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A Tale of Two Smart Cities. How Virtual Walls between Cities can Fall

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Declaration:
Hereby I declare that this doctoral thesis, my original investigation and achievement, submitted for the doctoral degree at Tallinn University of Technology has not been submitted for doctoral or equivalent academic degree.

Ralf-Martin Soe

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Lugu kahest targast linnast. Kuidas virtuaalsed piirid linnade vahel saavad langeda

RALF-MARTIN SOE

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List of Publications

The list of author's publications, on the basis of which the thesis has been prepared:

I **Soe, R.-M.** (2018). Smart Cities – From Silos to Cross-Border Approach. *International Journal of E-Planning Research,* Special Issue on Models and Strategies toward Planning and Developing Smart Cities, 7 (2), doi: 10.4018/IJEPR.2018040105 (1.1.)

II **Soe, R.-M.**, & Drechsler, W. (2017). Agile local governments: Experimentation before implementation. *Government Information Quarterly*, doi: 10.1016/j.giq.2017.11.010 (1.1.)

III **Soe, R.-M.**, & Mikheeva, O. (2017). The Combined Model of Smart Cities and Electronic Payments. In P. Parycek & N. Edelmann (Ed.), *7th International Conference for E-Democracy and Open Government (CeDEM)* (pp. 194-205). Krems (Austria): IEEE Computer Society, doi: 10.1109/CeDEM.2017.11 (3.1.)

IV **Soe, R.-M.** (2017). FINEST Twins: platform for cross-border smart city solutions. In In C. C. Hinnant & A. Ojo (Ed.), *dg.o '17: Proceedings of the 18th Annual International Conference on Digital Government Research* (pp. 352−357). New York: Association for Computing Machinery (ACM), doi: 10.1145/3085228.3085287 (3.1.)

Award: dg.o 2017 Best Management Paper

V **Soe, R.-M.** (2017). Data-based Energy Provision for Smart Cities. In D. A. Alexandrov, A. V. Boukhanovsky, A. V. Chugunov, Y, Kabanov, O, Koltsova (Ed.), *Digital Transformation and Global Society: DTGS 2017* (pp. 319-328). St. Petersburg: Springer, Communications in Computer and Information Science, doi:10.1007/978-3-319-69784-0_27 (3.1.)

VI **Soe, R.-M.** (2017). The role of demographics in cities. In C. C. Hinnant & A. Ojo (Ed.), *dg.o '17: Proceedings of the 18th Annual International Conference on Digital Government Research* (pp. 446−451). New York (USA): Association for Computing Machinery (ACM), doi: 10.1145/3085228.3085274 (3.1.)

Appendix:

VII **Soe, R.-M.** (2017). Smart Twin Cities via Urban Operating System. In R. Baguma; R. De'; T. Janowski (Ed.), *ICEGOV '17: Proceedings of the 10th International Conference on Theory and Practice of Electronic Governance* (pp. 391-400). New Delhi: Association for Computing Machinery (ACM), doi: 10.1145/3047273.3047322 (3.1.)

Author's Contribution to the Publications

Contribution to the papers in this thesis are:

II The author of this thesis is both the corresponding and the lead author. The author has been responsible for the research design and publication strategy throughout the process. The second author has significantly contributed to the overall scientific quality of the paper, especially in the theoretical part. In addition, the EU project Finest Smart mobility (CB359) team members have contributed to the empirical part of this thesis.

III This paper has 50/50 equal ownership. The author of this dissertation was responsible for the publication strategy, but content-wise, both authors contributed equally to the theoretical and empirical sections. In the empirical section, the author of this thesis was responsible for the Helsinki-Tallinn case study, and the co-author was responsible for analysing the Singapore-Hong Kong case.

