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Joint data platforms as X factor for efficiency gains in the public sector?

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Data analytics and interoperability have become pivotal issues for the creation of new public services. Furthermore, new informational technological (IT) solutions influence organisational boundaries and can become drivers of centralization or decentralization alike. In this article we argue that increasing capacity for data analytics and data use (e.g., through joint platforms) engender a new form of coordination in the public sector – **machine to machine coordination**. We seek to answer whether such coordination practices based on interoperable data platforms also introduce efficiency gains to the public sector? In this working paper we connect these three interrelated topics: first, how joint data platforms affect inter-organisational information sharing (i.e. collaborative service provision); second, if and how efficiency gains can be achieved by these collaborative initiatives; and lastly, how organisations and governance change in the public sector through the implementation of these initiatives. To exemplify this research puzzle, the case of the Estonian data exchange platform, X-road is examined.

Introduction

Nowadays e-government solutions are found to be the key strategy to improve government effectiveness and efficiency (e.g., Scholl 2010). Thus, information and communication technologies (ICT) can be now seen as an integral part of public administration reform. IT-based e-government innovations spur on work across organisational boundaries – standardizing information sharing, making information systems interoperable and harmonizing business processes – which creates new foundations for collaborative efficiency. Furthermore, there are problems which single organisations cannot solve alone and this forces public organisations to move from a culture of 'need to know' towards a 'need to share' (Dawes et al. 2009). Thus, public services are no longer provided in single organisations or through dyadic relationships between public sector bodies. The provision of public services requires input collected and processed by different organisations. This is spurred on by both austerity, (re-)centralization and need for better coordination enabled by ICT.

Greater information sharing, integration and inter-organisational collaboration is believed to lead towards a 'Smart State' (Gil-Garcia 2012); equally importantly, ICTs enable increased information flows from 'citizen experts' that could help solve public policy problems (Noveck 2015). Connected to this, scholars have argued that shared, timely and actionable information that enables to integrate public sector processes is key to smart governance in the 21st Century. Johnston and Hansen (2011) argue that with the increase of collective capabilities to govern, the public sector needs smart government infrastructure to deal with policy chal-

lenges. Integrating different public sector processes requires, however, the creation of an interoperable[1] IT-system or IT-platform (Scholl and Klischewski 2007). The implementation of intergovernmental information systems is believed to be the most significant organisational challenge of the current decade (Scholl and Klischewski 2007; Pardo et al. 2009), but it is also an area rife with conflict and failure.

However, with the emergence of blockchain and other peer-to-peer (P2P) technologies that enable decentralized yet safe sharing and storing of information, the question about ICT as enabler of inter-organizational collaboration becomes even more poignant. To simplify: ideally P2P technologies could enable rise of information sharing and storage that does not need any public entity to run such platforms. In fact, some of the ICT platforms employed already have some of the features of P2P technologies, in particular decentralization and time-stamping of data. This should make such platforms much more secure and difficult to hack or to abuse.

Thus, we can see that from the one hand the increasing importance of joint data platforms enable cross-sectoral consolidation and impose centralized service production routines; yet from the other hand, it may lead to highly decentralized service production models.

The impact of ICT in general, and IT platforms in particular, on organisational change in the public sector is still relatively poorly understood (Pollitt 2012; Nograšek and Vintar 2014). It can influence organisational structures, processes, culture and people in profound ways, albeit, the evidence to that regard is still very scattered especially concerning the implementation of e-government initiatives. Hence, e-government literature discussed different themes of possible change: automatization and elimination of processes, vertical and horizontal integration of business processes, information sharing on interpersonal, intra- and inter-organisational levels, change in the complexity work and work-loads for employees, communication channels, organisational behaviour etc. (see overview in Nograšek and Vintar 2014). Hence, if and how organisations have changed or become more effective/efficient is not thoroughly studied in the context of the public sector and collaborative efficiency research. There are both those who are highly optimistic about the radical change ICT will introduce to traditional bureaucracies (e.g., Pollitt 2010; Weerakkody et al., 2011; Brown et al 2014) and those who are more sceptical

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1 European Interoperability Framework (EIF) defines interoperability as the *"ability of disparate and diverse organisations to interact towards mutually beneficial and agreed common goals, involving the sharing of information and knowledge between the organisations, through the business processes they support, by means of the exchange of data between their respective ICT systems"* (European Commission 2010).

about the potential (e.g., Kraemer and King 2006). Nevertheless, the possibility to improve access to information by integration of registries and databases, efficiency, accuracy, transparency of processes and shorten the time for both administrators and citizens alike are often cited as the potential impacts of implementing ICT solutions and especially interoperable IT-systems (see overview in Nograšek and Vintar 2014; also Pollitt 2010). Especially in the context of Big Data, which by now should be cheaper to store, move around and analyse.

Most of the connected studies draw on information systems, information sharing, capability and enterprise architecture literatures (e.g., Pardo et al. 2011). At the same time, while technology has indeed a growing role in how information is stored, gathered, processed and shared among organisations (e.g., Hale and McNeal 2011), expectations that it will bring forth new capabilities for integration or new information sharing efforts have in reality realised only in few cases (Pardo, Gil-Garcia and Burke 2009). Instead, in most cases what has happened is digitization of existing routines and practices (Brown et al 2014).

Current work tries to go beyond the discussion outlined above and discuss the long-term effects of adopting interoperable IT-platforms in the public sector: first, on how it affects inter-organisational information sharing (i.e. collaborative service provision); second, if and how efficiency gains have been achieved by these collaborative initiatives in the broader eco-system of the it-platform; and lastly, how organisations and governance have changed in the public sector through the implementation of these platforms. As discussed above with P2P technologies, by platforms we mean technological structures – centralized or decentralized in nature – that make data interoperable and more easily available for the application of data-analytics. These issues are exemplified through a case study of the Estonian across government data exchange layer – the x-road – which is widely credited to be one of the efficient and functional e-government architectures around (e.g. as mentioned in Dunleavy and Margetts 2015).

