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THE ANATOMY OF DIGITAL TRADE INFRASTRUCTURES

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Abstract

In global supply chains information about transactions resides in fragmented pockets within business and government systems. The lack of reliable, accurate and complete information makes it hard to detect risks (such as safety, security, compliance, commercial) and at the same time makes international trade inefficient. The introduction of digital infrastructures that transcend organizational and systems domains is driven by the prospect of reducing information fragmentation, thereby enabling improved security and efficiency in trade process. The potential of such digital trade infrastructures has been showcased in demonstrator settings, but in practice adoption and growth has been slow. In order to understand the problem at hand and build cumulative knowledge about its resolution, we need a way to conceptualize the different infrastructure initiatives. This paper therefore develops the Digital Trade Infrastructure Framework that aims to identify the structural components (anatomy) of the digital infrastructures in the trade area. The framework is developed through an empirically grounded analysis of four digital infrastructures in the trade domain within the conceptual lens of digital infrastructure. The framework can be used to position digital trade infrastructure initiatives to allow for cumulative knowledge building about its challenges as well as to articulate forward-looking agendas covering to development of instruments to oversee its resolution.

Keywords: International trade, Digital infrastructure, EU, Institutional innovation, eGovernment, Governance

1 INTRODUCTION

In global supply chains information about transactions resides in fragmented business and government systems. Parties are often reluctant, or even legally not allowed to share data (Jensen and Vatrapu 2015, Jensen and Vatrapu 2015). As a result, the flow of goods is accompanied with information streams of poor quality and end-to-end supply chain visibility is extremely challenging to achieve (Jensen and Vatrapu 2015). The lack of reliable, accurate and complete data makes it hard to detect risks (such as safety, security, compliance, commercial) and at the same time makes international trade inefficient.

Governments and interest organizations involved in international trade are increasingly recognizing the resolution of information fragmentation as one of the key challenges for improving the conditions for international trade. In the EU, the adoption of digital technologies to reform control processes has been a key ambition in the continuously revised Multi-Annual Strategic Plan (MASP) for customs development (TAXAUD 2008). Digital enablement of trade has also been the focus of a stream of EU funded research and development projects (e.g. CORE, CASSANDRA, CONTAIN, INTEGRITY, ITAIDE, etc.). Common for several of these initiatives is that they in various ways seek to promote the development of digital trade infrastructures (DTIs). In the digital trade context, different digital trade infrastructure concepts have emerged such as Single Window, National Community Hubs , and Data pipelines (see Hesketh, 2010; Stijn et al., 2011; Klievink et al., 2012, Tan et al., 2011). Recently data pipelines have been further conceptualized as Thick and Thin depending on whether actual documents are exchanged in the Data Pipeline or only limited event data is exchanged (Janssen et al., 2015).

A digital infrastructure (DI) can be seen as a Systems-of-Systems (Hanseth, Monteiro et al. 1996, Hanseth and Lyytinen 2010) that transcends organizational and systems domains, reducing information fragmentation. DI is an open, dynamic, complex, and networked artefact and that can been defined as "an integration of a finite number of constituent systems which are independent and operable, and which are networked together for a period of time to achieve a higher goal" (Jamshidi, 2009, p. 2). In the trade area, it has been argued that digital infrastructures that transcends the current information silos can enable more efficient risk assessment, supply chain optimization and cost savings (Baida et al, 2007, Baida et al., 2008, Rukanova et al., 2009; Tan et al., 2011; Henningsson, Gal et al. 2011, Jensen and Vatrapu 2015). In demonstrator installations of infrastructural innovations such as Single Window, National Community Hubs , and Data pipelines, it has indeed been showcased that a range of benefits can be derived from reducing information fragmentation in trade (see Hesketh, 2010; Stijn et al., 2011; Tan et al., 2011).

However, outside the controlled environment of demonstrator installations, the adoption and growth of DTIs has been limited. Accounts from the field report that conflicts related to data sharing, standards, financing and benefits distribution make infrastructural initiatives come to a halt (Klievink et al. 2012). Some of the reported issues correspond to issues of technological complexity and actor enlistment that are known challenges within the digital infrastructure literature. Other issues seem to be specific to the trade domain with its intricate interplay of governments at national and international level to control the flow of goods and in influencing decisions related to infrastructural initiatives (Henningsson, Gal et al. 2011, Jensen and Vatrapu 2015). This far, little cumulative knowledge development has been made about the specific challenges of developing infrastructures in the trade area. In consequence, even less is known about how these challenges can be mitigated in the design and implementation processes.

One important aspect of building an understanding of why and how a digital infrastructural initiative in the trade domain frequently comes to a stall is to be able to understand the specificity of an initiative. That is, how are the many attributes of a digital infrastructure configured in this specific instance. Only when this can be done, it is

possible to contrast different infrastructural initiative to learn across attempts and to eventually understand the challenges faced when developing DTIs and what are ways to overcome these. Therefore, the aim of the paper is to show the components (the anatomy) of a DTI. This paper should be seen as a stepping stone in the efforts to increase our understanding and provide grounds for cumulative learning regarding DTI with the ultimate goal to better understand the challenges faced by DTI initiatives and how these can be overcome to move such initiatives from initiation to implementation and adoption.

To this end, through an empirically grounded analysis with the conceptual lens of DI this paper develops the *DTI Framework*. This DTI Framework is built around three dimensions identified in the DI literature, i.e. architecture, process and governance, which are further detailed specifically for DTI domain by contrasting four attempts to build digital infrastructures within the trade domain. As such, the framework (and more specifically its architectural dimension) also carries an understanding of what sets infrastructural development in the trade domain apart from the development of DI in general. The resulting framework can be applied to characterize specific DTI initiative, for cross-case comparison of DI initiatives and for outlining further research directions for further articulating problems and developing tools to advance the understanding of issues that such initiatives face. This is a necessary first step in order to help developing instruments to help addressing these issues and for creating grounds for these initiatives to be further advanced towards implementation and adoption.

2 DIGITAL INFRASTRUCTURE DESIGN

Until recently, the IT artefacts covered by the term Digital Infrastructure (DI) have been seen and approached as large-scale or global types of IT systems, and the methodologies and approaches have been tailored to address problems with the development of IT systems. However, a range of cases in the public domain have, in very painful ways, demonstrated the fundamental difference between DI and global IT systems and the inadequacies of following approaches used for systems development to address the specific problems of DIs (Damsgaard and Lyytinen 2001, Sauer and Willcocks 2007, Hedman and Henningsson 2015, Rodon and Silva 2015).

In the search for explanations and solutions to effective DI development, the extant research portrays the DI development challenge as two-fold. One part of the challenge originates in the inertia of the installed base. The installed base refers to the pre-existing components of the DI that constitute the starting point for any development attempt; they include existing work practices, human resources, standards, technological artefacts and organizational commitment (Ciborra & Hanseth, 1998; Hanseth & Lyytinen, 2010; Monteiro & Hanseth, 1996). Because it is rarely possible in DI development to redesign the DI from scratch, development always "wrestles with the inertia of the installed base and inherits strengths and limitations from that base" (Star & Ruhleder, 1996, p. 113).

