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Document Version
Accepted author manuscript

Published in:
Information Systems Journal

DOI:
10.1111/isj.12146

Publication date:
2018

License
Unspecified

Citation for published version (APA):
Jensen, T., Vatrapu, R., & Bjørn-Andersen, N. (2018). Avocados Crossing Borders: The Problem of Runaway Objects and the Solution of a Shipping Information Pipeline for Improving International Trade. *Information Systems Journal*, *28*(2), 408-438. https://doi.org/10.1111/isj.12146

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Journal article (Accepted manuscript)

This is the peer reviewed version of the following article: Jensen, T., Vatrapu, R., & Bjørn-Andersen, N. (2018). Avocados Crossing Borders: The Problem of Runaway Objects and the Solution of a Shipping Information Pipeline for Improving International Trade. *Information Systems Journal*, 28(2), 408-438. DOI: 10.1111/isj.12146, which has been published in final form at http://dx.doi.org/10.1111/isj.12146.

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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 three predominant challenges to containerized shipping that effectively become trade barriers: international trade cost, lead time uncertainty and security risks. We employ Activity Theory to holistically describe, understand and analyze the shipping activity in the international trade eco-system 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 (a) inefficient collaboration across loosely coupled activity systems and (b) fragmented information infrastructure (II). We propose the solution of Shipping Information Pipeline (SIP), a shared Information Infrastructure, thus facilitating collaboration in containerized shipping and contributing to lowering trade barriers. SIP can significantly improve containerized shipping resulting in estimated potential benefits of up to 4.7% growth in global GDP.

Keywords: Activity Theory, Containerized Shipping, International Trade, Knotworking, Runaway Object, Mycorrhizae, Supply Chain Management, Information Systems, Information Infrastructures

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 the more than forty other actors in the eco-system encounter numerous challenges, especially administrative barriers. Consequently, there is a huge potential for savings. Both the maritime industry and a range of public authorities (customs officers, veterinary and health inspectors, anti-narcotics 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, Alhammadi, & Brynjolfsson, 2014; Westerman, Bonnet, & McAfee, 2014) and sharing between Inter-Organizational Systems

(IOS) via Electronic Data Interchange (EDI) (Robey, Im, & Wareham, 2008). However, almost all successful IOS within international maritime shipping are national or regional implementations (Jensen, Tan, & Bjørn-Andersen, 2014), 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 et al. (2010), who add digital and information infrastructures to the IS research agenda. Further, Weill and Woerner (2016) 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 II. Furthermore, large EU initiatives[1] propose accelerating trade by implementing IT innovation for global supply chains (Tan et al, 2011). However, in spite of these efforts, currently, there has been no real-world adoption of a global information infrastructure (II) within the global supply chain for international trade, including containerized shipping.

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 non-tariff 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, non-tariff barriers do not generate incomes or revenues. As such, reducing non-tariff barriers can potentially benefit all stakeholders involved in containerized shipping.

In order to answer the research question stated above, we employed Activity Theory (AT) in order to provide a framework for describing, understanding and analyzing the activity of containerized shipping. AT 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 under-researched phenomena of sparsely connected actors indirectly interacting (Spinuzzi, 2011) across multiple national borders and organizational boundaries in the domain of maritime

[1] Data pipeline was one the innovations demonstrated in the ITAIDE project (January 2006-June 2010) http://cordis.europa.eu/project/rcn/79327_en.html, INTEGRITY project (June 2008 – May 2011) http://www.integrity-supplychain.eu and elaborated in the Cassandra project (June 2011 – August 2014) http://www.cassandra-project.eu and http://www.COREproject.eu (May 2014 – April 2018) 20161128.

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 employed AT to conduct a multi-level 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 hetergenous eco-system for international trade. We adopt a non-dualist 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 SIP significantly contributes towards solving the major challenges of containerized shipping which is estimated to beneficial impact through increasing globalization and increasing GDP significantly by lowering non-tariff barriers.

[2] According 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*."

[3] According 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).

[4] According 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).

[5] According to Engeström (2007), *"Mycorrhizae represent relatively durable horizontal connections across activity systems." and "They are made up of heterogonous 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."*

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) states that after the industrial revolution and the invention of the computer and the Internet, the invention of the standarized container "has propelled the globalization of the world economy" (ibid.). Since the introduction of the standard container in the late 1950's 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] percent of non- bulk 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 use of refrigerated containers, perishables (e.g., fruit) can retain high quality, even if the transportation time is as long as several weeks. This creates new export possibilities for perishables (vegetables, fruits, flowers, etc.) for 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 (e.g., the importer or the exporter). Figure 1 presents a schematic overview of international trade.

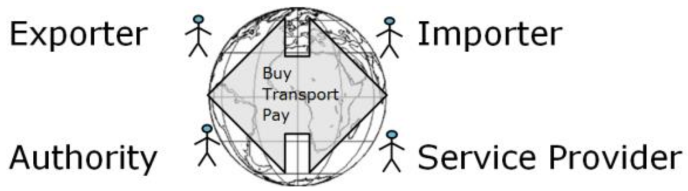

Figure 1: The main roles of the actors and main activities in international trade. (Adapted from the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT 2001)

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 goods (e.g., 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 (e.g., for phytosanitary import requirements, health security, hazards, smuggling, as well as collecting tariffs and other fees) that become barriers to trade.

[6] In 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 non-bulk goods.

As we present and discuss in the next three subsections, the regulatory barriers imposed by authorities are not the only barriers. Of the challenges that relate to information that can be addressed by IT, there are three major ones related to containerized shipping. These three main challenges are also called the main non-tariff 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 assosiated risks are the greatest challenges. Accordingly, the authorities govern all goods moving in and out of their territory (e.g., by controlling documentation and by inspecting goods), thereby impacting the uncertainty with respect to lead time for traders. Next, we discuss in detail these three trade barriers.

Trade Barrier #1: High International Trade Cost

Crossing international borders presents costly barriers. The total annual, world-wide, extra costs due to administrative burdens are estimated to be in the range of 257 billion USD (United Nation ESCAP, 2014). There are two main determinants of the trade cost for perishable goods such as fruits and vegetables: (a) the production price in the local export market, which is lower in East Africa than it is in Europe and (b) 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. Based on our findings, we purport that international containerized shipping is generally inefficient. Accordingly, we foresee a potential for improvements, especially with IT, since the majority 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 (e.g., phytosanitary inspections).

Figure 2: Breakdown of retail cost for general goods in international trade.

Trade Barrier #2: Uncertainty about Lead Time

The two key issues for importers of perishable goods such as fruits and vegetables in international trade are the quality of the product which determine 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 and 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 (e.g., 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. Due to the variation in lead time, the average industry reliability in containerized shipping is

67.8%[7] which makes it challenging to plan and coordinate the subsequent activities (e.g., when the goods will reach the retail distribution - the stores and the final consumers), making marketing and sales challenging and business risky.

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 new trade barriers (e.g., 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. Due to 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).