We show that as public sector IT platforms are moving closer to or imitate in some key aspect P2P technologies, what we see emerging is not only the question of efficiency – and how to measure it as it takes the form of externality and not simply saved costs – but also **emergence of a new form of coordination**. Namely, non-hierarchical and decentralized P2P networks enable **machine-to-machine coordination** without significant human input (next to well-known typology of coordination by hierarchy, networks and markets). Such coordination and data flows make increasingly also external data – smart dust of millions of smart phones,

social media feeds, environmental, traffic etc. sensors – crucial for public IT platforms. Thus, we argue that one of the key issues with public sector IT platforms is the need to understand what are the characteristics of this new form of coordination within the public sector.

Theoretical considerations

Traditionally collaborative efficiency studies cover reforms that are made to change structures and processes more cost-effective through cooperation between different organisations. The efficiency gains are associated with centralized resources, economies of scale and also specialization. This also includes ICT infrastructure consolidation – IT platforms – that facilitate inter-organisational information sharing. ICT in this regard is expected to strengthen communication between organisations, create and integrate common IT-services within government and adopt service-oriented architecture and business information systems to manage and organise public services across public organisations (Morgeson and Mithas 2009). Usually, to enhance collaboration and cooperation inter-organisations shared databases are expected to be established which coincide with the delivery of e-services, more effective e-commerce solutions and increase in transparency of government (see literature in Hamza et a. 2011). Inter-organizational information sharing is, thus, expected to influence service quality by coordinating service delivery across various public organisations (Zheng et al. 2009), but the effects of ICT in organisations can be much larger.

ICT has the potential to decrease the number of needed hierarchical levels pointing towards flatter hierarchies (Van Veenstra et al., 2010), creating network structures instead (Pollitt 2010) and thus, contributing to the creation of horizontally linked independent agencies (O'Donnell et al. 2003). This development can be taken even further by P2P technologies such as blockchain and others that essentially operate as public ledgers of information that are (supposedly) safe and de-centrally managed. (See, e.g., Davidson, De Filippi and Potts 2016; Swan 2015)

Data transparency and integration in government can have both monetary and non-monetary benefits inside and outside of public administration (Casalino et al. 2013). The benefits include reduced cost and time for innovation/services, speed of operations, and foundation for performance improvement, legitimacy gains, increased government accountability etc., while there is a danger for technological lock-in, decrease in privacy and the effect of digital divide regarding access to services (see also Margetts and Dunleavy 2013). Namely, information systems need to maintain a high level of flexibility to be able to cope with changing requirements

(Bekkers 2009). One of the preconditions for the development is to link government data and integrate public sector systems by making information systems interoperable. At the same time, linking government data in a useable format is costly and the practical approaches to do it at scale are not that well established (Lopez et al. 2012, 2). Government information systems are integrated within the context of lingering Weberian bureaucracies with precise task allocations and hierarchy that the possibilities technology creates transcend (see e.g., Van Cauter et al. 2015).

Towards new paradigm of coordination

The key issues to handle policy challenges governments are facing today are access to open data, shared information, continued engagement and coordination (Gil-Garcia and Sayogo 2016). But the value from Big Data is not so much anymore the data itself. One of the main components of e-government is the ability for public and private organisations and individuals to share and integrate information and analyse it across traditional boundaries (Gil-Garcia et al. 2005; Pardo et al. 2011). E-government has been observed to develop in stages: while it is relatively easy to reach the first information services, however, when more changes in internal administration and business processes are required, the more complex it gets and the more difficult it is to make progress (Groznik and Trkman 2009). Opening data to citizens is not good enough anymore; trust is earned through the ability to link data with other data (Höchtl and Reichstädter 2011, 334). However, cross boundary information sharing is found to be a significant gatekeeper to more advanced e-government developments (Klievink and Janssen 2008; 2009).

Nevertheless, it is assumed that gradually information in the public sector will be shared – first, intra-organisations, then inter-organisations and then on inter-government (Yang and Wu 2013). Thus, there should be a gradual tendency toward integration of trusted social networks, shared information, integrated data and interoperable technical infrastructure (see e.g., Gil-Garcia, Pardo, and Burke 2010). In essence, IT platforms potentially can break down barriers between information that is either internal or external to public sector and typically governed by different rules (of privacy etc.) and integrate different data in respective layers. Thus, we argue that deeper integration of data and data sharing leads inevitably to increased machine-to-machine communication; and integrating external data from smartphones, social media and myriad of sensors will also only increase such interactions. Accordingly, we argue that at one point when such interactions become dominant forms of information sharing and processing, we can speak of a new form of coordination, what we call **P2P or machine-to-machine coordination**. In effect, at such critical point collaborative efficiency becomes a coordination practice sui

generis. However, the first step is the potential to integrate data to use data analytics to build value on the former.

Integrating government information systems

Scholl and Klischewski (2007, 897) define integration as *"forming of a larger unit of government entities, temporary or permanent, for the purpose of merging processes and/or sharing information."* Increased integration and information sharing can lead to the development of joint IT-systems and changes in business processes (Gil-Garcia, Chengalur-Smith, et al., 2007). Usually, open data and open government initiatives spur on development of these IT platforms that create interoperable systems and standards. This does not mean only technological standards, but also non-electronical issues and inter-organisational relationships at different levels (Ferrario and Guarino 2008; Kubicek et al. 2011). In many cases it is not a technological challenge nor is the availability of technology sufficient for success (Dawes et al. 2009), but success depends more on organizational, legal, political, and social aspects connected to the project, for example, the level of trust in the public administration system in the various connections between the agencies (e.g., Dyer and Chu 2003; Luna-Reyes et al. 2007). Especially, as organisations may find that by opening up their data, they are giving away some of their autonomy and power (see discussion in Yang and Wu 2014) and in some cases, the change in power relations is indeed happening (Tõnurist 2015). Thus, it is also a social challenge for the government (Traunmüller and Wimmer 2004) that relies heavily on management issues; namely, how to make agencies with specific capabilities partner effectively with external organisations (see Pardo and Burke 2009 on this issue).

