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Digital Trade Infrastructures and Big Data Analytics: The concept of Value as a Linking Pin

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Abstract
This paper is largely empirically driven and reflects research and insights gained in the last 13 years of involvement in a series of innovation projects (ITAIDE, CASSANDRA, CORE[1], PROFILE[2]) related to scaling-up digital infrastructures in the area of international trade. Most of the project efforts and related research have been focus on the processes of upscaling of digital infrastructures from initial R&D and proofs of concepts towards large-scale piloting. As part of the CORE project, piloting took place also with the IBM and MAERSK-led blockchain-enabled digital trade infrastructure, which is now commercialized to a global scale under the name Tradelens[3]. In the context of these projects authorities at the border were major stakeholders involved in the innovation process. The goal was that by accessing commercial and supply chain data available via the digital trade infrastructures authorities could perform better risk analysis and provide trade facilitation to companies in return. At the end of the CORE project massive amount of data became available to the authorities for piloting. In order to be useful for the risk analysis processes this external data however needed to be further combined with internal data from the systems of the authorities and further analyzed . As a result, the PROFILE project was initiated in 2018 which focuses on the use of data analytics on internal and external data sources to improve risk assessment. From a theoretical perspective it appears that the literature on big data and analytics and the literature on upscaling of digital trade infrastructures focus on quite different issues. However, based on the flow of the projects where we have been involved they appear closely inter-related. The main question that we aim to explore is: *What is a potential conceptual ground to link research on upscaling digital trade infrastructures with research on big data analytics*? In this paper we propose to use the concept of *Value* as a linking pin. Understanding this link is essential, as it can reinforce both data analytics research and upscaling of digital trade infrastructures research. While this paper is predominantly focused on the trade domain insights may be useful in the broader setting for exploring conceptual links between information infrastructure research and big data analytics research.

Keywords: Digital trade infrastructures, big data analytics, value

1. Introduction

This paper is empirically driven and builds upon insights gained through the 13 year involvement in a series of projects related to setting-up and scaling up information infrastructures in the area of international trade (digital trade infrastructures). The first three projects (ITAIDE (2006-2010), 17 partners; CASSANDRA (2010-2014), 26 partners; CORE (2014-2018), 81 partners) focused on initial R&D, upscaling and large-scale piloting of digital trade infrastructures such as data pipelines (Hesketh, 2010) that can be used by businesses to share supply chain information. Authorities on the other hand can pull business data from the source via a data pipeline, reuse the data for a more efficient risk assessment processes of reliable companies and can provide companies with trade

[1] http://www.coreproject.eu/
[2] https://www.profile-project.eu/
[3] https://www.tradelens.com/

facilitation in return[4]. One of the digital trade infrastructure initiatives driven by IBM and MAERSK was also piloted in the CORE project and is now being commercialized on a global scale as a global blockchain-enabled infrastructure under the name Tradelens. A key challenge in all these developments was how to scale-up these digital infrastructure innovations from initial R&D towards large-scale piloting and implementation. From the point of view of the authorities (in our case customs) these data pipeline initiatives needed to be driven by business drivers and developed and up-scaled by businesses. Therefore in the CORE project major efforts were developed for articulating the benefits and potential value that digital trade infrastructures can bring to the different stakeholder groups. Once these infrastructures are in place authorities could connect to them and use the information for performing risk analysis. From the risk analysis perspective in the projects the authorities wanted to get access to as broad data set as possible in order to be able to examine which data is of value to them in their risk assessment processes. At the end of the CORE project, however, when the operational systems of a major carrier were linked to the digital trade infrastructure millions of events were made available to the authorities in a matter of weeks via a pilot dashboard. This led to another major challenge, namely how to make sense out of the data and combine it with other data available in the customs systems to be able to generate insights useful for the risk analysis process. Subsequently the next project started in 2018, namely the PROFILE project. The goal here is not any more on how to scale-up digital trade infrastructures but how to use big data analytics and combine internal customs data with external data coming from digital trade infrastructures and platforms to improve the customs risk targeting.