The other part of the explanation relates to the coordination of the diverse set of actors, each of whom is responsible for a part of the DI. The coordination challenge of DI development originates from the fact that most

DIs are distributed across a diverse set of actors who must each mandate change in the socio-technical components that they control. As a consequence of the dispersed and distributed ownership, lack of centralized control is a fundamental attribute of DI development (Ciborra and Hanseth 2000). Typically, different actors develop the DI "in modular increments, not all at once or globally" (Star 1999, p. 382). This incremental process is, furthermore, highly political, with struggles for influence and control (Sanner, Manda et al. 2014).

Recognizing the dual challenge of installed base inertia and the coordination of distributed control, the general conclusion in the extant literature is that effective development of DI requires approaches that are different from the traditional system development methods (Hanseth and Lyytinen 2010, Tilson, Lyytinen et al. 2010). As noted by Edwards et al. (2009, p. 369), particular stakeholder groups "rarely if ever 'build' infrastructure; they must nurture it and, if they are lucky, help it to grow". Therefore, DI development generally draws on the metaphor of cultivation. Following the cultivation metaphor, approaches to DI development provide guidance on "how to 'cultivate' an installed base and promote its dynamic growth" (Hanseth & Lyytinen, 2010, p. 15). Generally, suggestions on how to cultivate a digital infrastructure focus on three design domains: *architecture*, *governance* and *process*.

The architectural design of DI is the design domain that has received the most attention in research. Architecture refers to the components of the DI and how they are connected. Because DIs are socio-technical, any DI will contain both social and technical components. The social components include stakeholders and practices for using the DI. Edwards notes that ''. . .although 'infrastructure' is often used as if it were synonymous with 'hardware'. . . all infrastructures. . . are in fact socio-technical in nature. Not only hardware but organisations, socially-communicated background knowledge, general acceptance and reliance, and near- ubiquitous accessibility are required for a system to be an infrastructure'' (Edwards, 2003, pp. 187–188). Drawing on Edwards, 2003, Gal, 2008, p. 18 states: ''Technically, the construction of an infrastructural system requires the establishment of protocols and standards that enable the system to be used and seamlessly connect with other systems. Socially, its construction necessitates the elaboration of a system of classifications that symbolically represent and organise things in society: people, classes, geographical areas, religions, civil status, and so on.''

Regarding governance of DIs there is an extensive body of research demonstrating the shortcomings of traditional IT management strategies, including hierarchical organizational structures and distribution of decision rights, careful planning and execution of plans for the management of DIs (see for instance Ciborra et al.,2000, and Hanseth and Ciborra 2007). But research on what kind of governance regimes that actually works is largely lacking, with just a few exceptions, which include the research on the evolution of the Internet presented above. Another exception is Constantinides' (2012) research in which he draws extensively upon Elinor Ostrom's (1990) research on "Governing the Commons". Based on Ostrom's research Constantinides (2012) describes three kinds of property or decision rights related to an DI: constitutional, collective choice, and operational. Operational rights refer to rights related to access and contribution and extraction of resources – i.e. rights to access an DI. Collective choice rights refer to rights of removal, management and exclusion of users, while

constitutional rights refer to who may or may not participate in making collective choices. Constantinides (2012) sees the allocation of these three categories of rights as central to the governance of DIs.

The process design refers to how the DI is being built, which is complementary view on DI design. Henfridsson and Bygstad (2013) have reviewed and reinterpreted all DI cases reported in IS journals. They found 41 different cases, out of which they considered 17 unsuccessful and 24 successful. All successful infrastructures started small and evolved into large ones. Approaches for growing an infrastructure from an initial setup solving a very specific problem for a minor group of stakeholder, to a more generic solution that is adopted by a larger group of users include the creation of an 'attractor' (Braa, Macome et al. 2001), adherence to design principles that enable growth (Hanseth & Lyytinen, 2010), incremental functional deployment (Aanestad and Jensen 2011), promotion of generative evolutionary mechanisms (Henfridsson & Bygstad, 2013) and the establishment of 'killer apps' (Eaton et al., 2014) for the active management of the growth of the installed base.

3 METHODOLOGY

Recognizing the nascent stage of knowledge on our topic, we attend to our research objective by an approach similar to analytic induction (Patton, 2002). An analytic induction approach starts deductively with the formulation of a guiding framework, which is empirically validated and extended by analysis of case data. In this study, we use the three design domains of DI (i.e. architecture, governance and process) as general theoretical framework for analysing cases within international trade to establish the relevant sub-dimensions of each design domain.

3.1 Case background

In line with our analytic inductive approach, we searched for cases that would allow us to reveal contextual elements influencing the work with digital infrastructures in international trade. As a basis for our analysis we took four international trade infrastructure initiatives, namely the Felixstowe Case in the UK; The FloraHolland case (The sea and air trade lanes from Kenya to the Netherlands); the Shipping Information Pipeline (SIP) initiative of MAERSK and IBM, and the Neutral Logistics Information Platform (NLIP) initiative of the Netherlands. Each of these is briefly introduced below:

- The Felixstowe Case (UK): the goal is to link a National Hub for information exchange between businesses and the authorities to international, private Thick Data Pipelines.
- The FloraHolland case: focuses on a specific trade lane for importing flowers from Kenya to the Netherlands via Sea and Air by using a Thick Data Pipeline. This trade lane further zooms in the complexities related to coordinated border management involving two different authorities (i.e. Customs and Phyto-sanitary), as well as on mutual recognition of ePhyto certificates.
- The Shipping Information Pipeline (SIP) initiative: an attempt of MAERSK and IBM to develop a Thin Data Pipeline for international trade.

- The NLIP initiative: an attempt to set-up a national digital infrastructure in the Netherlands.

3.2 Data collection

For each of the cases we collected data within the broadly defined streams of digital infrastructure research. The data collection, summarized in Table 1, relied on interviews, participation in face-to-face meetings, and used documentation (emails, project reporting and evaluations) for triangulation purposes.

Case	Data collection
Felixstowe Case	Data regarding the Felixstowe case was collected during 2014-2016 as part of the CORE project. Data was collected through documentation provided by project partners, as well as through interviews and regular communication (e-mails, face-to-face meetings, conference calls) with partners involved in the Felixstowe development.
The FloraHolland Case	Data collection took place predominantly in the period 2014-February 2016 as part of the CORE project. Two of the authors of this paper were involved in various roles including project coordination; analysis and provided input for key project deliverables. The involvement included continuous communication (face-to-face, via phone and e-mail), and collaboration with the other project participants; participation in key meetings and events; access to primary and secondary data.
The Shipping Information Pipeline	Data collection took place predominantly within in the period 2014-February 2016 as part of the CORE project. Three of the authors of this paper were involved in various roles including project coordination; analysis and provided input for key project deliverables. The involvement included continuous communication (face-to-face, via phone and e-mail). This demo is still in the initiation phase and further piloting is scheduled later in 2016. The concept has been already developed and the technical infrastructure is currently being built.
NLIP	The data collection related to NLIP was done predominantly by one of the authors, who participated in NLIP from the very beginning. From 2012 until 2016 he was a member of the NLIP Sounding Board, participated in key meetings and discussions. One of the other authors also started attending the NLIP Sounding Board meetings in 2016. The research team had also access to meeting notes and documents accumulated throughout the history of the NLIP development.

