selected among a range of possibilities and are diverse in regard to geographic, organizational involvement in international trade, etc. The selected projects were regarded by the involved organizations as the most promising ones, and the organizations decided to pursue those activities / projects. Other activities / projects were disregarded mainly because they obviously were not feasible or they were acceptable by only one or few of the organizations. Explicit activities /projects that only regard within one organization have been deselected and excluded from the project streams (e.g. a strategic project involving top management within the private company and dedicated to the shipping information pipeline). Further funding to continue required the organizations to justify the funding of those activities / projects selected to move on, thereby deselecting others. Details of why some activities / projects were selected are not dealt with in this paper.

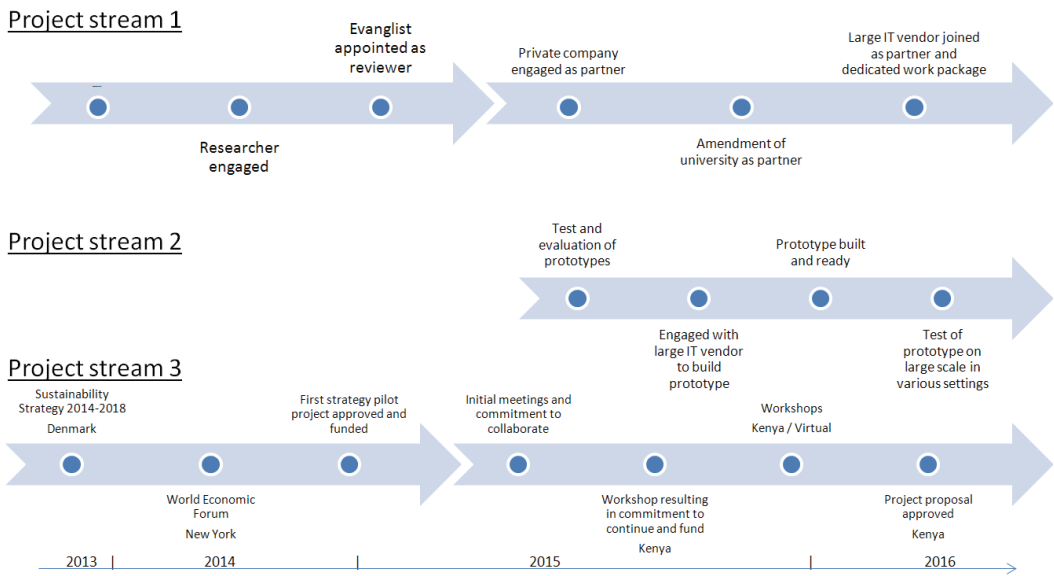


Fig. 1. Overview of selected activities related to the research grouped into streams of projects.

The three streams of projects are illustrated in figure 1 and they are different in several ways and also share some commonalities. Two of the project streams initially had a regional focus but with international ambition, respectively, EU and East African Community; the third project initially had a global focus. In all three projects, the technology evangelists are prime drivers, respectively, from a large IT vendor, a university and a non-profit organization. Two of the projects depend on external funding other than from the driving organization, whereas one has

internal funding. None of the driving organizations is directly involved in the business of international trade, which they expect will benefit. In all three project streams, the driving organization has realized that involvement of other organizations is critical for success.

The three project streams each uniquely named the IT artifact⁹⁵ they were pursuing, even though they started with the same set of conceptual ideas. A few driving organizations who were directly involved in international trade were behind the concept, but for various reasons, they did not see themselves as driving the development of the IT artifact.

4.5 Data collection

The data for the activities in the three project streams in this paper were collected over a period of three years by actions such as driving, facilitating and engaging in meetings, workshops and conferences in close collaboration with key representatives and insiders at the organizations related to the individual project stream. The activities included preparation, communication, agenda building, documentation, reports, follow up communication, etc. Additionally selected key stakeholders were interviewed, e.g., the initiators of most of the projects / activities in project stream one.

The major events relevant for the ISAR within the three project streams are listed in the appendix. The analysis has been performed in a discourse with the involved representatives and stakeholders from the multiple organizations where the researchers understanding has been validated or modified in the context. For example the researcher drove the formulation and writing of the new project proposal regarding the large scale pilot testing and gathered written support from the major stakeholders e.g. EU TAXUD, EU MOVE, US DHS/CBP, the large IT vendor, the private company, the various authorities, etc.. Additionally at several occasions the ideas, material etc. have been taken over by other representatives as their opinion (with or without reference). For example a representative takes ownership and presents the idea of II theory to another project/activity setting. Another example is that a manager presents the concept, idea, theory and solution to a management meeting to gain support for it and possible funding. In this way the project moves on without direct involvement of the researcher and this is taken as a validation of the research that other stakeholders take it on.

⁹⁵ Data pipeline, Shipping Information Pipeline (SIP), Supply Chain Visibility Platform (SVP) and Transport Logistic Information Pipeline (TLIP)

5 Project streams and results

The activities in the project streams all focus on improving international trade by utilization of modern IT for enhanced collaboration by sharing information. The history of the idea came from two official EU delegates from The Netherlands and United Kingdom customs visiting China (according to the interview of Heijman from Dutch Customs in 2006). The idea to get data directly from the source and to share data via an electronic data pipeline [64] caught on in the EU, and research funds were made available for a range of research projects. The latest of the EU research project (CORE) was part of the first project stream. Representatives from the private company through this researcher got engaged in the latest EU research project and became interested in the idea of an IT artefact to facilitate global trade, and thus initiated activities for the two other project streams.

The researchers and the representatives from the private company are knowledgeable in IT, and the basic technology idea is to use modern IT for a solution based on the Internet as a common shared II where information remains at the source and only a link to the information is shared. For the activities in each of the project streams, the driving organization's willingness to engage, commit and invest both time and money is taken as positive evaluation. Other activities and projects have been discontinued⁹⁶. Selected activities are grouped into three project streams described below: 1) The European Union research projects regarding international trade, 2) Large global IT vendor prototyping a new concept for a possible IT solution and 3) Trade facilitation in East Africa.

5.1 Project stream 1: The European Union (EU) research project

EU has the intention to increase supply chain security for international trade. It is EU's most ambitious research projects in international trade aim to deliver solutions for practice. The latest research project CORE regarding international trade has more than seventy organizations as partners, and the ambition is within four years to reach solutions that will be adopted by practices, resulting in increased security in international trade. The authorities' risk assessments are mainly based on information about the shipment, the goods and the shipper, accordingly, receiving qualitative information and information systems becomes critical in the authorities' risk assessments.

⁹⁶ The private company in the period changed strategy to reduce cost by approx.10 %

Several proposed solutions are being developed in different work packages, one of which is the solution outcome of this research. The partners' work packages include not only representatives from the shippers' association, the carrier and the EU authorities directly involved in international trade, but also several IT vendors and consulting companies. The project is co-led by two consulting companies. The partners in the work packages meet in various constellations at workshops and conferences approximately one to three times per year. A number of reports and demonstrations are promised as deliverables within the four year period. The demonstrations typically include three stages: set up design of the IT artefact, demonstration of practice use case for a specific trade lane, and intelligent dashboards for reporting.

The researcher and IT representatives from the private company have successfully introduced utilization of modern IT based on II theory as one of the solutions to be demonstrated, thereby challenging the initial design of the work packages that were built on IOS based on EDI messages. The IOS based on EDI messages is costly especially the investment and change cost and is only used by few of the organizations in global trade and only for a minor part of the total communication. The idea to use a shared II for shipping information is inspired by the principles of the Internet. As an example in one work package, the initial solution consists of a connectivity infrastructure and two dashboards for Dutch customs and for businesses which are private companies as shipper, freight forwarder and consulting firms. The dashboard for customs is the most developed of the two dashboards and is integrated directly to the customs' information systems. The leading partners of the work package have engaged with IT competent researchers and consultants who are working with the IT vendors toward the design of the IT artefact (the data pipeline). The initial design for the connectivity is utilizing EDI based IOS where data are interchanged based on standardized formats for the data.

The prototype by the large IT vendor utilizes a new approach towards IOS based on only exchange of events and leaving the information at the source. The researcher and the IT representatives from the private company first proposed a new concept based on II theory which were adopted by other researchers and promoted in other work packages. Later the possibility to utilize the prototype developed by a large IT vendor was introduced, which is described in the second project stream and which was adopted by the project management to form a new dedicated work package. This new approach differs from the traditional IOS utilizing modern IT principles, where the detailed data / information is not exchanged, but instead, a link (URL) to the detailed information is provided similar to the Internet.

5.2 Project stream 2: Large IT vendor prototyping a new concept for a possible IT solution

The large global IT vendor was convinced to adopt the new concept for enabling supply chain visibility with the aim to ease collaboration in global trade. The large IT vendor had earlier in one of the above-mentioned research projects (ITAIDE) developed a solution for demonstration purposes in 2006-2008 (based on IOS theory). The researcher and the IT evangelist from the private company promoted the new concept towards the large IT vendor who was already a main supplier of IT services to the private company, but the prototype was not part of their agreement. The IT evangelist from the private company organized a number of workshops and meetings involving 20-30 people, including the architects behind the previously developed solution; the outcome was a decision to continue the collaboration towards a prototype and to be engaged with the head of a centre of excellence from the large IT vendor. The architecture of the prototype was developed over a series of workshops. After “dancing” around the funding for nearly a year for the development of the first prototype, a team of IT and logistics evangelists succeeded in raising internal venture capital funding the new prototype. It was developed by the large IT vendor in 2014, based on the new concept of II and in close collaboration with the researcher and IT representatives from the private company.

The large IT vendor is present globally and many of its clients are public authorities but also large private companies. The architects and developers behind the prototype are part of the centre of excellence within international trade and have extensive experience from many of the large IT vendor’s clients’ projects around the globe. Several of the large IT vendors’ clients are interested in trying out the prototype.

The solution prototype is named Supply Chain Visibility Platform and is being “sold” to potential clients. The solution basically exchanges information about supply chain events and offers document storages to the clients. The solution complies with a range of standards and is built on an open source code.

5.3 Project stream 3: Trade facilitation in East Africa

In East Africa trade facilitation is important and one of the main drivers in facilitation of trade is the newly developed information systems for authorities’ administration and, as the next step, information sharing among the information systems becomes important.

As described earlier, the owner of the private company decided to sponsor a first pilot project utilizing the IT artifact based on II theory; they then formed a project team, including

representatives from the owner organization and the private company plus the researcher; additionally, a local representative was hired in East Africa. The representatives engaged a NGO for trade facilitation in East Africa TradeMark East Africa (TMEA) to drive a project for the development and implementation of a shared II which they named Transport Logistic Information Pipeline (TLIP). In spring 2014, the researcher, evangelists from the NGO and the above mentioned representatives held a workshop followed by a range of meetings to exchange information towards forming a project.

A workshop was held in April 2015 with more than 60 representatives among others from the major public authorities involved in international trade in the countries in East Africa Community (EAC). A consensus was reached towards pursuing the TLIP and three working groups were set up on: Legal and Policy Environment, Technological and ICT Environment, Administrative and Management/Business Environment, and Research and Development. Based on this, a project proposal was brought forward to EAC and approved to fund the development of the TLIP. The TLIP both facilitates trade information within the EAC and for international trade Initially, evangelists from the NGO in close collaboration with the researcher and the local representative developed a handbook and presentations on the TLIP for communication purposes, e.g., used at World Trade Organization's conferences towards forming a global alliance for trade facilitation⁹⁷ that intends to adopt and promote utilizing shared II for shipping information.

5.4 Similarities and differences among the project streams

In all three project streams the intention to provide solutions for the issues and challenges had been publicized for years without getting solutions adopted successfully in practice. Utilizing ISAR, a mixed team of researchers and practitioners developed and promoted a new concept for sharing information for international shipping, which for all three has been adopted by the driving forces within the related projects.

In the first project stream, the initial research and the preceding projects followed qualitative methods – specifically, the living lab method –the method has been rather successful both for researchers (since they published quite a number of books, papers and articles) and for the practitioners. The private contributors in the research project were subsidized for their

⁹⁷ <http://www.tradefacilitation.org/>

development of new solutions and the public contributors in the research project showed action towards improving the situation. In any case, the outcome of the research projects was not adopted by practitioners afterwards, which is considered to be the ultimate success criteria by the sponsors and initiators (EU). For all the project streams, the initial concept and belief of the IT people involved were based on the successful IOS theory with EDI messages.

Following ISAR, the researchers and the evangelists of the private company were successful in all three project streams to initiate and convey the basic idea of utilizing modern IT based on II theory to share information for international trade. In the initial research projects researchers and practitioners could meet (e.g., meetings, workshops and conferences several times per year) but perform their work in their own office location. In the three project streams applying ISAR, the researchers and the evangelists worked closely together, e.g., they were located in the same office and engaged jointly in for meetings (in average several per week) and workshops (in average several per month), etc. involving quite some travelling, which can be characterized as working in a team.

In all project streams, the team of the researchers and the evangelists initiated the collaboration (e.g., called for meetings / workshops etc., and engaged other technology evangelist(s) from the driving organization to take the lead), so they could be characterized as having a kind of incubator, facilitator or advisory role, which is very different from the traditional roles e.g. as customer and vendor and manager which the researcher and practitioner used in the initial research projects.

The driving organizations in all three project streams had very skilled IT competencies engaged as IT evangelists - in contrast to the previous research projects where the practitioners (e.g., customs, specified the requirements without great IT competencies) were supported by researchers and IT vendors that contributed with detailed IT competencies (and their associated solutions). In all three project streams the starting point was, and still is, to use modern IT to create an "Internet for shipping information" for improving the international trade, thereby taking a technology perspective and keeping possibilities open rather than deterring from a user' requirements perspective and trying to match IT possibilities, which can be characterized towards a more agile and modern evolutionary approach rather than the traditional waterfall project approaches. For the initial industrial researcher, the funding was granted upfront, but for the three project streams the funding was not given but became part of the challenge for the

team of the researcher(s) and the evangelist(s) to raise funding for the continuation of the research activities/project(s).

The project streams differ in regard to the driving organization and their motives. The main driving organization is respectively: an EU funded ecosystem of consultants, research groups of the universities, authorities, etc., primarily based in The Netherlands and United Kingdom; the large IT vendor; and the NGO; all of whom clearly have very different motives. Geographically, they differ: the eco system is country based (The Netherlands and United Kingdom); the NGO is region based (East Africa); and the IT vendor and the private company are global organizations. In the initial research projects, the driving organization was one of the operational organizations in the supply chain for international trade, (e.g., Dutch customs, a freight forwarder, a terminal operator, etc.), having an obvious tendency to ensure own interests. This is in contrast to the three project streams where none of the leading organizations are directly involved in the operation of the supply chain for international trade (except for the private company – which is very aware of balancing own and the overall interests). They can thus be more of a neutral partner accepted by most of the practitioners, not having to consider own interests in the operations.

In summary, the framing of the actions and initiatives as research project is welcomed and prioritized by participants primarily for three reasons:

1. they are struggling with some challenges addressed by the projects,
2. the research project becomes a neutral ground with legalized reasons for meeting with others,
3. participants have access to knowledge from experts, for example, in trade, security and IT, (specifically the relatively new II theory).

The research element in the above project streams demands that the researcher(s) contribute both with knowledge (e.g., new IT trends) and facilitate the engagement. Participants deciding to continue their engagement and showing commitment to taking the next steps in the project can be considered as successful control measures for the activities/projects. Finally, the proof will be when: 1) practice adopts and uses the new IT artifact based on II theory, complementing the existing IOS theory solutions with EDI messages and 2) an indication is given as to the outcome of the large scale pilot test package, merging project streams one, two and later three.

6 Discussion

In the following is first discussed how ISAR contributes to the research differently than other previously used research methods in the international trade domain. Second, new insights relevant for IOS theory and II theory are offered. Last, is showed how ISAR supports collaboration in a multiple international, organizational setting and discuss what makes ISAR useful in this research.

6.1 Comparing previously used methods and ISAR

Previous research projects have successfully used research methods other than ISAR, but have failed to deliver - as the initiators / sponsors expected - a change in practice (adoption of the proposed solutions). Prior to project stream one - in the last decade - EU has funded a range of rather large research projects, e.g., ITAIDE, Contain⁹⁸, Integrity, Cassandra, Smart CM⁹⁹ and iCargo¹⁰⁰, focusing primarily on national or regional part of international trade, including successful evaluation, and demonstrating several proposed solutions using the living lab method [65]. Noteworthy is that the predecessor's research projects (e.g., ITAIDE) in project stream two are included in the above. The mentioned research projects have delivered the promised deliveries by demonstrating possible solutions, e.g., for a few containers, and can therefore, from the EU project officer's point of view, be regarded as being successful, even though none of the solutions has been adopted in practice and developed further than for the demonstration (as mentioned earlier, this is considered to be the ultimate success criteria by the initiators of the research being EU DG TAXUD and EU DG MOVE). One explanation is that when EU sponsors research it means that the organizational set up for research projects is given, thereby separating the initiator and the project management roles, and thus the initiators are at arm's length distance from the research projects.

The purpose of the Living Lab method is to demonstrate possibilities for addressing the issues and challenges in the ecosystem of global trade, specific to the individual research projects. The AR aim is to create a change in the ecosystem. Use of Living Lab can be regarded as a first step in motivating organizations to initiate change. This, unfortunately, has not been the result of any of the demonstrations in the earlier mentioned EU funded projects. If Living Labs is

⁹⁸ www.containproject.eu

⁹⁹ <http://www.smart-cm.eu/>

¹⁰⁰ www.i-cargo.eu

regarded as the initial step in an AR project, accordingly, the relevance criteria of the Living Lab becomes its usefulness in a change project. The initiators / sponsors of the living lab research projects aim at jump-starting a change or an improvement in practice, and, in this regard, the living lab project demonstrators failed for various reasons, the most important of which are that the purpose of the Living Labs method is limited to demonstrations only and is not concerned about the next step in an improvement project.

Utilizing ISAR can help practitioners progress with their challenging tasks of producing ‘impossible’ outcomes (impossible for the individual organization to reach). Based on the progress and engagement of the organizations in the three project streams (including their willingness to fund), ISAR seems to be successful in enabling both practitioners’ progress with their challenging tasks by surviving and gaining support for continuing collaboration in the multiple organizational settings towards ‘impossible’ change in practice. This has been demonstrated for hundreds of containers, thus enabling researchers to produce new knowledge. ISAR differs from previous research projects in at least three ways:

- 1) the conceptual framing is changed from IOS theory (based on EDI messages) to II theory;
- 2) multiple private and public organizations are engaged from both the exporting and importing countries / regions; and
- 3) the action orientation and engagement of the representatives from the various organizations.

The three project streams in multi-organizational settings in international trade demonstrate that by utilizing ISAR, researchers and practitioners can produce outcomes adopted in practice, which have not been reached thus far by utilizing the more traditional quantitative and qualitative methods. ISAR kicks in and outperforms the more traditional research methods in this complex multi-organizational setting in international trade. The outcomes of the research can potentially significantly impact both the IS research field and the world of practice.

6.2 ISAR research contribution to IOS and II

The research from the three project streams have generated new insights into a new concept for IOS and into bootstrapping II in a multiple organizational setting, potentially having significant impact both in the IS research field and global trade.

The IS theoretical frame work has been (and to some extent still is) IOS based on EDI messages in the three project streams. II have been introduced as a competing theory and has gained momentum among some of the organizations, e.g., public authorities, universities (e.g., a senior

researcher used it and started to promote II theory in other work packages) and a few IT suppliers (e.g., a product development manager at another leading IT vendor with more than 35,000 connecting organizations globally), providing solutions specific to trade based on IOS with EDI messages. The senior researcher started developing complementary II based solutions involved in the CORE research project, and the project management and sponsors agreed to change the budget allocations to establish a separate work package to demonstrate the II theory based possibilities working even on a large scale with thousands of containers shipped.

In the second project stream, the large IT vendor had several years previously delivered a prototype in one of the previously mentioned research projects (ITAIDE) based on IOS theory with EDI messages. The researcher and the IT evangelist from the private company succeeded in convincing IT evangelists at the large IT vendor to use II theory and further to build a prototype from scratch, and, in the end, the IT vendor funded the development of the prototype. Note: the industrial researcher had insight into both IT / IS and the domain of global trade, and teamed up with IT skilled evangelist(s) when trying to pursue the organizational representatives and their IT competencies to change their theory in use from IOS (based on EDI messages) toward being open for II theory.

IOS based on EDI messages have been rather successful [8] also in international trade [6, 7, 9, 19], but as revealed for the researched supply chain for international trade, IOS based on EDI messages are only used in practice between organizations with large transaction volume, e.g., between shipping lines and authorities. The organizations in the supply chain for international trade in practice use a range of communication channels, with e-mail being the most predominant. It is noteworthy that the successful IOS based on EDI were developed in the 80's and since the Internet provided easy e-mail communication, this might be an explanation of why IOS based on EDI messages have not evolved but are being "out competed" by e-mails. The previous research projects in all three project streams have struggled to be adopted in practice, even those successful in developing solutions based on IOS. There seems to be a need for reinventing IOS with solutions that can compete with e-mail communication (Author 2016 forthcoming).

II raise challenges other than information systems, and, accordingly, the traditional IS research (which tends to focus on one organization and/or one information system) cannot be used directly, calling for IS research specifically on II [66]. The reason is that the nature of II is very different from that of information systems, since an information system is normally controlled

and governed by one organization. The same is true for platforms where II involve many organizations that need to align to a common governance and control. Similarly, the funding of information systems is normally based on one organization.

For II, the organization developing, using and operating it are normally different from the funding organization, e.g., when venture capitalists or a government fund the development of an idea / infrastructure. The funding of II is a challenge, as described for all three project streams, where funding originated from various sources (e.g., EU, , EAC, venture capital fund) on top of the organizations investing time and money. The business model behind the governance of II tends to become a barrier for the generative ability. To lower the entrance barriers, it is proposed that the entrance to an II has to be affordable, preferably even free for at least an initial use¹⁰¹. For the shared II for shipping information collaboration in global trade to materialize as IT artifacts, a multiple organization effort is needed to co-create value. Value co-creation is a current discourse in both the organizational science and IS research communities, to which this research potentially could contribute.

An additional insight gained is that in order to be accepted and for practitioners to move forward, the questions about the business model and governance have been kept “floating” and decisions postponed. At the same time, the basic design principles of the shared II are evolving, e.g., the principle that only supply chain events with URL are shared and that detailed information as documents are kept in the control of the source at any server and governance they prefer (Author 2016 forthcoming).

6.3 ISAR in a multiple organizational setting

ISAR enabled the researchers and evangelists in the multi international organizational setting (in the selected supply chain trade lanes for global trade) to provoke actions that drove the research forward, which is very different from more traditional IS research that normally focuses on one organization. In the multiple organizational setting, given the supply chain for international trade, there is not one organization in charge / in control; ISAR could enable the collaboration, including between public and private organizations, and engage organizations to take a leading role, e.g., to raise funding.

¹⁰¹ The Freemium pricing model is an example where the initial sign up and use is free, but additional services are applicable to fees.

The researchers kept the long term potential impacts as a guiding star, to which all the organizations could agree, aim for, and [argued internally] benefit from, since an increase in world trade is estimated to impact the national economy and the wealth of the societies involved [67]. ISAR guided the collaboration not only between practitioners but also between researchers and practitioners; further, it ensured that the results, insights, reflections and learning were documented scientifically. Possibly most importantly, the method provided a neutral ground under the ‘research umbrella’ for the various stakeholders to meet and engage without commitment.

The possible outcome for practices of each activity and project in the project streams could be phrased as either accepting or rejecting the action, collaboration or innovation proposed. In most cases, there seems to be a consensus decision towards continuing with activities and collaboration in the search for an even better innovation to improve the current situation. Thus far, the organizations involved in all three project streams have agreed to commit by continuing to invest in the projects that give them successful AR-actions. Other activities did not get support and collaboration was discontinued.

The earlier mentioned implications and outcomes of ISAR in the three project streams are remarkable in several ways. The practitioners find the research relevant for their practices and the impacts are multi organizational and significant, both for the individual organization and at society level. Accordingly, for researchers within the IS research field, the adoption and use of ISAR can lead to extraordinary publications, compared to more traditional publications. The researchers can bring newest knowledge on detailed topics to practitioners, which they often lack, since their main theoretical knowledge often dates back years; meanwhile, new paradigms and new trends have emerged.

The practitioners often have challenges that are outside their comfort zone, but through the collaboration with skilled and knowledgeable researchers they can find solutions to address their problems. The practitioners bring deep insights from experience of practice, including its challenges, which the researchers alone would never be able to get. The collaboration might involve practitioners from organizations that normally do not collaborate, and the research offers a neutral zone for the practitioners to engage with practitioners even from competing organizations. Collaboration of a diverse and competent group with members representing different perspectives provides the foundation for great and unforeseen outcomes to address the challenges in practice. This is especially true within the information technology area where new

opportunities rapidly raise and a more faceted discussion can be fruitful for both practitioners, researchers and for the solutions. In the domain of international trade, the potential impact for the organizations involved can be significant and even have an impact on society and the national economy.

In the described research project streams, the researchers used ISAR to facilitate collaboration among multiple organizations, and three characteristics are highlighted that supported the engagement of the organizations and facilitated collaboration among them:

- 1) The research formed a neutral ground / setting for the collaborative partners to engage and meet with other organizations, despite the nature of the relationships involving either authorities and private operators - with their legally given relations or competitive private organizations.
- 2) The research became an occasion and was legitimized to be an acceptable reason for the collaborative partners to engage, even though the business case may not have been clear or positive for the individual organization, but they all saw long term potential benefits.
- 3) The research team provided IT insights and capabilities, especially pointing in the direction of utilizing modern IT, specifically II to complement the existing IOS based on EDI messages, and, e.g., the e-mail based communication by providing a shared information infrastructure for the operational collaboration among the multiple organizations involved in the supply chain for international trade (starting with specific selected trade lanes).

7 Conclusion

This ISAR research provides evidence of how researchers as engaged scholars through collaboration with practitioners can reach outcomes which they would otherwise never have obtained by facilitation of collaboration across boundaries, national borders and cultures in the multi organizational and competitive setting of international trade towards facilitating global trade. ISAR has guided the collaboration between researchers and practitioners and facilitated a shift in the organizational representative's IS theory from IOS (EDI message based) towards II theory, accordingly they engage, support and commit to continue involvement in the research and development of a shared II for international trade.

This paper demonstrates that ISAR can produce remarkable outcomes and potentially make a significant impact on both the IS research field and the world of practice, particularly in the supply chain for international trade with a complex interaction between multiple organizations.

The linkage between local and global actions is indeed needed in order for the shared II for global trade to become sustainable, including the alignment between developed and developing regions (Author 2016 forthcoming). The three project streams can be characterized as open ended, evolving and ‘floating’ [68] rather than as being structured networks and processes. The three project streams continue towards the next phase with test of the realized solution on a large scale based on thousands of containers shipped between continents. The impacts are that shared II will lower trade barriers estimated to increase trade boosting growth in the countries involved. Additional project streams for additional trade lanes are planned to be started. Hopefully this research will inspire more researchers to use ISAR and that practitioners will request more use of ISAR.

7.1 Limitations

Regarding the theoretical contributions, this paper attempts to convey a description and discussion of part of the research in the project streams; other participants, especially practitioners, might provide different versions. Regarding rigor, the results are based on activities/projects in three project streams that focus only the selected supply chain trade lanes for global trade, which is rather limited.

Research utilizing other research methods would not reveal similar insights and depth of learning; further, it probably would not have been possible to engage both practitioners to participate at all (e.g., to fill in a survey). This calls for additional research based on ISAR to be conducted to verify (or reject) the theoretical contributions and / or to extend them.