Theoretical Framework

For our analysis of the shipping activity, we selected Activity Theory (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 three domain-specific challenges of trade barriers to containerized shipping in the heterogenous eco-system 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 three activity systems in Figure 4 are separated by time, geography, government,

[7] Global carriers are ranked, e.g., by SeaIntel (http://www.seaintel.com/ 28062016), on reliability to arrive and depart on time (within +/- 24 hours of estimated time), and Maersk Line is the best in class with, e.g., reliability of 80.2% in January 2015 compared to industry average of 67.8% http://www.seaintel.com/index.php?option=com_seaintel&view=singleissue&issue=57&type=SLP 28062016.

culture, linguistics, literacy, and, to some extent, technical capabilities. Compared to most other system theories that assume one given power structure or governance model inside the system, AT is explicit about the rules and governance and the organization (e.g., 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 eco-system.

Activity Theory

Both Activity Theory (AT) in general and Cultural Historical Activity Theory (CHAT) in particular have their origins in the Soviet Psychology of Vygotsky, Luria and colleagues (Roth & Lee, 2007; Vygotsky, 1930/1980, 1962). AT 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, 2014; Jensen & Vatrapu, 2015). Originally, AT provided a holistic, materialistic and non-dualist conception of human activity in terms of three mutually interlinked elements: subject, object and community resulting in an outcome. The subject 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 three additional mediating elements: (a) the rules that mediate between the actor and the community, (b) mediating artifacts/ tools/equipment which the actor uses in relation to the object, and (c) the division of labor which 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.

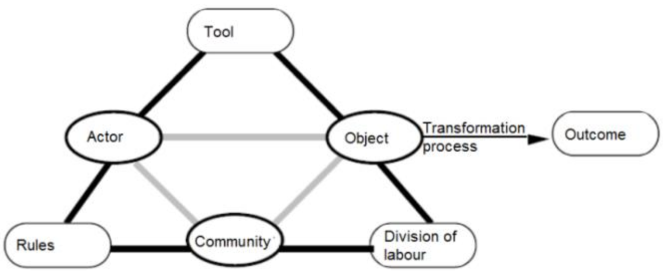

Figure 3: Basic structure of an activity system with embedded the mediating relations modified after Engeström (1987) and Kuutti (1996), with the term actor used instead of subject because of the actor's association with actions

Engeström (2008 p.222) proposes utilizing five principles of AT: object orientation, mediation by tools, mutual constitution of action and activity, contradictions and deviations 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 utilize information and IT tools to mediate 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 which, 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 (e.g., 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 one organization can perform in one continuous process independent of other actions involving others.

Third Generation Activity Theory in Information Systems

AT research in IS (D. Allen, Karanasios, & Slavova, 2011; D. K. Allen, Brown, Karanasios, & Norman, 2013; Hasan, Kazluaskas, & Crawford, 2010; Karanasios & Allen, 2013, 2014; Kari Kuutti, 1991; K Kuutti, 1996; Kari Kuutti, 1999) has predominantly focused on delineation[8] (Engeström,1999) of either the narrow phenomena of mediated interaction between a) the human actor (the subject) and the world (the object) or b) the networked phenomena of multiple, densely connected actors directly interacting across system limits sharing a boundary object or network object (Y. Engeström, 1999; Spinuzzi, 2011), which Engeström (1987) termed Third Generation AT. We have found it particularly relevant to utilize 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 three central conceptual terms of runaway object, knotworking, and mychorrhihze were previously provided in the footnotes. The three conceptual terms are now elaborated below. Inspired by the concept of a 'runaway world' (Giddens, 1991, 2002; Giddens & Pierson, 1998), Engestrom (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 concept of mycorrhizae is the hidden and invisible organic

[8] According to Engeström (1999), ''Delineation is the very act of identifying the personal and geographical locus and limits of the activity''

texture underneath visible fungi in biology, with reference to Allen (1991) and Sharma & 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. 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 events and information about them will reduce the runaway effect. Although Spinuzzi (2011) only found one 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 the discussion section.

Method-Movements of Activity Theory and Information Systems: Research Objects Allignment

The Method-Movements for AT distinguishes between four different kinds of objects: (1) individual activity object, (2) shared boundary object, (3) shared network object and (4) runaway object. Method-Movement 1 is characterised by a single activity system involving one actor and his/her relationship to a particular object (e.g., individual usage of an iPhone or a navigation system). Method-Movement 2 is characterised by two activity systems involving two different actors sharing a boundary object (e.g., exchanged between two actors, such as the shipment and/or a container identification number). Method-Movement 3 is characterised by a network of multiple activity systems that share object(s) constituted by multiple components, (e.g., logistic network utilizing IOS with many EDI/XML messages). Finally, Method-Movement 4 identify and deal with object(s) that are "transformed via knotworking in substrates of mychorrhizae" (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 lacks of empirical studies focusing on a runaway object, and the phenomena of sparsely connected actors indirectly interacting is under-researched (Spinuzzi, 2011).

The object in focus with the four different levels of the Methods-Movements for AT can be aligned to the IS research objects as shown in Table 1 below.

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

Table 1: Selected IS research objects aligned with AT objects according to the Methods-Movements of AT.

We find IS research on all four 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 e.g. on Information and Communication Technology (ICT) centers on sharing a boundary object (e.g. emails possible with attachment of entities from within an organization's Enterprise Resource Planning System (ERP) communicated in-directly between two organizations) similar to AT's focus on shared boundary objects. On the third lvel we find EDI messages interchanged in a network sharing objects where service providers offered a hub for exchange of EDI messages, which in IS research is termed Inter-Organizational Systems (IOS) based on EDI messages (Krcmar, Bjorn-Andersen, & O'Callaghan, 1995). There are other examples of network sharing objects such as programmers co-developing 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.

AT provides dimensions (see Figure 3), enables the breakdown in activity, actions and operation, and articulates not only evolving, but 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 in order to be able to design IT solutions especially if central control/governance is unobtainable.

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.

Research Method: Revelatory Case Study

We employed 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 presumed 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 one organization, we study containerized shipping for the complete supply chain for international trade involving multiple organizations located in different continents. Within this huge area, we decided to limit our focus to one 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.

Research Design

Our research design consisted of in deepth analysis of the journeys of twelve shipments of avocados, conucting meetings/interviews with a total of forty involved actors from the more than thirty 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 (e.g., communication using different communication channels as documents, fax, emails, Inter-Organizational Systems (IOS) based on EDI/XML messages, etc.).

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). Due to 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.

Unit of Analysis

The relevant unit of analysis is the containerized shipping of shipments in refrigerated container(s). The actual international shipment activity *uses* the refrigerated container(s) which 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 international shipment - continously moves in time and geographical location. Further, the physical container is invisible for most actors most of the time and only becomes "visible" through related documents and information. These documents and information are stored in in various different 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 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 kilometers on land, plus 8,000 nautical miles at sea[9]. To study all movements, the researcher to 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.

Traditionally, the outcome of the shipping activity in the form of a transfer of containers to the destination can be observed at discrete intervals (e.g., 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 (e.g., 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 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,

[9] http://www.sea-distances.org 2017.01.21

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, written material regarding procedures were collected and documented. In the later phase of the research, when tracing shipments and meeting actors, the researcher presented and demonstrated the proposed solution in order 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.