Table 1. Data collection for the four cases

3.3 Data analysis

We examined and made sense of the data within the three dimensions of digital infrastructure research discussed in section Two (namely architecture, process and governance), guided by the logic underlying analysis strategies

associated with less procedural versions of the grounded theory methodology (Bryant and Charmaz 2007). At the core, we started with the three dimensions identified in theory (i.e. architecture, process and governance) and we used the "constant comparative analysis" to identify sub-categories, and attempted to link this evolving set of concepts to the higher-level categories (Charmaz 2000). Eventually, the higher-level categories and the sub-categories identified from the cases were consolidated into the emergent DTI characterization framework.

During the data analysis we used our own observations accumulated through our continuous engagement in the project, we reviewed project documentation such as deliverables, reports and meeting notes available from the cases. Two of the authors engaged in a number of sessions to discuss the findings from contrasting and comparing the cases. The third author played the role of a critical reviewer of the findings.

When looking at the architectural component, we compared and contrasted the cases and tried to identify common dimensions that we can use to characterize the DTI initiatives. While the initiatives were quite different they all aimed to facilitate international trade processes, which involved interactions among business and government actors. By comparing and contrasting the cases we also identified actors such as Port Community Systems which plaid a role in facilitating these interactions. We therefore included the concept of intermediary actors. Next to that when comparing and contrasting the initiatives we saw that while in some cases the actors who were directly involved in supply chain initiatives (such shippers, freight forwarders, carriers) were driving the DTI development, in other cases the associations were in the lead. We therefore made an explicit distinction among direct and indirect actors.

In our analysis of the four cases we also saw that some initiatives aimed to introduce National Hubs, while others aimed at Think or Thick Data Pipelines. To capture that diversity we introduced the concept of DTI type, where we distinguished among Data Pipelines (Thick/ Thin) and National Hubs.

By doing the continuous comparison and contrasting we also saw differences in the scope of the initiatives: while some were focusing on a national level, others had international scope (2 or more countries) and other global ambition. As such we introduced also the concept of levels under the Architecture dimension in our framework.

Regarding the process dimension, we again compared and contrasted the cases. We saw clear differences, i.e. whereas some initiatives were in the early initiation phases, others were already in operational phase. Next to in we distinguished New services as a separate phase, as in two of the cases there were prominent discussions about the development of Smart apps as new services that can be offered on top of the infrastructure once the infrastructure is operational. The issues related to these phases were quite different, therefore we decided to introduce phases and sub-categories of the process dimension.

Finally, when looking at infrastructure governance we found out that while in all the cases it was considered as an important dimension, in 3 out of the four cases the governance was informal, and only in one case there as a

formal board. We therefore introduced formal/ informal as sub-dimensions to indicate a maturity level of the development of governance structures for the DTI initiatives. As governance was considered important but the governance structures in the cases were not well developed, in order to give further structure to the governance dimension we introduced the analytical categories of decision rights (Constantinides, 2012) discussed earlier, namely constitutional, collective choice and operational. We then looked back at the cases and based on earlier research (Klievink et al., 2012) and empirically from the four cases we identified that in all cases cost-benefit sharing, standards and data access are key decision areas. We included these as sub-categories of collective choice rights, as these pointed to specific decision areas related to DTI initiatives.

In the process of development of the DTI we gained empirical insights in a grounded manner by comparing and contrasting the cases and we also iteratively when back and forth from the case findings to literature and vice-versa. As a result, we also further sharpened our thoughts and we linked our findings to concepts and findings from literature. Annex 1 contains a detailed table linking the dimensions of the framework to the four cases and relevant literature. The resulting DTI Framework is presented and illustrated in the next section of this paper.

4 RESULTS: DIGITAL TRADE INFRASTRUCTURE (DTI) FRAMEWORK

Table 2 and its visual representation in Figure 1 below present the *DTI Framework* we derived based on the analysis process presented in Section 3. The framework is structured around the three components identified in the DI literature (architecture, process and governance) as overarching dimensions and it further specifies sub-categories of these dimensions based on the four cases and insights from literature.

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

Table 2. DTI Framework

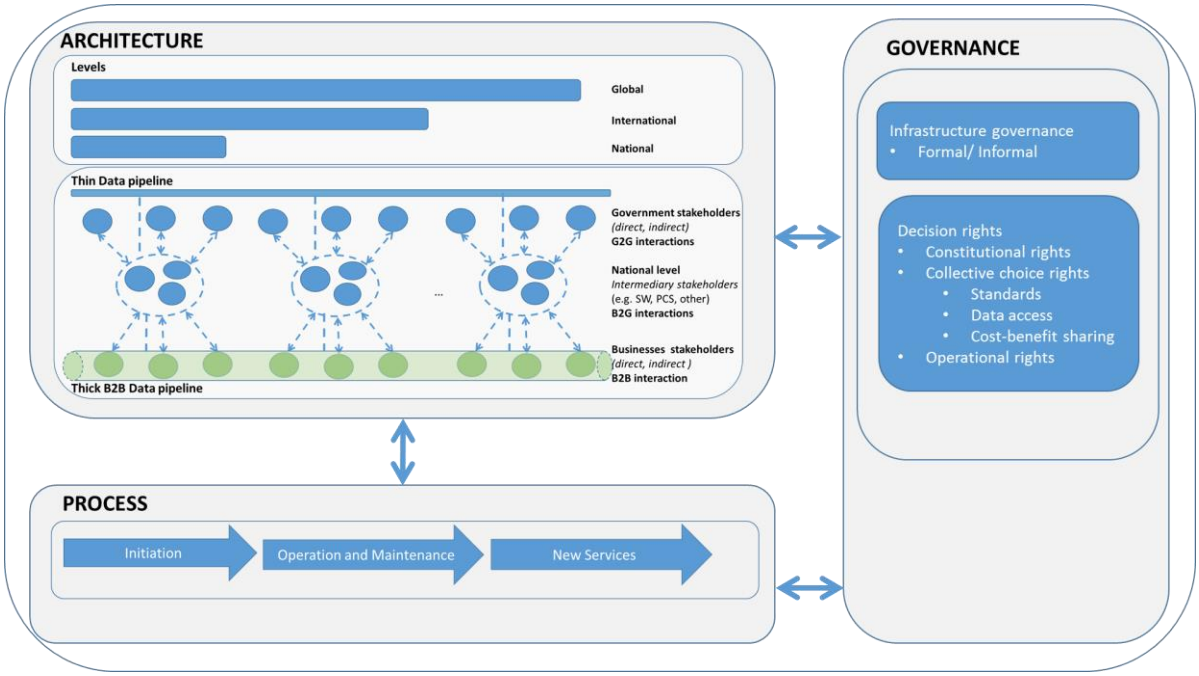


Figure1. Visualization of the DTI Framework

Under *architecture*, we distinguish among (a) Levels (National, International, Global); (b) Actors (Business, Government, Intermediary; as well as Direct, Indirect); (c) Interactions (Business-to-Business (B2B); Business-to-Government (B2G); Government-to-Government (G2G)); (d) DTI types (National Hub, Data Pipeline (Thick/ Thin))[1].