Introduction

> *It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us, we were all going direct to Heaven, we were all going direct the other way – in short, the period was so far like the present period, that some of its noisiest authorities insisted on its being received, for good or for evil, in the superlative degree of comparison only.*
>
> Charles Dickens, *A Tale of Two Cities* (1859)

1. Focus and aim of the thesis

This thesis analyses the rising phenomena of smart cities in the case of two Northern-European cities: Helsinki and Tallinn, and it is interested in how cities can become smart jointly. In general, the administrative and legal set-up of cities has a strong tendency to be horizontal, with digital innovations introduced in isolation. This vertical digitalisation can eventually lead to digital islands where everything works digitally but only locally, as smart-city solutions have the tendency to be isolated and fragmented. Vertical digitalisation is understood here as isolated digitalisation within one structural unit (e.g. single department or city), whereas horizontal digitalisation is cross-structural (across many departments or cities).

Similarly, in the famous novel by Charles Dickens, Paris and London were isolated by the sea when the novel was written, a physical link (the Channel Tunnel) was opened only a hundred years later. This dissertation is interested in how to build a virtual tunnel between two cities, both specifically and generally. The key argument is that a fully connected digital macro-region between multiple cities is at least technologically feasible but it does not appear automatically; it requires a high level of political priority in order to tackle organisational, technological, legal and cultural barriers and to provide effective incentives. To simplify, a physical railroad tunnel between the two capitals has been debated over the last two decades; it would be a true flagship project globally, costing up to € 20 billion, according to the preliminary results of the FINEST Link project.[1] This thesis, making no statement regarding the physical tunnel and whether it would be a white elephant or not, states that a virtual tunnel with a harmonised digital macro-area could also be considered, as part of the physical one, or even instead of it. Macro-region, in the present context, refers to a regional and geographical area that consists of multiple cities. This can correlate with the local regional units (e.g. counties) but is not always the case (e.g. cross-border cities from different countries).

In the case of Tallinn and Helsinki, around 8–9 million people commute between the two cities annually, less than 100 km and a 2-hour ferry ride apart. Both cities brand themselves as smart or digital cities, but the challenge is that two smart cities do not automatically equal one smart region. Even geographically, close-by cities can still produce macro-regions where digital solutions are isolated and the only working solution for commuters is the analogue service based on paper and cash. This can be illustrated by three real-life cases:

[1] www.finestlink.fi

Public transport tickets. According to **I**, the cities of Helsinki and Tallinn have replaced cash-based systems with radio-frequency identification (RFID) cards. Helsinki still has a few ticket machines available, whereas in Tallinn, there are none left. On the other hand, the RFID cards are based on different standards and cannot be used in both cities. This means that for cities where a significant share of people commute regularly, smart solutions have produced more burdens: a commuter needs to have two RFID cards and follow rather complex charging and identification instructions. On the other hand, cash-based options are more expensive. In Tallinn, for example, a single journey purchased with cash is € 1.60, whereas an RFID-based ticket for one hour is € 1.10 and for one day, € 3.00 (early 2018 data).

In Tallinn (**I**), **municipal parking** has been organised by text messages since the early 2 000s, and over 90% of parking is mediated by SMS. Helsinki, on the other hand, has an app-based solution for digital users. Every day, a few thousand cars from Tallinn and Helsinki cross the border, and they face parking barriers. A Finnish car parked in Tallinn cannot use a simple text message (no roaming) and needs to either purchase an Estonian SIM card or pay in cash for parking. The challenge is that there is only a limited number of municipal parking machines left. On the other hand, Estonian car owners cannot park their cars in Helsinki without moving to the smartphone-based option. For them the analogue option is to pay in cash and the smart option is to download a smartphone-based parking application (e.g. easyPark, Parkman) and tie it with a credit card. This assumes that a car owner has a smartphone, a credit card and the motivation to learn how to use a parking application.

Digital signing. In Tallinn (and Estonia generally), business people and civil servants sign legally binding documents using their electronic identity; only a small minority signs them on paper anymore. On the other hand, pdf-signed (print and scan) documents are generally considered ineligible, only electronic identity and paper with authentic ink signatures are considered valid. In Helsinki (and Finland as a whole), people tend to sign mainly on paper with pdf-based signing also in place for limited (legally less binding) documents. This has generated a situation where the most practical way to sign legally binding documents is via the analogue ink-signed paper solution.