Specifically in regards to information sharing there are two main dimensions to cross-boundary information sharing: horizontal and vertical (Zheng et al., 2009; Yang et al. 2014). The first denotes information sharing between parallel governments agencies; while the vertical dimension describes personal, hierarchical, geographic and developmental level bounds to information sharing (ibid.). Hence, also information systems development is influenced by the differences in decentralization and centralization trends in governance that manifest themselves in e-government developments (e.g., Fraefel et al. 2013). For example, decentralization in e-government developments can put limits to interoperability between public organisations and their data sets (ibid.), leading to duplication and possibly, also lack of cooperation. Thus, trends of centralization have been previously tied to cross-boundary information sharing in the public sector, where web-based services centralize processes and functions of government agencies (e.g., Artigas et al. 2009; Aagesen et al. 2011).

Hence, e-government development through inter-organisational information sharing is closely connected to process integrations and moves towards information systems interoperability (Scholl and Klischewski 2007; Scholl et al. 2012). This, however, introduces a high degree of complexity into the public sector and the response to deal with the general trends towards interoperability are different. Bekkers (2009), for one, outlines how through back-office information integration in government facilitates front-office services and interaction with citizens. He outlined four different ways this integration can manifest itself: through centralization (central data depositories), interface connection (individual interfaces between organisations), information brokerage or clearing house (information intermediary that exchanges data) or shared information infrastructure (same databases with one administrative point). At the same time, centralization – whatever form it takes – can also induce conflicts within the public sector, their specialized tasks (creating barriers to innovation and responses to local needs) and thus, expectations to standards of information exchange (Scholl and Klischewski 2007). As such, there are both advantages and disadvantages to IT-infrastructure-led centralization in the public sector and balance between centralization/decentralization is a key issue in IT platforms development. However, before discussing the potential benefits of these initiatives, the success factors and determinants of the former will be briefly outlined.

Determinants of interoperability initiatives

While interoperability in government is usually understood as a technical capability of government, it facilitates not only technological integration, but also process and information sharing, institutional and functional dimensions (Scholl et al. 2012). Usually these technical solutions create a whole IT-ecosystem around it. Hence, interoperability has multi-service, multi-stage (multiple sequential stages of service where several separate providers can be involved), multi-area (services from and to various geographical areas), and multi-file (services involving multiple directories and files) scopes (Kubicek et al., 2011). There are technical, syntactic, semantic, and business process layers to interoperability (Kubicek and Cimander 2009).

The success of inter-organisational information sharing is dependent on various socio-technical factors. Gil-Garcia and Sayogo (2016) review prior literature and propose a list of seven major categories determinants of inter-agency information sharing: (1) information, (2) technology, (3) managerial, (4) organizational, (5) policy, (6) political, and (7) contextual. Technological factors are influenced by technological compatibility between organisations, technical infrastructure and interoperability stan-

dards. From organisational and managerial factors financial resources and the size of organisations seem to influence the success of inter-organisational data sharing the most (see also Yang and Maxwell 2011). Slack resources are important to manage collaborative initiatives in government to government information sharing (Tolbert et al. 2008). Furthermore, under Gil-Garcia and Sayogo's (2016) organisational factors formalization, bureaucracy and centralization also influence information sharing between public bodies, especially when they have conflicting agendas and goals. But not only, also individual level factors – leadership and active management support – are influence the success of intra-organisational information sharing projects. Under political and institutional determinants, the effects are found to be dual (ibid.): on the one hand, supportive legislation can create better governance conditions, while on the other hand, legislation usually assigns specific responsibilities for specific agencies, thus, limiting the potential for collaboration and intra-organisational information sharing. Finally, intra-organisational information sharing is embedded in specific context and thus, the culture, trust, nature of incentives in the prevailing social, political and economic context can be an important factor in the success of these initiatives. Thus, governance models can have a significant impacts on intra-organisational collaboration and information sharing in government. Consequently, there are various layers to the success of inter-organisational, many of which are multi-level with ties between interpersonal, intra-organisational and inter-organisational factors (Yang and Maxwell 2011).

As there are many different actors involved, then inter-organisational information sharing faces also many challenges (Gharawi and Dawes 2010; Gil-Garcia et al. 2009; Pardo et al. 2009b; Pardo and Tayi 2007; Gil-Garcia et al. 2009). Thus, collaborative governance and inter-organisational information in e-government initiatives can have many different barriers on various levels from strategic, technological, policy and organisational barriers (Zheng et al. 2009; Pardo et al. 2011) including overambitious goals, incompatibility of standards, data ownership and privacy, low stakeholder commitment etc. Many, if not most, of the most influential barriers lie in the legal/institutional realm rather than technology (Isomaki and Liimatainen, 2008; Gil-Garcia et al., 2009; Lampathaki et al. 2009). Organizations tend to digitize first their existing (often idiosyncratic) routines and processes, whereas inter-organizational collaboration assumes standardization of organizational practices across the sector, which at least in short run increases rather than decreases costs for individual organizations. This applies equally to different technological strategies from platform government stressing on modularization (Brown et al 2014) to P2P solutions.

While during the last decade public sector has moved from a model of information protection to emphasising information sharing (Wixom and Todd 2005), privacy and confidentiality concerns are still considered as the key issues of intra-organisational information sharing in the public sector (Pardo et al. 2009b). Hence, interoperable it-systems/it-platforms need to address security and data confidentiality concerns with appropriate authorization and authentication; otherwise, government and private users will not give data access over (e.g., Liu and Chetal 2005).