Under *process* we make a distinction among three phases- Initiation, Operation and Maintenance, and New Services. Under *governance* we distinguish among Infrastructure Governance (Formal/ Informal) and Decision Rights (Constitutional, Collective choice, Operational). We further identify Standards, Data Access, and Cost-Benefit Sharing as sub-categories of collective choice rights.

4.1 DTI Architecture

The architectural dimension of the DTI Framework enabled us represent the four different initiatives using the same concepts and visualize them in a similar way (See Figure 2). This enables us to reason in a structured way about the focus of each initiative and enables us to look for architectural similarities and differences.

[1] The Thick and a Thin data pipeline are included here to capture the analytical concepts. The Thin and Thick data pipelines represented in Figure 1 suggest one possible positioning (e.g. Thick Data Pipeline limited to the Business-to-Business actors), however other configurations are also possible. The figure also includes three National Hubs connecting business and government actors but depending on the scope and ambition of the infrastructure initiative the role and number of National Hubs can also vary. National Hubs are used here as an organizational configuration that enables exchanges among business and government actors on a national level and does not address a technical architecture (i.e. the technical architecture can vary).

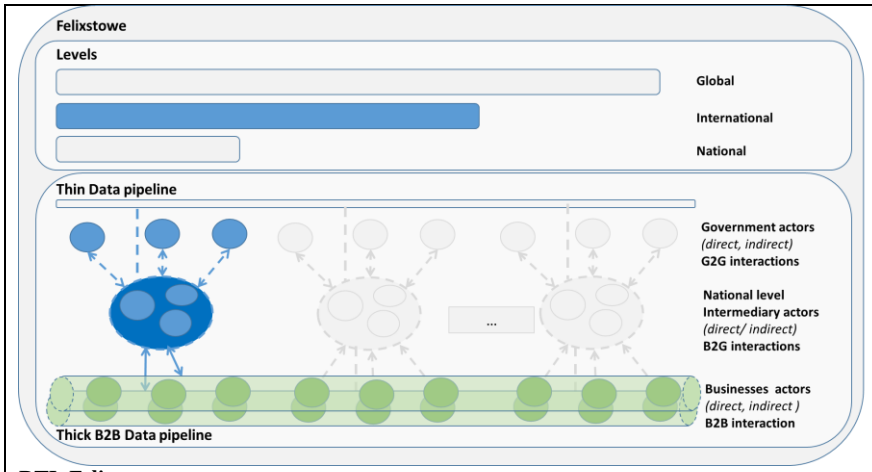
If we look at the Figure 2 we can see that the initiatives range from national to international to global and they also differ in terms of the DTI type that they try to establish. The NLIP and the National Hub components of the Felixstowe case (the private Hub Destin 8 and the public attempt (OneGov) to establish such a Hub) are all examples of initiatives that try to establish a National Hub to optimize the information exchanges among businesses involved in international trade in that country and the involved government authorities. It would be meaningful to compare these initiatives in order to gain further insights in what are issues related to setting-up National Hub infrastructures.

Looking at the Felixstowe, the FloraHolland, and the SIP cases, all of them focus also on Data Pipeline DTI. We see different choices about the infrastructure type, however: the Felixstowe case focuses on Thick Data Pipeline (where actual documents are exchanged) and has ambitions for international coverage; the FloraHolland case also focusses on a Thick Data Pipeline but is limited to a specific trade lane, whereas the SIP case focuses on a Thin Data Pipeline (exchanging only event information and links to documents rather than the documents themselves) and has a global ambition.

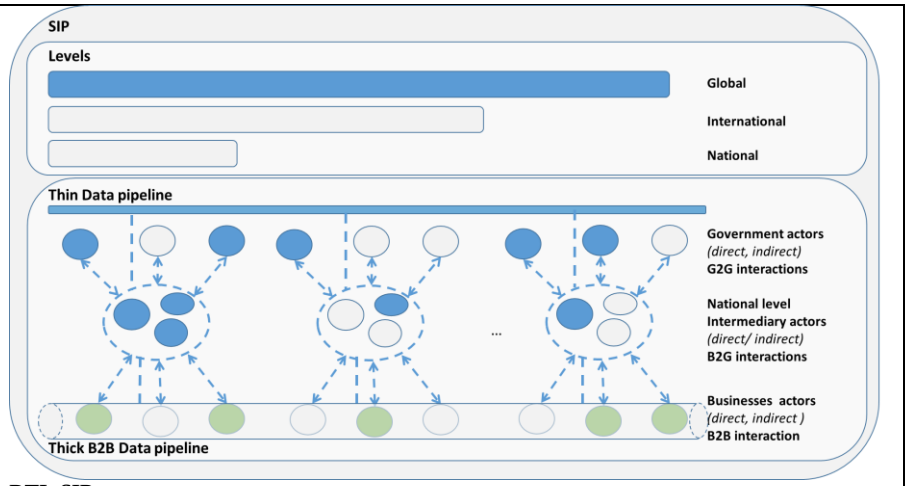
The architectural component of the framework also helps us to see how different initiatives fit together. A global Data Pipeline initiative like the SIP aims for global coverage but it will rely on existence of other parts of the infrastructure- such as the availability of National Hubs to connect to national governments in different countries, as well as Thick Data pipelines which could further facilitate the actual document exchange among parties if needed.

Thus, the architectural component can be useful for both looking for meaningful comparison cases (e.g. comparison of National Hub DTI initiatives; comparison of Thick Data Pipeline initiatives), as well as for identifying complementarities among different DTI initiatives and how they can be combined as part of a larger DTI.

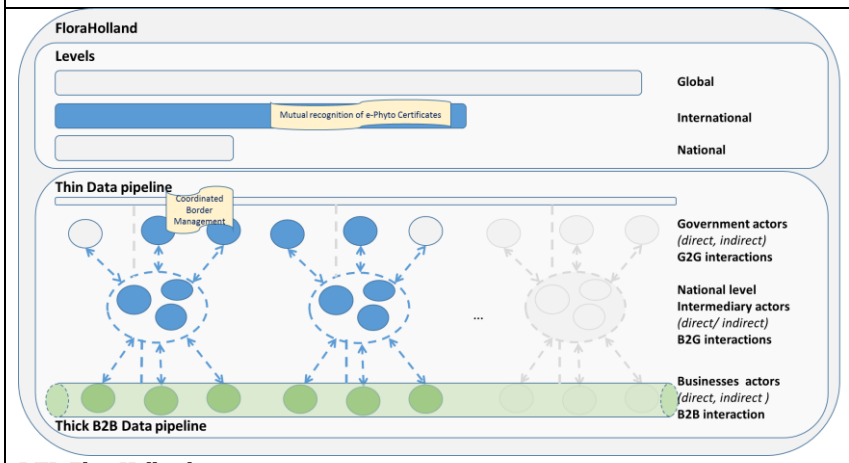
What is also interesting to mention is that the levels in the architectural component can be used in different ways. The most obvious is that they can be used to characterize the scope of the initiative. However, they can be also useful for reflecting on developments at other levels which can have influence on the DTI initiative (Rukanova et al., 2009). For example international regulations, global standards or actors with global influence may influence the development path of e.g. national initiatives. An anecdotal example from NLIP (a national level initiative) is that although significant effort and time were put in developing data sharing concepts that are useful for both the business and government actors involved, later in the process it was discovered that these concepts could not be implemented due to restrictions on a level higher (i.e. restriction posed by the EU level, namely the EU privacy law). As a result, a lot of efforts and time, as well as positive momentum were lost and the initiative was put on halt, which blocked it from further implementation. It is therefore important to keep the different levels in mind in order to trace possible external influences on the DTI initiatives and consider these influences when defining strategies for action.