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Appendix: Major action research events

	Action	Where	Participants	Outcome
Spring 2013	Hired Industrial Ph.D. student from summer 2013	The private company	The IT evangelist, professors at two universities	Action research grounded in practice of global trade
Fall 2013	Reviewer of EU funded research project Cassandra	Belgium	IT evangelist from private company	Become official reviewer
Ultimo 2013	Sustainability Strategy 2014-2018 ¹⁰²	Denmark	Top management of owner organization of the private company	Approved and published
Spring 2014	EU funded research project CORE	Holland and UK	The researcher and the IT evangelist in the private company	The private company partner in project
Spring 2014	Initial meetings	Kenya	Trade Facilitation organization in South and the private company	Agreement to collaborate
Spring 2014	Initial meeting	Denmark	The owner organization of the private company, ICC, WEF, USAID	Agreed on agenda
Summer 2014	Pilot project proposed as first project within the Sustainability Strategy ¹⁰³	Denmark	Top management of owner organization of the private company	Approved with funding
Summer 2014	Design	Denmark	Researcher and IT evangelists of the private company	“Shipping Information Pipeline” design concept
Fall 2014	Prototype development	Denmark	Researcher and IT students	Prototypes of “Shipping Information Pipeline”
Fall 2014	II theory concept presented at CORE workshops		Researcher associated with the action researcher and the IT evangelist in the private company	Shift in IS theory towards II
Winter 2014	Evaluation of prototypes	Denmark and Holland	Researcher and logistic evangelist of shipper	Evaluation of prototypes and adjustment of design properties
Winter 2014 / 2015	Workshops	Denmark and Holland plus virtual	Researcher, IT evangelist and representatives from the private company and representatives	Shift from EDI based IOS towards II as design properties for a shared shipping information pipeline

¹⁰² <http://www.maersk.com/sustainabilitys>

¹⁰³ Project proposal for Sustainability Council Reducing trade barriers in East Africa

	Action	Where	Participants	Outcome
			from the large IT vendor	for the supply chain for international trade
Spring 2015	Internal venture capital fund	Large IT vendor	Head of centre of excellence	Funding of prototype
Spring 2015	Initial Workshop	Kenya	Representatives from EAC and researcher	Support for the initiative “Trade Logistic Information Pipeline “
Spring 2015	Development of solution based on II theory	Holland and Egypt	IT architects and software developers	Prototype “Supply Chain Visibility Platform”
Summer 2015	Initial workshop	Denmark	Researchers, evangelists from the private company, the large IT vendor, Dutch and US customs	Support and plan for large scale pilot research project
Fall 2015	Workshop	Kenya / virtual	Representative from EAC and from EU authorities	Support for the initiative
June / July, October and December 2015	Conferences	Switzerland and Kenya	World Trade Organization	Establishing of a task group. Public pre-launch Establishing Global Alliance for Trade Facilitation ¹⁰⁴
Spring 2016	Project approval for funding	Kenya	Tax revenue authorities in the five EAC countries and Trade Facilitation organization in South	Support by EAC’s tax revenue authorities with funding from TMEA
Spring 2016	Live demonstration	Trade lanes: US – EU and EAC - EU	Researcher, representative from the private company and the large IT Vendor	Demonstration
Spring 2016	Separate work package in the CORE project	Belgium	Project Officer (EU)	Dedicated project
Summer 2016	Large scale pilot project	Trade lanes: US – EU and EAC - EU	A dedicated team lead by the researcher, the IT evangelists from the private company and the large IT vendor	Scale

Table 1: Selected major events related to the research out of the many events. The events are documented in various means, e.g., minutes of meetings, handbook, articles, websites, blogs, and film.

¹⁰⁴ <http://www.tradefacilitation.org/>

Paper 2 The information infrastructures design space: A literature review

The Information Infrastructures Design Space: A Literature Review

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Abstract. This paper develops a framework for characterising the design space of Information Infrastructures (IIs). Existing research has generally sought to unravel the convergent characteristics and mechanisms uniting IIs across a wide range of manifestations. In this research, we explore this divergence within the II design space. We do so by reviewing the II literature, focusing on the two domains of design situation and design resolution. Design situation refers to the relevant dimensions of the context in which an II is employed. Design resolution covers the dimensions along which the socio-technical constituents can be assembled to form an effective solution. The resulting framework allows for the comparing and contrasting of II initiatives, and contributes towards a cumulative knowledge process aimed at a more refined understanding of how an II can be configured to address the specific problem at hand.

Keywords: Information infrastructures · Digital infrastructures · II design space · Literature review

1 Introduction

Information infrastructures (IIs) or digital infrastructures [1–3] are today present in areas as disparate as health care, payments and law enforcement. Paralleling the growth in practical manifestations, IIs have received increasing attention in the academic literature. Here it is argued that II needs to be conceptualised as a specific class of IT artefacts, characterised by the number and heterogeneity of the interconnected socio-technical components, which are typically co-managed by a wide range of diverse organisational entities [1, 3].

However, previous literature on II is limited in that research has generally searched for the *convergent* themes and the ‘essence’ of the II artefact [4]. Implicitly or explicitly, research has theorised about IIs based on an assumption of IIs as a homogenous group of artefacts. In strong contrast, a comparison of practical manifestations also shows important differences the artefacts denoted as II. The II concept covers a wide range of adopters such as regional bank networks, national health authorities and global research initiatives, among others. IIs can also differ in scales of implementation, as well as various levels of the maturity and heterogeneity of the constituent IT components. A comparison of the internet with a national patient registry shows important differences in the problem situations that warrant different configurations of effective II resolutions.

The existence of variety in the II artefact is frequently recognised in passing. For example, Tilson et al. [2] suggest that IIs should be defined with respect to the entity being supported or enabled as global, national, regional, industry, or corporate infrastructures. Similarly, Henningsson and Zinner-Henriksen [5] as well as Constantinides and Barrett [6] explicitly recognise that their theoretical contributions pertain to IIs with collaborative governance structures. *Divergence* has, however, never moved to the forefront of II theorisation. Therefore, the objective of this paper is to unfold the divergence in the class of IT artefact commonly referred to as II and to develop a conceptualisation of II that encompasses the variety that exists within this artefact class.

To do so, we undertake a developmental review [7] of the II literature with the focus on construct divergence. Specifically, we focus on divergence within the two domains of *design situation* and *design resolution*. Design situation refers to the relevant dimensions of the context in which an II can be employed. The domain of design resolution covers the dimensions along which an II can be configured to be effective in a given situation. The II design space then refers to the combined possibility of matching both situation and resolution dimensions.

Under the assumption that there is no single best way to configure an II, but that the many possibilities to configure an II must be adapted to the problem situation at hand, the framework developed here allows researcher and practitioners to understand and define the specificity of a given II manifestation. In this capacity, the framework allows for cumulative knowledge-building about divergence in II challenges as well as the articulation of forward-looking agendas covering the development of granular II approaches tailored to subsets of artefacts.

2 Research Design and Method

The study design of this review rests on a view of II management based on contingency theory. Contingency theory [8–10] argues that there is no best way to organise a corporation, to lead a company, or to make decisions. Instead, the optimal course of action is contingent (dependent) upon the situation at hand.

A contingency view of II entails a fundamental assumption that there is no single best way to assemble the socio-technical II artefact. Instead, the way in which the II should be assembled in order to be effective is contingent on the problem it is intended to address. As argued in the introduction, the contingent course of II assemblage has largely been overlooked in the literature that has searched to establish the distinctiveness of the II artefact compared to traditional IS.

Following a contingency view of II, the literature review presented in this paper is conceptualised as a review of the relevant dimensions in two domains: *design situation* and *design resolution* (Fig. 1). In the review of the design situation we aim to unearth the findings of previous research in terms of relevant characteristics to consider when shaping an II, including, for example, the number of actors and the geographical dispersion. In reviewing the design resolution, we aim to capture the findings of previous literature in terms of relevant alternatives to configuring the socio-technical components of the II.

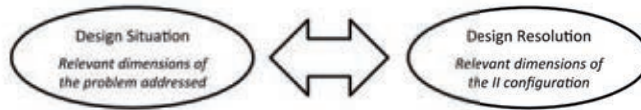


Fig. 1. Research design: the II design space

Article search took place in two supplementary phases. The first articles search included a keyword search within the leading IS journals, often referred to as “the basket of eight”. The keyword-driven search provided a collection of twenty articles from seven sources. The keyword search was supplemented with backward (scanning of references) and forward (examination of citations) searches in order to identify further high impact research material [11]. Within this search, only articles with more than 35 citations in subsequent publications were also subject to review. The backward search rendered 10 more articles and the forward search identified two additional articles of relevance. In total, 32 articles were included in the final sample (see the table of results in Sect. 3).

The analysis involved a parallel mapping of the features of the situation and resolution of an II described by the authors. This process led to the identification of 43 variables within the areas of situation and resolution. Following a consistent method of comparison, the variables were specified by uniting overlapping features. The result of this process was the creation of a concept matrix representing which concepts are examined in each of the reviewed articles [11].

3 Review Results: The II Design Space

The dimensions of the II design space are graphically depicted in Fig. 2. Table 1 maps the dimensions to the reviewed literature. Since IIs are socio-technical constructs, the relevant dimensions span both social and technical aspects in both design situation and design resolution.

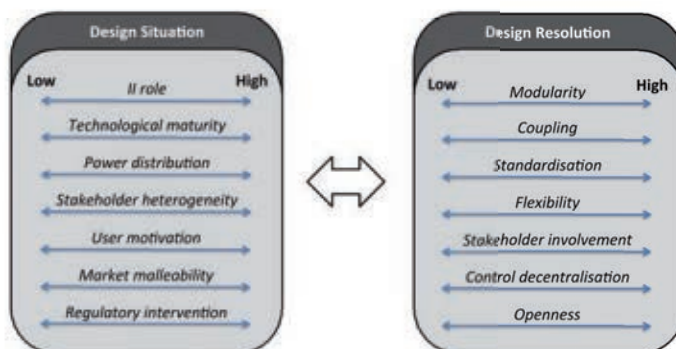


Fig. 2. The II design space

Table 1. Results

Variable / source	Aamstad and Jensen, 2009	Angelides and Agius, 2000	Ardagna and Francalanci, 2005	Bietz et al., 2010	Broadbent and Weill, 1997	Chung et al. 2003	Ciborra, 2000	Constantinides and Barrett, 2014	Damsgaard and Lyytinen, 1998	Edwards et al., 2007	Garfield and Watson, 1998	Grisot et al., 2014	Hanseth, 2000	Hanseth et al., 1996	Hanseth and Lyytinen, 2010	Henfridsson and Bygstad, 2013	Henningsson and Henriksen, 2011	Hsu et al., 2015	Iannacci, 2010	Monteiro, 1998	Monteiro and Hanseth, 1997	Nielsen and Aamstad, 2009	Pollock and Williams, 2010	Reimers et al., 2004	Reimers et al., 2014	Ribes and Finholt, 2009	Rodon and Silva, 2015	Sahay et al., 2009	Sanner et al., 2014	Star and Ruhleder, 1996	Tilson et al., 2010	Vaast and Walsham, 2009	
Design Situation																																	
<i>II role</i>					x		x								x																		
<i>Technological maturity</i>																		x						x	x								
<i>Power distribution</i>																										x							
<i>Stakeholder heterogeneity</i>					x	x	x	x		x	x			x				x				x		x							x	x	
<i>User motivation</i>																																	
<i>Market malleability</i>																										x	x						
<i>Regulatory intervention</i>		x									x	x						x	x						x	x						x	
Design Resolution																																	
<i>Modularity</i>				x	x		x				x				x	x											x		x				
<i>Coupling</i>					x						x						x											x		x			x
<i>Standardisation</i>								x	x		x			x	x			x				x											
<i>Flexibility</i>	x					x	x	x	x		x		x	x	x		x			x					x				x	x		x	x
<i>Stakeholder involvement</i>	x							x	x				x			x																x	x
<i>Control decentralisation</i>										x	x						x																x
<i>Openness</i>								x	x																								

3.1 Situation Domain

The situation domain describes the context in which the II is built. Literature discusses a variety of dimensions in this sense, as well as their possible effects on the design and development of an II.

II Role. This variable concerns the type of need that the II is intended to cover. The role that the II is expected to play within the organisation (or any other broader user community) can reveal the “position” of the technology. Broadbent and Weill [12] describe IT infrastructures as serving a utility, dependent or enabling role. More specifically, a utility infrastructure is intended to facilitate economies of scale leading to cost efficiencies. Ciborra et al. [13] explains that although this II aims to achieve efficiency in processing and transmission activities, it is not likely to interfere with the attached applications or processes. A dependent infrastructure is created to address particular strategic needs, such as the support of specific business processes, meaning that the relevant investment is closely linked with business strategy [12, 13]. Finally, an enabling infrastructure aims to facilitate innovation with a focus on the longer-term horizon [12], preparing the ground for new applications and business processes through architecture and structure. This type of II also highlights the issue of alignment with business strategy [13].

Hanseth and Lyytinen [1] discuss another perspective with a different terminology, distinguishing between vertical infrastructures which provide functionality that is directly deployable by users and horizontal support infrastructures which include protocols or interfaces for further deployment of applications. The latter group can be

further divided into transport and support infrastructure, based on the specific functionality that the protocol or interface aims to provide.

IT Maturity. This variable investigates the concepts identified in the literature and expresses both the familiarisation with IT and, in a broader sense, the maturity of the users regarding technology. The IT maturity of the user base also constitutes a factor that should be examined in order to understand the technological background of an II. For example, Reimers et al. [14] suggest that national culture regarding the use of IT plays a role in the design and the adoption of an II. Their study investigates e-business systems in China, where the particular cultural characteristics increased the requirements for local adaptation and reduced the ease of adoption. The findings of the empirical study by Hsu et al. [15] also suggest that the level of IT knowledge impacts relevant decisions, with IT-savvy organisations tending more towards innovative and promising solutions.

Power Distribution. The structure and relationships between the users and the broader stakeholders can have a dominant position regarding the situation for an II development. The hierarchical balance of stakeholders defines the ways in which power relations and roles are formed. Reimers et al. [14] examine the structure of the value network and more particularly the forms of fragmentation and collaboration in its component parts. This type of approach can be extended to the internal environment for the case of IIs in order to investigate the relationships between the various stakeholders. More particularly, this variable examines how they are structured and how they interact, for example whether they are equal, or whether there is one stakeholder with a leading role who is individually responsible for decisions without participation from the rest of the actors.

Stakeholder Heterogeneity. The definition by Star and Ruhleder [3] describes IIs as embedded in social structures, meaning that they entail a “taken-for-grantedness” within organisational structures, in terms of being inherent resources for the user community that new participants are acquainted with. Ciborra et al. [13, p. 32] explains that IIs represent “an alliance between humans and non-humans where the latter (architectures, operating systems, standards) seem to have a say as important as the humans”. The human component has been referred to as human infrastructure, and includes the knowledge and skills for managing IT resources [12, 13, 16]. On these grounds, while the utilisation of an II usually extends the boundaries of a certain group of users, this is shared within a wide reach involving a broad community consisting of diverse stakeholders [17]. For this reason, this variable may have a variety of parallel manifestations. Firstly, heterogeneity can be examined in terms of the geographical reach; i.e. the geographical territory that the II covers. This reach can be regional, national or global [2, 14]. Edwards et al. [18] also refer to this II categorisation and consider the possibility of a national cyber-infrastructure to extend national borders and achieve global adoption. Moreover, Garfield and Watson [19] discuss the effects of national differences in mindset, values and culture on II policies, while Hsu et al. [15] highlight the challenges related to institutional factors and social norms which are embedded within efforts to establish global IIs.

Besides the geographical aspect, the range of the intended user base is a key feature of the heterogeneity of II users. Reimers et al. [14] refer to the boundaries within which the II is used, involving firms, industry segments, or value systems. In addition to this, the authors also point out the difference in needs among the variety and type of actors involved; for example, business-to-customer and business-to-business infrastructures are expected to have distinctive characteristics. Nielsen and Aanestad [20] also mention the different scales an II can serve, involving corporate, business sector and universal levels, while Tilson et al. [2] differentiate between corporate and industry infrastructures.

The variable of heterogeneity also refers to the level of uniformity of the intended users' needs and intentions. The variety of actors involved in the establishment and development of an II create a complex network of relationships which entails a particular balance of powers [13]. Consistency can be examined through a variety of lenses as the relevant research suggests. Examples for assessing this involve the degree of business process alignment, variability in IT sophistication [14] and cultural and organisational differences [6, 18].

User Motivation and Support. User motivation towards the II project and can therefore enhance the image of the organisational setting in which an II is built. Ribes and Finholt [21] also note this, focusing on the field of scientific IIs in which the unique and individual needs of scientists can have an influence on the development of an II. More particularly, they argue that the competing interests and ambitions of the scientists involved (e.g. in terms of publications or academic position) may hinder the development of a community and thus prevent contribution to a shared infrastructure. On these grounds, the authors recognise the value of the contribution of II developers/users and, more importantly, the need for management to motivate them in order to ensure that their contribution is aligned with the overall II objectives.

Market Malleability. Examining market conditions can help to illustrate the particularities of various II problems and the level of fit of the respective solution. The state of the market or industry, and, more particularly, its malleability, can reveal the tendency towards stability or innovation to be enabled by an II. In this context, Reimers et al. [14] refer to the age or level of maturity of the industry, while Reimers et al. [14] elaborate further by referring to the level of industry consolidation. According to these authors, consolidation and IIs have a dual relationship in this case; that is, higher levels of consolidation lead to higher collaboration and therefore the emergence of IIs, while at the same time the emergence of IIs contributes to higher consolidation. Furthermore, Reimers et al. [14] suggest an examination of the level of competitive pressure based on Gibbs et al. [22] who consider it a key factor determining e-commerce diffusion.

Regulatory Intervention. Government or regulatory intervention is also a variable in this group. Given that IIs can be of public or private interest or even a combination of both, the role of government intervention can considerably influence their environment. For example, certain infrastructures are initiated and supported by public bodies in order to enhance national security or to contribute to economic growth [18].

Reimers et al. [14] examine the effect of government policies on standards. The authors find that in cases where standards are imposed at a government level, the need

for collaboration at organisational level is higher than in the case where standards are developed by the companies themselves. In addition to the area of standards, Reimers et al. [14] also suggest that governments can influence aspects such as industry structure, IT use and dynamics among industry associations. Although these are not directly connected with the design of an II, they certainly affect the closer context and the stakeholders involved, and can determine the following stages and ultimately the outcome of the II. Reimers et al. [14] describe highly regulated industries as having high demand for inter-organisational IS, affecting, among other things, their need for uniformity. This can be easily leveraged to the II level and to the role of regulatory requirements in key decisions affecting their design characteristics and reach [23]. Regulation has also been characterised as a restriction on or requirement for standards adoption [15, 24, 25] as well as relevant to flexibility in the design of IIs [2].

3.2 Resolution Domain

A generally agreed-upon element of II research is the fact that IIs constitute combinations of technical and social components [1, 2, 18, 26]. For this reason, the design resolution domain comprises variables concerning the design and implementation of an II from a technical and social perspective. These aspects constitute the object of interest of a considerable proportion of the literature examined, since they are directly linked with the IIs under study.

The technical design refers to the architecture of the II and involves variables that describe how the technical components are interlinked. These variables concern the modularity, looseness of coupling, standardisation and flexibility of an II. The social aspect of the design refers to the governance of the II. This begins with the level of participation of users during the development of the II and continues with the way it is managed and controlled, although it also refers to the public or private image it adopts. The relevant variables are stakeholder involvement, control decentralisation and openness of an II.

Modularity. One of the key features of an infrastructure is that it does not instantly develop to its full extent but is built through modular increments to independent systems and networks which are gradually integrated, leveraging the existing dynamics of the installed base [3, 14, 18]. Hanseth et al. [27] and Hanseth and Lyytinen [1] discuss the concept of modularity as a scheme of connected and interrelated ecologies, where sub-infrastructure are built in layers on top of one another, linking networks and connecting separate components and thus creating an interdependent structure. Additionally, Chung et al. [16] describe this modularity as being based on processing programming routines in separate modules, which enables the management of software applications and Bietz et al. [28] point out that contrary to IS, a key characteristic of IIs is that they are embedded and therefore operate using networks of linked nodes and webs.

Another perspective on modularity relates to cost efficiency. Ardagna and Francalanci [29] suggest that distributing a system computing load to multiple machines, and positioning them according to certain communication patterns, can influence network costs.

Looseness of Coupling. This essence of networked architecture gives rise to the need to build connectivity between the various components. This connectivity is realised through coupling, a feature that can define one of the key dimensions of an II's architecture. In contrast to physical infrastructures, which have tight coupling between technical and service delivery components, the modularity and recursive organisation of IIs enables generativity and the creation of new capabilities [2]. The authors underline that "disconnecting" these two dimensions leads to a reallocation of control and thus enables other users (non-owners of the physical parts) to use and develop the services and application in alignment with their own needs and interests. For example, two technological components can be aligned in order to interoperate through an application programming interface (API) which provides a very high potential for customisation and innovation [28]. Furthermore, Rodon and Silva [30] refer to APIs as a means of fostering external innovation within an II.

Moreover, Henfridsson and Bygstad [26] consider loose versus tight coupling to be a key distinction for IIs, arguing that it can significantly affect their evolution. The issue of connecting components and networks has also been addressed through the concept of gateways, which act as links consolidating the infrastructures [18]. Gateways provide a means for adaptation or conversion between different formats, in order to enable communication among isolated systems or modules and allow them to act as integrated systems [31].

Standardisation. The concept of standardisation has been widely discussed in the relevant literature and is considered one of the key factors not only for an II's stability but also for its capability for expansion. The connection and integration of the modular elements requires technical effort, which creates the need for specifications in order to facilitate these endeavours. Hanseth et al. [27] refer to standards as indispensable tools allowing infrastructure partners to communicate. The authors comment that in the absence of standards, this communication can be enabled via bilateral agreements or proprietary protocols, although such alternatives are harder to manage and usually more costly.

Rodon and Silva [30] also present the various options in terms of integration. In particular, they refer to stratification, which constitutes a means for integrating and standardising behaviour in a consolidated hierarchical structure, while the option of meshworking does not involve standardisation but instead a more distributed and independent assembly of parts.

Moreover, as Chung et al. [16], Hanseth et al. [27] and Sahay et al. [32] argue, standardisation enables compatibility between components via the ease of adherence to the interface specifications. More particularly, the use of standardised features and components enables attachment to other infrastructures, thereby increasing the quality of transparency and the broader reach of an II [3].

Edwards et al. [18] discuss three types of gateways and their meaning in terms of standardisation. Dedicated gateways are designed for the unique needs of a system and signify a low level of standardisation. Generic gateways show a moderate level of standardisation, applying widely accepted standards concerning system interconnection. Finally, meta-generic gateways show the highest level of standardisation, by

defining a protocol or framework for the formulation of standards, rather than the standards themselves.

Monteiro and Hanseth [33] refer to standards as the technical foundations regulating the communicative patterns of an II. This is particularly useful given the increasing trend in favour of decentralised operations and their need to customise different features, since this increases the need for standardised integration tools as well as for flexible technologies, as further elaborated below [3]. On these grounds, Hanseth [17] describes the use of standardised interfaces integrating different elements such that modularity is not visible, although the II can be seen as “irreducible”.

Flexibility. Flexibility has been described as a feature of the technical design of an II that not only enables but often determines its possibility for growth, since a lack of flexibility, or “irreversibility”, may act as a barrier to evolution [27]. This is because an II can allow innovation in business processes and capabilities, and this potential is illustrated through the flexibility of the infrastructure’s components [16].

In other words, flexibility is argued to be a necessary feature for embedding in the technical design of an II, with the aim of enabling continuous growth so as to meet user needs [14, 32], thus offering a major competitive advantage to organisations within the rapidly evolving and highly competitive business environment [16]. Despite this, the digital nature of IIs suggests that, in principle, the only boundaries to an II’s capability for application or service development are set by its own technical design and configuration [2].

Ciborra et al. [13] discusses the dilemma between high flexibility, enabling unforeseeable business redesign in the future, and low flexibility, based on consistency with ongoing strategic needs. From a more technical perspective, Tilson et al. [2] refer to “upward flexibility” as the ability to create applications or services using the II’s basic communication and storage capacity. Grisot et al. [34] describe this phenomenon as “innovation in infrastructures” which can be experienced when IIs are designed in a generic way.

This concept is parallel to modularity; Chung et al. [16] and Hanseth et al. [27] mention the latter as a means of enabling the flexibility of an II. This is possible because modularity accelerates the development and modification of applications and at the same time allows interoperability with other systems. Similarly, Tilson et al. [2] explain the concept of “downward flexibility”, which signifies that interconnectivity can be provided by a variety of digital or physical networks. Such flexibility is provided by “the malleability of software implementing the logic laid down in layers over the physical layer of interconnected hardware” [2, p. 6], which is linked to the concept of modularity as described above.

One of the primary challenges in designing and implementing a successful II lies in achieving a balance between the contradictory aspects of an II. Flexibility and stability have both been widely argued to be key features of an II; however, it is possible that their coexistence creates a controversial relationship or dilemma. Star and Ruhleder [3] point out that the inherent flexibility of an II can act as an enabler of innovation, although such innovation and evolution might be hindered in the case of an incumbent infrastructure facing lock-in situations. Impediments to evolution can also be induced by increased standardisation and a focus on stability, which might prevent decentralised

initiatives. For example, applying technical specifications that are not available for public use can limit the possibilities for evolution through external sources [5]. Ciborra et al. [13] also acknowledges this paradox and suggests that the optimal solution would combine decentralised generativity capabilities with centralised control over resources and processes.

Stakeholder Involvement. The socio-technical nature and, more particularly, the role of the stakeholders involved create a challenge regarding the connection and coordination of the range of stakeholders, which may have diverse needs and interests [1]. Constantinides and Barrett [6] also discuss user heterogeneity as a challenge which leads to a need for extensive coordination and collective action, and underline that the motivation of lower-layer levels can be significantly affected by their degree of inclusion in relevant decisions.

This issue has also been discussed by Hanseth and Lyytinen [1] on the grounds that traditional top-down design approaches pose challenges regarding the fulfilment of the needs of an II's wide user base. Following a top-down approach based on critical stakeholders' agreement might provide some stability; however, such an approach disregards the complexities and possibility of evolution of an II, thus limiting its flexibility [34].

Control Decentralization. Henfridsson and Bygstad [26] discuss the options of management rights given to the user institutions, or a centralised position usually held by a state authority. Tilson et al. [2] examine the level of centralisation in terms of control of the services deployed, critical resources, data ownership and data management. Data management, and especially decisions about sharing, storage and preservation, is also discussed by Edwards et al. [18]. More particularly, the authors argue that the emergence of true infrastructures happens when locally built and centrally governed systems are connected into networks involving decentralised coordination and control. Constantinides and Barrett [6] describe a "polycentric" governance approach in which individual centres or units are entitled to independence within their specific area, thus distributing governance into wider networks. The authors support the argument that flexibility is higher when governance is decentralised, but also argue that such an approach can lead to increased complexity and divergence from the initial vision. Moreover, they suggest that decentralised autonomy should be authorised to all stakeholders to the extent that their autonomy does not disturb the other independent units.

Openness. Ciborra et al. [13] uses another categorisation based on the categorisation of the infrastructure as open or closed. Closed infrastructures are suitable for restricted and controlled environments, such as specific organisations. On the other hand, open infrastructures have a public nature, and are available for use and further development by broader user communities. Constantinides and Barrett [6] also examine an II as a private or public good with regard to its properties and more particularly the benefits it provides.

4 Discussion and Conclusion

The main argument of this paper is that within the class of II artefacts, there are important differences in both the problems addressed and the II solutions crafted to address these problems. Based on this position, we have reviewed the high quality and high impact literature on II to unearth the relevant dimensions of the II design space. We found that the problem side of II design, the design situation, has been framed in terms of seven dimensions: II role, technological maturity, power distribution, stakeholder heterogeneity, user motivation, market malleability and regulatory intervention. We also found seven dimensions that had been reported as relevant in framing the solution side of II design, the design resolution, and these were modularity, coupling, standardisation, flexibility, stakeholder involvement, control decentralisation and openness. Here, we report on all 14 dimensions as continuums where any given II artefact can, at least in theory, assume any value and characterise a unique II design. Taken together, these 14 dimensions also illustrate the aspect of divergence within the artefact class of II, a divergence that needs to be taken into account to understand the many struggling II projects throughout the world.

As in any research, our findings are subject to limitations and validity constraints. Although we have employed a broad and comprehensive approach to the article search, it cannot be guaranteed that we have been able to identify every relevant article and every relevant variable in the selected articles. The research also involves certain limitations and acknowledges certain weaknesses. One of these is linked to the filtering of literature sources, which was performed in order to ensure the identification of high quality literature but which may have hindered the finding of additional sources which could have enriched the content of the literature review. Regarding the formation of the framework, although the concepts used as variables have been selected as being commonly referenced aspects of IIs, they could be considered rather broad and theoretical, with potential for being significantly enhanced with more detail, especially concerning the technical aspects of the II design. Furthermore, as research in this area develops, more relevant dimensions will be discovered. We are, however, convinced that the main argument of the paper, that within the class of II artefacts there is important divergence, rests on a solid foundation.

The design of the conceptual research means that we identify two important limitations on the scope of the review. One is that we do not intend here to say anything about which attributes of resolution match which attributes of situation. Second, we also omit the process view of II development. Both of these limitations are important areas for exploration in future research.

The main academic contributions of this paper are the critical argument that the way in which the II artefact is conceptualised needs to be reconsidered, and the multi-dimensional framework characterising the II design space, presented in Fig. 2. Although previous research has discussed a variety of settings and problems in which IIs arise, it has only provided general guidelines on how IIs should be built, overlooking the diversity of potential conditions around them. In view of this, the most important implication of this research concerns the expression of the need to examine

the unique context and environment surrounding each II individually, rather than treating all cases in the same way.