Nevertheless, also technical factors matter. Usually, government-to-government (G2G) information sharing goes through two phases: catalogue access (availability of information sharing infrastructure) and transaction capability (possibility to exchange data in real time) (Reddick 2004). Prerequisites of the former are uniform data formats and secure exchange processes (Mckinnon et al. 2005). Technical mismatch between organisations can be a considerable barrier between intra-organisational information sharing (due to incompatible information systems, standards, legacy infrastructures), for which standards and platforms are developed (Gil-Garcia and Pardo 2005; Gottschalk and Solli-Saether 2008; Bekkers 2009; Ferro and Sorrentino 2010). Lack of interoperability standards sets a technological barrier to e-government development, especially, in G2G information sharing efforts (Skiftenes 2006). Interoperability requires, therefore, standardisations and for the former information security concerns can become major determinants of inter-organizational information sharing (Yang and Wu 2013).

Towards collaborative efficiency through interoperable it-platforms?

As argued above, collaborative efficiency through it-platforms in government is nowadays strongly tied to the issue of e-government interoperability – sharing information and integrating service delivery – which is supposed to signal e-government maturity (Estermann et al. 2009; Gottschalk 2009). It is found to be a precondition to collaborative efficiency and effectiveness of government (e.g., Gottschalk and Solli-Saether 2008): giving citizens access to electronic 'one-stop shopping', creating possibilities for faster e-service delivery with less costs and fewer errors (Sharma and Panigrahi 2015). Furthermore, the more mature the IT platform the more likely it is that the attention will switch from technical issues to organisational processes and structures (Janssen and van Veenstra 2005). Hence, one of the main preconditions of e-government developments is the interoperability of information systems. However, for collaborative efficiency public organisations need both effective strategies to control information exchange and also an effective strategy to manage operations in public organisations. Hence, IT platform develop-

ment has to go hand-in-hand with the 'business' development of the agency. High levels of interoperability are supposed to facilitate innovation (Ebbers and van Dijk 2007; Pardo and Burke 2008), enable system integration, intra-organisational information sharing and collaboration across organisational boundaries (see further Pardo et al. 2011). Public sector organizations that encourage collaboration are also those who spur on organisational learning. Organisations that participate in these initiatives have usually a successful collaboration track record and they actively look for possibilities to partner across organisations (Pardo et al. 2011, 9). At the same time, too much collaboration between organisations – centralization – can hinder innovation due to numerous and conflicting expectations (Torugsa and Arundel 2015).

Thus, the goal of many of these initiatives is to increase the effectiveness and efficiency of available services by harmonizing procedures (Hamza et al. 2011). Thus, the discussion so far is very much in line with the traditional collaborative efficiency arguments outlining the benefits from shared investments (Kwon et al. 2009) and technical specialization/expertise (Gil-Garcia and Pardo 2005; Fedorowicz et al. 2007). Through interoperability projects civil servants expect service enhancement, time savings/speed-ups, improvement in information quality and new services (Scholl et al. 2012).

However, how is success measured? Reviewing 19 interoperability cases in Europe Scholl et al. (2012) find that definitions and basic metrics on what success implicitly means were frequently absent; although, measurable process improvement and faster processing speeds and more general service quality improvements were cited among the project documents. IT-systems also fail in the public sector, but these failures usually receive limited coverage (Van Cauter et al. 2014). At the same, capability to carry out performance evaluations is deemed important for carrying out any e-government initiatives to not only measure the effectiveness and efficiency of the projects, but also to control the costs and benefits connected to the initiative (Iribarren et al. 2008). This means not only the identification of direct costs of the initiative, but also the costs of the stakeholders. What is more, the long-term effects on the governance of different policy fields are not clearly outlined as well.

From the overview above we can form the following rough theoretical expectations: first, IT platforms initially digitalize existing routines of information gathering and sharing both in intra- and inter-organizational dimensions, without engendering significant changes to service delivery or to the organizations involved; second, with increasing sophistication, IT platforms become to embody more and more P2P like features (in

terms of decentralization, interoperability, security, transparency) engendering increased machine-to-machine traffic and hence coordination; third, notwithstanding increasing technical complexity, public sector has difficulty in conceptualizing and measuring the impact of IT platforms and hence their efficiency gains; fourth, adding new services on IT platforms is relatively difficult as platforms are first of all developed for internal use and embody existing organizational routines; fifth, achieving radical efficiency in inter-organizational IT platforms is both technological as well as organizational challenge with clear trade-offs such as between automated decision-making and value-based judgements.

Methodology

Taking the above discussion into account the role of interoperable IT-platforms will be analysed through the case study of the Estonian across government data exchange layer – the X-Road. Estonia in general has been associated internationally with a strong e-state profile and recently the country has been trying to take lead in cybersecurity norms (Crandall and Allan 2015). Famous for it e-government developments, the X-Road has been promoted both internally and internationally as a more efficient data exchange methods avoiding high costs associated with systems of bilateral connections (see e.g., Dunleavy and Margetts 2015). Thus, the case-study provides a useful test-bed for understanding the potential and barriers to collaborative efficiency in the 21st century as well as enables to shed light on the emerging P2P/machine-to-machine coordination practice in public sector. The analysis of the case study is two-stage: first, document analysis and second, in-depth interviews of the central managers – Information Systems Authority (*Riigi Infosüsteemi Amet (RIA)*) - and the original creators of the initiative.

The case of the X-Road

The Estonian e-government infrastructure consists of many components and the largest of them is the X-Road (see overview in Kalja et al. 2015) that provides interoperability to the state information systems (Haav 2011). The X-Road is the secure Internet-based exchange layer for information systems for the Estonian public sector. The aim of the X-Road was to modernize access to national databases by making them a common source for which the public services could be based on. X-road services enable to read and write data and moreover, the platform provides a secure solution for both the inquiries into different databases and for the exchange of data and the possibility to provide services via web portals. Consequently, it is both a technological and organisational envi-

ronment for data exchange providing multi-level authorization, authentication, high-level log processing systems, encryption and time stamping services. Hence integrity of the data exchange is a key component to the X-Road: by now all inquiries and replies are digitally signed and time stamped and all service providers have public key certificates.