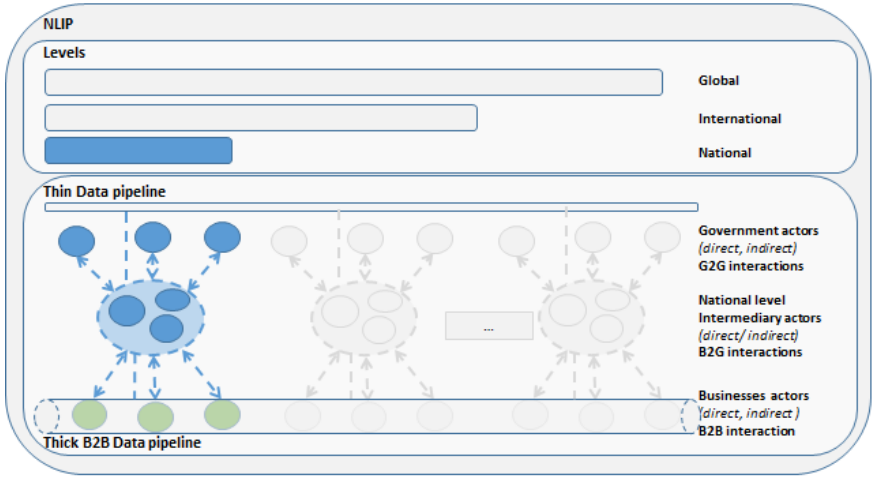
DTI: Felixstowe case
Scope: International;
Aim: To illustrate the development of a Thick data pipeline that links to a National Community Hub in UK (Destin 8 is a private hub; OneGov- a public hub under development)



DTI: SIP case
Scope: Global;
Aim: To illustrate a global Thin data pipeline that connects business and government actor (public good philosophy)



DTI: FloraHolland case
Scope: International
Aim: Trade lane specific thick data pipeline to facilitate information exchange related to export of flowers from Kenya to the Netherlands. It is in particular interesting, because it shows how a DTI can enable Coordinated Border Management between Customs and Phyto-sanitary inspection agencies at national as well as international level (across inspection agencies between Netherlands and Kenya).



NLIP Case
Scope: National
Aim: The focus is on the development of a national community hub to facilitate information sharing among business and government actors in the Netherlands.

Figure 2. Using the Architectural component of the DTI Framework to describe the four cases

4.2 DTI Process

The second component of the DTI Framework focuses on the process. As discussed in Section Three, by comparing and contrasting the initiatives we saw the need to conceptually differentiate among three phases, namely: (a) *Initiation*, (b) *Operation and maintenance*, and (c) *New Services*. Especially in the SIP demo and the NLIP case we see that a lot of complications arise when it comes to the initial investment and who will invest in the infrastructure. Specifically in the initiation phase, issues related to cost-benefit and infrastructure governance are related to how to get stakeholders on board and make them invest and commit to adopt the DTI.

Once such an infrastructure is up and running (operation phase) the governance issues and the cost benefit issues become quite different, as they relate to development of business models for the operation and maintenance. In the Felixstowe case for example, the initial investments were already done in the past by commercial parties and in the Operation phase the Pipelines are now commercially run with a viable business model behind them, where users pay fees for services offered by the infrastructure providers.

In the cases analyzed, most of the initiatives are still in Initiation phase, however discussions about the New Services phase are vividly present. In the SIP case, a new service App was developed before the infrastructure was in place to gain users' interest and experience. In NLIP the parties are eager to develop new Apps however they are waiting for the infrastructure to be in place so that they could offer their new services. At the same time the initiatives that we are analyzing are still trying to gain financing for the Initiation phase or in search for business models for the Operation and Maintenance phase. Such business models are not directly obvious due to the different parties involved and the public and private interests. The issue of fair cost-benefit sharing (part of the Governance component of DTI Framework) comes repeating as a discussion point, especially in the NLIP case. The DTI is expected to bring savings and efficiency gains to the parties in the chain but it is not obvious how these gains will be redistributed in the chain. In the cases analyzed, substantial efforts are put now in addressing this issue. As we can see, discussing the DTI process immediately links to issues related to DTI governance and this illustrates that the issues are very much inter-linked.

4.3 DTI Governance

Governance is the third dimension of our framework. In the complex multi-actor network of stakeholders governance is very important but remains a challenging issue to address. In only one out of the four cases (NLIP) there was a formal governance structure in the form of a governance board. In all the other three cases the governance was informal. In the Felixstowe case the private providers of Data Pipelines and the private Hub had their governance internally organized but the collaboration among the Pipelines and National Hubs (Destin 8 and OneGov) were managed informally. The FloraHolland case is still in early demonstrator phases but there is a Steering Group of decision-makers from the key partner organizations which oversees the process at the moment but their role is informally defined. The SIP case is driven mainly by MAERSK and IBM but formal governance structures still need to evolve.

One observation that we can derive regarding the governance dimension is that although it is very important to address it the governance is still a complex area that needs to be further understood.

As discussed earlier Constantinides (2012) sees the allocation of three categories of rights (i.e. constitutional, collective choice, and operational) as central to the governance of DIs. To recall, *operational rights* refer to rights related to access and contribution and extraction of resources – i.e. rights to access a DI. *Collective choice rights* refer to rights of removal, management and exclusion of users, while *constitutional rights* refer to who may or may not participate in making collective choices. These categories can help us to further reflect on the four cases and derive insights for further research.

Reflecting on the four cases and looking at these decision rights in relation to the phases that we identified we can say that the decision rights as defined by Constantinides (2012) mostly apply to the Operation and Maintenance phase, as they seem to assume the existence of the DI. It is interesting however to explore the possible links of the conceptual categories of decision rights in relation to the case findings, as well as the other phases we defined.