Looking at literature the research on big data and analytics focusses on quite different aspects compared to the issues related to upscaling of digital trade infrastructures. For example (as will be discussed in more detail later in this paper) some of the big data analytics research goes into data analytics methods and concerns, or the management of big data and the related big data challenges and that seems as a quite different stream of research compared to the issues on upscaling digital trade infrastructures and the questions that were raised there. Still, based on our project experience it seemed that the developments related to upscaling of the digital trade infrastructures and the data analytics work in the PROFILE project are tightly inter-related. The main question which we therefore address is: *What is a potential conceptual ground to link research on upscaling digital trade infrastructures with research on big data analytics*? To address this question in this paper, and building on Günther et al. (2017) we propose that such conceptual link can be established via the concept of *Value*.

The remaining part of this paper is structured as follows. In the next section we provide further background information on the international trade domain and background research on digital trade infrastructures, mostly carried out in the context of the projects under consideration. In section three we provide an introduction to the research related to big data and analytics. In section four we propose to use the concept of *Value* as a linking pin between up-scaling digital trade infrastructures and big data analytics. We end this paper with discussion and directions for further research.

2. International trade domain and digital trade infrastructures

Our analysis focusses specifically on digital infrastructures in the trade domain, also referred to as Digital Trade Infrastructures (Rukanova et al., 2018a). International trade is a quite unique domain for several reasons. First of all there is a large international and global dimension as goods produced in one part of the globe are sold and imported in another part. This brings challenges as the goods need to physically travel across the world, crossing territories of different countries and need to be delivered physically in good condition to the end customer. Second, information streams and documents need to be in place to prove that the commercial transaction has taken place and all the legal and regulatory requirements for exporting/ importing the goods are met. This information resides in separate IT systems, and paper documents still need to accompany the flow of goods (Tan et al., 2011, Jensen & Vatrapu, 2015; Janssen et al., 2017). As earlier research following avocados across borders concludes,

[4] Further details about the international trade domain and the data pipeline is provided in the next section

while the physical flows are quite optimized, there is a large potential for streamlining the information flows (Janssen et al., 2017; Jensen & Vatrapu, 2015). Third, authorities at the exporting and importing countries have responsibilities to protect the safety and security of citizens, to collect the respective duties etc. which requires strict controls. At the same time authorities have a role to facilitate the economic growth and facilitate trade. There is potential for significant efficiency gains and reduced costs if relevant improvements in border administration and transport and communication infrastructures are made. For example, as a report of the World Economic Forum indicates "if every country improved just two key supply chain barriers – border administration and transport and communications infrastructure and related services – even halfway to the world's best practices, global GDP could increase by US$ 2.6 trillion (4.7%) and exports by US$ 1.6 trillion (14.5%)" (World Economic Forum, 2013, p. 4). As such, authorities need to accommodate two principle objectives: One is the need to monitor and control the flow of goods to ensure public concerns such as safety and security, public health, revenue collection are safeguarded; the other is to help ensure that controls do not add to costs that undermine business competitiveness, and to support business through trader facilitation (or sometime referred to as the elimination of red-tape in international trade) (Tan et al., 2011).

To address the dual concerns of authorities for increased control and trade facilitation, over the last decades the ideas of reusing business data from the source available in the supply chain for government control purposes have gained attention (Tan et al., 2011, Hesketh, 2010). To allow access to the source business data and reduce the information fragmentation in supply chains Hesketh (2010) recommended the setting up of seamless, integrated, electronic data pipeline. Klievink et al. (2012) define the data pipeline concept as an IT innovation that enables the capturing of data at its source. By connecting various business data sources and information systems, a data pipeline provides the required digital infrastructure for inter-organisational information sharing and for voluntary information sharing of business data with the government. Rukanova et al. (2018a) developed a framework to help to analyse digital infrastructure initiatives for international trade (also called Digital Trade Infrastructures), like data pipeline, systematically. In their work Rukanova et al. (2018a) build upon the definition of Hanseth and Lyytinen [8, p. 4] where digital infrastructures are defined "as a shared, open (and unbounded), heterogeneous and evolving socio-technical system (which we call installed base) consisting of a set of IT capabilities and their user, operations and design communities" and focus on digital trade infrastructures specifically.