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). In order to improve on the robustness of the overall results of the case study, the research design involved several actors in each organization. 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 carried out 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 transhipments 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 in terms of firm and market attributes. Accordingly, we selected a set of representative importers based on the recommendations of the respective trade associations. Key influencers from trade facilitation organizations and authorities were been 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 semi-structured interviews and composition of focus groups, we were assisted by the General Secretary of the Dutch association of fruit and vegetable importers, FrugiVenta, 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 identified key documents (e.g., customs declarations) and identified key information items for the logistics coordination (e.g., estimated time of arrival).

The research data for this paper were collected over a period of more than three years (2013-2016) by interviewing key actors in the organizations, visiting field sites, observing specific shipments, conducting a set of focus group interviews and meetings. In total, we were able to identify more than thirty different organizations involved in the different constellations of containerized shipping within the trade lane for perishables from Kenya to Europe. Table 1 in Appendix A 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. After this analysis, 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.

Limitations

We acknowledge the limitations of our case study in analyzing containerized shipping for shipments in only one international trade lane of fresh avocados between two nations and considering only the supply chain (not the related financial transactions). Acknowledging this limitation, we believe never the less 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 supply chain infrastructure, utilizes the same type of service providers, and has to pass the same type of authorities[10] who perform the same type of activities utilizing similar or even the same ERP systems and IOS. That said, we acknowelge that our findings need to be evaluated and replicated by future research for other trade lanes, geographics, commodities, etc.

Analysis

We shall now present the findings from our AT analysis of the case study of twelve international shipments of avocados from farmers in Africa to retail distribution centers supplying stores in the EU. *First*, we analyze containerized shipping activity for the avocados across borders and we identify three activity systems: export, shipping and import. *Second*, we analyze and decompose the actitivies into actions constituting the 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

[10] Except for the phytosanitary inspections which do not apply for general cargo.

understanding and 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 authoriteis.

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 two seals by the representatives of the authorities and by the carrier. 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 transhipment en route in Oman and 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 warehouse for storage, phytosantary 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, as mentioned previously in the domain-specified challenges section (e.g., from Kenya to the Netherlands it takes between 24 and 34 days, depending on the route and circumstances.).

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 (in our case, avocados in refrigerated containers). The outcome is a transferred object (shipment 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 three relatively independent activity systems: export, international shipping (seavoyage) and import. These areas have different national and regional rules for export and import. Further, a separate set of rules applies for international shipping[11] in international waters.

[11] The 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

While the physical object/shipment of avocados are obviously transferred from one activity system to the next (Figure 4), we found that the information exhange between the three activity systems is very marginal. In system theory, e.g. Bertalanffy (1968) defines a system as the group of elements that have as few as possible connections to the environment. 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. Accordingly, the three activities are delineated in three very different communities: Kenya in East Africa, the Netherlands in EU, and the international container shipping industry for the seavoyage, each of which is governed by its own set of rules. The deliniation of the borders between those activity systems are the international borders specifically customs area at the ports or other area governed by customs e.g. bonded warehouse.

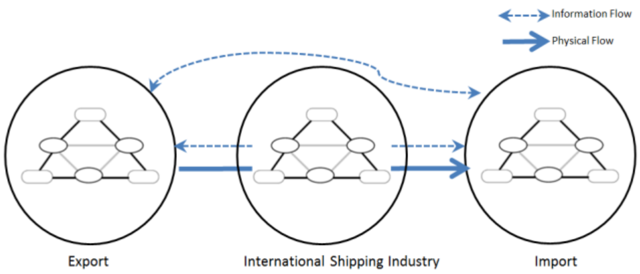

Figure 4: The AT system of the exporter and the AT system of the importer are linked across the borders by the international shipping industry through the object/shipment in container(s) and a few related information/documentations.

AT terms and dimensions, see Figure 3, are used to analyze containerized shipping. The *activities* are **export**, **international shipping** and **import** that transform the object of the shipment of goods loaded in containers from the exporter to unloaded goods at the importer via international shipping. *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 (e.g., the Fresh Producers Exporters Association in Kenya and the Dutch association of importers of fruits and vegetables FrugiVenta), in addition to the authorities in the exporting country and the authorities in the importing country. 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 country or region (e.g., Dutch and EU regulations). The *tools* are the refrigerated container, the various dedicated equipment and means of transport, information systems (with hundreds of documents/information per shipment), 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 3 in Appendix B presents a descriptive overview of the three activity systems of containerized shipping for international trade.

As illustrated in Figure 4 and described in Table 3 in Appendix B, our analysis applying AT revealed that it is only the object (fresh products in the refrigerated containers) and a couple of documents (e.g. bill of lading[12]) are connecting the activity systems of export, international shipping and import. Across the activity systems only the importer and the exporter interact. 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 e.g. the shipping line via a logistics service provider. Furthermore, the trader (importer/exporter) will select service providers (e.g., freight forwarder) and shipping line, depending on the actual business situation and offer given. Within each of the three 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 (e.g., 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 experincing unreliable lead times. Furthermore, it is costly, risky and difficult, as discussed earlier.

Actions by Organizations for Containerized Shipping

After the separation and analysis of the main activity of containerized shipping into three activities, we applied AT to decompose each activity (export, import and international shipping (seavoyage)), indicating that each activity consists of multiple actions and that multiple organizational boundaries are crossed on the specific shipment's journey.

[12] '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)

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 **eight** times[13], has crossed organizational boundaries of at least **ten** companies, and has been handled by at least **eleven** authorities. In total, at least **forty** actors in more than **thirty** organizations[14] located in **seven** countries[15] are involved in the transport and administration of the fresh products from Kenya to EU. The trader (vary depending on inco terms for trade, but in the cases of avocados, it is the importer) delegates and pays service providers to act on their behalf. Figure 5 illustrates the main actors and their primary action within each of the three activity systems of containerized shipping utilizing the supply chain for international trade.

Figure 5: Containerized shipping via the specific trade lane for avocados from East Africa to European Union decomposed into three activities: export, international shipping and import delineated in Kenya, in the Netherlands and in international waters, each governed by national, regional and international shipping rules, involving various actors performing actions structured along the supply chain.

Our analysis shows that each organization in Figure 5 is rather efficient in performing its own action(s). Most organizations have also implemented dedicated physical equipment, as well as one 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 e.g. single-window system, as recommended by United Nations[16]. The actors creatively generate new documents (e.g., the information objects of check-lists 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

[13] An example of a shipment border crossing on its journey from Kenya to the Netherlands involves crossing borders (governed by authorities) of five nations eight times: Kenya – International Sea - Oman, Oman – International Sea – U.K., U.K. – Belgium, Belgium – the Netherlands. Further, the nations passed are members of different regional communities: East African Community, Gulf Union and European Union.

[14] Examples 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 & Customs (U.K.), 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.

[15] Examples of seven nations involved in a shipment's journey from Africa to Europe: Kenya, Oman, U.K., Belgium, the Netherlands, India and Philippines.

[16] United Nations Centre for Trade Facilitation and Electronic Business, U. C. (2005). "Recommendation and Guidelines on establishing a Single Window to enhance the efficient exchange of information between trade and government." Recommendation No. 33.

involved and the associated borders and boundaries incur costs that provide an explanation for the first trade barrier regarding the international trade cost described earlier.

Knotworking Operations for Containerized Shipping

In order 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 align along the supply chain for the physical object of the refrigerated containers (Figure 6). However, several actions are performed in parallel (e.g., 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 government authorities, many activities can be performed by a range of organizations that are competing to perform specific actions (e.g., 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 (more than hundred related documents/information per shipment).