Both public and private institutions can connect their information systems with the X-Road. Hence, the X-Road enables secure data exchange between government registries and creates the possibility to transfer data securely between government and individuals. Furthermore, it creates the possibility for individuals to access data in public sector databases. Figure 1 below highlights the different components of the Estonian e-government infrastructure. As can be seen, the Estonian e-government is largely based on the X-Road project (e.g., Sepper et al. 2010), where civil servants, legal entities and civilians can use open databases as much as they are entitled to do so (Kalvet 2007, 15). The key element to widespread usage of the e-government infrastructure is electronic ID card that functions as access interface for both public and private sectors. In essence, all authentication services in Estonia use ID card (from e-voting and digital signature to logging into private banks accounts).

The X-road is managed by the Information System Authority (RIA).

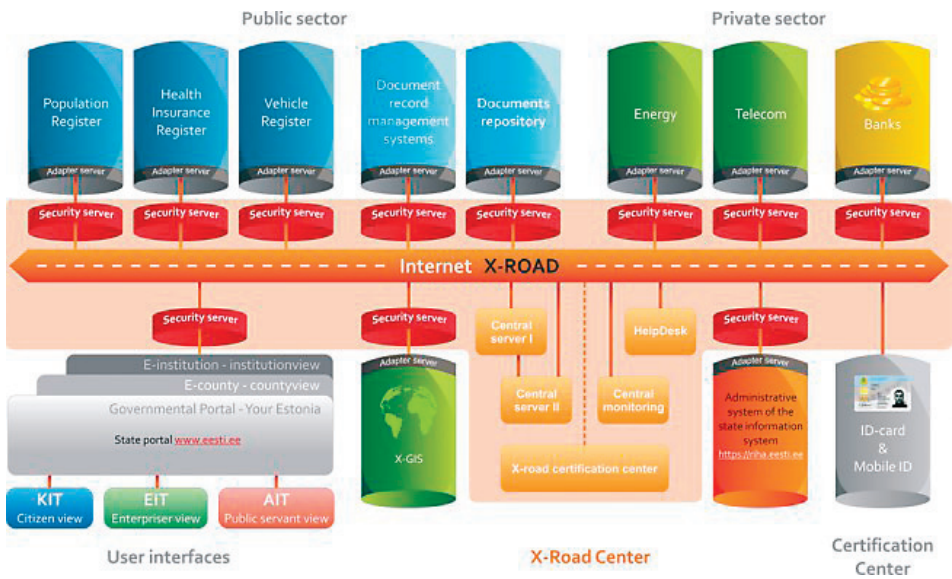

Figure 1. Estonian e-government infrastructure

Source: e-estonia.com, accessed 14.03.2016.

Background of the X-Road concept

In the 1990s, there were many information systems in the Estonian government and some core registries had multiple layers on different administrative units (e.g., the population registry was compiled on the municipal, county and state level). There was little integration in the back office administration in government and the bureaucratic burden was relatively high. In the beginning of 2000s many projects emerged discussing interoperability and coordination of information systems. In these discussions security issues seem to prevail. There was a widely covered case of a hacker (Imre Perli, 1996) creating a 'super database' that created concerns of centralizing government data into a single point of failure. As the planned system was supposed to operate over the Internet it was subject to availability threats; if something happened to the computing centre, all critical services would be down. This spurred on the distributed data architecture of the X-Road, which is still the staple or 'ideology' of the data exchange layer today.

The development of the X-road – based on a distributed data architecture – started in 1998; the first pilot was completed in 2000 when three databases were joined over XML-RPC (a remote procedure call (RPC) protocol which uses specific markup language (XML)). There were several technological solutions, however, the main question was if to use technology from a commercial firm or to use open software. In the beginning of 2000 the first procurement was made. A company called Assert won the tender and by today one of their then partners – Cybernetica AS – has become one of the main developers of the X-road. Hence, the birth of the X-road was not a big innovation in the context of technology, but a new solution for e-state services – *"a philosophy rather than technology"*. Similarly to the Internet, the system was decentralized as much as possible and this has allowed the system to scale extremely well. This means that from the outset the X-Road was designed to be completely decentralized and thus follow the basic P2P 'philosophy' of coordination. Interoperability has been key to the development enabling data exchange between different information systems. The man requirements covering the development of the X-Road were: (1) integrity and authenticity, (2) confidentiality and authentication, (3) high availability and scalability (Ansper et al. 2013).

In accordance with the main principles, the data exchange happens over public Internet which is cheaper than direct data exchange lines – more expensive options were out of reach for the project during the beginning of its development. Every organization is identifiable (encrypted certificate) and data exchange happens over an encrypted path that is only open for the time that it is necessary to exchange data. Data owner can require its client to identify themselves (with the ID card). All inquiries are logged, however, unstandardized inquiries are not possible as all model

inquiries are pre-prepared. The functionality of the X-Road was created to follow a service-based logic. The data exchange layer offers service-based solutions to the usage of data and the development of state information services. Meta-services within the X-Road and data processing solutions for individual users are all considered to be services. These are run over secure servers and higher loads are distributed over parallel servers. The X-road also provides a MISP (mini-information-service-portal)[2] option for those organisations that are required to share information with citizens (e.g., smaller municipalities), but lack the funds to build up more capable services. More confidential inquiries are not handled over the MISP.

Most X-road users are passive meaning that they make inquiries over the X-road, but do not own their own databases or if they do, then they do not share these with other X-road users. The most important users are data service providers: they share their data or collect the former (e.g. if your family name is changed in the Population Register, it will be automatically updated in other registers such as medical etc.). All state registries are data service providers. It is possible to read and renew data at the same time. Hence, it is possible to make complex enquiries for very different registries.