When studying the upscaling of digital trade infrastructures research has been focusing on capturing the complexity involved. Research has been focusing on the collaborative processes in the innovation phase and how multiple parties (businesses, government and technology providers) progressed towards jointly developing and piloting with new concepts for digital trade infrastructures (Tan et al, 2011, Frößler et al., 2019); on understanding the regulatory environment (Rukanova et al., 2009) in which these innovations take place; on the efforts the innovators take to mobilize collective action and gain critical mass (Rukanova et al., 2008; van Stijn et al., 2009); on understanding the role of public funding in this upscaling process (Rukanova et al., 2018b), as well as the complex government- to-government and government-to-business alignment processes that need to take place to realize the benefits (Rukanova et al., 2017). As upscaling heavily depends on the incentives of parties to further take the lead to invest in the development of the infrastructure, or to join an infrastructure as a user, cost-benefit analysis was crucial in the upscaling of digital trade infrastructures. Especially in the CORE project which focused on large-scale piloting research focused on value articulation and cost-benefit elicitation. In order to make these costs and inefficiencies explicit, further analysis was focused on developing dedicated cost models to make the costs and inefficiencies explicit to help to make the better business cases for upscaling the infrastructures (Grainger et al., 2018; Arsyida et al., 2017). Risk analysis tools for a multi-actors setting were also developed with the goal of articulating complex dependencies and identifying value that is not immediately visible when looking at only one actor in the chain but looking at actor-interdependencies across the whole chain (Ravulakollu et al., 2018). As such value articulation has become a key element when upscaling digital trade infrastructures, especially in the stage of the CORE project when large-scale piloting was taking place and the value articulation was a key factor for moving further towards commercialization.

3. Research on big data analytics

While in digital trade infrastructure research the focus so far has been mostly on upscaling issues, research on big data and analytics focusses on other issues. Big data and data analytics (DA) has received a lot of attention over the last decade and practitioners and researchers are looking into the transformative power of this technology to create for example competitive advantage or increase transparency. Big data has been considered to be a breakthrough technological development which brings opportunities, as well as challenges (e.g. Fichman et al., 2014; Chen et al., 2012; Gunther et al., 2017; Sivarajah et al., 2017). Big data can be seen as " a massive amount of digital data being collected from all sorts of sources, is too large, raw, or unstructured for analysis through conventional database techniques" (Kim et al., p. 78) and analytics used on top this data can help to generate new insights[5]. Chen et al. (2012) examine the evolution of business intelligence and analytics and they capture the increasing complexity in the use of analytics, starting with business intelligence and analytics applied to structured data in data base management systems, evolving to include also unstructured content available on the web, and now moving to mobile and sensor-based content. The application domains vary from eCommerce and Market intelligence, to eGovernment and politics, Science and technology, Smart health and wellbeing and security and public safety. That brought the need to further develop analytic methods such as (Big) data analytics, text analytics, web, network and mobile analytics. Apart from opportunities research on big data analytics has also pointed out to challenges related to using big data. Sivarajah et al. (2017) developed a framework that helps to conceptualize the different types of Big Data challenges in the data lifecycle. They identify three groups of challenges as follows: a) data challenges that relate to the characteristics of the data itself; b) process challenges related to the processing of data, and c) management challenges related to understanding and analyzing data. Sivarajah et al. (2017) also provide classification of the different types of data analytics methods. By looking at the continuum from information to insight to decision and action they identify several types of analytics, namely: a) descriptive analytics that help to understand what happened in the business; b) predictive analytics which aim to identify what is likely to happen in the future; c) prescriptive analytics or analytics that help responding to Now what? and So what questions. Next to that the authors also identify d) inquisitive analytics which are aimed at helping to comprehend why is something happening in the business; and e) pre-emptive analytics, looking into the question of what is required to do more.