The use of refrigerated containers and dedicated physical infrastructure enable efficient movement of containers to new export markets, thereby opening new export businesses e.g. of avocados. As one 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. East Africa, for example, continues to invest in establishing and improving the infrastructure of roads, rails 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 in a matter of a few weeks. Unfortunately, reliability of containerized shipping[7] 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.

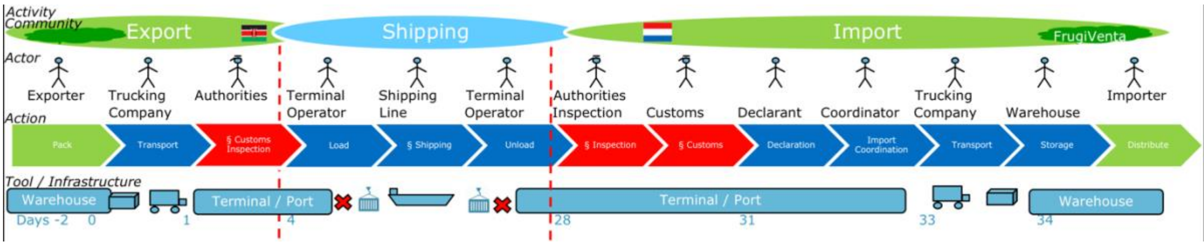

Figure 6: Containerized shipping of avocados from Kenya to Europe and the physical infrastructure/supply chain with indication of lead time in days for a shipment based on the GPS tracking.

Figure 6 presents a simplified picture of the physical infrastructure/ supply chain for containerized shipments. The figure also shows the actors' actions in the three activity systems of export, shipping and import in a sequence along the journey with barriers to pass (e.g., 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 actors[17] in different and ever changing organizational constellations. This is what Engestrom (2007) refers to as 'knotworking.' 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 uncertainly 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. Due to this uncertainly, 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.

[17] The 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

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, e.g., EU.

Our analysis of the shipments showed that over one **hundred** documents and pieces of information were used as boundary objects between the organizations. These documents and information are the boundary objects 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 in their organization's own ERP systems. 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 one user interface, often referred to as a "single window system." However, in the case of avocados, the documents are filed in at least **five** different systems of the authorities. Each of the service providers also utilize a range of ERP systems, e.g., for operation, for customer relation and for accounting. For example, in connection with one of the shipment's analyzed the trader utilized at least **three** ERP systems and the shipping line at least **five** ERP systems.

In summary, we found more than **thirty** ERP systems were involved in the shipment of this study, excluding e-mail, fax or similar information exchange systems. Although the information about shipments was captured in more than thirty 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), 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 characteristic that the dominating communication patterns were peer-to-peer. We found chains of peer-to-peer communication where the shipment information was re-typed or copy+pasted from or into the actor's ERP system or local storage. Interestingly, when 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. Examples of knotwork of the shipping information are described in Appendix C.

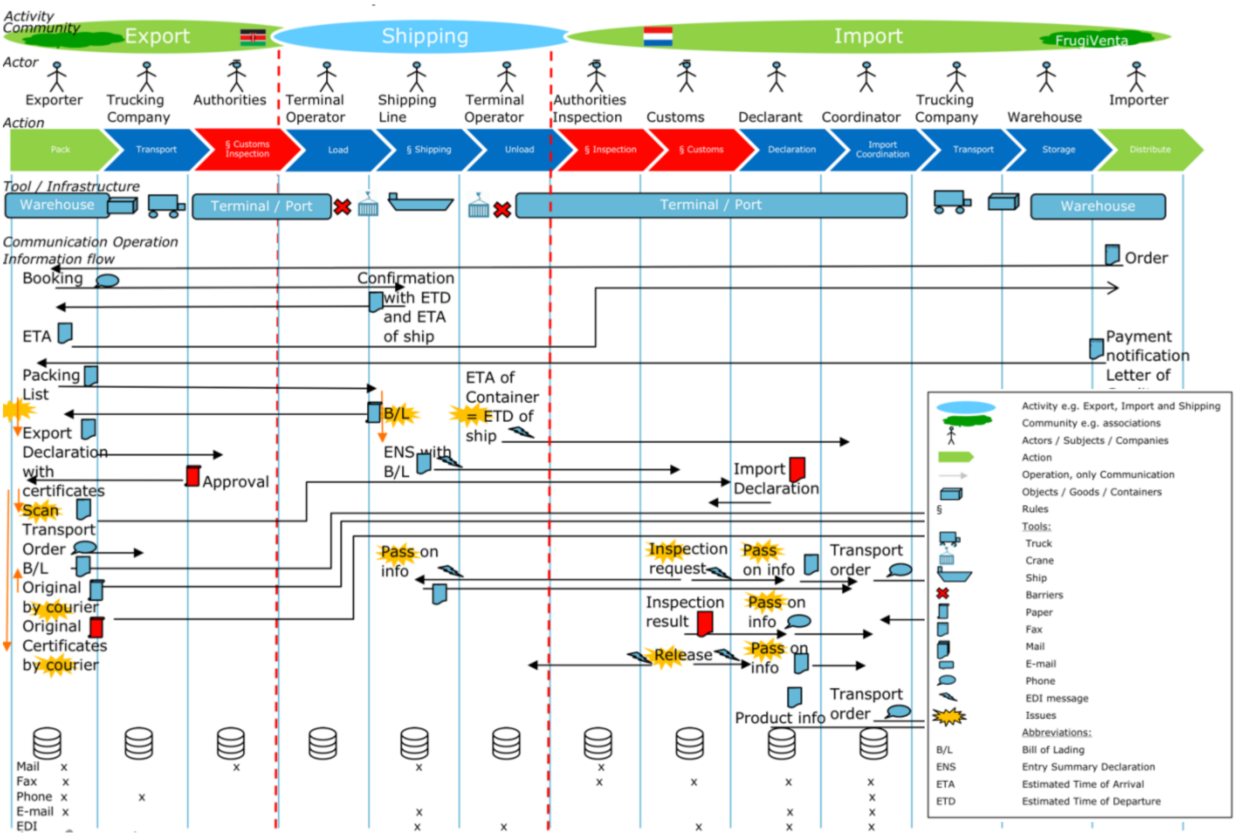

Figure 7: Selected documents and information used in peer-to-peer communication utilizing various ICT channels (in the lower part of the figure) to coordinate operations for containerized shipping along the supply chain for international trade.

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 based on 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 (e.g., 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 but possibly amended, 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 utilized ERP systems for managing 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. We therefore focused on the shared boundary objects between organizations and found many related documents/information representing same shipment but with the many different aspects of the shipments. The actors utilized a wide range of communication channels with a bilateral communication pattern along the supply chain. However, the end result was that 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 (a) inefficient collaboration knotwork across loosely coupled activity systems, and (b) fragmented mycorrhizae (read II) impacted the overall efficiency of containerized shipping negatively. We found that six of the twelve shipments covered in this research study did not follow the "happy path" but experienced delays or other issues impacting product quality due to lack of information or missing 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.

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, we propose a solution in the form of a shared information infrastructure (II) for shipping information, Shipping Information Pipeline.