Initial development and road to adoption

The data exchange system was initially developed in the spirit of 'start up government' – in the initial year 3.5 full time positions were connected to the project. In fact, most studies regarding the e-government development show that enthusiastic and visionary public servants were behind the developments (see overview in Kalvet et al. 2012). This was facilitated by an exceptionally high trust between high-level politicians and IT-engineers (esp. the relationship between the then prime minister Mart Laar and Linnar Viik in late 1990s, early 2000s). Hence, many of the developments, including the X-Road were technocrat-led and tended to disregard broader debates on privacy, utility etc. Hence, legislatively there was large legal barrier to the adoption of the X-Road as the cross-use of data from different databases – the core task of the X-Road – was not allowed meaning that for each case a special permit from the Data Protection Inspectorate had to be obtained. However, relatively quickly, in late 2001, an amendment to the law was added exempting the X-Road from the rule. Thus, politically there was very high trust – *"blind trust"* – in the technical solution, even if most politicians did not arguably understand the technology and the level of security behind the development. Thus, for example,

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[2] "The mini-information-service-portal (MISP) is a universal X-Road client application that enables people or applications to use X-Road services based on the respective protocol via an ID-card authenticated channel."

the X-road can guarantee that the process by which data is exchanged is secure, but cannot assure that the partners use the data correctly. The 'just do it' logic may be, especially, effective in the beginning of the initiative to get results fast and supersede competing objectives from citizens, politics, economic actors etc. (Höchtl and Reichstädter 2011, 332).

At the same time, after the initial years (2002-2003) there was doubt in the success of the data exchange systems from the side of the involved ministries (even resulting in calls of shutting down the project) as it did not introduce a radical shift in the e-government operations to begin with and most public organisations were hesitant in joining the project. First, it was feared that the security protocols would take up too much time and create bottlenecks within the system. This, however, turned out to be not the case. Furthermore, there was a fear that data accuracy would come under fire when databases were made open to citizens who could see the information collected by the government about them. This did not realise either. The first public organisations that joined resulted from salesmanship from the small team, who used the open data argument – it should be possible for citizens to see which data government collects about them – to induce public organisations to join the X-Road rightfully anticipating that parallel organisations relying on the same data (now made available to citizens) would want to get easier access to the same information electronically. Also resources were considered a barrier for the early adopters, who could not afford to buy unplanned security serves etc. to make the investment to join the data exchange layer. For this, the team created small investment grants and in early phases of the adoptions gifted hardware to potential public sector users.

Furthermore, the team used personal experience to propose interoperable e-services to public organisations. One of the most cited cases here was the parental benefit case with the Social Insurance Board, where the parent had to file up to seven applications to different government bodies to receive the resource. After the re-designed e-service over the X-Road, only one electronically signed application was needed as the hospital registered the birth and all other data on the rights was checked by machine-to-machine interaction online.[3]

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[3] By today the Social Insurance Board is technologically ready to launch a completely seamless (machine-to-machine) parental benefit service, meaning that parents would not need to do anything to opt for the financial benefits (unless they want to opt out). The existing barriers to that shift are legal and organizational, yet one can expect the shift to take place soon. Interestingly, a representatives of the Social Insurance Board do not expect that machine-to-machine coordination would significantly save costs, however, the cross productivity gain is expected to be significant from the citizens' perspective (time saved, increased trust towards government etc).

With these cases and the high support from politicians, by 2005 legislation stated that all state institutions had to join the X-Road and conduct their data exchange over the technological solution. The effect of the legislation has been somewhat disputed. The early developers see it more as a reason to involve latecomers to the system as joining the X-Road was considered a *"VIP club pass"* by then. Indeed, previous studies have shown that collaborations between institutional entities proceeds fastest in peer-type cases, where organisations have relative independence to participate and find consensus (Bekkers 2005). However, organisations creating the biggest traffic on the X-Road today, joined in the later phase and somewhat reluctantly due to the legal compulsion. As the security benefit is somewhat vague to most public sector organisations (and the IT for e-service development is outsourced to private companies who find the X-road data protocols sometimes tedious to deal with preferring to create one-to-one access points between organisations for concrete e-services) many of the benefits of the system were not understood. This can be seen to follow our theoretical expectation that initially IT platforms are used to digitize existing data and service delivery without substantive changes to service delivery or to organization.

Technological development

Technologically the X-Road has no radical innovation components and as was stated several times by the experts: *"its more about the way of thinking"* and *"ideology behind the development"*. Thus, all the technological solutions and standards existed before the creation of the X-Road, while the technological development in the specific context of Estonia created a legal and organisational ecosystem around itself. One of key elements of this ecosystem is also wide acceptance of electronic ID.

The first version of the X-Road was adopted in 2001. The development of the X-Road has been gradual, carried out in small steps and no big evaluations/changes have not been implemented to the core approach. The development of the data exchange layer has been largely led by security concerns and the fact that newer technology has become available (Kalja et al. 2013). In 2001 when the first version of the X-Road was adopted there was an issue of authentication, as the ID card – later made compulsory to all residents in Estonia – was not yet issued (January 2002). Hence, the other staple of public key infrastructure – the ID card (providing an electronic authentication and authorisation mechanisms to individuals) – developed independently from the X-Road project (Ansper et al. 2013). This also meant that the signatures on X-Road inquiries had an unclear status in connection to the Estonian Digital Signatures Act. Furthermore, commercial banks, who later became lead users of the

X-Road, had their own Internet banking solutions, but after consultations with the managerial level of the financial institutions, they joined the X-Road providing an authentication service to begin with.

The second version of the data exchange layer was completed by 2003 replacing the XML-RPC data access protocol with SOAP (Simple Object Access Protocol). However, the latter was fully enacted on all X-Road components in the fifth version of the system. The early switch in protocols was fortunate and spurred on by the recommendation made by the World Wide Web Consortium (W3C) in 2002 allowing the use of different standards (WSDL, UDDI) still in use today – this saved a lot of development resources to the government (Kalja et al. 2013).