In the context of big data analytics Kim et al. (2014) point out that parties recognize that being able to create value from big data "represents a new form of competitive advantage" (Kim et al., 2014, p. 85). However in a recent study Günther et al. (2017) conclude that although big data has been considered to be a breakthrough technological development there is still limited understanding of how organizations translate its potential into actual social and economic value. As such researchers have acknowledge the key role of understanding *Value* in the context of the big data analytics research. To address this issue, Günther et al. (2017, p. 202) propose that it is imperative for organizations to "continuously realign work practices, organizational models, and external stakeholders interest to realize value from big data". Günther et al. (2017) formulate a number of propositions and propose an *Integrated model of big data value realization*. In their model Günther et al. (2017) position *social and economic value of big data* in the middle and they propose that in order to address the value of big data, parties need to look at the interrelationships among three levels as follows: (a) *work practice level;* i.e. working with big data analytics in practice; (b) *organizational level;* i.e. developing organizational models; (c) *supra-organizational level*; i.e. dealing with stakeholders interests. As directions for further research Günther et al. (2017) call for further empirical research to examine the cross-level interactions and alignments. Some initial application and extension of the Günther et al. (2017) model has already been done in the international trade domain for articulating value of big data analytics for the customs risk analysis (Rukanova et al., 2019). Furthermore recent research on data driven business models and data driven services (Kühne et al., 2019; Engel & Ebel, 2019; Hunke et

[5] We use big data analytics or data analytics together as when looking solely at big data will not help us to understand its value for an organization, it is when some analytics are run on this data that you may come to insights that can generate value.

al., 2019) can also be very instrumental to help to further articulate value articulation and value generation based on big data and analytics.

4. Upscaling information infrastructures and big data analytics: Value as a linking pin

Based on the discussion above we propose that the concept of *Value* can be used as a linking pin between research on upscaling of digital trade infrastructures and research on data analytics. Especially we propose to build upon Günther et al. (2017) to further establish that link. The left hand side of Figure 1 below contains the adapted Günther et al. (2017) model when applied in the context of international trade and customs risk analysis (Rukanova et al., 2019).

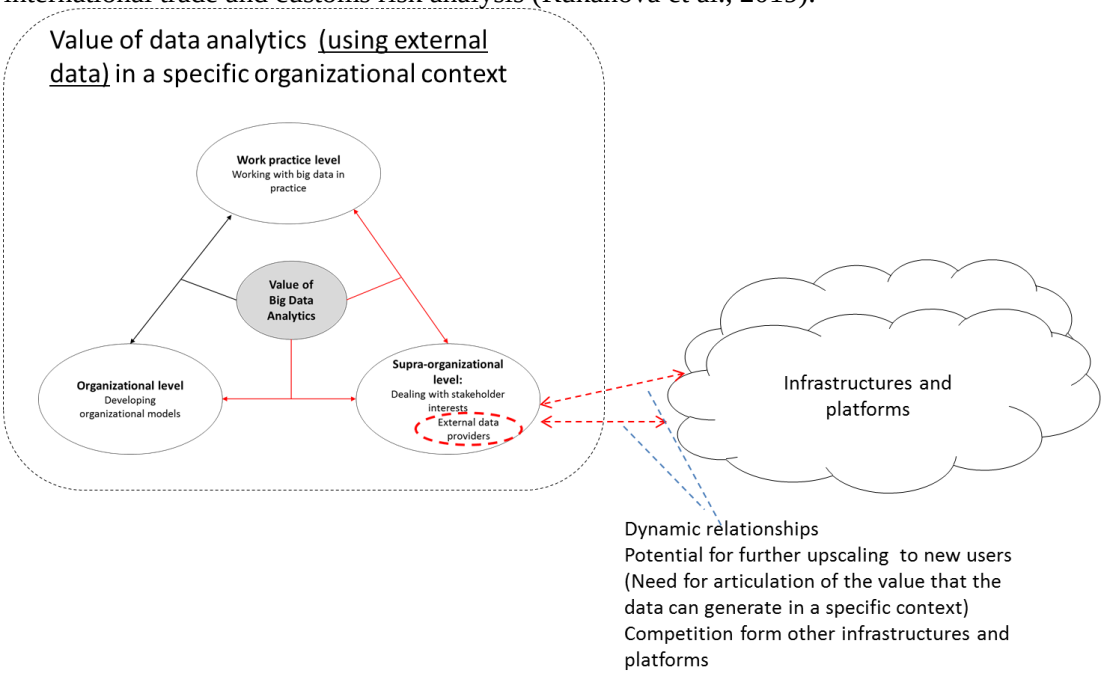

Figure 1. Linking the Value of Data Analytics model with Information Infrastructures and platforms