The Runaway Object of the Shipment

The three 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 three different activity systems for containerized shipping utilizing 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 ten 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 (e.g., that the quality of the fresh products is decreased due to 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. E.g. authorities have specific concerns such as security which can delay the shipment. If the 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 commuication. Furthermore, direct communication can become bi-directional and faciliate 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 (e.g., 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 one trader referred to a missing phytosanitary certificate that prevented the pick up 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 (the shipment) 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 of shipping information, we propose an information systems solution of a shared Information Infrastructure (II) that creates visibility and improves trust for containerized shipping.

The Proposed Solution of Shared Information Infrastructures

When shipping containers, shippers and everybody else in the eco system 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), especically II (based on EDI/XML messages) for accelerating global supply chains (Tan et al 2010). 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 (utilizing 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, e.g., the World Wide Web. 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 source detailed information, e.g., 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 couriers. This is indicated by the red paper icon in Figure 8. Our proposal is that SIP do not replace but augment the existing EDI/XML messages. Accordingly, URLs to the EDI/XMLs can be shared via SIP.

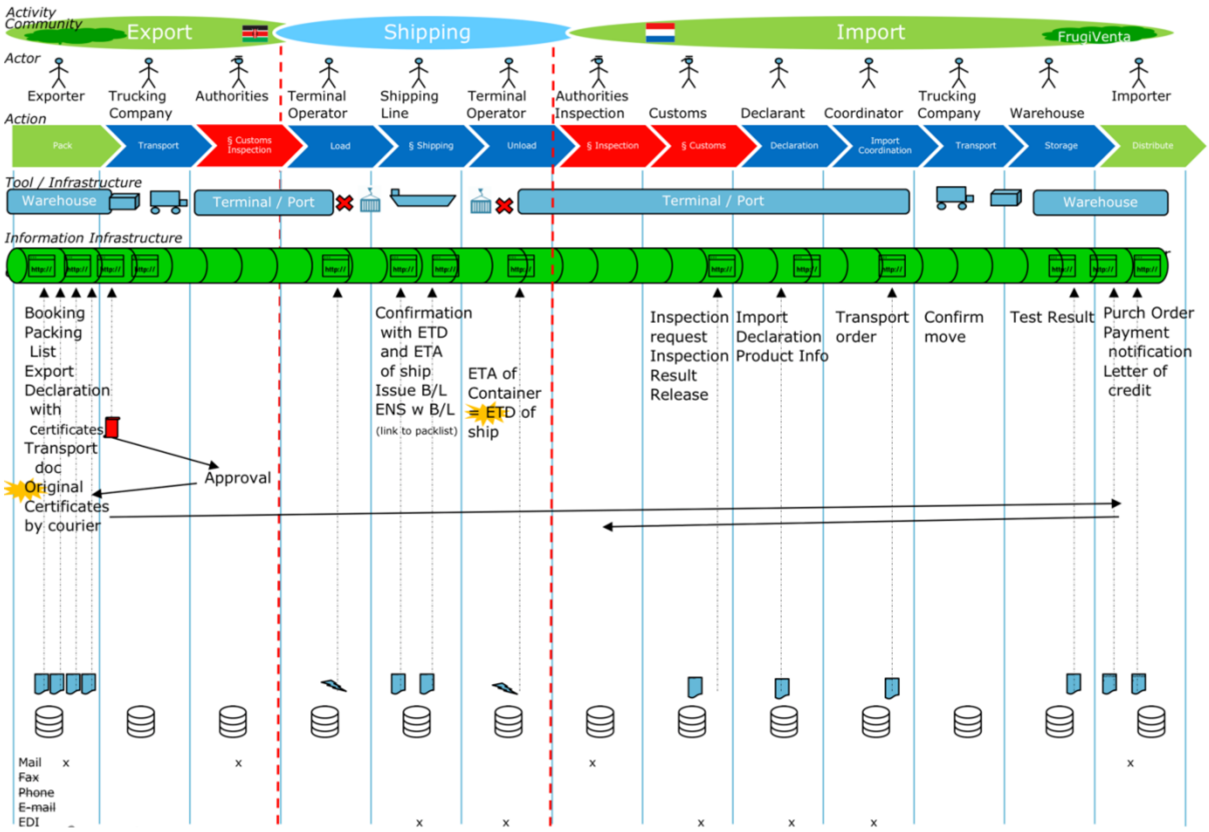

Figure 8: The concept of the Shipping Information Piopeline for containerized shipping. All documents are digitalized and stored at the source with remote access to authenticated actors in the different activity systems. For the phytosanitary certificate, the authorities require the original paper document to be present upon importing.

One of the design principles of the SIP is to persistently store the information at the source and only share referential pointers and meta-data – simlar to the design of the World Wide Web (WWW) (Berners-Lee 1999). The shipping activity is a range of operations forming actions whereof the events 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 a URL for each event. 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 e.g. 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 which 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 2011). We claim that collaboration will be significantly improved through lower cost and a widely shared mycorrhizae. This could increase usage, especially by lowering the cost by utilizing the benefits provided by the II. Not only will our proposed approach lower transaction costs through providing real time information, but 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 is accessed through clicking on the associated URL for an event directing to, e.g., the associated document displayed in a web browser.

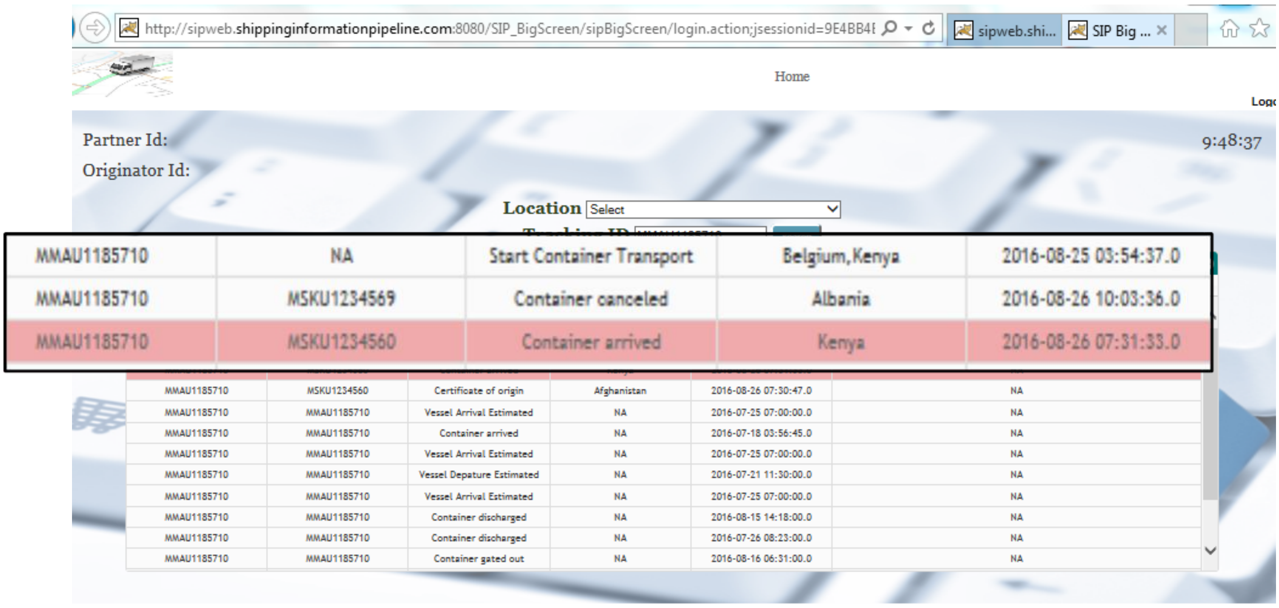

Figure 9: The Shipping Information Pipeline, example of user experience from one of the prototypes showing the Big Screen proving overview of shipping events for a shipment with one container. Note, the information shown is from a technical test with relevant stakeholders.