Our multi-dimensional characterisation of the II design space allows for further theorisation of the II artefact resting on a view of divergence within the artefact class. For further research, the framework provides a tool to characterise a specific II and to contrast it with other known examples in order to find patterns linking scenarios to outcomes. This is particularly useful in areas where efforts to establish effective IIs have shown to be especially difficult for II development, such as in international trade, health care and finance [35–38].

Further theorisation would also include a search for an explanatory and design theory that matches distinct subsets of the II artefact class and to find archetypical II designs. That is, in theory, the positioning along the dimensions in the framework can be freely combined. In reality, however, it seems that certain choices within these dimensions go more naturally together. These ‘natural fits’ in dimensions indicate that there might possible archetypical II set-ups of design attributes that align with each other. The implication of this finding is that anyone interested in the shaping of an II cannot make independent choices regarding the dimensions, but have to recognise the systemic dependencies between the choices. That is, one specific choice will influence the possibility for choices in the other decision points. It also follows that these archetypical designs may have specific configurations between situation and resolution dimensions. For example, what would be the design principles for the success of an II built nationally with high regulatory involvement? Would these principles be different in a setting with a low distribution of power and a homogenous user base?

A final academic possibility granted by the framework is to develop process theory based on certain process-defining characteristics. While the II process has generally been described as cultivation, recognising divergence may reveal additional insights as to why this process takes different paths in different attempts.

In practice, the framework in this paper has at least two valuable areas of use. The obvious lesson to be learnt is that there is no single best way to build an II. At the same time, it becomes more evident that there is more than one situation in which the need for an II arises. The theoretical framework presented above can aid practitioners in the analysis of the design space of their IIs and support them in their decision-making processes.

Practitioners can also use the framework as a starting point to analyse the critical ‘must-win’ battles of their II designs. For example, for an II built on a high degree of openness the must-win battle might be fast user enrolment for expansion of the II, while an II with high regulatory support might have more stamina in user enrolment. Similarly, a low or high level of user heterogeneity or power distribution entails different critical battles to be managed in the socio-political dimensions of the II design space.

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Appendix: Review methodology and article selection

A literature search involves the process of seeking quality scholarly research material relevant to the phenomenon of investigation. This "mandate" points to the need to properly define quality research material. The field of IS and IT displays an abundance of publications in a respectively high number and variety of sources (Vom Brocke et al., 2009), which often include "non-refereed work or questionable sources" (Levy & Ellis, 2006, p. 185). For this reason, queried sources should be filtered in order to refine the results originating from quality and trustworthy research.

Literature review guides on IS research (Levy & Ellis, 2006; Webster & Watson, 2002), suggest that the major literary contributions building the necessary theoretical foundations are published within leading peer-reviewed journals. Therefore, the first search field includes the leading IS journals often referred to as "the basket of eight" ("Senior Scholars' Basket of Journals", 2011). The search in the above sources is keyword-driven in order to extract a large number of articles. Specifically, the condition used was:

("Information Infrastructure" OR "Digital Infrastructure")

AND

("Information Technology" OR "Information Systems")

This condition was searched in the articles' entire content, and not only within the titles, so as to ensure that articles with misleading titles were not excluded. Furthermore, a time restriction was set so as to draw articles published within the time period between 1980 and 2016.

The above search yielded many articles that could not be usefully connected to the objective of the literature review. Therefore, the first round of screening focused on the titles and abstracts of the articles and subsequently the ones which were deemed irrelevant for the research were removed from the set of findings. The second review round was performed through more careful reading of the contents of the articles and excluded even more samples which had limited or no input on the issue of II design. As a result, the keyword-driven search provided a collection of twenty articles from seven sources.

Using time restricted keyword search in a limited set of databases and specific publication sources led to narrowness of the literature background. This happens because keywords in IS literature are diverse and evolve over time (Levy & Ellis, 2006). For example, the object of study for this research has been demonstrated within examined literature in a range of terms

such as Information Infrastructure, Digital Infrastructure, Cyber Infrastructure and Inter-Organizational Infrastructure. The keyword condition presented above eliminates research work that uses other terminology to describe the same phenomenon. Hence, keyword search is supplemented with backward and forward approaches in order to identify further useful research material (Levy & Ellis, 2006; Webster & Watson, 2002).

More specifically, the articles qualified within the screening and selection process are subject to backward references search, i.e. the scanning of their references in order to detect prior work that will help to support the understanding of the origins or foundations of the object of study (Levy & Ellis, 2006) or of specific arguments articulated by the authors. Hence, articles that had more than 35 references in subsequent publications were also subject to review, adding ten more articles to the literature base. For example, the article entitled "Management by maxim: How business and IT managers can create IT infrastructures" by Broadbent and Weill (1997) is one of the most quoted works discussing the challenges involved when creating an II; however, it was not retrieved through the database search due to the fact that the journal where it was published (Sloan Management Review) is not included in the "basket of eight" IS journals. In addition to this, this search also helped to extract non-journal work, e.g. the book *From Control to Drift: Dynamics of Corporate Information Infrastructures* (Ciborra et al., 2000) which constitutes one of the most referenced pieces of work but would be impossible to otherwise trace due to the source limitations in the keyword search.

Additionally, the articles qualified through the screening and selection process are also subject to forward references search, i.e. the reviewing of articles citing them with a scope of obtaining further knowledge as well as examining follow-up research or fresh developments on the object of study (Levy & Ellis, 2006). Two articles were retrieved via this approach.

The below tables present lists of the reviewed literature organized by method of search.

The tables present the results of the literature review regarding Information Infrastructures in IS research publications within the time period between 1980 and 2016.

Table 1 shows the results based on keyword search respectively within IS top journals. Table 2 and Table 3 show the results of backward search and the forward search utilizing the references identified in previous search. The tables list authors, year of publication, title and source.

Table 1. Keyword-driven literature database search

#	Author	Year	Title	Source
1	Aanestad & Jensen	2011	Building nation-wide information infrastructures in healthcare through modular implementation strategies	Journal of Strategic Information Systems
2	Angelides & Agius	2000	Eight scenarios of national information superhighway development	Journal of Information Technology
3	Ardagna & Francalanci	2005	A cost-oriented approach for the design of IT architectures	Journal of Information Technology
4	Broadbent et al.	1999	The Implications of Information Technology Infrastructure for Business Process Redesign	Management Information Systems Quarterly
5	Constantinides & Barrett	2014	Information Infrastructure Development and Governance as Collective Action	Information Systems Research
6	Grisot et al.	2014	Innovation of, in, on infrastructures: Articulating the role of architecture in information infrastructure evolution	Journal of the Association for Information Systems
7	Hanseth & Lyytinen	2010	Design theory for dynamic complexity in information infrastructures: the case of building internet	Journal of Information Technology
8	Hanseth et al.	2006	Reflexive Standardization: Side Effects and Complexity in Standard Making	Management Information Systems Quarterly
9	Henfridsson & Bygstad	2013	The generative mechanisms of digital infrastructure evolution	Management Information Systems Quarterly
10	Henningssson & Henriksen	2011	Inscription of behavior and flexible interpretation in Information Infrastructures: The case of European e-Customs	Journal of Strategic Information Systems
11	Hsu et al.	2015	A legitimacy challenge of a cross-cultural inter-organizational information system	European Journal of Information Systems
12	Ianacci	2010	When is an information infrastructure? Investigating the emergence of public sector information infrastructures	European Journal of Information Systems
13	Nielsen & Aanestad	2009	Control Devolution as Information Infrastructure Design Strategy: A case study of a content service platform for mobile phones in Norway	Journal of Information Technology
14	Reimers et al.	2014	How do industry-wide information infrastructures emerge? A life cycle approach	Information Systems Journal
15	Ribes & Finholt	2009	The Long Now of Technology Infrastructure: Articulating Tensions in Development	Journal of the Association for Information Systems
16	Rodon & Silva	2015	Exploring the Formation of a Healthcare Information Infrastructure: Hierarchy or Meshwork?	Journal of the Association for Information Systems
17	Sanner et al.	2014	Grafting: Balancing Control and Cultivation in Information Infrastructure Innovation	Journal of the Association for Information Systems
18	Star & Ruhleder	1996	Steps toward an ecology of infrastructure: Design and access for large information spaces	Information Systems Research
19	Tilson et al.	2010	Digital Infrastructures: The Missing IS Research Agenda	Information Systems Research
20	Vaast & Walsham	2009	Trans-Situated Learning: Supporting a Network of Practice with an Information Infrastructure	Information Systems Research

Table 2. Backward search

#	Author	Year	Title	Source	Citeations
21	Broadbent & Weill	1997	Management by Maxim: How Business and IT Managers Can Create IT Infrastructures	Sloan Management Review	555
22	Ciborra	2000	From control to drift: the dynamics of corporate information infrastructures	Book - Oxford University Press	783
23	Chung et al.	2003	The impact of information technology infrastructure flexibility on strategic alignment and application implementations	Communications of the Association for Information Systems	150
24	Damsgaard & Lyytinen	1998	The role of intermediating institutions in the diffusion of electronic data interchange (EDI): How industry associations intervened in Denmark, Finland, and Hong Kong	The Information Society	177
25	Edwards et al.	2007	Understanding Infrastructure: Dynamics, Tensions, and Design	Technical Report	258
26	Hanseth & Monteiro	1997	Inscribing behavior in information infrastructure standards	Accounting, Management and Information Technologies	417
27	Hanseth et al	1996	Developing information infrastructure: The tension between standardization and flexibility	Science, Technology & Human Values	474
28	Monteiro	1998	Scaling information infrastructure: The case of next-generation IP in the Internet	The Information Society	116
29	Monteiro & Hanseth	1996	Social Shaping of Information Infrastructure: On Being Specific (In Information technology and changes in organizational work About the Technology)	Book - Springer US	451
30	Reimers et al.	2004	The shaping of inter-organizational information systems: Main design considerations of an international comparative research project	Bled e-Commerce Conference	35

Table 3. Forward search

#	Author	Year	Title	Source	Citations
31	Bietz et al	2010	Synergizing in cyberinfrastructure development	Computer Supported Cooperative Work (CSCW)	52
32	Pollock & Williams	2010	E-infrastructures: How do we know and understand them? Strategic ethnography and the biography of artefacts	Computer Supported Cooperative Work (CSCW)	71

Paper 3 Ships & roses: A revelatory case study of affordances in international trade

SHIPS & ROSES: A REVELATORY CASE STUDY OF AFFORDANCES IN INTERNATIONAL TRADE

Completed Research Paper

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Abstract

International trade involves crossing several organizational boundaries. This revelatory case study follows fresh cut roses' journey from the growers in Kenya to the retail distribution in Holland and shows relatively high barriers related to the associated activities, information and documents, etc. Our empirical findings reveal the serious limitation that existing inter-organizational system (IOS) only facilitates actor-to-actor information forwarding in a communication chain of peer-to-peer communication along the supply chain and has no provision for persistent and simultaneous exchange of information between multiple actors. To address this limitation, we conducted a comparative analysis of affordances of the existing vs. future inter-organizational information systems with a focus on sharing critical information. Our extended analysis shows that modern IT features supporting affordances could be useful for the actors' collaboration in the trade lane of the roses. We discuss some of the benefits of our proposed approach (e.g. lower transaction cost and real time information) but also raise some concerns (e.g. about trust and governance) which calls for further research.

Keywords: *Inter-organizational Systems, International trade, Activity Framework Theory, Affordances, Information Infrastructure, Supply Chain Analysis.*

1 Introduction

International trade involves crossing organizational boundaries. For example, when shipping roses from Kenya to European Union, multiple organizations are required to transport the roses from the growers in Africa to the retail distributors and consumers in Europe. For general international traded cargo average retail cost breakdown is as follows: 1/3 product cost + 1/3 retail distribution cost + 1/3 international trade cost. In this paper, we focus on the international trade cost which is broken down into 1/9 physical transportation cost with remaining 2/9 of the cost accrued from barriers that exist when crossing national borders and organizational boundaries (Anderson & Van Wincoop, 2004). Compared to general cargo, the international trade costs are even higher for roses because they need to be refrigerated during the transport and additional phytosanitary inspections are required. Therefore, improvements addressing barriers related to crossing the organizational boundaries can have significant impact with regard to international trade. Importantly, reduction of the cost of the barriers is estimated to have significant impact on not only international trade volume but also GDP. For example, an improvement to half-way of regional best practice is estimated to have similar impact as removing all tariffs resulting in increased trade volume by 15% and GDP by 5% (WEF, 2013). Such improve-

ments are important for the economies of the countries involved in international trade (e.g. Kenya). In this regard, this paper investigates how modern IT could help support efficient and effective administration related to crossing organizational barriers in international trade and thereby lead to reduced trade costs, increased trade volumes, and ultimately economic growth.

1.1 Research Question

Situated in the domain of international trade as discussed above, this paper addresses the following research question: *What are the administrative issues preventing efficient international trade of flowers, and how can those issues be addressed by utilizing modern information technology?*

The remainder of the paper is organized as follows. First, the theoretical framework is presented and discussed. Second, methodological considerations are discussed and case study data collection events and methods are listed. Third, results from empirical analysis are reported. Fourth and last, empirical findings are discussed, implications for research are generated and future work is outlined.

2 Theoretical framework

The theoretical framework for the research project draws upon concepts from four different theoretical streams: (a) infrastructures theory for supply chain analysis, (b) activity theory for domain analysis, (c) inter-organizational system theories and information infrastructures theory for organizational boundary crossing analysis, and finally (d) affordances from ecological psychology and human-computer interaction for IT-artefact analysis. We found the need to utilize all four theoretical lenses to understand the different issues in and aspects of the phenomena: supply chain for *international trade of fresh cut roses across multiple organizational boundaries and borders from Kenya to EU involving multiple IT systems*.

Organizational boundaries and inter-organizational conflict has been recognized and theorized for years. Recently, the topic of electronic cross-organizational and cross-border collaboration has gained renewed interest (Aldrich, 1971; Evan, 1965; Romano, Pick, & Rozbicki, 2010). Analyzing the organizational boundaries and boundary objects alone from micro-agent level will prevent a holistic understanding of the phenomena at the meso level of organizations and macro structural level. Similarly, employing exclusively the meso and macro levels will not reveal the motivations and behaviours of actors, logistics details, and IT affordances at the micro level. As the proverb goes, we needed to know not only about the individual trees in the forest but also have an overview of the forest. An additional reason for including the theory about information infrastructure and affordances within Human Computer Interaction (HCI) is that they represent two elements of modern IT in form of the internet and social web which might offer potential solutions to improving the international trade. We present and briefly discuss the four theoretical lenses below.

2.1 Supply Chain Infrastructure

Infrastructure is basic physical (and organizational) structures needed for facilitation and operation of a society and necessary for an economy to function (Sheffrin, 2003). The term typically refers to the technical structures that support a society such as roads, bridges, water supply, sewers, electrical grids, telecommunications and so forth. It can be defined as "the physical components of interrelated systems providing commodities and services essential to enable, sustain, or enhance societal living conditions" (Fulmer, 2009). Infrastructures are characterized by nodes and means of connection as basis for activities, and that they are constantly evolving. The two key issues for the international trader of fresh products such as cut roses are the quality of the product and the international trade costs. The quality of cut flowers is strongly related to the lead time for getting them from the grower to the consumer (Christopher, 2012; De Treville, Shapiro, & Hameri, 2004; Stewart, 1995) and integrity of the cold supply chain. Our analysis starts with following the roses in the supply chain utilizing the established physical infrastructure with nodes in a net of routes (Christopher, 2012; Mangan, Lalwani, & Butcher,

2008). The supply chain analysis does focus on the physical world in order to address the involved actors (e.g., the exporter) who are geographically localized in their national communities and are governed by their national rules. Further, the actors use local technologies and equipment when handling the goods, related documents and information.

2.2 Activity Theory Framework

Activity Theory Framework (ATF) helps analyze the various supply chain infrastructure elements mentioned above from domain-specific systemic perspective. ATF provides a conceptual vocabulary as well as theoretical mechanisms that are relevant and useful for the description of the part of the international trade that takes place in the individual geographical area (e.g. Kenya for the export). Activity theory in general and Cultural Historical Activity Theory (Chatterjee, 2010) in particular have their origins in the Soviet Psychology of Vygotsky, Luria and colleagues (Roth & Lee, 2007; Vygotsky, 1930/1980, 1962). Activity theory has been applied in multiple academic domains such as developmental psychology (Wertsch, 1985), educational psychology (Jonassen & Rohrer-Murphy, 1999), learning sciences (James G Greeno, 1998), human-computer interaction (Kaptelinin, 2006; Nardi, 1998), information systems (Mursu, Luukkonen, Toivanen, & Korpela, 2007) and international trade (Jensen, Bjørn-Andersen, & Vatrapu, 2014). Instead of the standard ATF term of subject for human participants, we employ the term actor as it better emphasizes the actions contributing to completion of the activity. For analysis of empirical data collected (methodology section forthcoming), we follow Activity Theory Framework's dimensions for an activity: *actor, object, community, tool, rules, division of labor* and the *outcome*. An activity comprises of actions which are in turn constituted by operations. Further an activity is driven by a motive, each action has a goal and there are conditions for the operations (Kuutti, 1996). In our analysis, an activity can include actions of several actors each with their own motive but an action is performed by only one actor. Regarding the operations constituting an action of an actor, we have limited our description to include only the operation(s) in an action that other actions depend on (e.g. an authority update the status information to "permission to remove" the container from customs area which is relevant for the actor going to pick up the container).

2.3 Inter-Organizational System

Extant literature on the utilization of IT for collaboration across organizational boundaries and national borders is primarily focused on IOS (Kaniadakis & Constantinides, 2014). The extant literature on IOS employs more than 25 theories (Madlberger & Roztocki, 2008) and no single theory stands out as predominant. The majority of research regarding IOS is focused on EDI (Reimers, Johnston, & Klein, 2004), and a majority of the described IOS are successfully utilizing EDI (Robey, Im, & Wareham, 2008). For international trade, the benefits of facilitating IOS based on EDI is well documented (J. King & B. R. Konsynski, 1990; King, 2013; J. L. King & B. R. Konsynski, 1990) and it has also been pointed out that the cost of change are relatively high (Henningsson & Bjørn-Andersen, 2009). Recent research projects have revealed the potential benefits for actors involved in international trade by utilizing IOS based on EDI messages for collaboration across organizational boundaries, for example ITAIDE project (Tan, 2010), Contain project¹, Integrity project², Cassandra project³. An information infrastructure is "*a shared, open (and unbounded), heterogeneous, and evolving socio-technical system consisting of a set of IT capabilities and their users, operations, and design communities*" (Hanseth & Lyytinen, 2010). Based on our literature review, we observe that the use of e-mail does not seem to have been considered a means of communication for IOS. In contrast, for international trade, the do-

¹ <http://www.containproject.eu/>

² <http://www.integrity-supplychain.eu/>

³ <http://www.cassandra-project.eu/downloads/>

main of this case study, our empirical data analysis (Results section forthcoming) reveals e-mails as the dominating mean of communication in practices.

2.4 Affordances

Having conceptualized the phenomena ("international trade of fresh cut roses from Kenya to EU") from the supply-chain infrastructures, activity systems and IOS perspectives, our theoretical attention is now focused on conceptualizing and understanding the socio-technical interactions in terms of how the IT affordances are perceived and appropriated by actors. Based on foundational research in ecological psychology (Chemero, 2003; Gibson, 1979; J. G. Greeno, 1994; Sanders, 1997; Stoffregen, 2000; Turvey, 1992) and the enactive approach in the philosophy of mind (Garfinkel, 1967; Noë, 2004; Schütz, 1967), Vatrapu (2010) defines affordances as "*meaning-making opportunities and action-taking possibilities in an actor-environment system that are relative to actor competencies and system capabilities*". This definition of affordances applies the relational ontology of affordances in ecological psychology to information systems and allows us to conceptualize and analyze meanings and actions made possible by the IT-artefacts both at system design-time and the real-time of actual use by actors involved in international trade. Here, our theoretical focus is in the Human Computer Interaction (HCI) subfield within the Information Systems discipline (Zhang & Li, 2004). The "Gibsonian" affordance theory suggests that successfully conveying the possibilities for meaningful action offered by a technology to the user should be a top priority in the design of interactive systems. The concept of affordances as action possibilities within modern IT systems has been employed in IS recently and we draw from this growing body of IS literature (Davern, Shaft, & Te'eni, 2012; Pozzi, Pigni, & Vitari, 2014; Treem & Leonardi, 2012) and extend the notion by including meaning-making opportunities based on Vatrapu (2010). In summary, the theoretical framework of supply-chain infrastructure, inter-organizational system, activity theory framework and affordances allow us to conceptualize, describe, understand, and analyze the different micro, meso, and macro levels of the phenomena of this case study: international trade of fresh cut roses from Kenya to EU. We present methodological considerations and data collection events and methods next.

3 Methodology

The unit of study is the international shipment (of fresh cut flowers) with related documents and information across multiple organizational boundaries and national borders. We employ the method of revelatory case study to investigate the international trade of flowers to Europe to address the research question. The case study method is especially relevant to our research problem since in international trade there are many more variables of interest than data points and therefore the results of the research relies on multiple sources of evidence with data convergence. A case study investigates a contemporary phenomenon in depth and within its real-life context (Yin, 2009). A revelatory case study (Sarker, Sarker, Sahaym, & Bjørn-Andersen, 2012) can potentially help to explain presumed phenomena in real-life interventions that are too complex for the survey or experimental research methods. We regard our case study as a revelatory case study since we as researchers have the "opportunity to observe and analyze a phenomenon previously inaccessible to social science inquiry" (Yin, 2014). We acknowledge that data collection methods for studying IOS involve a dilemma between authentic access to practices and the ability to thematize knowledge of practices (Reimers et al., 2013). Further, we recognize the difficulties studying IOS especially across borders which involves both private and public organizations (Reimers, Johnston, & Klein, 2010a, 2012), and we are inspired by a framework which views IOS as constellations of aligned practices (Reimers, Johnston, & Klein, 2010b). Due to the complexity of international trade, we have selected to focus only on the supply chain (and not the financial aspects) for a specific trade lane for roses from East Africa to Europe. In our case we have access to multiple organizations involved in the international trade across the private and public sectors. The data for this paper is collected over a period of 6 months by interviewing key actors in the organizations, visiting field sites, observing shipments of roses, conducting a set of focus group inter-

views and meetings in close collaboration with a key insider at the trader organization. Table 1 presents an overview of the empirical data collection.

Date and location	Event	Participants	Focus
2014-06-03 Delft, Holland	Meeting / presentations	Traders, authorities and researchers	Introduction to traders business
2014-06-04 Naaldwijk, Holland	Site visit and meeting	Traders and researchers	Follow the logistic flow
2014-07-08 Nairobi and Mombasa, Kenya Salalah, Oman; Antwerp, Belgium Aalsmeer, Holland	Shipment from Kenya to Holland	Roses in containers	Collect communication, information and documents plus container monitoring data
2014-09-09 Sosterberg, Holland	Meeting	Traders, authorities and researchers	Understand actors involved
2014-11-17 Delft, Holland	Meeting	Traders, authorities and researchers	Understand authorities procedures
2014-11-18 Aalsmeer, Holland	Site visit	Traders, authorities and researchers	Follow inspection by authorities
2014-11-18 Aalsmeer, Holland	Meeting	Traders, authorities and researchers	Understand objectives of key actors
2014-11-19 Aalsmeer, Holland	Meeting	Trader informant	Analysis of communication by trader
2014-10-12 – 2014-12-20 Weekly virtual meeting	Validation	Trader informant	Validation of findings

Table 1. Overview of Empirical Data Collection

4 Analysis

Our analysis starts by following the roses in the supply chain from the growers' fields to the retail distribution, adds the actors, documents needed, information systems involved, and the IOS communication to describe what's going on when a trader ships roses from Kenya to EU.

4.1 Supply Chain and Infrastructure Analysis

The supply chain for the roses from the growers in Africa to the retail stores in Europe is relatively straight forward. The roses are cut at the grower's farm in the high land of Kenya where they also are quality assessed, packed and brought to the traders' facility in Nairobi and after consolidation loaded into a refrigerated container. The container is transported approximately 500 kilometers by truck to Mombasa, the nearest port served by container vessels, where it awaits the booked vessel. In the terminal at the port, the container is loaded by crane on the vessel bound on its journey for Europe. The container is transshipped to another vessel in Salalah, Oman before it enters Europe in the port of Antwerp, Belgium. The container might be inspected and / or scanned before it's cleared by the authorities to entering EU. It's possible to apply for a postponement of the customs clearance and the inspection by the phytosanitary authorities to another customs location in this case at the freight forwarders location at the flower auction and distribution center in Aalsmeer in Holland. The container goes by truck to the flower auctions in Aalsmeer, Holland where the roses are unloaded from the container to special designed handling units and trolleys. The flowers then await custom and phytosanitary inspection and clearance. After clearance the flowers are moved to a special treatment location inside the FloraHolland premises to be processed which takes about 1-2 days. Then they are ready to be sold at the flower auction. The buyer(s) of the flowers are now in charge of the onward distribution to the retail primarily by truck.

The supply chain's nodes and legs in the transport is a relatively simple chain with nodes at the exporters consolidation centre in Nairobi, the custom's territory at the terminal in the port of Mombasa, the custom's territory for transshipments in the port of Salalah in Oman, the Belgian custom's territory in the port of Antwerp, the bonded warehouse of the freight forwarder at the trader's auction and distribution centre in Aalsmeer in Holland; and with the transport legs in between the nodes by trucks on the roads and by container vessels servicing the routes of international container shipping plus special equipment for internal transport of containers at the ports (e.g. cranes for transferring from quay to the container vessels).

The transport of the roses utilizes the established infrastructure for containerized cargo combining several mode of transportation. The infrastructure is based on the standardization of containers which enables relatively easy shift in mode of transport (Levinson, 2010), e.g. from road to sea. Besides the container the main elements in the infrastructure are roads, trucks, ports with container terminals, container vessels, and other special designed equipment (e.g. straddle carriers, container cranes and container scanners). For refrigerated containers, additional equipment and supplies as power and monitoring are needed to ensure integrity of the cold chain e.g. the temperature is kept at the right level during the transportation. The total lead time is approximately 34 days of which the roses are on the move two third of the time and the rest is spent standing still waiting for outcomes of administrative processes. Part of the waiting time is planned slack to allow for uncertainty of the next mode of transport and in the administration procedures. (The reliability of shipping is in average 73,1% according to survey from SeaIntel September 2014). For example, at least 24 hours prior to start of loading, the authorities in the EU have to be notified. Since the loading might take several days, it is required that the container is at the port of departure on Monday for the vessel scheduled to depart on Thursday from Mombasa, Kenya.

We find that for the majority of the journey (of the roses), none of the actors know exactly where the roses are. Instead they know only the planned and recorded actual time and date for certain events and hereof only a few are communicated to other actors. For example, the pickup of the stuffed container is planned and agreed with the trader and the freight forwarder only, the planned and actual load and discharge of the container with the roses is booked, recorded and publicly available but not communicated. Similarly, the entrance and exit of customs areas recorded by the terminal operator and communicated to the port community system is only accessible for paying members of the port community. We find that the actors have learned to live with the lack of information about the containers. The trader reports several occasions of no shows, delays and of unexpected arrival of containers. These kinds of events and the uncertainty due to the lack of insight (e.g. of the arrival date of the container with the roses) makes it difficult to plan the retail distribution, especially in connection with events and holidays with fixed dates e.g. Mother's day.

4.2 Analysis of Activity System and Organization Boundary Crossing

The Activity Theory Framework (ATF) provides a set of dimensions for the analysis of the systems. Especially, ATF is well-suited for analyzing a multiple system environment involving diverse organizations in different national settings. Table 2 below is the essence of the ATF analysis followed by short descriptions related to each dimension. The table columns are structured according to the supply chain events for the roses' journey as identified in §4.1 above.

Several of companies and organizations are involved in the international trade of the roses from Africa to Europe. The trader of the roses acts as the value captain of the supply chain. The trader uses a range of service providers for the transportation of the roses in the container(s). They engage with a shipping line for the deep sea ocean transport, freight forwarders for the land transport and other service agents are involved as well. The objectives for the trader are to *"reduce the number of inspections which generate unpredictable disruption of the flow in the supply chain and to reduce the administrative burden and associated cost"* (presentation at meeting in June 2014). Today the

transport of the roses is as air cargo to lower the lead time. The possibility to transport by sea will reduce the cost of the transport by half but also prolong the lead time significantly.