It shows that *Value* of big data analytics in a specific organizational context depends on the relationships among *work practices* where big data analytics is applied, the *organizational model* and the *supra-organizational* arrangements. In their further operationalization of the model Rukanova et al. (2019) explicitly place the external big data providers at supra-organizational level, as they are one of the stakeholders which organizations embarking on external big data would need to manage. These external data providers are on their turn linked to infrastructures or platforms where the big data is generated from. And from an organizational point of view there are many external data providers that can potentially hold data that may be of value for a user organization. The red arrows in Figure 1 between the infrastructures/ platforms and the supra-organizational level that deals with management of the external stakeholders indicates a dynamic relationship. For the infrastructures to grow and gain new user communities they need to be able to show how they can generate value for these new users. As discussed earlier, in the last phases of CORE and in the follow-up further commercialization activities for scaling up some of the digital trade infrastructure the search for value and the value articulation was a major aspect for the further growth. In the case that we are looking now the value that we are interested to explore is from these big infrastructure providers to be able to provide big data for analytics purposes, so that is a specific case compared to other value that the platforms can generate for potential users.

From an organizational point of view the value of the big data from the external data providers is not immediately clear. On a work practice level it will be a search process on where in the process (at work practice level) to place the data analytics; with which other data to combine the big external data;

how to measure performance. Also there are multiple data providers so it is not immediately clear with whom to engage. Organizationally there are terms and conditions, policies which encourage or inhibit organizations to engage with obtaining data form infrastructures and platforms. Therefore there is a dynamic relationship: from a digital trade infrastructure growth perspective there is a need to better understand the opportunity for further growth especially when it comes to using big data analytics. From an organizational perspective it is necessary to evaluate the value of big data and to make decisions whether and how to engage with external data providers. On this interface there are a number of interesting research directions where further research can proceed to tighten the link between big data analytics research and digital trade infrastructure research.

For example: for some platforms/ infrastructure providers that are able to generate big data Customs is often not the primary user group. Engaging in interactions would allow the infrastructures/ platform providers to better understand and elicit new potential value that their big data can generate for this new user group. This would reveal new business opportunities for further growth. However this also adds concerns and complexities that need to be tackled on the interface. For example, this data is in many cases not owned by the platform or the infrastructure provider and there need to be careful consideration on the terms and conditions that this data is provided and on the engagement processes with the parties that are providing data to the infrastructure. This makes the providers of data to the infrastructure and the users of big data more tightly intertwined. Furthermore there are also complexities related to the organizational model as even if there is a very clear case that the external data may improve the work practice level of an organization, organizational policies and constraints may prohibit the use of that data or engagement with specific external infrastructure / platform providers. We will not go in further detail here but what we sketch so far are only a number of questions and specific cases can reveal further the complexity of this relationship.

Conclusions and directions for further research

At the beginning of this paper we asked the question *What is a potential conceptual ground to link research on upscaling digital trade infrastructures with research on big data analytics*? There is one thing that is clear. Infrastructures and platforms generate big data. Big data analytics are performed on big data. So while research-wise these worlds are still loosely connected in reality they are very tightly coupled. In this paper, we propose to use the concept of *Value* as a linking pin and we build upon Günther et al. (2017) to further conceptualize how this link can be made. Big data is used by organizations to help organizations gain new insights. Organizations need to justify the use of big data and be able to articulate its value. Infrastructure and platform providers need to grow and involve new user groups and through big data is one possible path. We therefore see the concept of *Value* as one possible link to bridge the gap. This paper is empirically driven and limited to research in the area of digital trade infrastructures and research mostly conducted in the context of a series of EU-projects related to upscaling digital trade infrastructures and the use of big data analytics on data from such infrastructures. Further research is needed to demonstrate the applicability of the proposed concept in a wider setting, draw conclusions and outline more clearly directions for further research.

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