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 visibilty could be enhanced (e.g., 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 (e.g., spotting a “road block” ahead or a missing approval by another actor in another organization) and react in due time not only to remove it and avoid delays but also to increase reliability and probability of being on time.

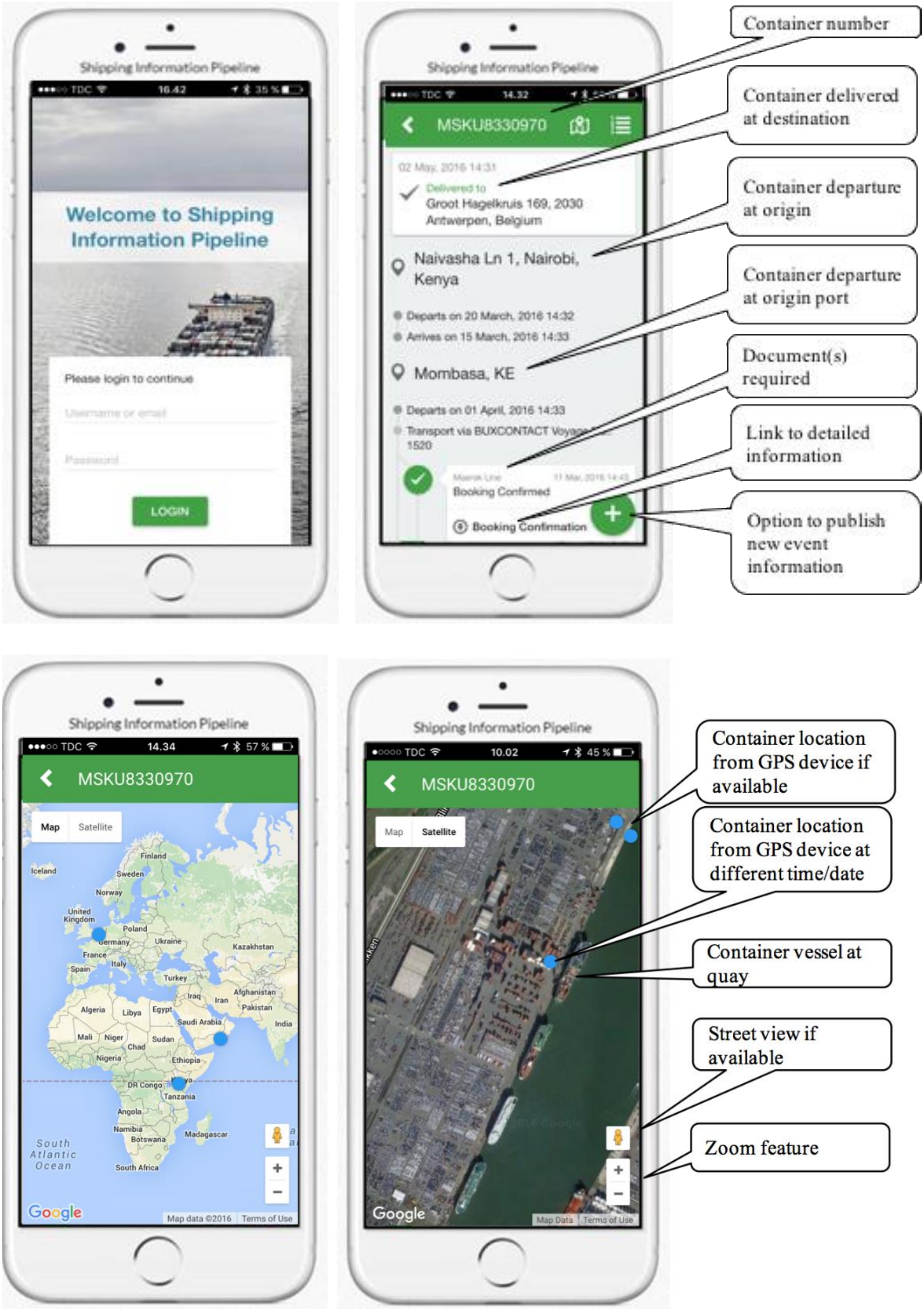

Figure 10: The Shipping Information Pipeline, example of user experience from one of the prototypes showing the SIP Application with log on screen and an overview screen combining shipping events and information links. Below is map with ports of origin, transhipment and destination, and detailed map of container location in Port of Antwerp.

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 Engestrom 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 Engestrom refers to as historicity. Furthermore, the SIP by its transparency reveals the knotwork of containerized shipping across borders and organzational 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 becoimng 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 eco-system.

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.

Implications for Practice

With regard to Supply Chain Management, extant research does not include managing the supply chain outside the visible horizon[18] (Carter et al., 2015) and has recently moved towards resilient supply chains (Sheffi, 2015). 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 ultimatively will not only reduce lead times and uncertainty for lead times but also reduce trade cost, especially indirect cost[19].

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 (through utilizing the Internet) facilitating visibility and transperancy into containerized shipping activity with reliable information (directly from the source) e.g. about the organizations behind the shipment and the content of the shipment which is foreseen to provide significant improvements compared to current situations, ultimatively 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[20]. As Ciborra (2002) 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 master 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 control capabilities just as much as they enhance them.

Conclusion

We find that Information Technology, specifically II can significantly contribute solving the major challenges of containerized shipping by providing a shared mycorrhizae, thus facilitating the knotwork of containerized shipping. Following IS design theory for II we designed SIP which is recognized, e.g., by World Trade Organization[21]. 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 1999). Subsequently, we developed the components **in** the SIP. After piloting selected trade lanes more trade lanes will be include and we expect a phase for creation of value added components and services **on** the SIP.

[19] Note that several studies find that indirect cost due to e.g. delays and buffering of stock to compensate for uncertainty in lead time are significantly higher than the direct cost e.g. 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).

[20] Press release and article in New York Times 20170226

[21] E.g. at the World Trade Organization Conference 2015.

We identified top three challenging trade barriers for containerized shipping in international trade: high trade costs, uncertain lead times and unknown security risks. Our analysis of shipments in one 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. Furthermore, we identified the lack of a shared mycorrhizae or II as root cause for all three challenges. To address this root cause and to heal and coalese the mycorrhizae, we proposed and designed SIP which is an II for sharing shipping information.

As illuminated in our analysis, the physical shipment in containers is by and large invisible to the actors. However, Rose George (2014)[22] 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 non-tariff barriers to half best practices (using IT) will increase trade by 14.5% and GDP by 4.7% (WEF 2013[23], 2016). Parts of our case study research data were collected and reported in connection with a report for the World Economic Forum (WEF, 2014). Further, our research findings have been presented and discussed at World Trade Organization conferences on several occasions. Furthermore, United Nations General Secretary, Ban Ki-Moon in the report *Mobilizing Sustainable Transport for Development* (2016[24]) 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".