The *constitutional rights* refer to who may or may not participate in making the collective choices. If we look at the SIP case, IBM and MAERSK are now driving the initiative and key challenges is how to mobilize a collective action to secure further funding and ensure wider adoption for this initiative. It is likely that the parties who participate in making decisions in the initiation phase are different from those making choices about the Operation and Maintenance phase and when it comes to New Services. For the New Services phase it may be possible that new parties enter which also gain decision rights and become a players in the decision-making process. Thus, it would be meaningful to extend the notion of constitutional rights also to the Initiation and the New Service phase and see what learnings can be derived from that.

The *Collective choice rights* as discussed earlier refer to rights of removal, management and exclusion of users. This definition is very much centred around the subject of users. If we broaden the view that the parties who have constitutional rights will need to make collective choices related to a number of areas (where users could be one of them for example), then we can further explore and identify which are specific areas related to the DTI for which collective choices need to be made (i.e. the collective choice rights could be exercised). Our case findings reconfirmed findings from prior research that important choices related to DTI relate to (a) standards; (b) data access; (c) cost-benefit sharing. (see Annex 1 for further detail from the case findings related to these categories).

The Operational rights as discussed earlier refer to rights related to access and contribution and extraction of resources – i.e. rights to access an DI. Again, this presumes the existence of the DI and the question is what would be the meaning if expanded to the other two phases. For the Initiation Phase it may be linked to investments needed in the set-up of the infrastructure and possible return on investment (in our cases we see that initial investment is crucial and securing such an initial investment is a difficult process). In the New Services

phase it may relate to rights of App providers to the infrastructure and value exchanges related to the use of the infrastructure and the offering of new services.

Another observation that we need to make is that the rights discussed above seem to assume that such rights are easily defined. In our case findings we saw however that most of the initiatives (except one) had informal governance, the rules were not explicitly defined. Furthermore, although these categories can help to bring further structure into key decision-making processes, the process dimension of how the actors come together and how are constitutional rights obtained, who drives and shapes this process and how does the actor configuration change and evolve through the different phases of the infrastructure development needs to be further conceptualized and explored. Analysis of collective action processes can be an interesting conceptual lens to further examine such processes (Rukanova et al. 2008)

5 DISCUSSION AND CONCLUSIONS

DTI are perceived to promise solutions for enhanced supply chain visibility and risk assessment, for enabling cost savings and allowing for trade facilitation (Henningsson, Gal et al. 2011, Jensen and Vatrapu 2015). There are a various efforts to set-up DTIs at national, international and global level. However the process of setting-up such infrastructures faces a lot of challenges as they involve multiple stakeholders (nationally and internationally), representing the businesses and the government bodies controlling the cross-border trade activities. Conflicts due to issues related to data sharing, standards, as well as who will finance such an infrastructure and how the costs and benefits will be shared bring such initiatives to a halt and as a result it is extremely difficult for DTI to be developed and scaled-up. At the beginning of this paper we argued that in order to understand the problem at hand, we need a way to conceptualize the different infrastructure initiatives and where they stand in the development processes, so that we can better diagnose the problems at hand and the challenges they face. In this paper, based on empirical insights from four such DTI initiatives we develop a DTI Framework to be used as a tool to reason about and compare different DTI initiative, to enable further accumulation of knowledge about DTI initiatives and what brings them to a halt and what are mechanisms that unblock these processes and allow for further upscaling and up-take of DTI.

Reflecting on the experience so far the DTI Framework has been useful as a conceptual lens to reason about the architecture, process and governance components of DTI initiatives and their interrelationships. Our analysis also illustrates that the architectural, process and governance component are strongly intertwined, and exploring these dependencies is necessary to gain better understanding of the complexities and problems at hand. The DTI framework allows us to characterize DTI, to look for meaningful comparisons of similar cases and to look for complementarities. Understanding better the complex interplay among architectural configurations, processes and governance of DTI will enable us to better understand the complex processes that drive DTI from Initiation to Operation and further growth through New Services. From all the components, the governance component (and it relations to the other two components) seems to be most complex to address, as it is the complex interplay of actors and decision-making processes that brings DTI to a halt or drive them to success.

As such this paper should be seen as a stepping-stone for further empirical research on DTI which could be fed back to practice in terms of models, best-practices and insights. The different components of the framework or their inter-relationships provide basis for deriving further research questions to better enhance our understanding on DTI initiatives. Looking at the process component a possible area of research would be to zoom into the Initiation phase and identify factors that block these initiatives and put them on a halt and what are mechanisms that unlock these processes and allow the DTI initiatives to move towards implementation. Regarding the governance, one possible question is to explore the processes of how constitutional rights are obtained and whether and how they change when the infrastructure develops from Initiation to Operation towards New Services. Cost-benefit sharing is another very interesting area, where further research can focus on identifying cost-benefit sharing models which are useful for supporting the business case in the initiation phase; cost-benefit models for supporting the business model for the Operational phase or Cost-benefit models for allowing App providers to the infrastructure. Regarding the architecture component possible areas for research is to carry out comparative studies and gain cumulative knowledge on what are complexities related to setting-up a specific DTI type (e.g. National Hub, Thick Data Pipeline or Thin Data Pipeline) and what are lessons learned.

To this end the DTI Framework and the utilization in this paper to characterize four DTI initiatives induce our understanding of both DIs in general, and what sets DTIs apart from other DI initiatives.

With regards to a general understanding of DI design, three important findings emerge. First, there is a tendency towards archetypical architectural DTI set-ups. That is, in theory, choices in decision points of the infrastructure can be combined freely. In reality, however, it seems like some architectural design choices go more naturally together. These "natural fits" of architectural design choices indicate that there might be possible archetypical infrastructure set-ups of design attributes that align with each other. The implication of this finding is that anyone interested in the shaping of digital infrastructures cannot make independent choices regarding the architectural design but has to recognize the systemic dependencies between the choices. That is, one specific choice will influence the possibility for choices in the other design areas.

Second, the different archetypical digital infrastructure set-ups seem to address different problems. Contrasting different set-ups is not about declaring one being better than the other. They are simply different tools, used in different scenario. The scenario is defined by of the infrastructure set-up. Depending on the set-up (level, actors, scope, etc.) a different archetypical set-up is suitable. For example, for the Felixstowe digital trade infrastructure with a more limited actor and geographical scope it was decided that the best set-up would be to exchange documents within the pipeline (and hence adherence to data standards was of key importance) and offer this as a commercial service. In contrast, the inclusive (geographically and actor) design of the SIP aiming for global scope led to a decision to a minimalist standardization (not standardizing data elements) and a common-good philosophy. Critically, the choice regarding decision points in the Felixstowe case would not be suited for the SIP case, and vice versa. So, the question to answer in a specific case then is: What is the problem to be solved and how to map the connectivity infrastructure set-ups according to that problem. To the extent that an infrastructure set-up design might be flawed, it is because the combination of attribute is not coherent, that the

elements for the DTI Framework are misaligned. For example, combining an international ambition with standardization of data elements is likely to be a futile exercise, as no global agreement can be made down to that level.