Main Supply Chain Activity Dimension	Growing East Africa	Export consolidation Nairobi, Africa	Land transport	Clearance for export Kenya	International Shipping	Clearance for import to European Union	Land transport	Import deconsolidation Europe	Retail Distribution
Actors Organizations and companies	Growers	Trader + Service provider	Service provider (freight forwarder)	Authorities + Freight forwarder	Terminal operator Shipping line	Authorities Clearance agent	Service providers	Trader	Retail / Consumer
Communities Associations Cooperatives	Cooperative of growers	Cooperative of growers	Alliances of national freight forwarders	East African Authorities/World Custom Organization	Alliances of shipping lines	European Tax Authorities World Custom Organization	Alliances of national freight forwarders	Cooperative of growers	Alliances and Cooperative of European Flower importers
Objects Goods (roses) Documentation / Information	Packing list and pro forma invoice Fresh cut roses in carton boxes Invoice	Consolidated packing list Roses in refrigerated containers	Refrigerated containers (with roses) Import declaration	Export declaration Phytosanitary certificate Certificate of origin EUR1 Movement Certificate /Form A	Refrigerated containers (with roses) ENS with B/L	MRN / DNL based on ENS) Import declaration	Refrigerated containers (with roses) Import declaration	Roses in refrigerated containers with related documents and information	Roses in special transport units with product description
Tools / equipment including enterprise information systems	Farms for growing roses Enterprise system	Special designed packaging material Local Enterprise system	Local means of transports as trucks Legacy system	Local authorities information systems e.g. KenTrade for export declaration etc.	Cranes etc. container vessels, information system of terminal operators and shipping line	Local port community information system, EU authorities information system	Local means of transports as trucks Legacy system	Special designed transportation units Enterprise system	Local means of transports as trucks, system
Rules	National regulations	Exporting regulations in country of origin Kenya	International trade regulations, seafarer rules, etc.	Exporting regulations in country of origin	International trade regulations, seafarer rules, etc.	Import regulations in EU and the importing country e.g. Belgian	Law road transport of goods	Importing regulations in country of destination	Rules regarding consumers rights
Division of work Motivation	Growing	Trading packing	Transport by truck	Controlling and inspection	Transport, storage shipping	Controlling and inspection	Transport by truck	Trading and distribution	Transport by truck,

Table 2. Activities for international trade of fresh cut roses's journey from Kenya to Europe with respect to selected actors, communities, objects, tools, rules, etc.

As it is to be expected, our analysis reveals that multiple national borders and organizational boundaries are crossed on the roses' journey. The rules and regulations that apply are given by the national and regional authorities governing the nations which the roses pass on its journey. The roses are all the way owned by the growers until they are sold at the flower auction in Aalsmeer. The trader might delegate the responsible for coordination of the transport to one service provider covering sev-

eral legs of the transport. The growers trust the trader who hands over the consignment the container with the roses to a chain of service providers: first the freight forwarder, then to the terminal operator in the port of Mombasa, then to the shipping line who interim transfer it to the terminal operator (and authorities) in the transshipment port, and back again to the shipping line, and then to the terminal operator in the port of destination, where the third party logistic partner takes over after clearance by customs and utilizes two freight forwarders for respectively scanning and transport to Aalsmeer in the Netherlands in their bonded warehouse awaiting phytosanitary inspection. Then and only then, the consignment is finally given back to the trader who will redistribute the roses to the new owners after the auctioning and processing. In total, the consignment of the roses has crossed national borders **five** times and has been handled and thereby crossed the organizational boundaries of at least **eleven** actors and **seven** authorities. In total, more than **seventeen** actors in form of companies and organizations are involved in the transport of the roses. The overall responsible actor is the trader who on behalf of the growers pays tariffs and also pays for the transport and other services provided by the service providers. In summary, our activity system and organizational boundary crossing analysis reveals that the roses' journey utilizes a rather complex set of organizations for its journey.

The authorities, both in Kenya and in Holland, are required to inspect the roses and performing risk assessments wherefore they like to know the organizations involved and what's inside the container. The exporting authorities in Kenya need to fill an internationally agreed upon phytosanitary form and even so the importing authorities in EU need to inspect the imported flowers upon arrival to EU. Additionally, the authorities demand certain documentation before the transport can be allowed, which is described more in detail in the following section. Both the private companies and the public organizations involved in the international trade of flowers are members of one or more communities in terms of the activity system. The traders in this case belong to a community in form of a cooperative of growers. Otherwise communities in terms of industry associations, collectives, and cooperatives are not directly involved in the shipment of the roses but to some extent provide guidance and connections. The actors, communities, tools, equipment, rules and procedures are located locally in their country except for the international shipping line and only the container (with roses) and related documents are exchanged between the involved organizations.

Having analyzed the global supply chain infrastructure in §2.1 and a decomposition of that into activity systems and boundary crossings (national and organizational) in §4.2 above, we turn our attention to the IT aspects of the phenomena by analyzing the inter-organizational systems and appropriation of affordances of IT-artefacts by individual actors in §4.3 and §4.4 respectively.

4.3 Inter-Organizational System (IOS) Analysis

To repeat, the physical activities related to the movement and transport of the roses in the international supply chain is described in §4.1 and §4.2 above. Findings so far show that each of the physical movements seems in itself to be with the planned speed and according to schedules. However, we find that it is the administrative procedures that result in delays and necessitate a built-in-slack in the supply chain. Therefore, we turned our analytical focus to the administrative procedures with respect to the inter-organizational systems and communications. This was done by analyzing the documentation and information exchanged between the organizations involved in the cut flowers' journey from Kenya to EU. The authorities require documentation both before allowing the export out of Kenya, before loading on a vessel if bound for EU and before the import to EU. Certain documents have to be approved before an action can be performed. For example, before entering the custom area of the port of Mombasa, the Kenyan custom need to clear the container and the content of roses for export, and at least 24 hours before departure of the container (with the roses) on the vessel in Mombasa an Entrance Summary Declaration (ENS) has to be filled to the authorities in EU. Otherwise, they can reject to allow the container's entrance to EU.

The content of the documents are primarily concerned with the goods (in our case the roses) but require the information to be formatted in a specified form. Besides these documents additional

documents are used between pair of actors in the supply chain. For instance, between the trader and the shipping line, seven types of documents are exchanged and two payments are transacted. For four of the seven types of documents mentioned above to be valid, it's required for them to be signed and stamped by authorized officers. As such, only the original of those documents are admitted as valid documents and requires a separate handling and are therefore sent by air courier from Kenya to Europe. On top of the required documents, additional information is required for the individual actor to be able to perform the operations involved. For example, the trader books the shipment with the shipping line and gets a confirmation of it. Another example is that the freight forwarder need a special document to enter the port area in Mombasa and in the port of Antwerp similar information is required to be able to pick up the container. Generally, information is not shared with any of the other actors. Additional documents, see appendix, are involved in the shipment of roses: the actors with the shipping line handles besides the Bill of Lading the following documents e.g. booking, booking confirmation(s), contract, amendment, shipping instruction and invoice plus a number of e-mails.

The relevant documents mentioned above are stored by each actor in their own enterprise information systems. Generally, the enterprise information systems can only be accessed by employees of the actor's organization and are not accessible by other actors. The total number of systems involved is more than **twenty**. This count does not include e-mail, fax or similar information systems. The authorities in both Kenya and Europe have each their set of information systems. The different authorities to a large extent have their dedicated systems. To some extent, some of the authorities' systems have been simplified to one user interface often referred to as a single window system. The documents are filed in at least **five** different systems of the authorities. The other actors also have various information systems which they utilize in connection with the shipment of the roses. Each of the service providers also utilize a range of enterprise information systems e.g. for operation, for customer relation and for accounting. For example, the shipper utilizes at least **three** enterprise information systems and the shipping line utilizes at least **five** enterprise information systems in connection with the shipment of the roses. Very few of the enterprise information systems are capable of communicating electronically with other information systems. For example, the ENS is communicated from the shipping line to the authorities information system Import Control System (ICS) via EDI communication and in return is received a Movement Reference Number (MRN) and possible a "Do Not Load" (DNL) message.

Similarly, the collaboration between the terminal operator at the ports and the shipping line, and the freight forwarder and the shipping line involves some EDI communication of some standard information but they also use additional communication channels. The communication is mainly done via e-mail and ordinary mail/courier for the original versions of the documents plus telephone for ad-hoc issues. The trader has a team of dedicated people for the shipment of roses and their archive folder contains approximately hundred e-mails for the shipment analyzed initially and hereof one third had attachments. Our analysis reveals that the IOS used is peer-to-peer based communication and for some information it turns out to be a chain of peer-to-peer communication where the information is re-typed or copy-pasted from or into the actor's enterprise information system. Interestingly, the operations employees at the trader confronted with those results commented: *"From my view point then it's just part of my daily tasks to answer the incoming e-mails in relation to the shipments by processing it and forward or reply to the e-mail. I never thought about this as a chain of communication."*

The IOS facilitates information forwarding from actor to actor in a communication chain of peer-to-peer communication along the supply chain. It's expected that the main reason for the use of peer-to-peer communication is historical and that the available and possible means of communication have been adopted instead of domain-specific design of IOS. Although the Internet had been adopted for communication recently it is only as a substitute for the older forms of peer-to-peer communication (e.g. e-mail has to some extent replaced fax and ordinary mail/courier).

Our analysis reveals that the individual actor has one or more enterprise information systems for handling needed documentation/information. Besides communication by e-mail and EDI, the actors ad-

ditionally use phone, text message, fax and other channels. This results in a range of fragmented and disconnected information infrastructures which is inefficient compared to having one common, persistent and shared information infrastructure and one communication channel for the IOS. Affordance analysis discussed next outlines the features of the current IOS (with the problem discovery of peer-to-peer communication chain) and specify the features of a future information infrastructure (with the solution proposal for a shared information provision and single communication channel).

4.4 Affordance Analysis

Each of the actors involved in the transport of the roses have their own motivation(s) and perform their own action(s). The growers want to grow and sell their roses preferable to export which is a growth potential for their business. The trader wants to earn profit by offering roses off the local season at a reasonable price and they would like to minimize their risk (e.g. lowering of the quality of the roses due to long lead times or breaking the cold chain). The freight forwarder and the shipping line earn revenues from moving goods primarily in containers and related services. The authorities ensure that the law and procedures are followed, collect tariffs, and minimize security risk. The individual actor performing a particular activity's operations might have additional motives and goals. He or she is the one performing the operations which enables the movement of the roses in the supply chain and/or initiate other actions to be performed by other actors. These actors are the ones that can facilitate or disrupt the flow in the supply chain and the collaboration with other actors by communication or lack of it. Our analysis shows that these actors appropriate a few types of IT affordances namely send, file, update and approve / sign information/documents besides affordances associated with physical activities (deliver, process, transport and inspect) and payment activities. To provide an illustration, consider the IOS set up for the communication back and forth of the packing list used for Bill of Lading (B/L). The packing list for the container / shipment is a major source for filling in the above required documentation e.g. the B/L. The fact that the documents have to be filled prior to the closing of the container means that the source is the "planned" packing list which might be slightly different from what actually is packed in the container. This means that the quality of the information provided in the documents can vary and might deviate from the expectations of the authorities. The communication of the packing list is a chain of peer-to-peer communication: first, the trader / shipper requests the involved growers (in this case **eight**) for their packing list and pro forma invoices which the shipper consolidates to one packing list that is checked, approved and send forwarded to the local freight forwarder in Kenya, who then forwards the content to the international shipping line who utilize a mix of a local office in Kenya and a shared service center in India. In case of the packing list for the Bill of Lading then **five** instances of e-mail communication spread over several days were recorded with at least **five** different people from the shipping line communicating back and forth in the communication chain via the freight forwarder to the shipper and in some cases to the growers. After the stuffing of the container there was no communication of the actual packing list or any correction to the planned packing list. This is also the case for other documents. Primarily, the communication was done by e-mail resulting in hundreds of e-mails in various actors' e-mail boxes. Table 3 below outlines the current affordances of IOS vs. proposed future affordances of information infrastructure.

Inspired by affordances of modern IT applications like Facebook and Dropbox, we propose that an information infrastructure facilitating features as publish, share and follow / subscribe potentially could facilitate a new way of inter-organizational sharing of information and documentation. An initial proposal is sketched in Table 3 in the Appendix but there is a clear need for further research to evaluate the proposal. The proposed shared information infrastructure has nearly the same number of actions and operations and this need to be addressed in future research. Comparing the current IOS and the proposed shared information infrastructure, one of the main benefits is that the latest version of the published documents always will be available to all actors with the rights to view or update them, whereby much of the e-mail communication can be avoided. Additionally the relatively high cost of change of IOS based on EDI (Henningsson and Bjørn-Andersen 2009) is expected to be lowered since the number of interfaces are reduced. The trader is positively inclined towards testing our

proposed shared information infrastructure approach on future shipments of roses. The trader foresees reduced number of communications via e-mail and more efficient handling of the documents and information for shipments in a shared way instead of current reliance on key actors' e-mail accounts. Further, the trader also believes that our shared information infrastructure proposal can help in preventing mistakes such as missing original documents and provide warnings about outstanding payments especially in the case of absence of key actors. Further, the importing authorities, on a trial basis, have opened in their enterprise system the possibility to file a link as part of the filing whereby it's possible for the authorities to be directed via a link to the updated version of the documents (e.g. the real packing list). We acknowledge that the above solution is focused on the structured information and that there is also probably a need for unstructured information exchange which could be facilitated by affordances offered by social media alike Facebook.

5 Discussion and Conclusion

Our revelatory case study of international trade of cut roses from Kenya to EU shows that with regard to the supply chain, the physical infrastructure is quite efficient but for half of the time of the journey the roses are standing still due to built-in-slack times or delays caused by administrative procedures. We find that the cross border related administration is cumbersome and accordingly relatively costly. Informed by activity theory framework, we reveal that the roses' journey crosses **five** national borders and **seventeen** organizational boundaries, with distinct characteristics in form of dedicated primarily local / national actors, communities, tools / equipment, rules and procedures while only the roses (inside the container) with related documents travels across the borders and boundaries. The inter-organizational system (IOS) between the organizations are peer-to-peer communication along the supply chain primarily by e-mail and to a limited extent by EDI messages and a range of other communication channels which results in actors using multiple information infrastructures. One common shared information infrastructure based on modern IT fueled by the internet could potentially improve the current peer-to-peer IOS and offer real-time information to the involved actors similar to the efficient physical supply chain infrastructure.

Informed by Gibsonian affordance theory, we presented a design sketch for utilizing modern IT-affordances on one shared information infrastructure. This, we believe based on our case study results, can enable a more efficient IOS which does not follow the chain-linked organizations of the physical supply chain infrastructure but allow to skip the chain and go directly to the source of the documentation/information (e.g. authorities access to the real packing list from when the container was closed and sealed at consignment completion point). We foresee that the proposed shared information infrastructure can improve the flow in the supply chain, reduce delays, reduce the built-in slack, decrease the amount of administrative work (e.g. to forward, update and re-type information), and reduce the number of inspections based on improved data quality by providing access for the authorities to updated source data, which eventually will reduce the international trade cost and at the same time potentially increase security. In summary, below are the current aspects of and issues in international trade of cut roses from Kenya to EU of which some can be addressed by the proposed shared information infrastructure:

- a. The roses cross multiple borders and a complex set of opaque organizational boundaries
- b. The authorities inspections and scans are performed both by exporting and importing nations authorities They demand a range of documents to be filed prior to movement of goods
- c. The administrative burden is rather high and costly
- d. The lead time and the slack built into the international shipping is several days for each port
- e. Multiple enterprise information systems are utilized by individual actors and not shared
- f. The IOS facilitates peer to peer communication only, which means no one has visibility e.g. of the actual location of the container or updated version of documents / information available

The primary theoretical contribution of the paper is the combination of four separate theories to propose a solution addressing both the high level overview and the low level details needed for designing and building an IT solution. Administrative issues, among a few others, are the main barriers preventing improved efficiency for international trade of flowers. Our proposal to use features of modern information technology to address the above revealed issues for the journey of the fresh cut roses is an alternative to the currently IOS in use which primarily is based on e-mail and some EDI communication. As Robey et al (2008) points out, IOS procurement decisions have moved from organizational to market-driven whereby the cost is the major driver for the actors preference of IOS. We claim that IOS could move further by lowering the cost by utilizing the benefits provided by the modern IT' affordances. We acknowledge not only the benefits of our proposed approach (e.g. lower transaction cost and real time information) but also some concerns (e.g. about trust and governance).

The secondary theoretical contribution is the application of affordance lens and definition that is in line with the enactive view in the philosophy of mind in general and ecological psychology in particular (Vatrapu, 2010). The definition of affordances as both "action-taking possibilities" as well as "meaning-making opportunities" relative to actor competences and system capabilities not goes beyond the current understanding of affordances in IS as solely action potentials (Davern et al., 2012; Pozzi et al., 2014; Treem & Leonardi, 2012) but also highlights the importance of the skills and competences of the actors involved and the capabilities and features of the systems used. In the domain of international trade, as shown by our case study, the affordance analysis uncovers the multitude of actions, meanings, actor competencies and system capabilities and problems with their current configuration. The design solution then can target one or more of the four elements in that configuration. Further, our analytical combination of activity theory framework analysis and ecological affordance analysis can be situated within recent theoretical work that provided an activity theoretical interpretation of affordances (Kaptelinin & Nardi, 2012).

The proposed IT solution can be characterized as an information infrastructure but one different from the standard EDI message based inter-organizational systems. We note that Hanseth and Lyytinen (2010) do not separate the type of communication in the information infrastructure since they have both business/industry EDI based IOS and the internet as examples of information infrastructure. We find that the concept of communication makes a crucial difference between the EDI message-based IOS and the proposed IT solution. Similar we find that the degree of standardization are very different for the information infrastructure for IOS by utilizing highly standardized EDI message and the "internet" for shipping information which like the web has very limited standardization required and none for the detailed information communicated. If the proposed IT solution is successful then it can become a new type of IOS and compared to the existing the EDI message-based IOS it's expected to be less costly or even free. Therefore, a successful demonstration of the proposed shipping information system is expected to be adapted rapidly by many of the organizations in the supply chain for international trade and might even be adapted by other business eco systems.

We acknowledge the limitations of our case study in analyzing just one shipment in one trade lane of fresh cut roses between two nations and only considering the supply chain (and not the related financial transactions). That said, our case study reveals results that we foresee to be applicable to international trade in general since it follows the same supply chain infrastructure and utilizes the same type of service providers and have to pass the same type of authorities (except for the phytosanitary inspections which do not apply for general cargo) which performs the same type of activities and affordances utilizing similar or even the same enterprise information systems and IOS. Therefore, it's reasonable to claim that international trade can potentially benefit from utilizing shared information infrastructures with modern IT-affordances. Of course, this claim needs to be further evaluated by future research. Our current and future work is focused on an evaluation of the potential use of features supporting modern IT affordances as a complementary means of communication compared to the existing IOS peer-to-peer email communication.

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Appendix A: Ten Most Important Required Documents

The ten most important required documents for the trade lane of fresh cut flowers from Kenya to European Union

1. Export declaration* filled by exporter which is the trader for the roses
2. Pro forma invoice filled by the growers and the trader (used by authorities to calculate tariffs)
3. Phytosanitary certificate for export*⁴ filed by a service provider for the exporter / trader on behalf of the growers
4. Certificate of origin* filled by a service provider for the exporter / trader on behalf of the growers
5. EUR1 Movement Certificate filled by the service provider
6. Bill of Lading (B/L)* filled by service provider(s) for the exporter / trader on behalf of the growers
7. Entry Summary Declaration (ENS) filed by shipping line 24 hours prior loading at port
8. Arrival Notification (AN) filed by shipping line upon arrival at port of destination
9. Import declaration filled by a service provider for the importer / trader on behalf of the growers of the roses⁵
10. Plant Health Movement document filled by a service provider for the importer / trader on behalf of the growers

* Original(s) with stamps and signatures are required

Appendix B: Inter-Organizational Systems: Current v Future Schematics



Figure 1. Current Schematic of IOS Communication following Supply Chain of Fresh cut Roses

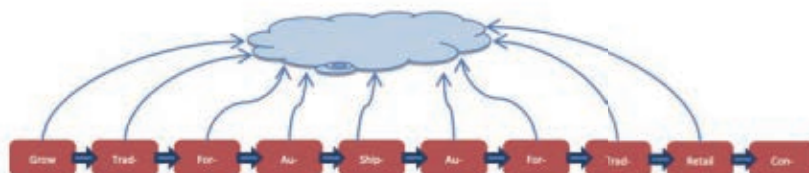


Figure 2. Future Schematic: IOS Communication utilizing Modern IT Affordances

⁴ According to EU regulation

http://ec.europa.eu/food/plant/plant_health_biosafety/trade_non_eu/docs/declarations_phyto_certificates_en.pdf

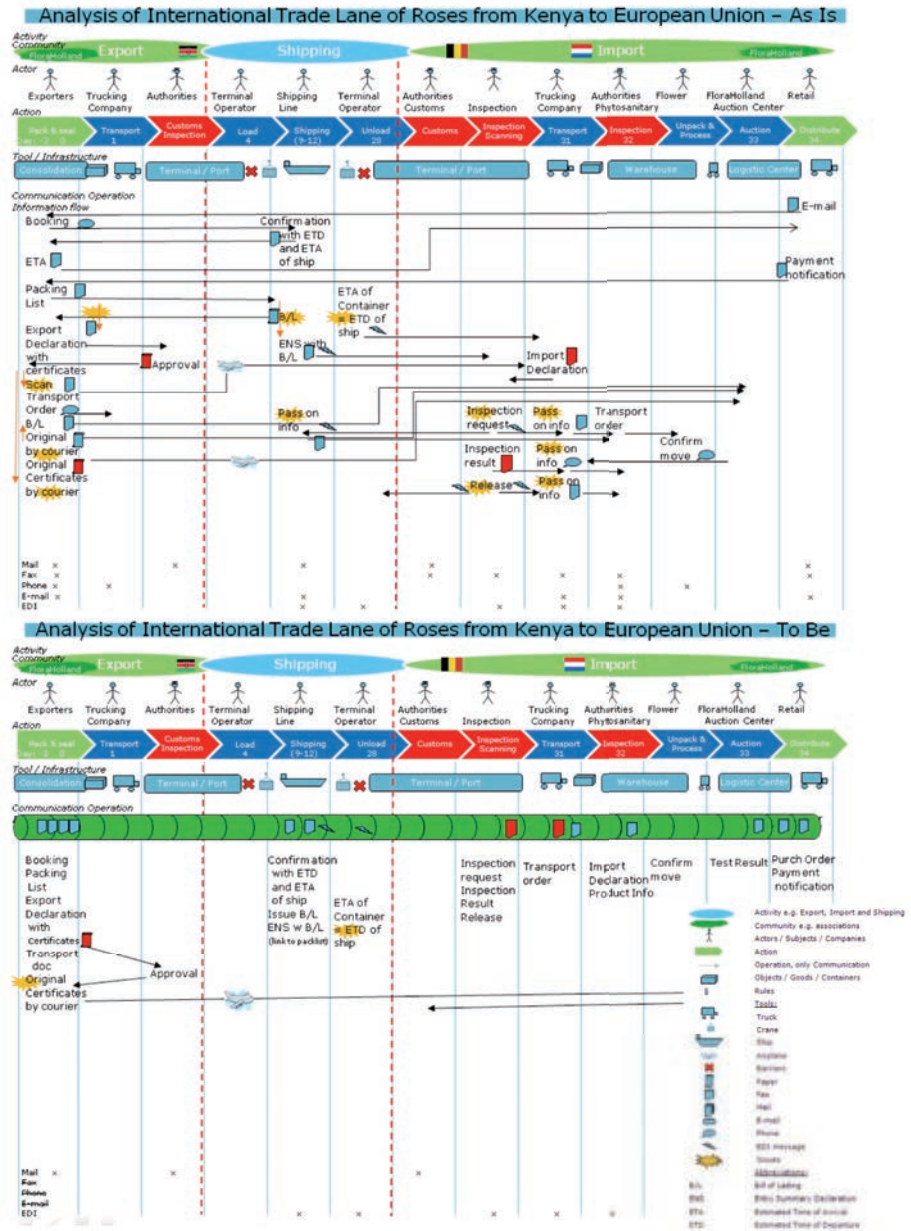
⁵ Fresh cut flowers from Kenya to Netherlands applies a import tariff of 8.5% (code 060311) <http://exporthelp.europa.eu/>

Appendix C: Affordances for Actors: Current v Future

Actors	Current IOS Affordances	Future Shared Information Infrastructure Affordances
Growers	2 <u>Send</u> confirmation of delivery with packing list and pro forma invoice 10 <u>Deliver</u> roses	2 <u>Publish</u> packing list and pro forma invoice 10 <u>Deliver</u> roses
Trader	1 <u>Send</u> request for deliveries 3 <u>Send</u> request for shipping 5 <u>Send</u> request for transport 7 <u>Send</u> packing list and pro forma invoice(s) 11 <u>Process</u> roses and <u>seal</u> container	1 <u>Send</u> request for deliveries 3 <u>Publish</u> request for shipping and container 5 <u>Publish</u> request for transport 7 <u>Publish</u> packing list and pro forma invoice(s) 11 <u>Process</u> roses
Service provider	6a <u>Send</u> confirmation of transport 8 <u>Send</u> forward etc. the packing list, pro forma invoice(s) and B/L 8a <u>File</u> export documents 8b <u>Send</u> request for inspection 12a <u>Transport</u>	6a <u>Publish</u> booking of transport 8a <u>Publish</u> export documents 8b <u>Publish</u> request for inspection 12a <u>Transport</u>
Authorities	12b <u>Inspect</u> roses and <u>seal</u> container 12c <u>Sign</u> documents for roses exported and seal 12d <u>Set</u> message for export to allow entre customs area	12c <u>Subscribe</u> and <u>Accept</u> / digital sign documents for roses exported 12d <u>Subscribe</u> and <u>Publish</u> permit message for export to allow entre customs area
Transporter, Terminal operator, Shipping lines	4 <u>Send</u> booking confirmation 9 <u>Send</u> back B/L etc. 10 <u>File</u> import documents e.g. ENS via EDI 13a <u>Transport</u> 13b <u>"Hand over"</u> when invoices are paid and presented with original B/L	10 <u>Publish</u> import documents e.g. ENS via EDI 13a <u>Transport</u> 13b <u>"Hand over"</u> when status is invoices paid and key provided
Authorities	14a <u>Issue</u> MRN / DNL message 14b <u>Scan</u> container 14c <u>Set</u> message "permission to remove" for import 14d <u>Inspect</u> roses 14e <u>Set</u> status "permission to move inside EU"	14a <u>Subscribe</u> ENS and <u>Publish</u> MRN / DNL message 14b <u>Scan</u> container 14c <u>Publish</u> message "permission to remove" for import 14d <u>Inspect</u> roses 14e <u>Publish</u> "permission to move inside EU" message
Service provider	6b <u>Send</u> confirmation of transport etc. 8c <u>File</u> import and movement documents 8d <u>Send</u> notification to inspection 15 <u>Transport</u>	6b <u>Subscribe</u> and <u>Publish</u> accept booking of transport etc. 8c <u>Publish</u> import and movement documents 8d <u>Publish</u> notification to inspection 15 <u>Transport</u>
Trader	16 <u>Pay</u> service providers and tariffs 17 <u>Send</u> message to growers 18 <u>Process</u> roses 19 <u>Pay</u> growers	16 <u>Pay</u> service providers and tariffs 17 <u>Publish</u> message to growers 18 <u>Process</u> roses 19 <u>Pay</u> growers
Retail Consumer	20 <u>Send</u> request for transport 21 <u>Transport</u> to stores / consumers	20 <u>Publish</u> request for transport 21 <u>Transport</u> to stores / consumers

Table 3. Affordance operations and types (underlined) with sequence numbering for international trade of fresh cut roses journey from Kenya to Europe. The physical ones are with bold text.

Appendix D: IOS: Current v Future Illustrations



Paper 4 Cloud solutions for the shipping ecosystem pose new opportunities

Cloud solutions for the shipping ecosystem pose new opportunities

Research

Abstract

This paper is a response to two quests for IS research formulated by Professor David Avison. First, it is an Action Research project actively describing how substantial societal benefits can be achieved. Second, it is a paper, which does not follow a rather futile attempt to develop theory in each and every paper, but excels through providing solutions to global problems. This is done by providing insight into initiatives, which will enable a dramatic inter-organisational re-engineering of the complex global containerised supply chain ecosystems for international trade carried by sea. What few realise is that up to 40 organisations can be involved in a particular shipment and that most communication is based on phone calls, e-mail or at best EDI exchanged between two organisations, meaning that up to half of all documents are seriously erroneous. This paper proposes using a cloud solution for sharing shipping information and accessing detailed information directly from the originating organisation. In essence, this provides an opportunity for re-engineering the supply chain management for international trade. The paper presents an analysis of the extremely complex current situation and proposes a radically new cloud based solution enabling re-engineering. To pursue opportunities, a new course needs to be set that would require a new mind-set for all organisations involved in global supply chain management in general and in containerised international trade in particular.