There are tens, probably even hundreds, of such examples of incompatible services between these two capitals. The list could be continued with, e.g., ordering a taxi or renting a car, planning a trip with a journey planner, using medical prescriptions or dental care in a cross-border way, access to public libraries etc. Although this thesis has set its focus on two medium-sized cities, the challenge is global and applies also to San Diego and Tijuana, Seattle and Vancouver, Hong Kong and Shenzhen, Singapore and Johor City etc. Nevertheless, the scope of this thesis is not to criticise cities for being fragmented, let alone to push for twin or fully federated cities. The scope is to define a problem, both theoretically and empirically, and to provide examples how smart cities can effectively aggregate into smart regions. For example, this thesis is interested in the services for harbours (**II**). The ports or Tallinn and Helsinki, although with the tendency and internal motivation to work independently, are essentially one ecosystem. A departing ferry from Helsinki to Tallinn automatically means an arriving ferry to Tallinn in roughly two hours with thousands of people influencing the urban transit – it makes sense for operators, ports, cities and ministries to collaborate with the aim of harmonised services for end-users.

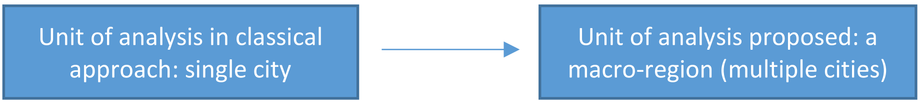
Already a decade ago Ruoppila et al. (2007) pointed out that despite many vision conferences, the cities of Tallinn and Helsinki lack joint services. They also give examples of other European multi-city cross-border macro-regions, such as the Øresund (Copenhagen-Malmö), Vienna-Bratislava and Liege-Maastricht-Aachen regions. Their conclusion is that cities need joint-delivery innovation projects, cooperation in developing a joint strategy and political commitment with effective resource allocations. This still applies, although the digitalisation of city services has substantially changed the field over the last 10 years, and therefore, the digital harmonisation of services can and must be considered in this context.

It should be noted that there are clear barriers to two-city collaboration in offering integrated or joint services (the barriers and enablers are discussed in **I**). Cities are essentially financed by their taxpayers, and they are in a competing environment with neighbouring local governments for resources that generate income (e.g. high-tech companies and skilled workforce). Cities have logical reasons for being "egotistic." Therefore, being horizontal and building barriers can be obvious and natural. On the other hand, there are top-down central governments and supranational initiatives that drive the twin-city concept in the areas where bottom-up collaboration between cities has not been effective, either due to a lack of capacity to introduce joint policies, limited financing instruments or just conflicting interests of cities. For example, the governments of Estonia and Finland have made progress in building a joint data-exchange layer (based on X-road, which is centrally described as an example in **I**, **II**, **III**, **IV**, **V** and **VII**). Full implementation of the Internet-based data-exchange layer with all government and local government databases interconnected, coupled with secure electronic identity, have made Estonia a globally recognised country with advanced digital government, and this also provides a very good starting point for analysing how cities can offer joint digital services. According to **V**, the Estonian e-government was evaluated as the best in Europe according to the European Commission Digital Economy and Society Index (DESI) in 2017. On the supranational level, the European Union has made a very strong push towards smart integrated cities by investing billions into joint mobility projects (e.g. TEN-T programme) and by means of effective price regulation over roaming charges for mobile calls and Internet data usage (since mid-2017, there have been no roaming charges for mobile calls, text messages and Internet data within the EU in the case of limited to moderate consumption).