Third, each of the archetypes seems to have their distinct "must win battles", depending on the process (i.e. the phase in which DTI is in), as well as the governance choices. For the SIP which is currently in its initiation phase, the critical "must win battle" is to mobilize the mass of supply chain actors to join the initiative. Such a design is subject to network effects: the more actors that join the initiative the greater the benefits for all. However, initially, there are no benefits of joining, in the same way that there would be no benefits of being the first (only) one with a telephone or a Facebook account. This is in the infrastructure literature called the "bootstrapping problem" and should be addressed through pre-emptive strategies. This relates to the complexity of governance of DTI in the initiation phase of the initiative. Research on mobilizing collective action can be used as inspiration for further research to address this problem (Rukanova et al., 2008).

The framework also carries an understanding of what sets infrastructural development in the trade domain apart from the development of DI in general. This is mostly captured in the architectural dimension of the DTI Framework. The specificity in the trade domain is related largely to two issues: (a) the very tight interactions of the supply chain actors with the authorities in international trade activities (e.g. submitting customs declarations and other documents for every shipment), and (b) the international and global dimension of the international trade activities which makes DTI development direct subjects to influence of international regulations and standards. This sets DTI initiatives apart from other DI initiatives such as setting up a National Health Infrastructure. And while it is definitely worthwhile carrying out comparisons and deriving learnings from other DI initiatives in other domains, the specificities of the DTIs and the related added complexities would need to be kept in mind.

For future work, it is critical to advance the understanding of DTI architecture set-up archetypes, building knowledge about which choice, and governance decision points, and processes go well together into coherent archetypes, which problems the archetypes can be used to solve, and the particular challenges of each archetype.

References

Aanestad, M. and T. B. Jensen (2011). "Building nation-wide information infrastructures in healthcare through modular implementation strategies." The Journal of Strategic Information Systems 20(2): 161-176.

Baida, Z., Rukanova, B., Wigand, R.T., Tan, Y.H. (2007). The Story of How Heineken's Supply Chain Benefits from Tight Collaboration with Government. Supply Chain Management Review, 11 (8).

Baida, Z., Rukanova, B., Liu, J., Tan, Y.H (2008). Rethinking EU Trade Procedures- The Beer Living Lab. Electronic Markets, 18 (1).

Braa, J., E. Macome, J. C. Mavimbe, J. L. Nhampossa, J. L. da Costa, A. Manave and A. Sitói (2001). "A study of the actual and potential usage of information and communication technology at district and provincial levels

in Mozambique with a focus on the health sector." The Electronic Journal of Information Systems in Developing Countries 5.

Bryson, J.M. (2004) What to do when stakeholders matter. Stakeholder Identification and Analysis Techniques. Public Management Review, 6(1), 21-53.

Ciborra, C. and O. Hanseth (2000). Introduction: From Control to Drift. From Control to Drift. C. Ciborra. Oxford, UK, Oxford University Press: 1-12.

Constantinides, P. (2012). Perspectives and implications for the development of information infrastructures, Information Science Reference.

Constantinides, P. and M. Barrett (2014). "Information Infrastructure Development and Governance as Collective Action." Information Systems Research 26(1): 40-56.

Damsgaard, J. and K. Lyytinen (2001). "The role of intermediating institutions in the diffusion of electronic data interchange (EDI): How industry associations intervened in Denmark, Finland, and Hong Kong." Information Society 17(3): 195-210.

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

Hanseth, O., E. Monteiro and M. Hatling (1996). "Developing Information Infrastructure: The Tension between Standardization and Flexibility." Science, Technology, and Human Values 21(4): 407-426.

Hedman, J. and S. Henningsson (2015). "The new normal: Market cooperation in the mobile payments ecosystem." Electronic Commerce Research and Applications 14(5): 305-318.

Henfridsson, O. and B. Bygstad (2013). "The Generative Mechanisms of Digital Infrastructure Evolution." Management Information Systems Quarterly Forthcomming.

Henningsson, S., U. Gal, N. B. Andersen and Y. H. Tan (2011). "The next generation information infrastructure for international trade." Journal of Theoretical and Applied Electronic Commerce Research 6(1): 1-15.

Hesketh, D. (2010). Weaknesses in the supply chain: who packed the box. World Customs Journal, 4(2), 3-20.

Jensen, T. and R. Vatrapu (2015). Shipping information pipeline: initial design principles. At the Vanguard of Design Science: First Impressions and Early Findings from Ongoing Research Research-in-Progress Papers and Poster Presentations from the 10th International Conference, DESRIST 2015. Dublin, Ireland, 20-22 May., DESRIST 2015.

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

Janssen, M., van Engelenburg, S., & Tan, Y.H. (2015). Comparing a Shipping Information Pipeline with a Thick Flow and a Thin Flow (working paper).

Klievink, A. J., Van Stijn, E., Hesketh, D., Aldewereld, H., Overbeek, S., Heijmann, F., & Tan, Y. H. (2012). Enhancing visibility in international supply chains: The data pipeline concept. International Journal of Electronic Government Research, 8 (4), 14-33.

Ostrom, E. (1990). Governing the commons: The evolution of institutions for collective action, Cambridge university press.

Rodon, J. and L. Silva (2015). "Exploring the Formation of a Healthcare Information Infrastructure: Hierarchy or Meshwork?" Journal of the Association for Information Systems 16(5): 1.

Rukanova, B., Baida, Z., Liu, J., Stijn, E. van, Tan, Y., Hofman, W., Wigand, R., Ipenburg, F. van (2011). Beer Living Lab – Intelligent Data Sharing. In: Tan, Y, Bjorn-Andersen, N, Klein, S & Rukanova, B. (eds.) Accelerating Global Supply Chains with IT-Innovation. Berlin: Springer-Verlag, pp. 37-55.

Rukanova, Boriana; Henriksen, Helle Zinner; Raesfeld, Ariane Von; Stijn, Eveline Van; and Tan, Yao-Hua, "A Collective Action

Perspective on Technological Innovation in Business/ Government Networks" (2008). EIS 2008 Proceedings. Paper 3. Available on-line at: http://aisel.aisnet.org/eis2008/3

Rukanova, B., Van Stijn, E., Henriksen, H. Z., Baida, Z., & Tan, Y. H. (2009a). Understanding the influence of multiple levels of governments on the development of inter-organizational systems. European Journal of Information Systems, 18(5), 387-408

Rukanova, B., Wigand, R.W., Tan, Y.H. (2009b). From National to Supranational Government Inter-Organizational Systems: An Extended Typology. In Proceedings of eGov 2009, LNCS, Springer.

Rukanova, B., Wigand, R.W., van Stijn, E., Tan, Y.H. (2015). Transnational Information Systems: A Multi-level, Conflict Management Perspective. Government Information Quarterly, 32, 182–197.

Sanner, T. A., T. D. Manda and P. Nielsen (2014). "Grafting: Balancing Control and Cultivation in Information Infrastructure Innovation." Journal of the Association for Information Systems 15(4): 220-243.

Sauer, C. and L. Willcocks (2007). "Unreasonable expectations - NHS IT, Greek choruses and the games institutions play around mega-programmes." Journal of Information Technology 22(3): 195-201.

Star, S. L. (1999). "The ethnography of infrastructure." American behavioral scientist 43(3): 377-391.