Keywords: Action Research, Inter-Organisational Systems, Information Infrastructure, Maritime Informatics, International Trade

1. The quest for actionable and valuable IS research

Professor David Avison has been one of the globally leading IS researchers for several decades, and he is one of the European researchers, who are spearheading a move to address the growing problem of IS research becoming less and less valuable due to our constant pressure to publish or perish. Unfortunately this development is taking IS research further and further away from its roots and even more importantly, further away from contributing to any of the three stakeholders, students, industry and society. We shall especially mention two of his key contributions to getting IS research back on track and increasing its value.

Firstly, David Avison has argued very strongly that we should not ALWAYS strive for theory (Avison & Malaurent, 2014). What is wrong with analysing and understanding the first fascinating applications of new technologies, the deep insights in fundamental processes, the exciting thick descriptions so useful for enabling learning of our students, or the important insight that will solve global warming? In most cases, we learn more from ‘strong’ cases than from weak theories. After all, there are no general theories in Social Science. We need to face the fact that IS is fundamentally a social science, not a natural science. By all means, if we have found generalisable patterns, and if our data allows us a reasonable basis for generalisations, let’s celebrate the theory. However, the value of most IS theories in our celebrated journals are at best a mirage, a theory about something very specific which will never be used by anybody. At worst so-called IS theories are a con trick performed by researchers to get editors to accept papers. As Avison and Malaurent (2014) write, it is a fetish. Most of the valuable IS research does not lend itself to generalisations in the form of theory. It is fundamentally wrong to search for non-existent theories. We strongly support this view, and this article is a good illustration of this perspective.

Secondly, our paper is a tribute to David and his great interest in Action Research. His most cited paper on this topic is just called Action Research (Avison et al., 1999). This is a very short paper, which is published in a tier 2 type journal (graded on an academic scale). However, it is an excellent and spellbinding paper, which has been cited 1386 times. This in itself shows the value. Just like David, we believe that Action Research is important especially because “the emphasis is more on what practitioners do than on what they say they do.” (ibid.). Accordingly, we have used Action Research as the methodology for this research. Further, the research is part of a research program, which is likely to have huge implications, as it is taking us a large step towards solving the extremely complex tasks of managing more effectively the huge processes involved in the maritime ecosystem for international trade.

2. Introduction to the Shipping Ecosystem

International trade is vital to the global economy. Growth in international trade fuels economic growth in the countries and regions taking part in international trade, the volume of which has been steadily increasing since the end of World War II. Approximately 80% of the international trade volume is carried in containers by sea. Millions of containers on thousands of vessels serve international trade, carrying goods around the globe in a complex network; for example, Maersk Line has around 600 vessels calling into one of the 276 ports served every 15 minute around the clock. The largest container vessels can carry more than 18,000 containers, where the documentation for one container can be as much as 200 pages.

The challenge is that the supply chain for international trade crosses multiple organisational boundaries and national borders. While the physical infrastructure is rather efficient, the information infrastructure is still traditional, very fragmented and poorly standardised,

utilising a huge variety of paper based, phone based and electronic communication channels. Traditionally, organisations are IT (Information Technology) islands, optimising their IT operations within the organisational boundaries, typically using proprietary IT solutions to perform their operational tasks and utilising standard communication solutions such as e-mail. The IT solutions can cross organisational boundaries, e.g. by providing web page interfaces for partners, enabling, for example, a shipper or a service provider to access information directly from the organisation’s IT system e.g. The Authorities’ Single Windows system (Tan et al., 2011).

However, in the complex inter-organisational supply chain ecosystem, consisting of many trade lanes crisscrossing each other, there is a huge degree of sub-optimisation and losses in overall effectiveness. Everyone is trying to optimise relationships with immediate partners, with little concern for overall effectiveness of the whole ecosystem. In fact, some organisations live from the information asymmetry and exploit information monopoly situations. It is estimated that the annual worldwide extra costs due to administrative burdens of crossing borders are in the range of \$257 billion (United Nation ESCAP, 2014).

One of the main reasons for this is that crossing international borders presents costly barriers. There are two main determinants of the trade cost for goods: (a) the production price in the local export market, which is lower in exporting country than importing country and (b) the international trading cost, which is the transportation cost and cost related to crossing borders. As illustrated in Figure 1, the costs for general international trade cargo can be broken into the following categories: 1/3 product cost at local export market + 1/3 retail distribution cost in imported country + 1/3 international trade cost. This paper focuses on the latter 1/3 international trade cost roughly broken down into 1/3 physical transportation cost and 2/3 administrative costs accrued from barriers when crossing borders (J. Anderson & E. van Wincoop, 2004). The fact that administration cost is double the physical transport cost supports our claim that international trade is relatively costly. Analysis of activities allows us to understand and explain the cost by the number of activities, missing or erroneous information, and different types of delays and risks (Jensen et al., 2017). Based on our findings, we purport that international trade is generally inefficient. Accordingly, we foresee a potential for improvements, especially using IT, since the majority of the cost is related to administration.



Figure 1. Breakdown of retail cost for general goods in international trade.

Our journey using the cloud for sharing shipping information started in 2006 with various partners attempting to re-engineer inefficient practices. In order to improve the situation, the European Union (EU) sponsored a number of research projects addressing the challenges related to international trade identified in this paper. The most important projects that (a) address the sharing of data among organisations in the ecosystem for international trade and (b) analyse the potential benefits for organisations involved by utilising advanced IT for

international collaboration are the following major EU sponsored projects: ITAIDE¹⁰⁵, Contain¹⁰⁶, Integrity¹⁰⁷, Cassandra¹⁰⁸ and iCargo¹⁰⁹. The CORE¹¹⁰ project is the latest and ongoing research project with more than seventy engaged partners/organisations (shippers, freight forwarders, shipping lines, customs, universities, IT vendors and consultants). In some of these projects, prototypes of solutions have been developed to demonstrate information sharing, including using containers with communicating sensors. We have also seen tests and evaluations of the prototypes in living labs for single trade lanes, thus providing insights to possible solutions and organisational set ups. The results have been a range of prototypes tested on real shipments to demonstrate possible solutions. Most have been a success; however, none has been realised beyond the prototype stage. It seems that the managerial challenges far exceed the technical implementation challenges.

3. Traditional Information Exchange Shipping Avocados

To understand the status of the supply chain for international trade, we take the example of following the export of avocados from a farmer in East Africa to a retailer in Europe. This is shown in Figure 2, where the different organisations are shown at the top of the figure, with lines indicating the different exchanges of information.

The journey starts with the farmer harvesting the avocados, after which they are transported on a pickup truck to processing and packaging in Nairobi (Jensen et al 2014a). Upon arrival of a refrigerated container to the local warehouse, approximately 100,000 avocados are loaded into the container, after which the container is sealed. The container is then trucked 500 km to Mombasa Port, where it awaits a container vessel. Via transshipment in Oman, the container arrives in Rotterdam Port, from where it is trucked to a warehouse for unloading and later retail redistribution.

The analysis of the trade lane from East Africa to Europe shows that for each shipment (like the one container with avocados) several hundred pages of documentation are exchanged primarily via e-mail and only five to ten chunks of information/documents are exchanged via Electronic Data Interchange (EDI) based Inter-Organisational Systems (IOSs). The journey for the avocados is costly in time and administration. It takes approximately 30 days, with crossing the ports at the national borders accounting for approximately 3-5 days at either end. More than thirty organisations are involved and the absence of one of the more than thirty documents can hold back the avocados on their journey in the container. Several of the documents need to be signed and stamped to be valid, after which they are sent by courier, following a route different from that of the container. We shall not go in detail with all the activities in Figure 2, since we hope that most of it is self-explanatory, and more important, it is mainly shown here to illustrate the high complexity and the many activities. One issue we would like to highlight in the figure is the five lines in the bottom of the figure. This shows that e-mail, and phone are used extensively for the exchange of information, and it is characteristic that these are not digitally integrated and stored for re-use or documentation.

We mentioned above that the administration is very costly, causing delays and uncertainty in the supply chain, where no one knows exactly where the container is. Accordingly, buffers

¹⁰⁵ www.itaide.org

¹⁰⁶ www.containproject.eu

¹⁰⁷ www.integrity-supplychain.eu/

¹⁰⁸ www.cassandra-project.eu

¹⁰⁹ www.i-cargo.eu

¹¹⁰ www.coreproject.eu

Within the last decade, EU authorities and WTO have aimed to harmonise their electronic interface into a single entry point named a single window solution¹¹¹. However, the current implementations are meeting resistance and lack of adoption. More advanced organisations are electronically linking up not only with their immediate trading partners (suppliers, customers and service providers handling outsourced tasks such as logistics and office services) but also with authorities (e.g. customs, port authorities and inspection agents) using, for instance, Electronic Data Interchange in addition to conventional communication systems such as courier mail, e-mail, fax, messages and phone. In these situations, organisations with a large number of transactions are typically working on optimising their interaction with their immediate partners by implementing bilateral Inter-Organisational Systems (Kaniadakis & Constantinides, 2014), thus achieving some improvement in productivity. However, the systems are often incomplete, they are quite costly, and they have to be augmented with e-mail, phone calls, SMS, etc. Organisations with a lower number of transactions typically do not even utilise EDI based IOSs. They depend on other means of communications, and the average organisation has hundreds of e-mails as part of their daily operation. Figure 3 shows examples of the existing, very complex, communication patterns in the existing ecosystem.

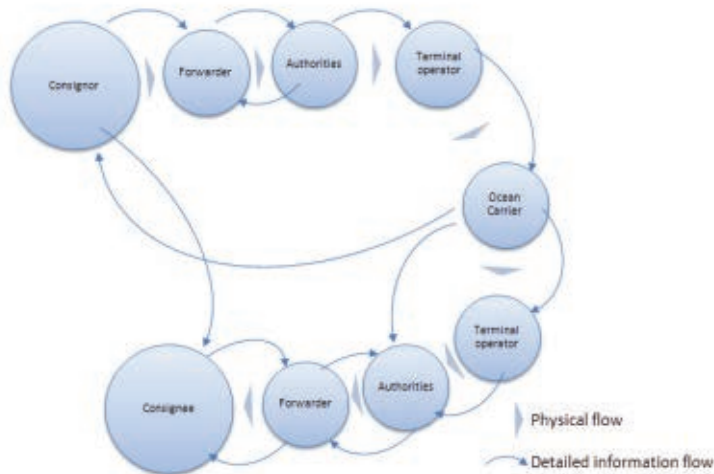


Figure 3. Existing communication pattern, where the detailed information follows the physical flow in the supply chain for international trade, and where all organisations are limited to the use of bilateral communication.

We have identified current solutions enabling sharing of information among multiple organisations utilising bilateral communications. However, within international trade, these solutions are either rather expensive or have a limited scope with regard to organisations/regions served (Reimers, Johnston, & Klein, 2004). For example, most large seaports have port community systems e.g. TradeNet used by the port community in Singapore (King & Konsynski,1990) and Portbase used by the port community in Rotterdam (Jensen et al 2014b) using IOSs based on local standardised EDI messages. However, every organisation is often only using a subset of the systems, and most systems are only available for organisations with local operations at that particular port. Furthermore,

¹¹¹ Single Window means that all actors will see the same information enabling better communication in the ecosystem.

systems are often relatively costly (Henningsson & Henriksen 2011) and, in most situations, they are subsidised.

Shipping lines, such as Maersk Line, are able to optimise a substantial chunk of the supply chain. However, both in the case of the port operator and the shipping line, the full supply chain is not covered. Furthermore, information exchange is typically based on EDI messages according to local standards for harmonised data, and they are often enforced by local authorities exploiting their monopoly situation. There are also a few solutions where IT vendors facilitate international exchange of information with a dominating market position in certain regions, but none has global coverage. Additionally, a few of the largest transport service providers offer the service to facilitate and exchange shipping information, but they are utilising their proprietary data formats, and they do not harmonise at an international level. In summary, the solutions offered are not only very fragmented but relatively costly and exhibit a lot of redundant and time consuming activities.

5. Future dedicated Shipping Information Cloud for Sharing Information

As an alternative to the plethora of bilateral communication, modern cloud-based IT provides opportunities to collaborate and share information worldwide across multiple organisations. Our research explores the possibilities of utilising a cloud and other modern IT for sharing information that could substantially improve the effectiveness of the trade lanes for the global ecosystem for international trade. In this way, we can say that we are responding to the request by Tilson et al (2010) for research regarding information infrastructures. We are following design guidance by Hanset and Lyytinen (2010), and we propose to develop a global cloud solution dedicated to shipping information. We name it ‘shipping information cloud’, where it is possible for ‘any’ organisation to join and offer services through Application Program Interfaces (APIs). The intention is to build the cloud solution on top of the World Wide Web/Internet, utilising the Internet for sharing international shipping information and documentation. Figure 4 illustrate the communication pattern in such a cloud based solution. The proposed cloud based solution shares only essential event information such as Estimated Time of Departure/Estimated Time of Arrival and other relevant events. Accordingly, the standardisation needed is minimised, it is intended to be free of charge (by purely utilising communication via the Internet) and will hopefully be attracting all types of organisations engaged in collaborative shipments in the supply chain for international trade. The new proposed solution complements the existing exchange of information, and the ambition is to provide a communication channel facilitating both the informal and the formal detailed information through one shared cloud. Only metadata and the URI¹¹² are exchanged via the cloud. The communication can be encrypted to ensure privacy. The URI points to a resource for more detailed information, e.g. a web service, a web page or a document accessible via the Internet. A wide variety of organisations can offer a range of web services and apps. The metadata for sharing shipping information initially contains the container ID and event information with date/time, location, and type of event, e.g. a container cleared for import. The event information will be immediately updated as soon as a new event occurs and in that way all organisations will be able to act on the latest information.

¹¹² URI Uniform Resource Identifier is the Uniform Resource Locator (URL), frequently referred to informally as a web address. See https://en.wikipedia.org/wiki/Uniform_resource_identifier

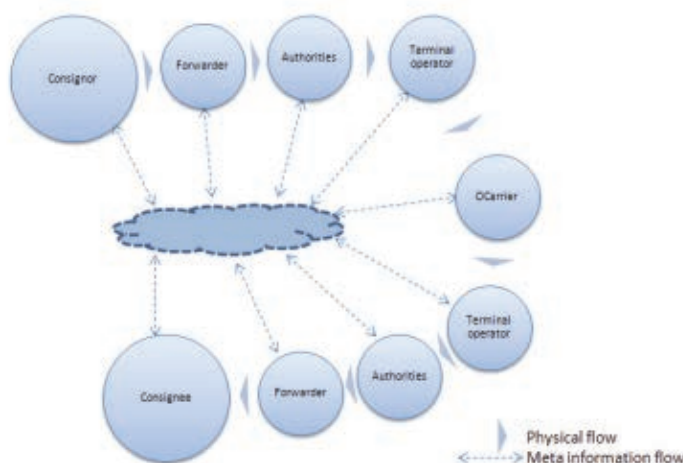


Figure 4. *The full implementation of the proposed solution using the shipping information cloud to share meta information.*

In the future, this proposed cloud solution for sharing shipping information (Figure 4) will mean all organisations will be communicating meta-information to the cloud, not to the immediate next organisation in the physical flow. Meta-information provides visibility, and it is worth noting that the meta-information are sufficient for coordination of the physical flow, given that the ecosystem has sufficient trust. For instance, many of the existing organisations in the ecosystem do not need to know detailed information e.g. regarding the contents of the container. Actually, we shall argue that over and above the original shipper and the recipient, only the authorities need to be able to check the detailed information, and it is best done utilising information/documents directly from the original source.

With the large, complex and geographically distributed ecosystem, we do not see any possibility for all organisations to agree on a detailed standard for data exchange and associated solutions, unless world bodies, e.g. the UN, were to pave the way¹¹³. Certain public organisations (having responsibility for customs, veterinary inspections, security, immigration, etc.) could demand certain solutions to be used within their country/region, but these would only cover part of the ecosystem, and it would likely conflict with (or at least be different from) what other organisations in the global ecosystem might demand. Furthermore, public organisations have been reluctant to provide solutions for various reasons, including the lack of funding or the risk of being criticised for hampering economic growth by adding costs to industry. Finally, within the ecosystem, some of the organisations compete strongly, and if a single organisation tries to push for a certain solution, there is a high probability that competitors will reject the adoption of that solution.

Addressing the very diverse and, to a large extent, unknown requirements, we propose an agile development approach, starting with a simple solution for one trade lane and then evolving to a global scale from there.

¹¹³ Acknowledging that limited set of ocean specific standards for international trade already exist e.g. UN/EDIFACT <http://www.uncece.org/trade/untidd/texts/unredi.htm>. However, practical adaption and usage prolong.

The starting point for developing what we have chosen to call a shared shipping information cloud is not unlike that of the underlying Internet and WWW, where the common TCP/IP protocol allows highly flexible and dynamic opportunities for exchanging information. Such a cloud enables everyone to offer new services and communicating, more or less, with everyone else.

To enable such a dedicated cloud, we suggest establishment of the following general principles:

1. Shared simple de facto standard messages (containing only a set of meta-information and no detailed information, as details cannot be shared for competitive reasons).
2. Multiple electronic dedicated clouds for shipping information will co-exist in different parts of the world. For the clouds to work internationally on a global scale, it is necessary to have one virtual cloud consisting of many integrated clouds.
3. System-to-system connection based on Web services and APIs for adding new services.
4. Formalised and standardised procedures for gaining access to specific information and who might be in a position to grant this access. Federated data dictionary identification and authentication of organisations (users).
5. Access provided based on the ‘friend of a friend’ principle¹¹⁴.
6. No shared database, e.g. containing detailed information such as contents of a container. This will typically be stored only at the document storage of the shipper.
7. Documents/detailed information should be stored and governed by the originating source, and should potentially be accessible to all those who have legitimate rights to obtain access;
8. No standardisation required for the detailed information/documents, any format is acceptable.

Private organisations in the ecosystem are competing and reluctant to share information. Similarly, authorities are reluctant to share information regarding security but, at the same time, they are eager to get quality information on which they can base their risk assessments. To address the need for information and the unwillingness to share information, an alternative to the traditional EDI based interchange of harmonised data/information is proposed. In this scenario, organisations can subscribe to receive notification when a certain type of information is available (for instance vessel arrival at port). The exchange of the detailed information can be left to a bilateral communication between the organisation interested and the organisation with the source information. In this way, only limited metadata is available in the shipping information cloud to enable the organisations interested in being notified of the existence of the information (Jensen and Vatrapu 2015). Only encrypted metadata will be exchanged via the dedicated cloud. The source organisation transfers the encrypted metadata information (and URI link) to the dedicated cloud, which then forwards the encrypted metadata information (and URI link) to the organisations that subscribe to this type of

¹¹⁴ ‘Friend of a friend’ principle means that if one organisation provides information to another organisation they trust, this second organisation can communicate to a third party that they trust. In this way, all three organisations share trust.

information. It is a prerequisite that both the publishing and subscribing organisations are authenticated to share meta-information via the cloud.

Standardisation efforts have been taken by various bodies (such as the United Nation and World Customs Organisation, as well as by individual regional and country authorities) towards harmonising the data interchanged e.g. utilised for statistics. Even so, the information exchange via EDI is rather limited compared to the information in use, that is, a few large organisations use EDI based interchange of data, but the main part of the communication is via paper, e-mail and a range of other communication channels. Instead of the ambitious harmonisation of data sets, the idea with the cloud is to share limited but enough metadata, e.g. estimated time of arrival, possibly with a link to more detailed information at the source. The link enables the interested organisation to request access to the information at the source, and if the organisation managing the source is authorising or granting access, the requester can be granted access, for instance to read the detailed shipping information according to the governance given by the source organisation. No standardisation is required for the detailed information/documents, any format works and by limiting the standardisation to the required small set of meta-information, the barriers to exchange will become lower. This will increase digitised international exchange, and we would see a substantially higher rate of adoption covering more information and documents.

6. Comparison of the three types of information exchange

The characteristics of our proposed solution is shown in Table 1 below, where we compare 1) traditional information exchange with 2) IOS solutions based on EDI and with 3) our proposed cloud-based solution allowing governed access to all digitised information/documents.

The traditional information exchange is exemplified in the above description of the avocados' journey and involves a range of different communication channels. The IOS based on exchange of highly standardised information utilising EDI is described above, and it is generally regarded as best practice within the ecosystem. However, that design can be vastly improved, and our shipping information cloud is the proposed solution utilising modern IT described in detail above.

The benefits of such a shipping information cloud variously affect private and public organisations involved in the supply chain for international trade. The benefits can even affect the administration at a country level.

First, private organisations can expect to experience the shipping information cloud improving not only the possibilities for more efficient logistical coordination but also lowering the different types of risks. This, in turn, will substantially reduce international trade costs, since the administrative border related part of international trade costs amounts to no less than 20% of total retail cost. These administrative costs could be dramatically reduced with the introduction of the shipping information cloud. In addition to the immediate savings, the traders, shipping lines and other organisations expect that lower international trade costs will increase trade volume, resulting in more business, especially for first movers capable of leading the overall re-engineering efforts.


Characteristics	Type of information exchange		
	Traditional	Inter-Organisational Systems	Shipping Information Cloud
Media, examples	Paper based, telex, fax, phone, e-mail	Electronic Data Interchange (EDI)	Events including EDI messages and other electronic messages
Formalisation of data/information	Non-formalised (Except standards regarding the communication)	Formalised (Based on e.g. ISO UN/EDIFACT standards)	Formalised metadata / information (ID and events) and links to document or web service
Degree of standardisation	No standardised information	Highly standardised data	Only IDs standardised globally
Use	Simple and easy	Complicated set-up and mapping of data	Simple and easy
Access	Inclusive Push	Exclusive Typically push	Inclusive Both push and pull
Electronic usage	Rather limited	EDI typically only used by organisation with large volume of transactions	Cloud-based for meta-information and bilateral for detailed information
Communication channel	Ad hoc communication channels	Variety of bilateral communication channels	Internet/cloud
Communication pattern	Peer-to-peer communication	System-to-system communication via service provider	System-to-systems communication via cloud for metadata and direct communication for detailed information
			
Private/public access to data/information	Private communication between persons in organisations	Private communication between organisations' systems	Public for some events (public available today) and private (encrypted) for other events
Coverage	Proprietary	Regional (in praxis for international trade: limited communication between continents)	Global One truth direct from the source
Price/Cost	Ordinary mail, and courier is expensive Electronic is less expensive	Prices initially based on ordinary mail Set up and changes/ maintenance costly	Basic service is free of charge and additional services can be charged Premium ¹¹⁵ model

Table 1. Comparison of information interchange: The traditional, the IOS based on EDI messages, and the proposed cloud-based solutions with governed access.

¹¹⁵ Premium model combines Free of charge services and possibility for charged Premium services as for instance used by LinkedIn.

Second, public organisations can also expect substantially improved data quality of information and much higher availability because detailed information/documents will be available directly from the source as soon as they are created/uploaded. This will substantially improve the possibilities of addressing issues such as security, health inspections, illegal emigration, safety and customs' evasions. Authorities will be able to improve their risk assessments, increase the probability of identifying fraud, improve accuracy for the calculation of tariffs, etc. We foresee that the digitalisation of information in the global containerised supply chain for international trade will catalyse a change process of optimisation and risk leveraging re-engineering.

Third, at country level, optimisation of the supply chain for international trade by utilizing the proposed shipping information cloud provide substantial societal benefits lowering the administrative barriers is likely to increase trade and Gross Domestic Product (GDP) significantly. For comparison, the World Economic Forum estimates that applying halfway global best practice to the lowest half will result in increased GDP of 5%. Such improvements are important, especially for developing countries like in East Africa (Sub-Sahara), where a similar estimate predicts an increase in GDP by 12% if applying halfway global best practice.

7. Implementation Challenges for a Shipping Information Cloud

To be successful, the new proposed cloud solution for sharing shipping information must be adopted by a large number of the organisations involved in the full ecosystem consisting of all supply chains of international trade. We believe it will, because, compared to today's situation, it will provide real time/updated information directly from the source which improves information quality, and the costs are going to be negligible compared to the current administrative cost.

Furthermore, the implementation of such a shipping information cloud will substantially reduce the number of errors (e.g. typing errors from re-entering information) and it will improve security risk assessment for protection of public interests. By enabling transparency of the status of the container/shipment and related information/documentation, providing visibility outside the current visible horizon (Carter et al 2015), supply chain coordination of the following activities is greatly eased. Accordingly, it will be possible not only to reduce the buffers and time delays built into today's supply chains, but it will also enable faster corrective actions to be taken. Overall, this will result in reduced international trade costs, leading to increased trade volume and increased revenue for the businesses involved.

The current complex ecosystem of international trade involves multiple organisations for a single shipment including both private businesses and public organisations. All stakeholders express positive attitudes towards implementation of shipping information cloud for the supply chain for international trade, but it is also clear that most of the private organisations are worried about their own competitive position, and without the cooperation of (almost all of the) major organisations, implementation of the shipping information cloud is not possible.

For private organisations, the paradox is that, on the one hand, the willingness to share shipment information is of crucial importance for success; on the other hand, sharing of information might compromise one's own competitive situation, especially for private organisations currently exploiting information asymmetries. For public organisations, the problem is that they need an increasing amount of information, both from private and public organisations in order to oversee security, trade regulations and customs. The result is that in many situations the information demanded might not be available from anyone, may be

delayed, or only available in poor quality. This represents a huge loss of optimisation potential, increased costs and potential security risks.

Large enterprises, e.g. Wal-Mart, have established standardised communication for the information related to their supply chain for international trade, gaining high transparency and high effectiveness in their supply chain. They require their suppliers to provide the information in the standard format and utilise technology to ease the capturing of data, e.g. barcodes, RFIDs, etc. The large enterprise holds the central database with all the trade data/information. In this situation, the central '300 pound gorilla' is calling the tune, and everyone else either has to conform or stop taking part. However, this is not the characteristic of most supply chains.

We believe that with relatively minor modifications these projects can be integrated into the shipping information cloud proposed in this paper. In addition, even though it is not possible to identify all elements of the information shipping information cloud, a number of key features are identified that illustrate the potential challenges and opportunities.

8. Re-engineering Opportunities

Even though everyone in the international trade ecosystem is positive towards a solution for sharing information/data and expects substantial benefits, none of the organisations has taken the lead. One of the reasons is that the organisations in the ecosystem for international trade are reluctant to share information/data at detailed level. Since harmonisation of data exchanges is very complex, organisations are only willing to share and harmonise detailed information/data with a few selected and trusted partners. Our research suggests that there are organisations willing to share event information, including status for the shipment/container (but not sharing the detailed information). We have built our proposal on these possibilities.

We have also found that there is a balance between the expected benefits and the willingness to invest/accept additional cost. One way to facilitate the uptake is if authorities are prepared to provide benefits (e.g. green lanes without inspections) to organisations that provide audited processes and high quality information, thereby offsetting additional costs. Possibilities to rebalance could have a positive effect on the success of a solution, and the public organisations could provide benefits or lower barriers for private organisations providing high quality data.

As we have pointed out above, sharing of detailed information/data seems to be an issue, both with regard to willingness to share and with regard to harmonisation during an implementation. We proposed instead that only meta-level and generic information/data (e.g. ID of container/shipment with date/time and location, plus link to detailed information for authorised users) should be shared. Our analysis indicates that with sharing such meta-information and the link to detailed information/data among relevant and authorised organisations (leaving the detailed information/data at the source) it is likely that 1) almost all of the coordination advantages could be achieved, 2) the willingness to share meta-information would increase, and 3) the possibilities of achieving harmonisation with limited standardisation would be greatly enhanced.

However, to pursue those opportunities a new course needs to be set that would require a new mind-set and a lot of knowledge in organisations involved in global supply chain management in general and in the containerised international trade in particular.

9. Concluding Comments

The challenges in the international trade ecosystem are huge, and the potential for global savings exceeds \$100 billion. In order to attempt to address this challenge, we have followed two recommendations of David Avison.

First, a significant part of the research project reported on above has been conducted as an Action Research project with 12 prototypes and pilot implementations, gradually honing in on the most effective solution, and discarding features that did not work.

Second, the temptation to strive for developing a theory has been resisted. At best, one can say that we are contributing to ‘theory light’. Although there could be other ecosystems, e.g. in international trade, where a solution like the one we present might be relevant, we are not striving to develop grand theories.

Our prime focus has been on developing a modern IT solution for a shipping information cloud for collaboration across multiple organisations, which can be instrumental in achieving huge improvements in effectiveness. This re-engineering of the shipping ecosystem, if implemented, promises significant improvements in security, risk mitigation, reliability, speed, return on investments, and transparency.