When municipal units, especially the capital Tallinn joined the X-Road with their many departments and a different user administration system new functionalities were needed and the third version of the system was developed in 2003-2004. Further developments and versions were led by increasing data security of the X-Road (e.g., allowing to exchange state secrets over the X-Road) and the following forth version was the one base on which large-scale IT-systems in Estonia were structured including the e-Health, Schengen information system and e-File systems (Kalja et al. 2015). With the rising number of services a special repository – catalogue of state's information systems – RIHA (administration system for the state information system) was created. Now all information systems joining the X-road have to be registered in RIHA. The fifth version developed 2009-2010 updated the system technologically. Currently the sixth version of the X-Road is going to be rolled out, which should also provide an interoperable cross-border X-Road version between Estonia and Finland (the potential to create an 'X-Road federation').

Data exchange on the x-road – potential for efficiency gains?

X-Road data exchange statistics are described in Table 1 below. By the end of 2015 there were approximately 44 million inquiries made over the X-Road a month. As described above, first expansion of the X-Road came by the small team behind the initiative selling the idea to potential partner. The second expansion of the X-Road came with the need to move large sets of data between the ministries and the courts (court adjudication register and court solutions). The third expansion was associated with the data exchange between the Citizenship and Migration Board and the Population Registry. However, the largest jump in the queries was in-between 2009 and 2010, when the digital recipe was initiated bringing the X-Road based services to everyday interactions of citizens.

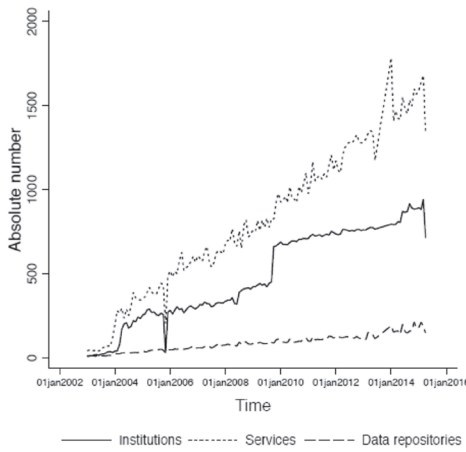
Table 1. Inquiries on the x-road

Year	Databases	Institutions	Services	Inquiries (in millions)
2015	219	939	1723	529.9
2014	213	916	1777	468.1
2013	152	775	1351	354.6
2012	128	763	1326	254.1
2011	128	751	1204	227.1
2010	119	710	1100	218.9
2009	111	676	976	98.1
2008	94	415	820	74.0
2007	83	331	661	42.7
2006	68	308	626	29.7
2005	50	289	487	13.5
2004	33	242	388	7.8
2004	18	36	118	0.6

Source: ria.ee, accessed 22.03.2016.

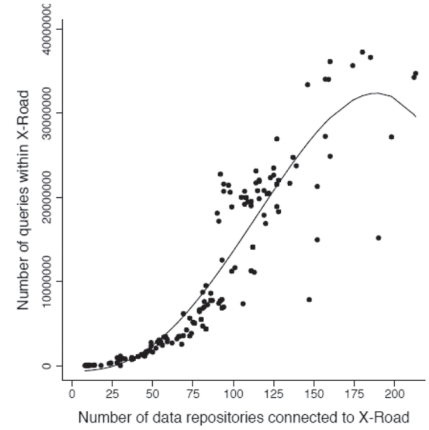
Biggest X-Road service providers by the number of inquiries are the Digital Prescription Centre, Population Registry, Digital Document Registry, Business Registry, Tax and Customs Board, Traffic Registry, e-File, Building Register, e-Pria, Interlyys. Almost one fourth of the transactions are carried out by the Digital Prescription Centre. The largest service users are e-Health, Centre of Registries and Information Systems and Police Departments.

Figure 1. X-Road developments based on log-data



Source: Vassil 2015.

Figure 2. X-Road inquiries



Source: Vassil 2015.

Figure 1 and 2 above show the developments of the x-Road in terms of institutions, services and data repositories showing the jumps in data exchange described above. The numbers of inquiries over the X-Road have, thus, increased exponentially, however, it is difficult to measure effects based on the log-data presented above: first, most of the inquiries are machine-to-machine interactions and thus, there is a lot of 'information noise' in the data; second, different operations conducted over the X-Road are very different compared to the time saved and quality for both the administration and citizens. This seems to confer our theoretical expectation that the more sophisticated IT platforms become, the more these platforms facilitate machine-to-machine type data queries and interactions. Furthermore, this also seems to confirm that collaborative efficiency is in fact transformed into a new form of coordination and thus existing concepts of externality and impact might be ill-suited here.

The authority in charge, RIA claims that the ecosystem connected to the X-Road is significantly more efficient than data exchange between the member organisations individually. This, first and foremost, because the secure platform for cooperative and secure platform exists already for all X-Road members. Citizens and officials can use predefined data inquiries to access relevant information from national databases given that they have permission to access the former and also they can exchange documents securely over the information system. Separate data usage contracts or data collection points are not necessary. This has created large cost savings for bigger service providers on the X-Road namely Tax and Customs Board and the Estonian Health Insurance Fund (connected to e-Health initiatives) that have downsized their organisations and lost the need for regional bureaus in their organisations. Thus, as to cite one of the interviewed experts: *"the X-Road in itself has no financial impact at all – all the effects are on the organisational level, in the ecosystem."* Furthermore, it is easier for public officials to bring out one-time-savings than to associate large organisational developments with the X-Road development. Furthermore, first evaluations in regards to the use and efficiency of the system are only now emerging, hence, it is very difficult to evaluate if the content of tasks of public organisations has changed considerably (although there is some indication that in some cases it may be so, Lember et al., forthcoming).

At the same time, as the development proceeded very fast with a small team in charge, the latter concentrated only on public sector partners and largely ignored private sector actors (although some – notably banks and energy providers have joined the X-Road). Furthermore, usually existing services were digitalised and thus, not many new services have emerged through the process. To some degree, X-road statistics are used to make

decisions, collaboration and input from citizens to the development, but this an exception rather than the rule. Consequently, the data exchange layer is now concentrating more on the business administration side creating more options for developing new services. This also includes automatic composition of services. This is confirming our theoretical expectation that IT platforms are difficult to use for citizen engagement or creation of new services.