[22] http://rosegeorge.com/site/books/ninety-percent-of-everything
[23] http://www3.weforum.org/docs/WEF_SCT_EnablingTrade_Report_2013.pdf
[24] https://sustainabledevelopment.un.org/topics/sustainabletransport/highleveladvisorygroup

References

Allen, D., Karanasios, S., & Slavova, M. (2011). Working with activity theory: Context, technology, and information behavior. *Journal of the American Society for Information Science and Technology, 62*(4), 776-788.

Allen, D. K., Brown, A., Karanasios, S., & Norman, A. (2013). How should technology-mediated organizational change be explained? A comparison of the contributions of critical realism and activity theory. *Mis Quarterly, 37*(3), 835-854.

Allen, M. F. (1991). *The ecology of mycorrhizae*: Cambridge University Press.

Anderson, J. E., & Van Wincoop, E. (2004). *Trade costs*. Retrieved from

Bertalanffy, L. v. (1968). *General system theory: Foundations, development, applications*: Braziller. New York.

Branch, M. A. I. (2008). *Report on the investigation of the structural failure of MSC Napoli, English Channel on 18 January 2007*. Retrieved from

Carter, C. R., Rogers, D. S., & Choi, T. Y. (2015). Toward the theory of the supply chain. *Journal of Supply Chain Management, 51*(2), 89-97.

Christopher, M. (2012). *Logistics and supply chain management*: Pearson UK.

Ciborra, C. (2002). *The labyrinths of information: Challenging the wisdom of systems: Challenging the wisdom of systems*: OUP Oxford.

Clement, A., & Wagner, I. (1995). *Fragmented exchange: Disarticulation and the need for regionalized communication spaces.* Paper presented at the Proceedings of the Fourth European Conference on Computer-Supported Cooperative Work ECSCW'95.

De Treville, S., Shapiro, R. D., & Hameri, A.-P. (2004). From supply chain to demand chain: the role of lead time reduction in improving demand chain performance. *Journal of Operations Management, 21*(6), 613-627.

Engeström, Y. (1987). Learning by expanding: An activity-theoretical approach to developmental research.

Engeström, Y. (1999). Activity theory and individual and social transformation. *Perspectives on activity theory*, 19-38.

Engeström, Y. (2007). From communities of practice to mycorrhizae. I J. Hughes, N. Jewson& L: Unwin (Red.). Communities of practice: Critical perspectives. London: Routledge.

Engeström, Y. (2008). *From teams to knots: Activity-theoretical studies of collaboration and learning at work*: Cambridge University Press.

Engeström, Y. (2009). The future of activity theory: A rough draft. *Learning and expanding with activity theory*, 303-328.

Giddens, A. (1991). *Modernity and self-identity: Self and society in the late modern age*: Stanford University Press.

Giddens, A. (2002). *Runaway world*: Profile books.

Giddens, A., & Pierson, C. (1998). *Conversations with Anthony Giddens: Making sense of modernity*: Stanford University Press.

Greeno, J. G. (1998). The situativity of knowing, learning, and research. *American psychologist, 53*(1), 5.

Grisot, M., Hanseth, O., & Thorseng, A. A. (2014). Innovation of, in, on infrastructures: articulating the role of architecture in information infrastructure evolution. *Journal of the Association for Information Systems, 15*(4), 197.

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

Hasan, H. M., Kazluaskas, A., & Crawford, K. P. (2010). Blending complexity and activity frameworks for a broader and deeper understanding of IS.

Headrick, D. R. (2009). *Technology: a world history*: Oxford University Press New York.

Henningsson, S., & Bjørn-Andersen, N. (2009). *Exporting e-Customs to developing countries: a semiotic perspective.* Paper presented at the Proceedings of the Second Annual SIG GlobDev Workshop, Phoenix, USA.

Henningsson, S., & Henriksen, H. Z. (2011). Inscription of behaviour and flexible interpretation in Information Infrastructures: The case of European e-Customs. *The Journal of Strategic Information Systems, 20*(4), 355-372.

Holloway, S. (2009). The transition from eCustoms to eBorder management. *World Customs Journal, 3*(1), 13-25.

Jensen, T., Bjørn-Andersen, N., & Vatrapu, R. (2014). *Avocados crossing borders: the missing common information infrastructure for international trade*. Paper presented at the Proceedings of the 5th ACM international conference on Collaboration across boundaries: culture, distance & technology, Kyoto, Japan.

Jensen, T., Tan, Y.-H., & Bjørn-Andersen, N. (2014). Unleashing the IT potential in the complex digital business ecosystem of international trade: The case of fresh fruit import to European Union.

Jensen, T., & Vatrapu, R. (2015). *Ships & Roses: A Revelatory Case Study of Affordances in International Trade.* Paper presented at the 23rd European Conference on Information Systems (ECIS) 2015.

Jonassen, D. H., & Rohrer-Murphy, L. (1999). Activity theory as a framework for designing constructivist learning environments. *Educational Technology Research and Development, 47*(1), 61-79.

Kaptelinin, V. (2006). *Acting with technology: Activity theory and interaction design*: Mit Press.

Karanasios, S., & Allen, D. (2013). ICT for development in the context of the closure of Chernobyl nuclear power plant: an activity theory perspective. *Information Systems Journal, 23*(4), 287-306.

Karanasios, S., & Allen, D. (2014). Mobile technology in mobile work: contradictions and congruencies in activity systems. *European Journal of Information Systems, 23*(5), 529-542.

Klose, A. (2016). The Container Principle: How a Box Changes the Way We Think. *Leonardo*.

Krcmar, H., Bjorn-Andersen, N., & O'Callaghan, R. (1995). EDI in Europe. *New York*.

Kuutti, K. (1991). Activity theory and its applications to information systems research and development. *Information systems research: Contemporary approaches and emergent traditions*, 529-549.

Kuutti, K. (1996). Activity theory as a potential framework for human-computer interaction research. In B. A. Nardi (Ed.), *Context and Consciousness: Activity Theory and Human-Computer Interaction* (pp. 17-44). Cambridge: MIT Press.

Kuutti, K. (1999). Activity theory, transformation of work, and information systems design. *Perspectives on activity theory*, 360.

Levinson, M. (2010). *The box: how the shipping container made the world smaller and the world economy bigger*: Princeton University Press.

MacCrory, F., Westerman, G., Alhammadi, Y., & Brynjolfsson, E. (2014). *Racing With and Against the Machine: Changes in Occupational Skill Composition in an Era of Rapid Technological Advance.* Paper presented at the ICIS.

Mursu, Á., Luukkonen, I., Toivanen, M., & Korpela, M. (2007). Activity Theory in information systems research and practice: theoretical underpinnings for an information systems development model. *Information Research, 12*(3).

Nardi, B. A. (1998). Activity Theory and Its Use Within Human-Computer Interaction. *Journal of the Learning Sciences, 7*(2), 257 - 261.

Reimers, K., Johnston, R. B., Guo, X., Klein, S., Xie, B., & Li, M. (2013). Novice-based data collection methods for the study of IOIS: practice probes and learning communities. *Electronic Markets, 23*(4), 285-293.