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Paper 5 Avocados crossing borders: The problem of runaway objects and the solution of a shipping information pipeline for improving international trade

RESEARCH ARTICLE

Avocados crossing borders: The problem of runaway objects and the solution of a shipping information pipeline for improving international trade

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Email: thomasemiljensen@hotmail.com; tj.digi@cbs.dk**Abstract**

This paper investigates the case of shipments of containers with avocados from farmers in Africa to grocery store shelves in the European Union. We find 3 predominant challenges to containerized shipping that effectively become trade barriers: international trade cost, lead time uncertainty, and security risks. We use activity theory to describe, understand, and analyze the shipping activity in the international trade ecosystem with focus on physical objects and their related information. We find that the shipment becomes problematic and can be characterized as a runaway object in the heterogeneous and multiple organizational setting of international trade. Our analysis of shipping reveals (1) inefficient collaboration across loosely coupled activity systems and (2) fragmented information infrastructures. We propose the solution of Shipping Information Pipeline, a shared information infrastructure, thus facilitating collaboration in containerized shipping and contributing to lowering trade barriers. Shipping Information Pipeline can significantly improve containerized shipping resulting in estimated potential benefits of up to 4.7% growth in global GDP.

KEYWORDS

activity theory, containerized shipping, information infrastructures, knotworking, runaway object, mycorrhizae

1 | INTRODUCTION

Containerized shipping accounts for a large part of international trade and is an important element in globalization. However, maritime shipping reliability is below 70%, rather costly and extremely inefficient; for example, when shipping containers, shippers and more than 40 other actors in the ecosystem encounter numerous challenges, especially administrative barriers. Consequently, there is a huge potential for improving the current

situation and for savings. Both the maritime industry and a range of public authorities (customs officers, veterinary and health inspectors, antinarcotics agents, etc) strive for increased efficiency by digitization and utilization of Information Technology (IT). However, the results of digitization thus far have been rather meager, mainly because each organization has digitalized its own specific enterprise realm, and there are very few examples of effective international interorganizational systems.

From an Information Systems (IS) perspective, extant research findings prescribe information digitalization (MacCrory, Westerman, Alhammedi, & Brynjolfsson, 2014; Westerman, Bonnet, & McAfee, 2014) and sharing between Inter-Organizational Systems (IOS) via Electronic Data Interchange (Robey, Im, & Wareham, 2008). However, almost all successful IOS within international maritime shipping are national or regional implementations (Jensen, Tan, & Bjørn-Andersen, 2014b), and these inadequately provide an overall solution to the challenges of coordination, effectiveness, and security risks for international containerized shipping. Alternative framings are proposed by Tilson, Lyytinen, and Sorensen (2010), who add digital and information infrastructures to the IS research agenda. Further, Weill and Woerner (2015) observe that "the move to digital creates a great need for more (digital and information) infrastructure" and further that top-performing companies spend 55% of their digital budget on infrastructure, which is approximately 50% more than the 37% spent by bottom-performing companies. Along the same lines, Hanseth and Lyytinen (2010) propose a design theory for information infrastructure (II). Furthermore, large EU initiatives¹ propose accelerating trade by implementing IT innovation for global supply chains (Tan, Bjørn-Andersen, Klein, & Rukanova, 2011). However, in spite of these efforts, currently, there has been no real-world adoption of a global II within the global supply chain for international trade, including containerized shipping.

1.1 | Research question

Situated in this background, this paper addresses the following research question:

How can Information Technologies in general and Information Infrastructures in particular contribute to solving the major challenges of containerized shipping?

We delimit this paper to focus exclusively on possible solutions provided by IT. It is worth noting that our use of IT prescribes information to be in digitized format. Additionally, we exclude any discussion of general tariff barriers, focusing exclusively on nontariff barriers challenging the efficiency and effectiveness of supply chains. The main reason is that normal tariffs are often politically decided to protect and/or provide income for a society. In contrast, nontariff barriers do not generate incomes or revenues. As such, reducing nontariff barriers can potentially benefit all stakeholders involved in containerized shipping.

To answer the research question stated above, we used activity theory (AT) to provide a framework for describing, understanding, and analyzing the activity of containerized shipping. Activity theory tends to focus on production activities and, as far as we know, has previously not been applied to trade activities. We apply AT to the underresearched phenomena of sparsely connected actors indirectly interacting (Spinuzzi, 2011) across multiple national borders and organizational boundaries in the domain of maritime containerized shipping for international trade. We use IS design theory for II to propose our solution of a shared II for shipping information.

This paper presents a case study of maritime containerized shipping for international trade following specific shipments of containers with avocados across borders from farms in Africa to retail stores in Europe. We used AT to

¹Data pipeline was the primary innovation demonstrated in the ITAIDE project (January 2006 to June 2010) http://cordis.europa.eu/project/rcn/79327_en.html, INTEGRITY project (June 2008 – May 2011) <http://www.integrity-supplychain.eu>, elaborated in the Cassandra project (June 2011 – August 2014) <http://www.cassandra-project.eu> and CORE project <http://www.COREproject.eu> (May 2014 to April 2018) 20161128.

conduct a multilevel description of shipping that unravels the "knotwork"² (Engeström, 2009) of activities and identifies the problems of fragmented II and of the shipment as a "boundary object"³ originally proposed by Star and Griesemer (1989), which then becomes a "runaway object"⁴ (Engeström, 2008) in the heterogeneous ecosystem for international trade. We adopt a nondualist materialistic distinction between representations of the physical shipment and its related documents and information, proposing the solution of a shared II to enable substantial efficiency gains by healing the fragmented II, which becomes an efficient "mycorrhizae"⁵ (Engeström, 2007) for both the direct and indirect information interactions. This contributes towards efficiency improvements in the containerized global supply chains for international trade.

The rest of the paper is organized as follows. First, we introduce the domain of containerized shipping for international trade and the challenges that have become substantial trade barriers. Second, we describe our theoretical framework of AT and method-movements of AT aligned to IS research objects. Third, we present the methodological details of the revelatory case study in terms of research method, research design, the unit of analysis, and research data collection, with a dataset overview in Appendix A. Fourth, we report key findings and insights from our theoretical analysis, revealing the root causes for the challenging trade barriers of inefficient knotwork and fragmented mycorrhizae. Fifth, we discuss how any given shipment becomes perceived to be a runaway object and propose the IT solution of shared II to facilitate the collaboration around shipping information for containerized shipping of shipments. Finally, we conclude by demonstrating how IT, specifically shared II as Shipping Information Pipeline (SIP) significantly contributes towards solving the major challenges of containerized shipping, which is estimated to beneficially impact through increasing trade, globalization and increasing GDP significantly by lowering nontariff barriers.

2 | DOMAIN: CONTAINERIZED SHIPPING FOR INTERNATIONAL TRADE

International trade plays an important role in the economic growth, social welfare, and human development of countries. In the world history of technology, (Headrick, 2009) after the industrial revolution two technologies stand out: the invention of the computer, and later the Internet, and the invention of the standardized container which "has propelled the globalization of the world economy" (ibid.). Since the introduction of the standard container in the late 1950s for increased intermodal productivity and decreased cost (Klose, 2016; Levinson, 2010), the volume shipped in standardized containers has grown (Klose, 2016). As Headrick (2009) points out, "containers reduced the cost of shipping so dramatically that today some 90%⁶ of nonbulk cargo worldwide moves on container ships."

The specific shipments in the focus of this paper are of avocados from East Africa to the EU. Through the invention and the use of refrigerated containers, perishables (eg, fruit) can retain high quality, even if the transportation

²According to Engeström (2009), a "knot refers to rapidly pulsating, distributed, and partially improvised orchestration of collaborative performance between otherwise loosely connected actors and activity systems. Knotworking is characterized by a movement of tying, untying, and retying together seemingly disparate threads of activity. The tying and dissolution of a knot of collaborative work is not reducible to any specific individual or fixed organizational entity at the center of control."

³According to Star and Griesemer (1989), a Boundary object is "an object which lives in multiple social worlds and which has different identities in each, and being "both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" (Star & Griesemer, 1989).

⁴According to Engeström (2008), "The societal relevance and impact of activity theory depend on our ability to grasp the changing character of objects. In the present era, we need to understand and deal with what I have called 'runaway objects.'" (Yrjö Engeström, 2008).

⁵According to Engeström (2007), "Mycorrhizae represent relatively durable horizontal connections across activity systems." and "They are made up of heterogenous participants working symbiotically, thriving on mutually beneficial or also exploitative partnerships with plants and other organisms. As I see it, knotworking eventually requires a mycorrhizae."

⁶In 2012, the international maritime industry carried the majority of traded goods estimated to be 99.9% by weight, 80% by volume and 70% in value (World Economic Situation and Prospects 2012. www.un.org/en/development/desa/policy/wesp/wesp_archive/2012wesp.pdf). The International Chamber of Shipping estimates maritime shipping carries 90% of international trade, and containerized shipping are estimated to account for at least 80% of nonbulk goods.

time is as long as several weeks. This creates new export possibilities for perishables (vegetables, fruits, flowers, etc) from the East African countries and increases the seasonal and product range of cheaper and/or better quality fresh products for the EU consumer.

International trade typically is initiated by traders (eg, the importer or the exporter). Figure 1 presents a schematic overview of international trade.

The importer and exporter typically agree to trade certain goods in exchange for payment. However, any international trade (except services and digitalized products) customarily involves service providers for the transportation of



FIGURE 1 The main roles of the actors and main activities in international trade. Adapted from the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT 2001)

goods (eg, shipping goods in containers), monetary transactions, and other related services. Additionally, by law, the authorities guarding national and regional borders must govern international trade when goods cross borders. They do this by controlling the products (eg, for phytosanitary import requirements, health security, hazards, smuggling, as well as collecting tariffs and other fees) which become barriers to trade.

As we present and discuss in the next 3 subsections, the regulatory barriers imposed by authorities are not the only barriers. Of the challenges that relate to information which can be addressed by IT, there are 3 major ones related to containerized shipping. These 3 main challenges are also called the main nontariff trade barriers in the domain of containerized shipping for international trade. The first challenge for traders is the international trade cost influencing whether their business becomes profitable or not and determining whether they want to trade at all for the particular commodity and trade lane in consideration. The second challenge for the traders is reliable logistics, specifically, the uncertainty regarding when goods will arrive. This uncertainty about the lead time impacts the trader's options to sell the goods, which then becomes a risk for the traders' businesses and their profitability. The third challenge for traders but even more for authorities relates to the security concerns and associated risks. Accordingly, the authorities govern all goods moving in and out of their territory (eg, by controlling documentation and by inspecting goods), thereby impacting the uncertainty with respect to lead time for traders. Next, we discuss in detail these 3 trade barriers.

2.1 | Trade barrier #1: high international trade cost

Crossing international borders presents costly barriers. The total annual, worldwide, extra costs due to administrative burdens are estimated to be in the range of 257 billion USD (United Nation ESCAP, 2014). There are 2 main determinants of the trade cost for perishable goods such as fruits and vegetables: (1) the production price in the local export market, which is lower in East Africa than it is in Europe and (2) the international trading cost, which is the transportation cost and cost related to crossing borders. As illustrated in Figure 2, the costs for general international trade cargo can be broken into the following categories: 1/3 product cost at local export market + 1/3 retail distribution cost in imported country + 1/3 international trade cost. In this paper, we focus on the latter 1/3 international trade cost roughly broken down into 1/3 physical transportation cost and 2/3 administrative cost accrued from barriers when crossing borders (Anderson & van Wincoop, 2004). The fact that administration cost is double, the physical transport cost supports our claim that international trade is relatively costly. Our analysis of the shipping activity and related knotworking allows us to understand and explain the cost by the number of activities, missing or errorprone information, and different types of delays and risks. On the basis of our findings, we purport that international containerized



FIGURE 2 Breakdown of retail cost for general goods in international trade

shipping is generally inefficient. Accordingly, we foresee a potential for improvements, especially with IT, since most of the cost is related to administration. Compared to general cargo, international trade costs are even higher for perishable goods, such as avocados, not only because they need to be refrigerated during transport but also due to essential additional actions (eg, phytosanitary inspections).

2.2 | Trade barrier #2: uncertainty about lead time

The 2 key issues for importers of perishable goods such as fruits and vegetables in international trade are the quality of the product, which determines the possible price to be obtained and the costs affecting the possible profitability. A major challenge for international trade of fresh fruit and vegetables is that if the lead time gets too long and/or the integrity of the cool chain breaks, the product quality—and thereby price—is reduced significantly. Additionally, uncertainty is created by the variation in lead time of international trade, and thus from business as well as national security perspectives making the cross border trade risky. The quality of the fruit and vegetables is strongly related to the lead time for getting the containers from the grower via the exporter, the importer and the retailer to the consumer (Christopher, 2012; De Treville, Shapiro, & Hameri, 2004; Stewart, 1995). As one of the study interviewees, an exporter, states: “you can take fruit (in a refrigerated container) to Europe in 25 days. The vessel sails out weekly (from Mombasa, Kenya). If you miss that then you have the fruit stocked with you for another whole week and that means a lot of losses (of avocados) and a lot of money losses.”

The lead time and its variation are influenced by the coordination of the logistics actions for the shipment(s) between organizations involved in the supply chain, by (missing or inadequate) infrastructures and by the actors' (lack of) efficiency, especially in handling the trade barriers involved in crossing borders. For certain products (eg, agricultural products such as avocados), the importing authorities request special certificates. Further, the authorities dynamically try to implement improvements, some of which become barriers in themselves. Because of the variation in lead time, the average industry reliability in containerized shipping is below 70%⁷, it is challenging to plan and coordinate the subsequent activities (eg, when the goods will reach the retail distribution—the stores and the final consumers), making marketing and sales challenging and business risky.

2.3 | Trade barrier #3: unknown security risks

Security risks are a major concern for authorities responsible for risk assessment of international trade. Further, since the 9/11 2001 tragedy, the authorities have enforced increased security levels for trade, including containerized shipping. To mitigate security risks, they have introduced new technologies such as scanners, IT solutions, and improvement programs. These changes have been seen by traders and service providers to be an imposition of

⁷The industry average reliability for vessel arrival on time was 67.8% for January 2015 and 69.2% (lowest 62.4% and best 77.6%) for January 2017 on the basis of 12 725 vessel arrivals with an average delay of 3 to 4 days for late vessels. Additionally, typically, the lead time for a container through a port is 3 to 5 days. Global top 18 liner carriers are ranked, eg, by Seaintel, on reliability to arrive on time within ± 1 day of estimated time, which is frozen 2 weeks prior. www.seaintel.com 20170321.

new trade barriers (eg, when authorities demanded a 100% scan, indicating how security impacts risk and becomes a trade barrier for traders). However, the security activities of the authorities are a "closed world" and invisible to outsiders. Because of resource restrictions, it is impossible for authorities to monitor and physically inspect all cargo, resulting in only a small percentage of shipments being inspected. The assessments by authorities are therefore based on information provided about physical objects. Unfortunately, the quality of the information provided for containerized shipping is rather low, around 60% (Branch, 2008 English Channel on 18 January 2007.2008, MAIB Report).

3 | THEORETICAL FRAMEWORK

For our analysis of the shipping activity, we selected AT, specifically, the Third Generation activity theory (Yrjö Engeström, 1987). Our theory selection was primarily related to the fact that AT is particularly relevant for decomposing activities into operational actions by actors and their collaboration among activity systems. In our post research reflection, we found the absence of power structures in AT to be especially relevant for the specific, heterogeneous settings with multiple organizations and multiple nations and regions involved in containerized shipping in the supply chain for international trade. All in all, we found the conceptual framework and methodological techniques of AT well suited for addressing the 3 domain-specific challenges of trade barriers to containerized shipping in the heterogenous ecosystem for international trade presented above.

Similar to the general system theory (Bertalanffy, 1968), AT focuses on shared elements within a system and the relation to other systems that are conceived as being separate. For instance, the 3 activity systems in Figure 4 are separated by time, geography, government, culture, linguistics, literacy, and, to some extent, technical capabilities. Compared to most other system theories that assume 1 given power structure or governance model inside the system, AT is explicit about the rules and governance and the organization (eg, of communities and division of work) and, as such, there may be several different governance structures. In this context, AT allows focus on the relations and structures of the systems, specifically relevant within an international, heterogeneous setting with multiple organizations in the ecosystem.

3.1 | Activity theory

Both AT in general and cultural-historical activity theory in particular have their origins in the Soviet Psychology of Vygotsky, Luria and colleagues (Roth & Lee, 2007; Vygotsky, 1930/1980, 1962). Activity theory has been applied in multiple academic domains such as developmental psychology (Wertsch, 1985), educational psychology (Jonassen & Rohrer-Murphy, 1999), learning sciences (Greeno, 1998), human-computer interaction (Kaptelinin, 2006; Nardi, 1998), information systems (Mursu, Luukkonen, Toivanen, & Korpela, 2007), and international trade (Jensen, Bjørn-Andersen, & Vatrapu, 2014a; Jensen & Vatrapu, 2015). Originally, AT provided a holistic, materialistic and nondualist conception of human activity in 3 mutually interlinked elements: subject, object, and community resulting in an outcome. The subject/actor situated in the community performs the activity targeting/regarding the object and resulting in an outcome. Subsequently, AT was extended to systems modeling by Engeström (1987) with 3 additional mediating elements: (1) the rules that mediate between the actor and the community, (2) mediating artifacts/tools/equipment that the actor uses in relation to the object, and (3) the division of labor that describes the structure (or lack of) for the community related to the object. The outcome of the activity is seen as a transformation process for the object. Figure 3 shows the basic structure of an activity system.

Engeström (2008 p.222) proposes using 5 principles of AT: object orientation, mediation by tools, mutual constitution of action and activity, contradictions and deviations (as source of change), and historicity. In our use of AT, an activity system performs an activity regarding the shipment of avocados that results in a transformation process with the outcome that the avocados are moved from Kenya to the Netherlands. The actions and operations are oriented towards the object being the containerized shipment. The actors use information and IT tools to mediate

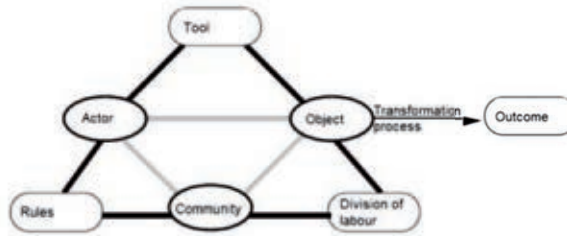


FIGURE 3 Basic structure of an activity system with embedded the mediating relations modified after Engeström (1987) and Kuutti (1996), with the term actor used instead of subject because of the actor's association with actions

between them and the object. The challenges—as described above with their contradictions and deviations—become barriers that inhibit the transformation process. Activities can be broken down into several actions, and actions can be further broken down into many operations. Thus, the level of activity is comprised of actions that, in turn, are constituted by operations. In our case of international trade, an activity can include actions of several actors, each with their own motive (eg, the exporter, importer, authorities and service providers). The action is determined as the sum total of all the operations an actor (or a group of actors) in 1 organization can perform in 1 continuous process independent of other actions involving others.

3.1.1 | Third generation activity theory in information systems

Activity theory research in IS (Allen, Brown, Karanasios, & Norman, 2013; Allen, Karanasios, & Slavova, 2011; Hasan, Kazluaskas, & Crawford, 2010; Karanasios & Allen, 2013, 2014; Kuutti, 1996; Kuutti, 1999) has predominantly focused on delineation⁸ (Engeström, 1999) of either the narrow phenomena of mediated interaction between (1) the human actor (the subject) and the world (the object) or (2) the networked phenomena of multiple, densely connected actors directly interacting across system limits sharing a boundary object or network object (Engeström, 1999; Spinuzzi, 2011), which Engeström (1987) termed Third Generation AT. We have found it particularly relevant to use AT for our analysis of containerized shipping in the heterogeneous domain of international trade where shipments (as objects) are shipped (transformed) across multiple national borders and organizational boundaries that vary from shipment to shipment.

Brief expositions for the 3 central conceptual terms of runaway object, knotworking, and mycorrhizae were previously provided in the footnotes. Two of the 3 conceptual terms are now elaborated below. The concept of mycorrhizae is the hidden and invisible organic texture underneath visible fungi in biology, with reference to Allen (1991) and Sharma and Johri (2002). We find the mycorrhizae metaphor very relevant and propose that infrastructures are a solution enabling connections between nodes in different systems and facilitating mycorrhizae. Inspired by the concept of a "runaway world" (Giddens, 1991, 2002; Giddens & Pierson, 1998), Engeström (2007) suggests that "runaway objects have the potential to escalate and expand up to a global scale of influence. They are objects that are poorly under anybody's control and have far-reaching, unexpected effects. Such objects are often monsters: They seem to have a life of their own that threatens our security and safety in many ways." Engeström (2008, p. 21) proposes the notion of mycorrhizae "to capture some crucial aspects of the new forms of social production that are gaining momentum with the help of the Internet." The runaway object, as defined earlier when referencing Engeström, is "shared by multiple activities with variable actors occupying different locations and collaborating irregularly" (Spinuzzi, 2011). In our context, we couple the runaway object to the uncertainty and foresee that visibility into

⁸According to Engeström (1999), "Delineation is the very act of identifying the personal and geographical locus and limits of the activity."

events and information about them will reduce the runaway effect. Although Spinuzzi (2011) only found 1 case that he would characterize as runaway object, we find substantial evidence for characterizing the containerized shipments as runaway objects. This will be elaborated below in Section 6.

3.2 | Method-movements of AT and IS: research objects alignment

The method-movements for AT distinguishes between 4 different kinds of objects: (1) individual activity object, (2) shared boundary object, (3) shared network object, and (4) runaway object. Method-movement 1 is characterized by a single activity system involving 1 actor and his/her relationship to a particular object (eg, individual usage of a phone or a navigation system). Method-movement 2 is characterized by 2 activity systems involving 2 different actors sharing a boundary object (eg, exchanged between 2 actors, such as the shipment and/or a container identification number). Method-movement 3 is characterized by a network of multiple activity systems that share object(s) constituted by multiple components, (eg, logistic network utilizing IOS with many EDI/XML messages). Finally, method-movement 4 identifies and deals with object(s) that are "transformed via knotworking in substrates of mycorrhizae" (Spinuzzi, 2011), where literature shows that there is an inherent risk of those object(s) becoming "runaway objects" (Yrjö Engeström, 2008). One example is health care teams and their interaction with electronic patient records. However, in the literature, there is a lack of empirical studies focusing on runaway object, and the phenomena of sparsely connected actors indirectly interacting is underresearched (Spinuzzi, 2011).

The object in focus with the 4 different levels of the methods-movements for AT can be aligned to the IS research objects as shown in Table 1 below.

We find IS research on all 4 levels of the methods-movements of AT. The focus of some IS research on Human Computer Interaction (HCI) is aligned to AT's original focus on a single object. Similarly, other IS research, eg, on

TABLE 1 Selected IS research objects aligned with AT objects according to the methods-movements of AT

IS Research Objects	Method-Movement of AT	AT Objects
Human computer interaction (HCI)	1	Single object (either physical object or information object)
Information and communication technology (ICT)	2	Shared boundary object
Inter-organization systems (IOS)	3	Network sharing object
Information infrastructures (II)	4	Risk of runaway object due to fragmented and inefficient mycorrhizae

Abbreviations: AT, activity theory; IS, information system.

Information and Communication Technology (ICT) centers on sharing a boundary object (eg, e-mails possibly with attachment of entities from within an organization's Enterprise Resource Planning System [ERP] communicated indirectly between 2 organizations) similar to AT's focus on shared boundary objects. On the third level, we find EDI messages interchanged in a network sharing objects where service providers offer a hub for exchange of EDI messages, which in IS research is termed IOS based on EDI messages (Krcmar, Bjorn-Andersen, & O'Callaghan, 1995). There are other examples of network sharing objects such as programmers codeveloping shared code. On the fourth level, we find as Engeström (2007) points out, the risk of experiencing runaway objects increases with fragmented, inefficient, or missing mycorrhizae. Tilson et al.'s (2010) call for putting II on the IS research agenda is in alignment with level 4 in the method-movements of AT.

Activity theory provides dimensions (see Figure 3), enables the breakdown in activity, actions, and operation, and articulates not only evolving but also dynamically changing relations (by boundary objects, knotwork, and mycorrhizae). Taken together, AT provides analytical capabilities that enable an in-depth description of the phenomena needed to be able to design IT solutions especially if central control/governance is unobtainable.

4 | METHODOLOGY

We now present the methodological details of the revelatory case study in terms of research method, research design, unit of analysis, and research data collection.

4.1 | Research method: revelatory case study

We used the method of revelatory case study (Sarker, Sarker, Sahaym, & Bjørn-Andersen, 2012) to answer the research question. A revelatory case study can potentially help to explain phenomena in real-life interventions that are too complex for the survey or experimental research methods (*ibid.*). However, while the typical case study only deals with 1 organization, we study containerized shipping for the complete supply chain for international trade involving multiple organizations located in different continents. Within this huge ecosystem, we decided to limit our focus to 1 specific international trade lane for perishables (fruits and vegetables) from East Africa to Europe. This trade lane regarded shipments in refrigerated containers from Kenya to the Netherlands via the ports of Mombasa (Kenya), Salalah (Oman), and Antwerp (Belgium) or Rotterdam (the Netherlands), depending on the specific route selected for individual shipments.

4.2 | Research design

Our research design consisted of in-depth analysis of the journeys of 12 shipments of avocados, conducting meetings/interviews with a total of 40 involved actors from more than 30 different organizations, and later presenting our proposed solution to some of the stakeholders for feedback and evaluation. The research design focused on the organizations and actors in the containerized shipping that could enable or prevent the refrigerated containers from being moved further in the supply chain according to plans. Any deviation would influence uncertainty in lead time and the overall efficiency. At the level of activities and actions, the research design entailed a description at a high level of abstraction of the different organizations and locations. At the level of operations, the research design focussed on those operations where one organizational actor handed over to another organization (eg. communication using different communication channels as documents by ordinary mail, fax, e-mails and IOSs based on EDI/XML messages).

We recognize the difficulties of studying inter-organizational communication involving both private and public organizations, especially across borders (Reimers, Johnston, & Klein, 2010a, 2012), and we draw from a framework which views this as constellations of aligned practices (Reimers, Johnston, & Klein, 2010b). Because of the complexity of international trade, we selected to focus only on the physical supply chain (excluding the financial aspects) with the related shipping information for containerized shipping via a specific trade lane from East Africa to Europe. The research design required us to access multiple private and public sector organizations involved in containerized shipping in the specific trade lane.

4.3 | Unit of analysis

The relevant unit of analysis is the containerized shipping of shipments in container(s). The actual international shipping activity utilizes the refrigerated container(s) that are always on the move or waiting in a fenced area with restricted access. Conceptually and methodologically, it is challenging that the unit of analysis—the shipment—continuously moves in time and geographical location. Further, the physical container is invisible for most actors most of the time and it only becomes “visible” through related documents and information. These documents and information are stored in various IT systems within each of the many organizations. Accordingly, receiving or accessing them involves communication across multiple organizational boundaries and national borders. To account for this, we tracked each shipment container using a GPS device mounted on the containers. This enabled verification of actual time and date for reported events.

Analysis of the shipping activity is also challenging because activities and actions cannot be observed, since they are abstract aggregations of operations. This means that only operations can be observed. Further, they can only be observed when the researcher and the actor are at the exact location of the operation at the time of the operation being performed. Furthermore, the locations for the operations are physically distant and constantly changing on the journey from Nairobi in Kenya to the importer's warehouse in the Netherlands approximately 600 km on land, plus 8000 nautical miles at sea.⁹ To study operations for example container transport and movements, the researcher traveled with the shipments. This can be challenging, since containerized shipping constantly attempts to move a shipment towards its destination. But following the shipments created a first hand insight.

Practically, the outcome of the shipping activity in the form of a transfer of containers to the destination can be observed at discrete intervals (eg, upon arrival). However, it is only if the researcher is allowed access to the typically fenced area for containers with restricted access or if the researcher can catch up with the moving container when it is on a speedy truck on the road or on a vessel (eg, in port or at sea) that it is possible to in depth understand and interpret operations and actions in the shipping activity.

To overcome these challenges, several shipments were traced involving meeting the various actors when they were expediting their operation (while they were constantly on the move, always in a hurry and most of the time speaking on the phone). This meant that their time for participation in this research study was very limited. As a consequence, we focused primarily on the actor's last communicative operation (and also on the physical movement of the container), that is, the collaborative effort that constitutes the knotworking within international containerized shipping. Accordingly, we focused on the communicative operations and requested capturing a copy or a picture of information/documents used by the actors. These documents formed a major part of the collected research material. Additionally, interviews, meetings, focus groups, and written material regarding procedures were collected and documented. In the later phase of the research, when tracing shipments and meeting actors, the researcher presented findings and demonstrated the proposed solution to validate the findings and obtain feedback from the actors. Additionally, the researcher presented and demonstrated the proposed solution to managers and key influencers in the organizations involved to obtain evaluation of the proposed solution.