Discussion and conclusion

The Estonian x-road case-study seems to confirm the theoretical expectations that we laid out above.

- First, IT platforms initially **digitalize existing routines** of information gathering and sharing both in intra- and inter-organizational dimensions, without engendering significant changes to service delivery or to the organizations involved;
- Second, with increasing sophistication, IT platforms become to embody more and more **P2P like** features (in terms of decentralization, interoperability, security, transparency) engendering increased **machine-to-machine traffic** and **hence coordination**. We can also talk about emerging coordination practice that provides a new alternative for public sector not only to increase inter-organizational efficiency domestically, but also in cross-border settings.
- Third, notwithstanding increasing technical complexity, public sector has **difficulty in conceptualizing and measuring the impact of IT platforms** and hence their efficiency gains;
- Fourth, **adding new services on IT platforms is relatively difficult** as platforms are first of all developed for internal use and embody existing organizational routines;
- Fifth, achieving radical efficiency in inter-organizational IT platforms is **both technological as well as organizational challenge** with clear **trade-offs such as between automated decision-making and contextual value-based judgements**.

The case of the X-Road has, thus far, showed us that interoperability and, thus, greater inter-organizational collaboration has been achieved through a distributed P2P-like data architecture. At the same time, it is questioned if the example could be scaled up for larger countries (see e.g., Dunleavy and Margetts 2015). First and foremost, this is due to the start-up government nature of the initiative and special conditions in Estonia that allowed to supersede lengthy debates regarding issues of data privacy and security. It is noteworthy, that private companies who have been developing the X-Road – Cybernetica AS and Aktors OÜ – have created

a similar data exchange layer to Azerbaijan, while Finland and the UK, who have also shown interest in the X-Road, are much slower in their progress. Nevertheless, Finland seems to have more concrete plans to adopt the data exchange model in the upcoming years.

When it comes to collaborative efficiency gains, then these are undoubtedly present for those with the largest data exchange volumes. As the development itself was not that expensive (the initial projections of the development investments are estimated to be only around 6 million Euros over the years), then it is not difficult to see the gain. Also, there has been radical increase of efficiency in terms of time saved for citizens (e.g. you don't need to physically see your family physician to get a digital receipt for a medicine; to fill out tax declaration online takes ca 10 minutes etc.). However, what the solutions has not delivered on, have been innovative solutions for e-services. One of the barriers mentioned here are low capabilities of public organisations in 'business' development. It is difficult for public sector organisations to break out from traditional routines, even if technologically there are not many barriers to push interoperability further.

In fact, we argue that instead of collaborative efficiency and service innovations, more sophisticated and widely used IT platforms lead to the emergence of entirely new phenomenon, namely that of **P2P or machine-to-machine coordination** practices. And this is the true X factor behind public sector joint data platforms. The main factors leading to coordination practices are: first, secure and widely trusted authentication system; and second, distributed system architecture. In Estonian case, these two factors enabled rapid legal developments to remove barriers for adding more and more public sector organizations to the platform that engendered then increased **machine-to-machine interactions**. Thus, such platforms can be highly effective and efficient, but they also seem to lock-in service development (as machine-to-machine interactions dominate and thus also development activities are geared towards these interactions) and make it difficult to integrate smart dust (smart phones, social media data, etc.) and thus also to not encourage inclusion of citizen expertise. The Estonian x-road case-study seems to confirm the argument that if technological solutions are introduced as another layer on top of existing services and activities (rather than building organizations around technological platforms), the innovation potential of public sector remains limited (Brown et al 2014).

The emergence of P2P coordination practices has also a direct bearing to Public Administration literature as it brings a new and additional dimension to the ways we understand governments in organizing public affairs.

Next to traditional coordination mechanisms (hierarchies, networks and markets, see Bouckaert et al. 2010), the **machine-to-machine coordination** brings to the fore both new possibilities as well as challenges. From the one hand, P2P coordination is based on a mix of traditional coordination elements. It is strongly hierarchical as code-based decision-making rules usually leave little choice for the involved stakeholders to bargain or negotiate about or even ignore the code-imposed rules.

It has also a strong element of network-type coordination, especially if organizations are given freedom to decide if and how to join as well as develop joint IT platforms. Also, P2P coordination can be used to facilitate bargaining and competition within and between public service providers. On the other hand, P2P coordination has emerged with distinctively new elements. It has the ability to automatically align organizational behaviour across the board, it can reduce the need for human interaction to zero and squeeze out contextual and value-based judgment in public service delivery, it places utmost importance on technological capacities as a main coordination resource that can fundamentally discriminate against certain stakeholders' groups or neglect important activities (e.g. substantial involvement of citizens' voice). Hence, also the downside of these automated processes to discretion of public sector employees and society at large has to be acknowledged. However, we cannot negate the fact that these processes are happening.

Thus, the joint data platforms and the analytics built on the former not only possess a great, albeit often limited, potential for radical increase in collaborative efficiency, but it may entail also a fundamental change in how governments coordinate public affairs. If this is the case, we also need to gain a better understanding about the implications of machine-to-machine coordination on collaborative efficiency and public service reform in general.

We end this discussion with the well-known contribution of the economist Harvey Leibenstein (1966) – X-efficiency. The X-efficiency hypothesis assumes that while production may be allocated to the "right" decision units (allocative efficiency), human behaviour is not perfect and thus, a disparity with the maximal effectiveness of utilization emerges (X-inefficiency). Now imagine a world where the "human" decision maker is taken out of the equation, will the public sector be as productive as it can be? We can see that in the world of Big Data and interoperable data systems machine-to-machine coordination is emerging. Thus far, it is limited to the analytic capabilities of human beings introducing a level of X-inefficiency of the system, but it may not be for long. However, it may be a totally different experience to live in an efficient world.

"The basic X-efficiency hypothesis is that neither individuals, nor firms, nor industries are so productive as they can be. /…/ in primarily market economies, X-inefficiency is frequently much more important as a social cost than is allocative efficiency."
(Leibenstein 1975, 582)

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