TAXAUD (2008). Electronic Customs Multi-Annual Strategic Plan - TAXUD/477/2004 - Rev. 8 - EN. Brussels, Belgium, European Commission.

Tan, Y.H., Bjorn-Andersen, N., Klein, S., Rukanova, B. (2011). Accelerating Global Supply Chains with IT-innovation. Edited Book, Springer

Tilson, D., K. Lyytinen and C. Sørensen (2010). "Research Commentary - Digital Infrastructures: The Missing IS Research Agenda." Information Systems Research 21(4): 748-759.

Annex 1: Linking the elements of the DTI Framework to the four cases and to literature

Tables 3-5 below link the architecture, process and governance components respectively to the four cases and literature.

Cases/ Literature links	NLIP	Felixstowe	FloraHolland	SIP	Cross-case Observations	Links to Literature
DTI Architecture						
Levels (National; International; Global)	National	National International	International	Global	The cases cover initiatives that vary in scope from national to international to global; Meaningful comparisons: • Comparison of national hub initiatives (i.e. NLIP and the national hub part of the DTI in the Felixstowe case); • Comparison of the data pipeline component of the Felixstowe DTI, FloraHolland DTI and SIP DTI.	Rukanova et al. (2009a); Rukanova et al. (2015)
Actors Actor (Business (B); Government (G); Intermediary(I)); Direct, Indirect)	B, G, I Indirect actors (mostly)	B, G, I Direct actors	B, G, I Direct actors	B, G, I Direct actors	Whereas in 3 of the four cases direct actors are main driver of the DTI initiatives, in the NLIP case the indirect actors (the associations) are the key drivers. In all initiatives business, government and intermediary actors are involved.	Bryson (2004)
Interactions (B2B; B2G; G2G)	B2B; B2G; G2G	B2B; B2G; G2G	B2B; B2G; G2G	B2B;B2G;G2G	In all four cases the DTI involve B2B, B2G, and G2G interactions	Rukanova en al. (2009b)
DTI Type (National Hub; Data Pipeline (Thin; Thick)	National Hub	National Hub (Two initiatives set-up to act as a national hub: Destin8 (private); One Gov (public)) Thick data pipeline for international B2B interactions and links to the national hub	Thick Data Pipeline (trade lane specific)	Thin Data Pipeline	The cases represent initiatives with different architectural configurations ranging from a national hub, thick, thin and trade-lane specific data pipelines.	Hesketh (2010); Klievink et al., (2012); Janssen et al., (2015)

Table 3. The architectural component of DTI Framework and links to the four cases and literature

Cases/ Literature links	NLIP	Felixstowe	FloraHolland	SIP	Cross-case Observations	Links to Literature
DTI Process						
Phase (initiation; operation and maintenance; new services)	• NLIP in Initiation phase	• Operation phase (National Hub, private) • Operation phase	• Initiation phase	• Initiation phase • A prototype	Most of the initiatives are in the initiation phase. In the Felixstowe case the development of the public hub is also in an initiation phase, the private pipelines and the private national hub are in an operational	(Aanestad and Jensen 2011)

	• There are discussions about how gain sharing will look in the operation phase as well as possibilities for development of Apps on top of the infrastructure in the New services phase	(Data Pipelines; private) • Initiation phase (National hub, public)		of a Smart App offered to gain insights into possible new services that can be offered on top of SIP once in operation	phase and have profitable business models. In the NLIP and the SIP case there is discussion already about development of Smart Apps on top of the infrastructure (New services phase).	

Table 4. The process component of DTI Framework and links to the four cases and literature

Cases/ Literature links	NLIP	Felixstowe	FloraHolland	SIP	Cross-case Observations	Links to Literature
DTI Governance						
Infrastructure governance • Formal/ informal	Formal (government board)	Informal	Informal	Informal	Only in the NLIP case there is a formal governance board; in all the other initiative there is an informal governance structure at the moment.	(Constantinides 2012, Constantinides and Barrett 2014)
Decision rights	Details below	Details below	Details below	Details below	As most of the initiatives are in Initiation phase and governance is often still informal, understanding governance issues related to DTI governance remain challenging and needs to be further explored.	(Constantinides 2012, Constantinides and Barrett 2014)
• Constitutional rights	Defined for the members of the governance board	Defined for the private pipelines and the private Hub	Not formally defined; there is a Steering Committee with decision-makers from key partners involved but roles informally defined.	Not formally defined; two key partners in the lead but formal structures not yet defined.		
• Operational rights	Not defined yet	Defined for the private pipelines and the private Hub	Not defined yet	Not defined yet		
• Collective choice rights	Rights to decide which projects to fund Broadly defined themes around technology; communities and application areas). The key decision areas	Not formally defined; The key decision areas below are identifiable in the Felixstowe case.	Not formally defined; The key decision areas below are identifiable in the FloraHolland case.	Not formally defined; The key decision areas below are identifiable in the SIP case.		

	below are identifiable also for NLIP.					
- Key decision areas (Standards; Cost-benefit sharing; data access)	See details below	See details below	See details below	See details below	In all the initiatives key decisions areas include standards, data access and cost-benefit sharing	Klievink et al. (2012)
Standards	Links to global standards; Development of standards for information sharing on national level	Choice for global standards for data/ document exchange	Choice for global standards for data/ document exchange	Choice for global standards for exchange of event information	In all initiative decisions about standards need to be made. All the initiative consider global standards. In NLIP there is also a focus on national standards development. In the Felixstowe and the SIP Case, there is a very distinct choice of international standards. There is choice for different standards though- In the Felixstowe case the focus is on standards for data/ document exchange; in the SIP case the focus is on standards that can exchange event information.	
Cost-benefit sharing	Key issue in NLIP; search for models for: - initial funding of the infrastructure and - fair models for gain sharing	The private pipelines and the private national hub have viable business models. The public hub needs to be developed and financed. It is still to be seen how the availability of the national hub will affect the cost-benefit models of the private hub/ private pipeline initiatives that are now pursued.	Private data pipeline Current focus on running the technical demonstrator; Preparation work on cost-benefit is done at the moment; discussions on cost benefit will be carried out in the next phase of the demonstrator.	Key issue: - Initial financing of the infrastructure - Choice for a common good approach	The cost-benefit issue is important in all initiatives. In NLIP and in the SIP case key issues is how to finance the infrastructure development in the initiation phase. A second key cost-benefit issue is to find models for cost-benefit sharing once the infrastructure is available (Operation phase)	

Data access	Key issue in NLIP	Information between pipelines is not shared;	Data access secured for the pilot; still to be seen how this could be arranged beyond the pilot.	Information about events and links to the data source shared can be shared. Access rights to accessing the data to be arranged among the parties themselves.	Decisions about data access are needed in all the initiatives. In NLIP this is one of the key discussion points. Furthermore in Felixstowe case there was an explicit choice not to share data among pipelines; in the SIP case event information can be shared, as well as links to documents (but the actual document exchange is out of scope).	

Table 5. The governance component of DTI Framework and links to the four cases and literature