4.4 | Research data collection

We acknowledge that research data collection methods for studying inter-organization communication comprise a dilemma between authentic access to practices and the ability to thematize knowledge of practices (Reimers et al., 2013). To improve on the robustness of the overall results of the case study, the research design involved several actors in each of the more than thirty organizations. In this way, as much as possible, we triangulated the empirical research data. According to Herriott and Firestone (cited in Yin, 2009), this increase the validity of our research results. The physical research data collection was performed in both East Africa and Europe, tracing the shipments on trucks on land, around in ports, and on board the container vessels. However, we did not sail with the shipments; neither did we observe the transshipments but took a plane instead.

Even the narrow field of exporting perishables from Kenya to the Netherlands is quite complex. There are several hundred importers of fruit in the Netherlands, representing a great variation of firm and market attributes. Accordingly, we selected a set of representative importers on the basis of the recommendations of the respective trade associations. Key influencers from trade facilitation organizations and authorities were extremely helpful in identifying and connecting us to organizations and individual actors. With regard to the selection of sites for visits and field observations as well as the selection of individuals for in-depth semistructured interviews and composition of focus groups, we were assisted by the General Secretary of the Dutch association of fruit and vegetable importers, FruglVenta, and by senior managers at the trade facilitation organization, Trade Mark East Africa. In addition to visits to exporters and importers, meetings and interviews were also conducted with actors such as public authorities, terminal operators, logistic service providers, and consulting companies. Finally, research data also consisted of

⁹<http://www.sea-distances.org> 2017.01.21.

identified key documents (eg, customs declarations) and identified key information items for the logistics coordination (eg, estimated time of arrival).

The research data for this paper were collected over a period of more than 3 years (2013–2016) by interviewing key actors in the organizations, visiting field sites, observing specific shipments, and conducting a set of focus group interviews and meetings. In total, we were able to identify more than 30 different organizations involved in the different constellations of containerized shipping within the trade lane for perishables from Kenya to Europe. Table A.1 presents an overview of the empirical research data collection.

For every new shipment researched, we encountered involvement with new organizations and new actors, as well as new information and new documents. However, as the number of shipments researched increased, the number of surprises in the form of new organizations/actors and new information/documents decreased. When we discovered this, we made the decision to end the data collection, as investigating more shipping lanes was unlikely to uncover new organizations/actors and new information/documents.

4.5 | Limitations

We acknowledge the limitations of our case study in analyzing containerized shipping for shipments in only 1 international trade lane of fresh avocados between 2 nations and considering only the supply chain (not the related financial transactions). Acknowledging this limitation, we believe nevertheless that our case study reveals results that could be applicable to containerized shipping for international trade in general, since containerized shipping worldwide follows the same type of containerized supply chain infrastructure, uses the same type of service providers, and has to pass the same type of authorities¹⁰ who perform the same type of operations and actions using similar or even the same ERP systems and IOS. That said, we acknowledge that our findings need to be evaluated and replicated by future research for other trade lanes, geographics, commodities, etc.

5 | ANALYSIS

We shall now present the findings from our AT analysis of the case study of 12 international shipments of avocados from farmers in Africa to retail distribution centers supplying stores eg, in the EU. First, we analyze containerized shipping activity for the avocados across borders and we identify 3 activity systems: export, shipping, and import. Second, we analyze and decompose the activities into actions constituting the division of work requiring collaborative efforts of the actors to discover the underlying knotworking, which provides some explanation of the relatively high international trade cost. Third, we untangle the knotwork of actions into operations especially focusing on communication operations, thus enriching our understanding causes of the uncertainty of, and variation in, lead time. Fourth, we identify the fragmented mycorrhizae for shipping information causing a lack of visibility and transparency, which enable us to understand the security concerns by the authorities.

5.1 | Avocados crossing borders

The physical flow of shipments of avocados in containers starts in Kenya where the avocados are harvested by a number of local farmers. The farmers will typically transport the avocados in open pickups either via a local market or directly to the packaging facility of the exporter. During the handling phase, a part of the avocados is discarded and only the best quality is selected for export. After washing, the selected avocados are packed into carton boxes. The boxes are palletized, stored cold, and later loaded into a refrigerated container at the packaging facility. The content is inspected for the declared goods and the container is sealed with 2 seals by the representatives of the authorities and by the carrier responsible for the international shipping. The container is then transported approximately 500 km by truck to the port of Mombasa, where it is stored until the container is loaded onto the vessel by the terminal operator and shipped to Rotterdam with

¹⁰Except for the phytosanitary inspections which do not apply for general cargo.

transshipment en route in Oman and optionally Antwerp. After arrival at the destination port, the container is unloaded by one of the local terminal operators, after which custom clearance is given to the importer before trucked to warehouse for storage, phytosanitary inspection, quality control, and processing. Finally, distribution to the retail industry is made via the grocery stores to the consumer. The duration of the shipping of avocados across borders varies, eg, from Kenya to the Netherlands it takes between 24 and 34 days, depending on the route and circumstances.

5.2 | Three activities of containerized shipping for international trade

We use AT to describe the phenomena of international shipping. The overall activity is shipping/transferring the shipment/object. The outcome is a transferred shipment/object (of avocados in containers) from the origin in Kenya to the destination in the Netherlands. Applying AT, we find that the main activity of containerized shipping for international trade involves the obvious crossing of national borders and can be described in terms of 3 relatively independent activity systems: export, international shipping (sea voyage), and import. These have different national and regional rules for export, import and shipping. Further, a separate set of rules applies for international shipping (sea voyage)¹¹ in international waters.

While the physical shipment/object of avocados are obviously transferred from 1 activity system to the next (Figure 4), we found that the information exchange between the 3 activity systems is very marginal. In system theory, eg, Bertalanffy (1968) defines a system as the group of elements that have as few as possible connections to the envi-

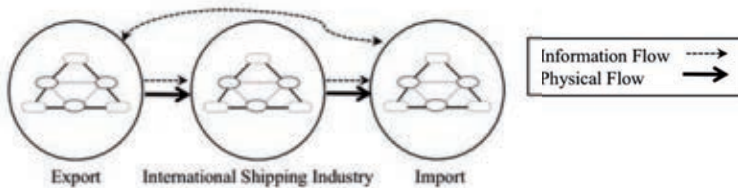


FIGURE 4 The AT system of the exporter and the AT system of the importer are linked across the borders by the international shipping industry through the object/shipment in container(s) and a few related information/documentations. AT, activity theory

ronment. This is exactly what our AT analysis reveals. Further, the rules in the form of laws and procedures governing activities are different for the countries, regions, and international seas passed on the journey. The 3 activities are delineated in 3 very different communities: Kenya in East Africa, the Netherlands in EU, and the international container shipping industry for the sea voyage, each of which is governed by its own set of rules. The delination of the borders between those activity systems are the international borders specifically customs area at the ports or other area governed by customs, eg, bonded warehouse.

The AT terms and dimensions, see Figure 3, are used to analyze containerized shipping. The "activities" are export, international shipping, and import that via international shipping transform the object of the shipment of goods loaded in containers from the exporter to unloaded goods at the importer. "Actors" include the farmers, the importers, the exporters, the distributors, the retail, the authorities, and different service providers. Each actor residing in a nation/region furthermore belongs to one or more "communities" in the form of various associations and organizations (eg, the Fresh Producers Exporters Association in Kenya and the Dutch association of importers of fruits and vegetables FrugiVenta). Further, the communities each have their focus, culture, language, etc. The "objects" are the shipment of goods meaning the fresh products in refrigerated containers and their related information. The "rules" are the laws and regulations for international trade, and local laws and procedures in the individual

¹¹The International Maritime Organization (IMO) is a specialized agency of the United Nations with 171 Member States. Its main role has been to develop and maintain a consistent regulatory framework for international shipping with particular focus on the areas of safety, security, environment and technical co-operation. www.imo.org. 20170124

country or region (eg. Dutch and EU regulations¹²). The "tools" are the refrigerated container, the various dedicated equipment and means of transport, information systems, etc. Finally, "division of work" includes the organization of the authorities, importers, exporters, and service providers with specialized capabilities for the movement of the containers, for performing quality control, thus conducting inspections on behalf of the authorities, etc.

Further, the authorities are the only actors allowed to release goods for export in the country of origin. In the country of destination, the authorities are the only actors that can allow the entrance of imported goods first into the customs area and later allow the same goods to pass out of the customs area towards its destination in the warehouse of the importer. Table B.1 presents a descriptive overview of the three activity systems of containerized shipping for international trade.

As illustrated in Figure 4 and described in Table B.1, our analysis applying AT revealed that only the object (fresh products in the refrigerated containers) and a couple of documents (eg. bill of lading¹³) are connecting the activity systems of export, international shipping, and import. Across the activity systems of export and import, only the importer and the exporter interact directly. Moreover, often the importers swap between a range of exporters in East Africa and from other countries, thus making close collaboration rather difficult due to a lack of a well-established level of trust. Typically, both the exporter and the importer will often communicate with, eg. the shipping line via a logistics service provider. Furthermore, the trader (importer/exporter) will select service providers (eg. freight forwarder) and shipping line, depending on the actual business situation and offer given. Within each of the 3 activity systems, there are plenty of organizations with each their enterprise resource planning information systems (ERP) in place that are intended to improve their organizational efficiency and security (eg. single window systems of Kenyan authorities).

In summary, our analysis illustrates inefficient collaboration across loosely coupled activity systems. In spite of the different links described above, boundaries between the three activity systems represent a major challenge and the crossing of the borders results in containerized shipping experiencing unreliable lead times. Furthermore, it is costly, risky and difficult, as discussed earlier.

5.3 | Actions by organizations for containerized shipping

After the separation and analysis of the main activity of containerized shipping into 3 activities, we applied AT to decompose each activity (export, import, and international shipping [sea voyage]), indicating that each activity consists of multiple actions and that multiple organizational boundaries are crossed on the specific shipment's journey.

Our in-depth analysis demonstrates that in the selected trade lane from Kenya to the Netherlands, each shipment of container(s) with fresh products has crossed national/regional borders at least 8 times,¹⁴ has crossed organizational boundaries of at least 10 companies, and has been handled by at least 11 authorities. In total, at least 40 actors in more than 30 organizations¹⁵ located in 7 countries¹⁶ are involved in the transport and administration of the fresh

¹²Union Customs Code https://ec.europa.eu/taxation_customs/business/union-customs-code_en.

¹³"Bill of lading" is defined by UN as "a receipt signed by or on behalf of the carrier and issued to the shipper acknowledging that goods, as described in it, have been shipped in a particular vessel to a specified destination or have been received in the ship owner's custody for shipment." (United Nation, 1971).

¹⁴An example of a shipment's border crossing on its journey from Kenya to the Netherlands involves crossing borders (governed by authorities) of 5 nations 6 times: Kenya—International Sea—Oman, Oman—International Sea—UK, UK—Belgium, Belgium—the Netherlands. Further, regional borders are crossed 2 times since the nations passed are members of 3 different regional communities: East African Community, Gulf Union, and European Union.

¹⁵Examples of organizations involved in shipment journeys from Kenya to the Netherlands are farmers, exporter, customs broker/consultant, freight forwarder (1), trucker (1), carrier/shipping line (1) and (2) with service centres in India and Philippines, Terminal operator (1), (2), and (3), Kenyan Revenue Authority (customs), Horticultural Crops Development Authority, Kenya Plant Health Inspectorate Service, Kenyan Port Authority, Oman Customs, Port Authority of Port of Salalah (Oman), HM Revenue and Customs (UK), Belgian Customs, Belgian NPPO, Dutch Customs, the Netherlands Food and Consumer Product Safety Authority (Nederlandse Voedsel en Waren Autoriteit, NVWA), freight forwarders (2), truckers (2), customs brokers/consultants (2), and importers plus distributor (1), retail, distributor (2), and consumers.

¹⁶Examples of actors located in 7 nations involved in a shipment's journey from Africa to Europe: Kenya, Oman, UK, Belgium, the Netherlands, India, and the Philippines.

products from Kenya to EU. The trader (varies depending on *inco* terms for trade) delegates and pays service providers to act on their behalf. Figure 5 illustrates the main actors and their primary action within each of the 3 activity systems of containerized shipping using the supply chain for international trade.

Our analysis shows that each organization in Figure 5 is rather efficient in performing its own action(s). Most



FIGURE 5 Containerized shipping via the specific trade lane for avocados from East Africa to European Union decomposed into 3 activities: export, international shipping, and import delineated in Kenya, in the Netherlands and in international waters, each governed by national, regional, and international rules, involving various actors performing actions structured along the supply chain [Colour figure can be viewed at wileyonlinelibrary.com]

organizations have also implemented dedicated physical equipment, as well as 1 or more ERP systems to support their actors' operations. To bridge the organizational boundaries, they share boundary object(s) with their direct partners using peer-to-peer relations and communications in handing over the container, dedicated documents and information, or shared access through, eg, single-window system, as recommended by United Nations.¹⁷ The actors creatively generate new documents (eg, the information objects of checklists for work procedures of truck drivers) that become facilitators for some and barriers for other actors. As Engeström (2009) observes, "The new objects are often not intentional products (outcome) of a single activity but unintended consequences of multiple activities" (p. 3). The total number of actions and organizations involved and crossing the associated borders and boundaries incur costs that provide an explanation for the first trade barrier regarding the international trade cost described earlier.

5.4 | Knotwork of operations for containerized shipping

To address the challenge for traders of (un)reliable logistic regarding when their goods will arrive, which is influenced by the second trade barrier regarding uncertainty of lead time of the physical shipment's journey in the global supply chain, we have analyzed the structure of actors' actions in the activity systems. The actions express the division of work and align along the supply chain for the physical object of the refrigerated containers, illustrated in Figure 6. However, several actions are performed in parallel (eg, authorities processing of documents can happen while the container is transported), not illustrated in Figure 6. One very important factor is that with the exception of authorities, many activities can be performed by a range of organizations that are competing to perform specific actions (eg, trucking). Since each of these organizations presumably are already focusing on improving their own performance, we decided that further decomposition of actions into operations would not reveal additional insights. Therefore, our analysis excludes the internal operations constituting the actions of each individual organization. Instead, our analysis focuses on inter-organizational operations using shared boundary objects of either the physical shipment of container(s) with the goods and/or related documents.

The use of refrigerated containers and dedicated physical infrastructure enables efficient movement of containers to new export markets, thereby opening new export businesses, eg, of avocados. As 1 trader states: "This business would not be possible without the reefer (refrigerated container)." The use of containers in the physical infrastructure, including dedicated equipment for container handling, has significantly increased the efficiency for handling of goods. Further, East Africa, for example, continues to invest in establishing and improving the infrastructure of roads, rails,

¹⁷United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT). Recommendation and Guidelines on establishing a Single Window. Recommendation No. 33. https://www.unecf.org/fileadmin/DAM/cefact/recommendations/rec33/rec33_trd352e.pdf



FIGURE 6 Containerized shipping of avocados from Kenya to Europe and the physical infrastructure/supply chain with indication of lead time in days for a shipment based on the GPS tracking [Colour figure can be viewed at wileyonlinelibrary.com]

and ports to facilitate the container transportation. The refrigerated containers can keep the fruit and vegetables fresh for weeks by storing them at a low temperature. Furthermore, by adding gas to the container, it is possible to prevent the fruit from having contact with oxygen, resulting in very little evidence of decay. This means that perishables can be moved very effectively from East Africa to Europe, even though the transport takes several weeks. Unfortunately, reliability of containerized shipping⁷ results in high variation in the actual lead time, which makes the business risky. Long lead time, evaporation of the protecting gas, and/or temperature fluctuations in the cool chain seriously impact the quality of the fresh products; consequently, a lower price may turn a profit into a loss.

Figure 6 presents a simplified picture of the physical infrastructure/supply chain for containerized shipments. The figure also shows the actors and the actors' actions in the 3 activity systems of export, shipping, and import in a sequence along the journey with barriers to pass (eg, customs' clearance at port terminals at borders). Accordingly, the supply chain provides a foundation for orchestration and coordination of the collaborative performance of actions performed often by different actors¹⁸ in different and ever-changing organizational constellations. This is what Engeström (Engeström, 2007) refers to as "knotwork." To be specific, knotworking within containerized shipping is constituted by the actor's operation signalling completion, which is often only indirectly communicated to the actor expected to perform the next action.

In general, we found the connections between the actors' actions durable and efficient with regard to the physical infrastructure. However, the coordination of the actors' actions occurs only through bilateral shared boundary object(s) in the form of peer-to-peer exchange of information and documents. We found that this is due to the fact that the physical shipment is rarely visible to any actor except for the particular actor performing an operation at a specific time. Accordingly, the shipment can be considered to be "outside the visible horizon" of all the other actors in the supply chain (Carter, Rogers, & Choi, 2015). This results in a partial and fragmented exchange of information (Clement & Wagner, 1995) leading to uncertainty about current state and lead times. This is a huge challenge with regard to actors' communication operations (knotworking) in the supply chain and is the root cause of the second trade barrier—the uncertainty about lead time. Because of this uncertainty, we found serious delays of shipments reducing reliability and a necessity to the built-in-slack and buffers in the supply chain, prolonging the general lead time.

5.5 | Lack of an efficient mycorrhizae for shipping information for containerized shipping

We now turn our analytical focus to the documents and information about shipments exchanged between the organizations involved in the journey of the containers from Kenya to, eg, EU.

Our analysis of the shipments showed that over 100 documents and pieces of information were used per shipment as boundary objects between the organizations. These documents and information are the boundary objects

¹⁸The actors work in shifts to keep shipping in operations around the clock, 24/7; the containers are loaded and trucked in weekends, which is latest possible but still in time to catch the departure of the vessel leaving Mombasa port Wednesday night.

used for the knotwork in Engestrom's terms. Although all documents pertain to the shipment of avocados, each individual organization requires specific aspects of the shipping information, and often the information needs to be formatted in a specific way. The relevant documents are stored by each actor eg. in their organization's own ERP systems or similar. Generally, the ERP systems can only be accessed by authorized actors in that particular organization and information is not accessible by actors outside that organization. The authorities in both Kenya and Europe each have their set of ERP systems. To a large extent, the different departments of the authorities have their dedicated systems, although we found that some of the authorities' systems were pursuing harmonization towards 1 user interface, often referred to as a "single window system." However, in the case of avocados, the documents are filed in at least 5 different systems of the Kenyan authorities. Each of the service providers also use a range of ERP systems, eg. for operation, for customer relation and for accounting. For example, in connection with one of the shipment's analyzed, the trader used at least 3 ERP systems and the shipping line at least 5 ERP systems.

In summary, we found that more than 30 ERP systems were involved in one shipment, excluding e-mail, fax, spreadsheet, or similar information systems. Although the information about shipments was captured in more than 30 ERP systems of individual organizations, the communication about the shipment information was done mainly via e-mail, ordinary mail/courier (for the original paper versions of documents), and telephone and text messages for any kind of ad hoc issues. The trader had a team of dedicated people for the shipment, and each of them had plenty e-mails and they shared some of those in their shared archive folders each containing several hundred e-mails for each shipment. Our analysis further showed that one-third of the e-mails had attachments. It was a characteristic that the dominating communication patterns were peer to peer. We found chains of peer-to-peer communication where the shipment information was retyped or copy + pasted from or into the actor's ERP system or local storage. Interestingly, when we presented with these results, one of employees at the trader commented: "From my view point ... it's just part of my daily tasks to answer the incoming e-mails in relation to the shipments by processing it and forward or reply to the e-mail. I never thought about this as a chain of communication."

Figure 7 illustrates a selection of the most critical documents and information shared among the organizations that can not only trigger and facilitate but also preclude subsequent actions in the containerized shipping in the supply chain. Detailed examples of knotwork of the shipping information are described in Appendix C.

The lower part of Figure 7 shows how and when actors use a variety of communication means, including e-mail, phone, text message, fax, ordinary mail/courier, and EDI/XML messages, where only the EDI/XML communication can be characterized as having stable, durable connections. In Engestrom's terms, we identify this kind of IOS on the basis of EDI/XML messages as a mycorrhizae. However, it is far from perfect and far too limited. Our AT analysis of the existing IOS-based EDI/XML messages shows that only a few of the hundred documents are communicated via EDI/XML and none of them internationally directly between the export and import activity systems. As described above, we found a range of communication means being used; this means that in AT terms, we found only fragmented mycorrhizae for the majority of information/documents communicated. Furthermore, the scarce information available was of poor quality (eg. the Bill of Lading only stated "said to contain" and the packing list was preliminary and created before the container was packed and sealed); it was not persistent enough, and it was not updated, leading to mistrust and security concerns. All of this explains the relatively low quality of the information experienced by authorities (Branch, 2008 English Channel on 18 January 2007. 2008, MAIB Report), which we found contributed to the third trade barrier identified as unknown security risks, especially for authorities.

We found that the actors in their respective organization used ERP systems for managing part of their documents/information and were striving to continuously improve their performance, thus enabling private companies to be competitive and the authorities to perform well, even under budget pressures. However, our AT analysis revealed that the knotworking of coordination of actions among multiple, geographically dispersed organizations was a major challenge, exacerbating the trade barriers of cost and lead time and its uncertainty. We therefore focused on the shared boundary objects between organizations and found many related documents/information representing same shipment but with different aspects of the shipments. The actors used a wide range of communication channels with a bilateral communication pattern along the supply chain. However, the end result was that

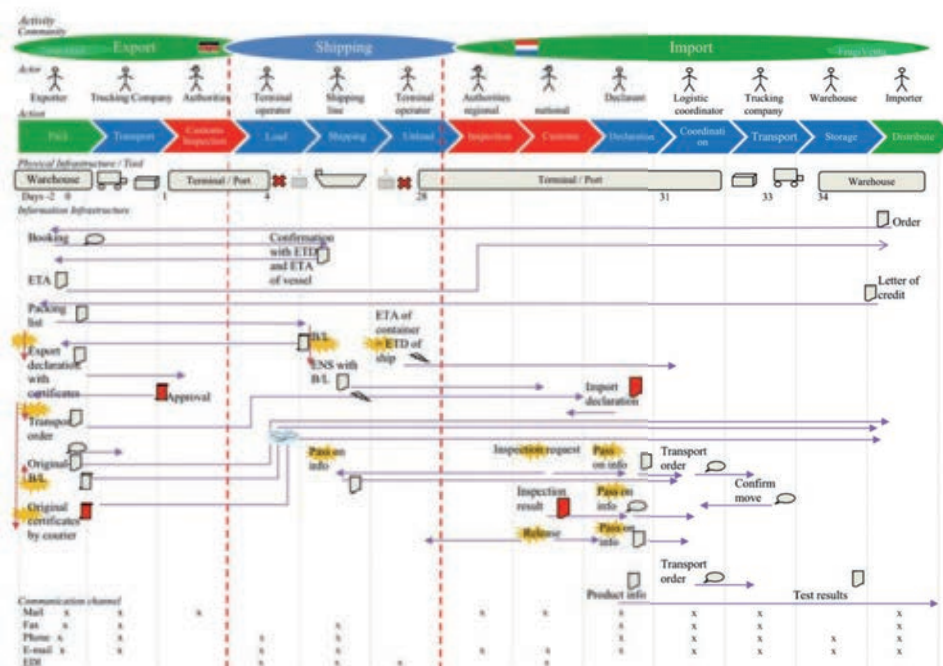


FIGURE 7 Knotwork of selected documents and information used in peer-to-peer communication using various ICT channels (in the lower part of the figure) to coordinate operations for containerized shipping along the supply chain for international trade. ICT, Information and Communication Technology [Colour figure can be viewed at wileyonlinelibrary.com]

the available information was not up-to-date and of poor quality. This led to the actors' experience of a lack of visibility into the objects' real status and location, making it tending a runaway object with all related uncertainties, security concerns, and business risks.

Our findings of (1) inefficient collaboration knotwork across loosely coupled activity systems and (2) fragmented mycorrhizae (read II) impacted the overall efficiency of containerized shipping negatively. We found that 6 of the 12 shipments did not follow the "happy path" but experienced delays or other issues impacting product quality because of lack of information or faulty information. This obviously had a negative impact on both the trade cost and the sales price of the imports to the retail—if the goods could be sold at all. We thus conclude that the lack of an efficient, shared mycorrhizae for shipping information supporting the knotwork is a root cause for the major challenges in containerized shipping.

6 | DISCUSSION

In the following, we discuss how the absence of an efficient shared mycorrhizae for shipping information gives rise to the phenomena of shipments being runaway objects. Further, to address these challenges within containerized shipping, with AT as the prime theory for our design we propose a solution in the form of a shared II for shipping information, SIP.

6.1 | The runaway object of the shipment

The 3 activity systems of export, shipping, and import are characterized by a massive but rather intransparent knotwork consisting of a complexity of actions and operations performed by multiple actors in multiple organizations spread across

different geographical locations and different time zones with different and unsynchronized working hours having different cultural backgrounds and being forced to use a language different from their native language. Furthermore, each of the actors in the different organizations in the 3 different activity systems for containerized shipping using the supply chain for international trade have their own motivation(s) and goal(s). The farmers want to grow and sell their avocados, preferably for export, which is a profitable growth potential for their business. A farmer located 70 km from Nairobi with 10 avocado trees explains: "Avocados are more profitable than the other things I grow." The importer wants to earn profit by offering fresh products at a reasonable price and they would like to minimize their risk (eg, that the quality of the fresh products is decreased because of long lead times or breaking the cold chain integrity). The freight forwarders, the transporters, and the shipping lines earn revenues from moving goods primarily in containers and related services. The authorities ensure that the law and procedures are followed, tariffs collected, and security risks minimized.

Finally, individual actors in each of these organizations performing a particular operation of an action in an activity might have additional motives and goals not totally aligned with those of their organization. Accordingly, they might be performing the operations that do not fully support the overall objective of facilitating the movement of the goods in the supply chain and/or do not support other actions to be performed by other actors. By their knotwork, actors are the ones that can facilitate or disrupt the flow in the supply chain and the collaboration for coordination of actions with other actors by communication or lack of it.

We found, the shipment being a shared concern of all actors in the organizations involved in containerized shipping. Further, all private organizations focused on improving effectiveness. Unfortunately, not all actors are concerned with the same aspects of the shipment. For example, authorities have specific concerns such as security, which can delay the shipment. If the varied concerns of the different actors with regard to the different aspects of the shipment could be reified into a shared mutual concern, it would motivate the actors, sustain their attention, orient their efforts, and provide meaning to their actions and operations. Further, it would be more effective if this reified shared mutual concern could be communicated directly instead of the current practice of indirect communication. Furthermore, direct communication can become bi-directional and facilitate feedback leading to increased understanding. At the macro level, such a shared concern exists, but on the micro level, it is not the case. As documented above, only few of the actors actually see or handle the container physically since the container is either being transported (eg, on a truck on the road) or is one of thousands on board a container vessel on the ocean or stacked in a fenced container terminal with restricted access. Even fewer of the actors see the fresh products since they are inside the sealed container—sealed early on its journey—and not opened until the final destination unless inspected by authorities who would reseal it immediately after inspection. Accordingly, most of the actors only know about the container/fresh products (the physical object) through information representing it (the information object) and further, they only share limited information/documents.

The container moves dynamically. As 1 trader referred to a missing phytosanitary certificate that prevented the pickup of the container and delayed the shipment 1½ days: Actors keep the information/documents in their organizations' ERP system, in their archive or on "some one's desk under a pile of paper." Accordingly, actors have their unique perceptions about the shipment. Further, those different perceptions and no real-time information available become a challenge to the shipment and its logistic flow. Anyhow, there is no doubt that the fragmented and poor information about the shipment/container/products and related uncertainty creates a situation where nobody knows, nobody has full control, which makes identification of responsibility unclear.

This raises severe security concerns for authorities, and it becomes a risky business for the traders, as described earlier. We use the concept of runaway object (Engeström, 2008) to describe the situational reality of our unit of analysis characterized by the invisibility of both the physical and information objects, that is, the poor quality of information, the uncertainty, the risk, and the security concerns. According to Engeström (2008), runaway objects are "poorly under anybody's control and have far-reaching unexpected effects that threaten our security and safety," especially in a runaway world that "seems out of our control" (Giddens, 2002). This is extremely problematic in a world where terrorism remains a major cause of security concern for international containerized shipping. Especially after

the 9/11 tragedy, the shipments tend to become runaway objects from the authorities' perspective, as they fear a possible threat by a container with explosives arriving in one of their ports.