Reimers, K., Johnston, R. B., & Klein, S. (2010a). The difficulty of studying inter-organisational IS phenomena on large scales: critical reflections on a research journey. *Electronic Markets, 20*(3-4), 229-240.

Reimers, K., Johnston, R. B., & Klein, S. (2010b). Toward a theory of IOIS variance: a new framework for studying inter-organisational information systems. *International Journal of Strategic Information Technology and Applications (IJSITA), 1*(3), 36-56.

Reimers, K., Johnston, R. B., & Klein, S. (2012). Evolution of inter-organizational information systems on long timescales: A practice theory approach. *Inter-organizational information systems and business management: Theories for researchers*, 38-54.

Robey, D., Im, G., & Wareham, J. D. (2008). Theoretical Foundations of Empirical Research on Interorganizational Systems: Assessing Past Contributions and Guiding Future Directions. *Journal of the Association for Information Systems, 9*(9).

Roth, W. M., & Lee, Y. J. (2007). “Vygotsky’s Neglected Legacy”: Cultural-Historical Activity Theory. *Review of Educational Research, 77*(2), 186-232.

Sarker, S., Sarker, S., Sahaym, A., & Bjørn-Andersen, N. (2012). Exploring value cocreation in relationships between an ERP vendor and its partners: a revelatory case study. *MIS quarterly, 36*(1), 317-338.

Sharma, A., & Johri, B. (2002). Arbuscular-mycorrhiza and plant disease. *Arbuscular Mycorrhizae: Interactions in Plants, Rhizosphere and Soils*, 69-96.

Sheffi, Y. (2015). *The Power of Resilience: How the Best Companies Manage the Unexpected*: MIT Press.

Spinuzzi, C. (2011). Losing by Expanding Corralling the Runaway Object. *Journal of Business and Technical Communication, 25*(4), 449-486.

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology,translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social studies of science, 19*(3), 387-420.

Stewart, G. (1995). Supply chain performance benchmarking study reveals keys to supply chain excellence. *Logistics Information Management, 8*(2), 38-44.

Tan, Y. H., Bjorn-Andersen, N, Klein, S, Rukanova, B. (eds.). (2011). *Accelerating Global Supply Chains with IT-innovation: ITAIDE tools and methods*: Springer.

Tilson, D., Lyytinen, K., & Sorensen, C. (2010). Research Commentary--Digital Infrastructures: The Missing IS Research Agenda. *Information Systems Research, 21*(4), 748-759. doi:10.1287/isre.1100.0318

United Nation ESCAP, R. (2014). Estimating the Benefits of Cross-Border Paperless Trade.

United Nation, U. (1971). Bills of lading.

Vygotsky, L. (1930/1980). *Mind in society*: Harvard University Press.

Vygotsky, L. (1962). *Thought and Language*. Cambridge: Massachusetts Institute of Technology.

WEF, W. E. F. i. c. w. B. C. (2014). Enabling trade: From valuation to action. *Report*.

Wertsch, J. (1985). *Vygotsky and the social formation of mind*. Cambridge, MA, USA: Harvard University Press.

Westerman, G., Bonnet, D., & McAfee, A. (2014). *Leading digital: Turning technology into business transformation*: Harvard Business Press.

Yin, R. K. (2009). *Case study research: Design and methods* (Vol. 5): sage.

Appendices

Appendix A: Research Dataset

Date and Location	Event	Participants	Focus	Selected Quotes / Citations
2013-09-01 Kenya	Interviews and observations / site visits	Farmer of avocado Exporter	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).”
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.”
20140527 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 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

Date and Location	Event	Participants	Focus	Selected Quotes / Citations
				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)."

Table 1. Overview of Research Dataset

Origin Date and Location	**Destination Date and Location**	**Transhipment**	**Shipment/Container ID**	**Commodity of Goods inside Container**
2014-02-17 Naiarobi, Kenya	2014-03-05 Dubai (U.A.E.)	Salalah (Oman)	MWMU6411112	Avocados
2014-02-17 Naiarobi, Kenya	2014-03-05 Dubai (U.A.E.)	Salalah (Oman)	MWMU6359992 to MSWU9089720	Avocados[25]
2014-05-08 Nairobi, Kenya	2014-06-05 Malaga (Spain)	Salalah (Oman)	MMAU1154601	Avocados
2014-05-08 Nairobi, Kenya	2014-06-03 Kent, U.K.	Salalah (Oman) Flexistowe (U.K.)	MMAU1080978	Avocados
2014-05-08 Nairobi, Kenya	2014-05-27 Dubai (U.A.E.)	Salalah (Oman)	MWC5324369	Avocados
2016-07-16 Nairobi, Kenya	2016-08-15 The Netherlands	Salalah (Oman) Antwerp (Belgiun)	MMAU1185710	Avocados
2016-08-03 Nairobi, Kenya	2016-09-07 The Netherlands	Salalah (Oman) Antwerp (Belgiun)	MMAU1113032	Avocados
2016-08-06 Nairobi, Kenya	2016-09-10 The Netherlands	Salalah (Oman) Antwerp (Belgiun)	MMAU1202274	Avocados
2016-08-06 Nairobi, Kenya	2016-09-10 The Netherlands	Salalah (Oman) Antwerp (Belgiun)	MNBU3436223	Avocados
2016-10-04 Nairobi, Kenya	2016-10-29 The Netherlands	Salalah (Oman) Antwerp (Belgiun)	MMAU1160902	Avocados
2016-10-08 Nairobi, Kenya	2016-11-05 The Netherlands	Salalah (Oman) Antwerp (Belgiun)	MMAU1047413	Avocados
2016-10-15 Nairobi, Kenya	2016-11-12 The Netherlands	Salalah (Oman) Antwerp (Belgiun)	MMAU1094945	Avocados

Table 2. Overview of research dataset of shipments/containers for analysis for containerized shipping.

[25] Harmonized system commodity code: 08044000 https://en.wikipedia.org/wiki/Harmonized_System 20170122

Appendix B: Decomposition of the main activity into three activity systems

Activity **Dimension**	**Export** **East Africa**	**International** **Shipping**	**Import** **Europe**
Actors	Farmers, Exporters, Authorities, Service providers, e.g., Transporters	Terminal operators, Shipping lines	Retail, Consumers, Importers, Authorities, Service providers, e.g., 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 ships, straddle carriers, 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, trading, packing, transport by truck, controlling and inspection	Transport, shipping, handling and storage	Trading, transport by truck, controlling and inspection, re- packing and distribution

Table 3: Decomposition and categorization of the three 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.

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 packing list for the B/L was copy+pasted (indicated by a red downward arrow in Figure 7) in **five** 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 related 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 that revealed more than **thirty** e-mails among at least **six** actors (located in Kenya, Nairobi and Mombasa, India and the Netherlands), the e-mails included scanned attachments of documents hereof some with additional hand-written notes of changes. At the service center of the carrier in India this was recorded as incidents involving at least **five** 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 200-250. 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 the EDI/XML message is the Entry Summary Declaration (ENS). 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 e.g. located in Port of Antwerp, Belgian nor the Dutch authorities in the Netherlands, instead they get a one 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).