To address the problem of dealing with this runaway object in containerized shipping and to solve the challenges of the lack of mycorrhizae for shipping information, we propose an information systems solution of a shared II that creates visibility and improves trust for containerized shipping.

6.2 | The proposed solution of shared information infrastructures

When shipping containers, shippers and everybody else in the ecosystem experience a number of administrative barriers to international trade. Both the maritime industry and the public authorities strive for increased efficiency by digitization and utilization of IT, for example, by implementation of Single Windows system (Holloway, 2009). We also see practice adherence and relevance for the guidance from IS research to transform industry by digitalization (MacCrory et al., 2014; Westerman et al., 2014) in terms of implementations of IOS based on EDI/XML messages (Robey et al., 2008), especially IT innovation for accelerating global supply chains (Tan et al., 2011). However, the improvements are few and far apart, and, to some extent, some of these IT implementations have even become barriers to trade because they are costly and only accessible for a local subset of the organizations' actors.

We found that the current communication among the organizations being used are based on a range of ICT, see Figure 7, with e-mail being the primary mode and limited use of IOS based on EDI/XML messages (using a network of EDI/XML message communication providers). One explanation is that e-mail provides an easy, flexible, and nearly free means of communication, especially compared to the relatively high cost of maintaining IOS based on EDI/XML messages (Henningsson & Bjørn-Andersen, 2009; Henningsson & Henriksen, 2011). As an alternative to IOS based on EDI/XML messages, we follow the recommendation of Tilson et al. (2010) pursuing II in our design of a solution intended to provide, heal, and coalesce the currently fragmented mycorrhizae for shipping information.

To provide the missing mycorrhizae for the knotwork of coordination, we propose to augment the existing mycorrhizae with a shared II for shipping information. This will be an overlay of the Internet and leverage, eg, the World Wide Web (WWW). We have named the solution Shipping Information Pipeline (SIP), see Figure 8 for illustration where little meta information and few URLs are shared among actors via the green pipeline. Note that the detailed information, eg, a packing list resides at the source under its governance, which is illustrated in the bottom of Figure 8. The SIP is a kind of domain-specific "Internet" for shipping information.

A major obstacle today is that the importing authorities require some certificates in original paper versions with stamps and signatures since digital versions are not accepted nor trusted. Accordingly, instead of digital communication, the certificates are sent by courriers. This is indicated by the red paper icon in Figure 8. Our proposal is that SIP does not replace but augment the existing EDI/XML messages. Accordingly, information about the EDI/XMLs can be shared via SIP.

One of the design principles of the SIP is to persistently store the information at the source and only share referential pointers and metadata—similar to the design of the WWW (Berners-Lee & Fischetti, 1999). The shipping activity is a range of operations forming actions whereof the event information for selected operations, particularly the hand over operations with detailed information concluding an organization's actions, are of relevance to be shared with other organizations. However, the design principles of WWW is to leave the detailed information at the governance of the source and only share a few meta information and an URL. As illustrated in Figures 9 and 10, there are a list of events each with an optional link to the detailed information. Additionally, in terms of communication pattern, our design marks a crucial difference from today's peer-to-peer communication facilitated by, eg, e-mails and IOS based on EDI/XML-messages to the proposed SIP solution's publish/subscribe communication.

As Robey et al. (2008) point out, IOS procurement decisions have moved from inside organizations to outside IOS service (based on EDI/XML messages) provided by third parties that are market driven. Accordingly, the cost is the major driver for the actors preference. We foresee that our proposal for SIP overlayed on the widely dispersed Internet can reduce the cost significantly compared to costly IOS based on EDI messages (Henningsson & Henriksen,

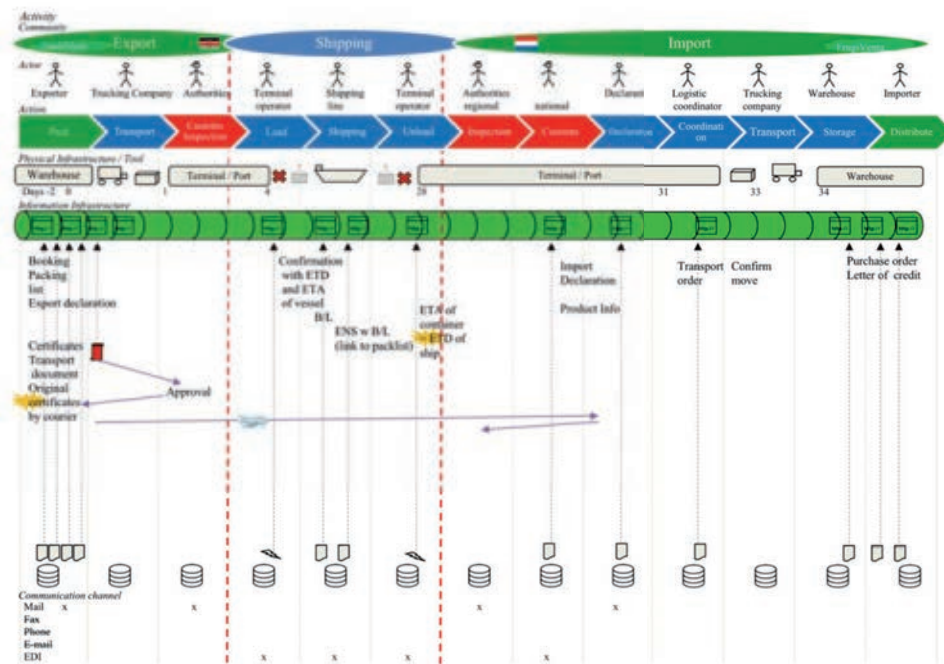


FIGURE 8 Efficient mycorrhizae enabled by the concept of the Shipping Information Pipeline for containerized shipping. All documents are digitalized and stored at the source with remote access for authenticated actors in the different activity systems. Except for the phytosanitary certificate, the authorities require the original paper document to be present upon importing [Colour figure can be viewed at wileyonlinelibrary.com]

2011). We claim that collaboration will be significantly improved through lower cost and a widely shared mycorrhizae. This will increase usage, especially by lowering the cost by using the benefits provided by the II. Not only will our proposed approach lower transaction costs through providing real time information, but also it will substantially contribute towards enhancing trust and governance.

Examples of potential SIP user experiences are illustrated in Figure 9 in a PC browser and in Figure 10 as a mobile application. Noteworthy is that detailed information for an event is accessed through clicking on the associated URL directing to, eg, the associated document displayed in a Web browser.

The visibility of GPS information from the container enables the actors to view the container's location and past journey on a map, which makes the physical object virtually visible. The visibility could be enhanced (eg, by a camera in/on the container streaming live from its location). Furthermore, the SIP enables transparency into the shipping information and documents, which enables transparency of past events and "road blockers" in case of incomplete or missing documentation explaining why a container is standing still and enabling the actor(s) to take action, decide, and operate. Furthermore, actors empowered with transparency can be proactive (eg, spotting a "road block" ahead, foresee a delay, or a missing approval by another actor in another organization) and react in due time not only to replan or to remove it and avoid delays but also to increase reliability and probability of being on time.

The SIP enables identifying the container with its geographical location, visibility on a map as shown in Figure 10, and identifying events, including transparency into related organizations (and actors). This is what Engeström refers to as delineation. Further, the SIP enables transparency on a map of its past geographical locations and transparency into previous events, including operational performing organization(s), which is what Engeström refers to as historicity.

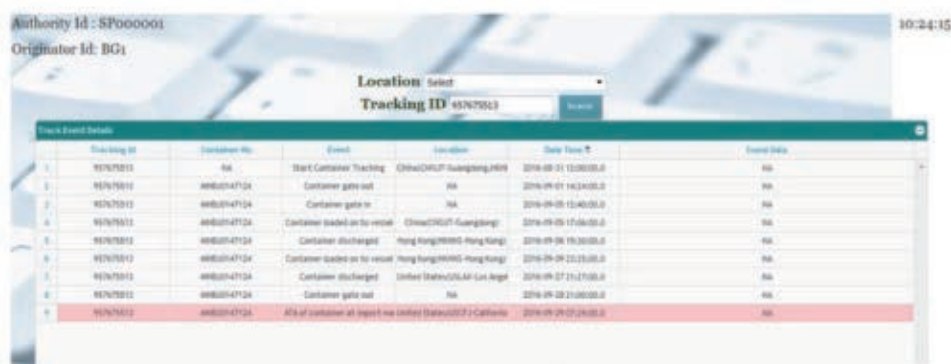


FIGURE 9 The Shipping Information Pipeline, example of user experience from one of the prototypes showing the a screen proving overview of shipping events for a shipment with 1 container. Note, the information shown is from a technical test [Colour figure can be viewed at wileyonlinelibrary.com]

Furthermore, transparency provided by the SIP reveals the knotwork of containerized shipping across borders and organizational boundaries. Additionally, the SIP provides easy access to the boundary objects of shipping information and to detailed information and documents (directly from source) for actors granted access. Accordingly, SIP provides a shared II improving the mycorrhizae for containerized shipping and reducing the tendency of the shipment becoming a runaway object. The AT terms enrich our understanding of the containerized shipping activity, enabling us to express in AT terms how the SIP through mycorrhizae facilitates delineation and historicity of containerized shipping and revealing the knotwork, including dependencies in the supply chain and the ecosystem.

6.3 | Implications for research

With regard to IS, the referential meta information in the proposed solution of SIP can in AT terms be interpreted as a new type of boundary object for collaboration at AT method-movement 4 level, complementing and reducing the effect of the runaway object. Accordingly, the referential meta information object would be a new research object for IS research.

With regard to AT, the SIP enables transparency into planned operations/actions/events, including the responsible organization that enables actors to act proactively. To our knowledge, AT does not include planning and proactive operations/actions; accordingly, we propose to extend AT with foresight and planning activities into the knotwork.

6.4 | Implications for practice

With regard to Supply Chain Management, extant research does not include managing the supply chain outside the visible horizon¹⁹ (Carter et al., 2015) and has recently moved towards resilient supply chains (Sheffi, 2015). The SIP enhances visibility into shipments of containers in the supply chain for international trade and accordingly, enables supply chain management outside the visible horizon of the actors foreseen to enable the supply chain management for increasing efficiency and improving reliability for shipments that ultimately will not only reduce lead times and uncertainty for lead times but also increase reliability and reduce trade cost, especially indirect cost.²⁰

¹⁹Including the focal company and its direct partners (Choi and Krause, 2006).

²⁰Note that several studies find that indirect cost due to, eg, delays and buffering of stock to compensate for uncertainty in lead time are significantly higher than the direct cost, eg, The Global Alliance for Trade Facilitation (<http://www.tradefacilitation.org/about-the-alliance.html>) and World Economic Forum (http://www3.weforum.org/docs/WEF_GETR_2016_report.pdf).

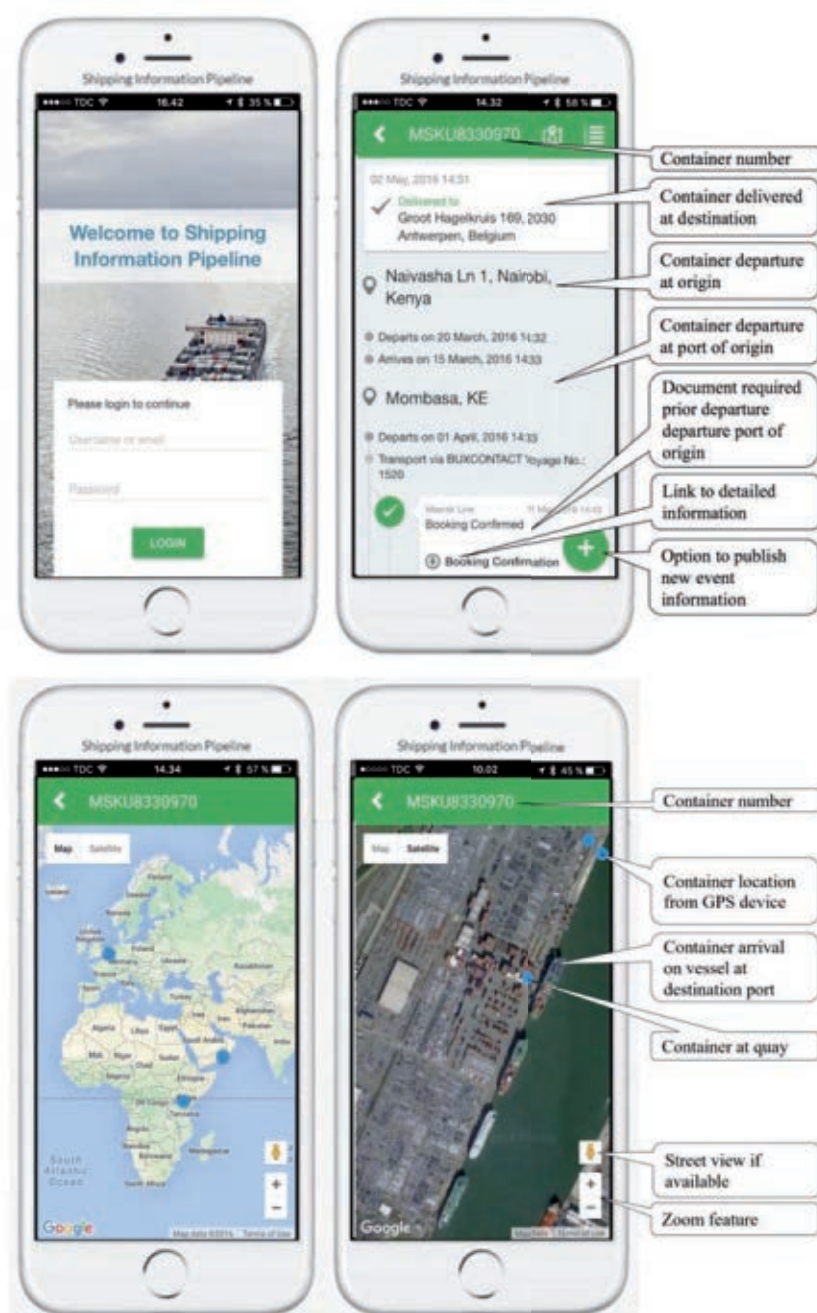


FIGURE 10 The Shipping Information Pipeline, example of user experience from one of the prototypes showing the mobile SIP application with log on screen and an overview screen combining shipping events and links to detailed information/documents. The maps shows ports of origin, transshipment and destination, and detailed map of container location in Port of Antwerp [Colour figure can be viewed at wileyonlinelibrary.com]

With regard to security concerns, we found that compared to the current situation with a fragmented mycorrhizae where shipments tend to become runaway objects, a well-designed SIP can enable efficient mycorrhizae with global coverage (through using the Internet) facilitating visibility and transparency into containerized shipping activity with reliable information (directly from the source), eg, about the organizations behind the shipment and the content of the shipment, which is foreseen to provide significant improvements compared to current situations, ultimately eliminating the runaway effect of shipments.

We have piloted the shared II, SIP, and are in the process of establishing a large-scale real-world field study of containerized shipping with the involvement of key stakeholders (US, EU, and EAC authorities, a large shipping company, and a large IT and II vendor). This is jointly funded by IBM and Maersk and publicly announced commercialization February 2017 as Global Trade Digitization solution.²¹ As Ciborra (2000) has foreseen, II are challenging: "We experience control in the age of globalization as more limited than ever. We are creating new global phenomena that we are able to control only in part. Although information infrastructures appear to be important instruments for governing global phenomena", they possess ambiguities which make their eventual outcome difficult to determine. Consequently, they may serve to "curb our governance capabilities just as much as they enhance them".

7 | CONCLUSION

We find that Information Technology, specifically II can significantly contribute to solving the major challenges of containerized shipping by providing a shared mycorrhizae, thus facilitating the knotwork of containerized shipping. Following Grisot, Hanseth, and Thorseng (2014), we first designed the conceptual architecture of the SIP inspired by IS design theory for II (Hanseth & Lyytinen, 2010) and by design of WWW (Berners-Lee & Fischetti, 1999). Subsequently, we developed the components in the SIP. After piloting selected trade lanes, more trade lanes will be included and we expect a phase for creation of value added components and services on the SIP.

We identified top 3 challenging trade barriers for containerized shipping in international trade: high trade costs, uncertain lead times, and unknown security risks. Our analysis of shipments in 1 specific trade lane revealed the knotwork for containerized shipping especially the document and information for cross border administration, which explain the unreliable lead times and relatively high trade cost. Further, we found that shipments tend to become runaway objects explaining the security concerns. Finally, we identified the lack of a shared mycorrhizae or II as root cause for all 3 challenges. To address this root cause and to heal and coalesce the mycorrhizae, we proposed and designed SIP that demonstrates an II for sharing shipping information.

As illuminated in our analysis, the physical shipment in containers is by and large invisible to the actors. Rose George²² characterizes "(Containerized) Shipping as the invisible industry" that is "ninety percent of everything": putting "clothes on your back, components in your car, food on your plate." Anyhow, containerized shipping is not as efficient as it should be, and the World Economic Forum estimates that reducing the nontariff barriers to half best practices (using IT) will increase trade by 14.5% and GDP by 4.7% (WEF²³). Parts of our case study research data were collected and reported in connection with a report for the World Economic Forum (WEF). Further, our research findings have been presented and discussed at World Trade Organization conferences on several occasions.²⁴ Furthermore, United Nations General Secretary, Ban Ki-Moon in the report *Mobilizing Sustainable Transport for Development*²⁵ mentions SIP as the example of IT solutions that support mobilizing sustainable transport for containerized shipping and estimates that "improvements in border administration, transport and communication infrastructure could increase global GDP by US\$2.6 trillion."

²¹Press release at TPM 2017 conference and article in New York Times 20170304.

²²<http://rosegeorge.com/site/books/ninety-percent-of-everything>

²³http://www3.weforum.org/docs/WEF_SCT_EnablingTrade_Report_2013.pdf

²⁴For example, at the World Trade Organization Conference 2015.

²⁵<https://sustainabledevelopment.un.org/topics/sustainabletransport/highleveladvisorygroup>

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APPENDIX A

RESEARCH DATASET

TABLE A.1 Overview of selected research dataset

Date and Location	Event	Participants	Focus	Selected Quotes/ Citations
2013-07-02 The Netherlands	Site visits and meetings	Shipping line, terminal operator, Dutch customs, and researchers	Container terminal and customs at Port of Rotterdam	
2013-09-01 Kenya	Interviews and observations/ site visits	Farmer of avocado	Export of fruits	"Avocados are more profitable than the other things I grow" "(the export) makes it possible for my children to go to school" "This business would not be possible without the reefer (refrigerated container)."
	Exporter			
2014-01-28 Terminal, Port of Rotterdam	Focus groups	3 representatives from authorities and 3 from private service provider	Shipping line and Dutch customs authorities	"The inspection takes few minutes"
2014-01-28, 30 The Netherlands	Interviews and observations/ site visits	3 logistic manager, fruit importers	Import of fruits to EU	"We use external scan." "We have a consultant coming every morning to clear on behalf of customs."
2014-01-29 Den Haag	Focus groups	Director and 8 logistic experts from 8 fruit importers	Association of fruit importers	"We never know where the container is, we dream to have a drone (to see it)."
2014-01-30 Terminal, Port of Rotterdam	Interviews and observations/ site visits	3 representatives from private service providers company and 3 advisors from special service providers	Import of fruit	"It is possible to book an appointment with the authorities for inspection."
2014-05-28 Nairobi, Kenya	Interviews	Logistic forwarder Service provider	Export of fruit	"We seal the container Sunday and get the approval from the authorities Monday."
2014-05-27 Nairobi, Kenya	Meetings and interviews	Customer relationship manager shipping line	Export of fruit	"Facilitation fee is needed in some instances."
2014-05-27 Nairobi, Kenya	Interviews, meetings, and observations/ site visits	Logistic manager (and partner/ owner) Exporter	Export of fruit	"The vessel sails out weekly (from Mombasa, Kenya). If you miss that then

(Continues)

TABLE A.1 (Continued)

Date and Location	Event	Participants	Focus	Selected Quotes/ Citations
				you have them (fruit) stocked with you for another whole week and that means a lot of losses (of avocados) and a lot of money losses. You can take fruit (in a refrigerated container) to Europe in 25 days."
2014-06-03 Delft, Holland	Meetings/ presentations	Traders, authorities, and researchers	Introduction to trader business	Customs officer: "The key is to know the shipper and what's inside the container."
2014-06-04 Naaldwijk, Holland	Site visits and meetings	Traders and researchers	Follow the logistic flow	Trader: "Any improvements reducing the cost by few percentages are interesting."
2014-07-08	Shipments from Kenya to Holland	Shipment in containers	Collect communication, information and documents plus container monitoring data	
2014-09-09 Sosterberg, Holland	Meetings	Traders, authorities and researchers	Actors involved	Customer officer: "Since 9-11 our effort on security have been a key focus"
2014-11-17 Delft, Holland	Meetings	Traders, authorities and researchers	Actors involved	
2014-11-18 Aalsmeer, Holland	Site visits	Traders, authorities and researchers	Follow inspection by authorities	Use Ipad for registration of inspection result.
2014-11-18 Aalsmeer, Holland	Meetings	Traders, authorities and researchers	Understand objectives of key actors	Traders focus on trade cost and lead time, and authorities on security.
2014-11-19 Aalsmeer, Holland	Meetings	Trader informant	Analysis of communication by trader	"I did not realize the complexity. I normally take one e-mail (for one shipment) at the time and never grab the holistic view."
2014-10-12 virtual meetings	Validations	Trader informant	Validation of findings	"I (with 20+ years in trading logistic) have never heard about this document (ENS)."
2015-04-12 Kenya	Site visits and meetings plus workshop	Forty authorities, exporters, freight forwarders, terminal operators, etc	Paper trail of container for export of perishables	

(Continues)

TABLE A.1 (Continued)

Date and Location	Event	Participants	Focus	Selected Quotes/ Citations
2015-11-29 Rotterdam	Conference practitioners	Fruit importers	Present and validate findings	
2016-03-07 Kenya	Site visits and meetings	Fifteen authorities, exporters, freight forwarders, terminal operators, etc	Verify findings for paper trail of container for export of perishables including solution	
2016-05-27 The Netherlands	Workshop	Traders, authorities, and researchers	Validate findings including solution	
2016-06-21 The Netherlands	Workshop	Traders, authorities, and researchers	Validate findings	
2016-08-31 The Netherlands	Workshop	Traders, authorities, and researchers	Validate findings including solution	
2016-11-24 The Netherlands	Site visit and meetings	Traders, authorities, and researchers	Validate findings including solution	

TABLE A.2 Overview of research dataset of shipments/containers for analysis for containerized shipping

Origin Date and Location	Destination Date and Location	Transshipment	Shipment/Container ID	Commodity of Goods inside Container
2014-02-17 Nairobi, Kenya	2014-03-05 Dubai (UAE)	Salalah (Oman)	MWMU6411112	Avocados
2014-02-17 Nairobi, Kenya	2014-03-05 Dubai (UAE)	Salalah (Oman)	MWMU6359992 to MSWU9089720	Avocados
2014-05-08 Nairobi, Kenya	2014-06-05 Malaga (Spain)	Salalah (Oman)	MMAU1154601	Avocados ^a
2014-05-08 Nairobi, Kenya	2014-06-03 Kent, UK	Salalah (Oman) Flexistowe (UK)	MMAU1080978	Avocados
2014-05-08 Nairobi, Kenya	2014-05-27 Dubai (UAE)	Salalah (Oman)	MWC5324369	Avocados
2016-07-16 Nairobi, Kenya	2016-08-15 The Netherlands	Salalah (Oman) Antwerp (Belgium)	MMAU1185710	Avocados
2016-08-03 Nairobi, Kenya	2016-09-07 The Netherlands	Salalah (Oman) Antwerp (Belgium)	MMAU1113032	Avocados
2016-08-06 Nairobi, Kenya	2016-09-10 The Netherlands	Salalah (Oman) Antwerp (Belgium)	MMAU1202274	Avocados
2016-08-06 Nairobi, Kenya	2016-09-10 The Netherlands	Salalah (Oman) Antwerp (Belgium)	MNBU3436223	Avocados
2016-10-04 Nairobi, Kenya	2016-10-29 The Netherlands	Salalah (Oman) Antwerp (Belgium)	MMAU1160902	Avocados
2016-10-08 Nairobi, Kenya	2016-11-05 The Netherlands	Salalah (Oman) Antwerp (Belgium)	MMAU1047413	Avocados
2016-10-15 Nairobi, Kenya	2016-11-12 The Netherlands	Salalah (Oman) Antwerp (Belgium)	MMAU1094945	Avocados

^aHarmonized system commodity code: 08044000 https://en.wikipedia.org/wiki/Harmonized_System 20170122.

APPENDIX B

DECOMPOSITION OF THE MAIN ACTIVITY INTO 3 ACTIVITY SYSTEMS

TABLE B.1 Decomposition and categorization of the 3 activity systems of export, import, and international shipping of the supply chain for containerized shipping for international trade of fresh products from East Africa to EU

Activity Dimension	Export East Africa	International Shipping	Import Europe
Actors	Farmers, exporters, authorities, service providers, eg, transporters	Terminal operators, shipping lines	Retail, consumers, importers, authorities, service providers, eg, transporters.
Communities, examples	Association of exporters in East Africa	Alliances of shipping lines, World Customs Org	Association of importers of fruit to the Netherlands
Objects	Fruit and vegetables loaded in refrigerated containers with related export documents and information	Sealed refrigerated containers (with fruit and vegetables) with related international shipping documents and information	Fruit and vegetables unloaded from refrigerated containers with related import documents and information
Rules	Exporting regulations in country of origin	International trade regulations, international seafarer rules, etc.	Import regulations in importing country and EU
Tools/equipment selected	Local means of transports as trucks, local authorities information systems for export declarations, certificates, etc, local terminal operators' information system	Container vessels, cranes, etc, local port community information systems, EU authorities information system for Entry Summary Declaration, shipping lines information system, etc	Local means of transports as trucks, local authorities information systems for import declarations, certificates, etc, local terminal operators information system
Division of work	Farming, exporting, packing, transport by truck, controlling and inspection	Transport, shipping, handling and storage	Importing, transport by truck, controlling and inspection, repacking, and distribution

APPENDIX C

EXAMPLES OF KNOTWORK FOR SHIPPING INFORMATION IN CONTAINERIZED SHIPPING

Let us consider some examples of knotwork for shipping information in containerized shipping for the specific trade lane analyzed. The examples are illustrated in Figure 7. The first example concerns the communication back and forth of the packing list, which is used in several key documents such as the Bill of Lading (B/L) and phytosanitary certificate. For instance, we found that the planned packing list for the B/L was copy + pasted (indicated by a red downward arrow in Figure 7) in 5 instances of e-mail communication spread over several days resulting in plenty of e-mails. Only when the container was stuffed was the actual packing list known. But the above-mentioned communication of the packing list in connection with declaration happened prior to the stuffing, and thus after the stuffing of the container there was no more communication of the actual packing list or any correction to the planned packing list attached to the already declared document. This results in the inconsistency between the declared packing list and the actual contents. This example illustrates one example of why the authorities often encounter inconsistencies in the shipping information declarations.

Another example is the weight estimation as part of the Shipping instruction document that revealed more than 30 e-mails among at least 6 actors (located in Kenya, Nairobi and Mombasa, India, and the Netherlands); the e-mails included scanned attachments of documents hereof some with additional handwritten notes of changes. At the service center of the carrier in India, this was recorded as incidents involving at least 5 different people internally from the shipping line communicating back and forth in the communication chain of carrier's service center to carrier's local representative to freight forwarder to the shipper and farmers. Furthermore, the truck with the container is actually weighted at stations on the road from Nairobi to Mombasa; however, those information are not shared with above mentioned actors.

A third example is that certain original paper documentation with several stamps and signatures of the exporting authorities were required by the importing authorities. Accordingly, the originals were sent by courier at an additional cost of USD 200 to 250. They are marked with a red document icon in Figure 7.

A fourth example concerns the fact that a few of the ERP systems were capable of communicating electronically with other information systems via IOS based on standardized EDI/XML messages, which is indicated with a flash icon in Figure 7. An example of an EDI/XML message is the Entry Summary Declaration (ENS). The ENS is communicated from the shipping line's dedicated ERP to the European Union authorities' Import Control System via EDI/XML messages-based communication; in return, a Movement Reference Number (MRN) is received and possibly a "Do Not Load" (DNL) message. However, the ENS is received in a local instance of the authorities ERP systems at first port of entry for the shipment and are not accessible by any of the other authorities, eg, located in Port of Antwerp, Belgian nor the Dutch authorities in the Netherlands, instead they get a 1 letter code message referencing to the B/L and for further information they will call by phone the authorities at first port of entry.

Additional issues are marked by a yellow icon in Figure 7 (not described in detail here).

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