The "Smart City" (or just smart city as used throughout the thesis) as a concept is generally theoretically limited and marred by a self-congratulatory tendency, as described in **I**, which makes it a buzzword that can be interpreted differently across – and even within – research disciplines. This thesis defines smart city as "using ICT in *the* city for achieving mobility and environment goals dealing with urbanisation," and it contributes to a novel sub-field of e-government. **II** describes how e-government theoretical concepts can be used for two-city digital-services joint provision. **III** compares Northern-European and East-Asian city-pairs (Tallinn and Helsinki; Singapore and Hong Kong) and concludes that urban financial services should be considered to be part of the smart-city concept. **II**, **IV** and **VII** propose an Urban Operation System, a data-exchange and decision-making layer for cities. **V** and **VI** aim to balance the smart city being too biased towards the mobility domain. **V** provides an example for how effective data exchange can contribute to the local energy market. **VI** stresses the importance of demographics (natural population growth and migration) and states that urbanisation is the main driver of smart cities that can increase social costs (e.g. healthcare) and thus put more pressure on mobility and environment.

This analysis is based on articles (**I**-**VI**) that aim to collectively provide an overarching framework for the smart city within the e-government domain that focuses on understanding the phenomena, components and drivers of smart cities. This framework makes three clarifying statements:

1. The smart city is driven by population growth in urban areas, which poses various mobility and environmental challenges;
2. Technology remains central as a tool in order to make cities smarter, but it is not a driver itself; and
3. Operationally, smart cities could be first of all evaluated based on their digitalisation-related projects, rather than just on the basis of macro-indicators.



The papers have been published within peer-reviewed journals and conference proceedings initiated and edited by e-government scholars. The accumulated contribution aims to change the unit of analysis from a single city to a macro-region with multiple cities, at least in the case of cross-border and heavily commuted cities. Therefore, when developing digital innovations, in some cases, it makes sense to analyse the macro-regions of multiple cities instead of isolated cities as single units. If the macro aspects are not considered, the path of development of smart cities is not or even less linear than otherwise and can lead to progress and regress at the same time. In the field of ICT, there are hundreds of standards, and picking different ones could be compared to having one city with left-hand traffic and another with right-hand one, in the most extreme case. Thus, coming back to Dickens, we do not know whether the current digital progress essentially leads to “the best of times and the season of light” or “the worst of times and season of darkness” for macro-regions.

2. Tallinn-Helsinki challenge

According to **IV**, two European capitals, Helsinki and Tallinn, are in a rather unique situation. Helsinki, the capital of Finland, belongs to one the wealthiest region in the EU and also globally. Tallinn, the capital of Estonia, is among the catching-up regions with fast and visible progress over the last two to three decades. There is approximately a two-three times wage difference between the two capitals, while they are physically less than 100 km apart (see Figure 1). A talented PhD student from Tallinn can earn more taking on a blue-collar position in Helsinki than continuing to pursue an academic career at home, for example. Economically, the cities are on different levels: Tallinn is a post-Soviet city trying to catch up, whereas Helsinki is by now already a well-developed city. Tallinn’s GDP per capita is roughly 2.5 times smaller than Helsinki’s.

As stated in **I**, **IV** and **VII**, Tallinn and Helsinki have been selected for the case study for the following reasons: 1. proximity (less than 100 km apart by sea from city centre to city centre); 2. frequent commuting; and 3. relatively high level of digitalisation of urban services. The aim of this analysis was to select heterogeneous cities applicable to any city-pair or macro-region globally, which is a key reason why national city-pairs (e.g. Tallinn and Tartu in Estonia or Helsinki and Tampere in Finland) were not a subject of analysis – they are more homogeneous and the results tend to be more country-specific.

Nevertheless, there are plenty of challenges regarding the interoperability of e-services even within local cities in Estonia and Finland.

The combined population of Estonia and Finland is 7 million. Approximately every 15^{th}–20^{th} Estonian lives in Finland and commutes back to Estonia on a regular basis. For Finland, Estonia is the most popular investment and tourism destination, roughly every fifth Finn stays over night in Estonia every year. The two countries speak unique Finno-Ugric languages. Both countries are considered globally strong in digital innovations. It should also be stated that the author of this thesis has been involved with more than five mid-to-large scale digitalisation projects of Helsinki and Tallinn as a field expert over the past five years, thus also being a commuter himself.

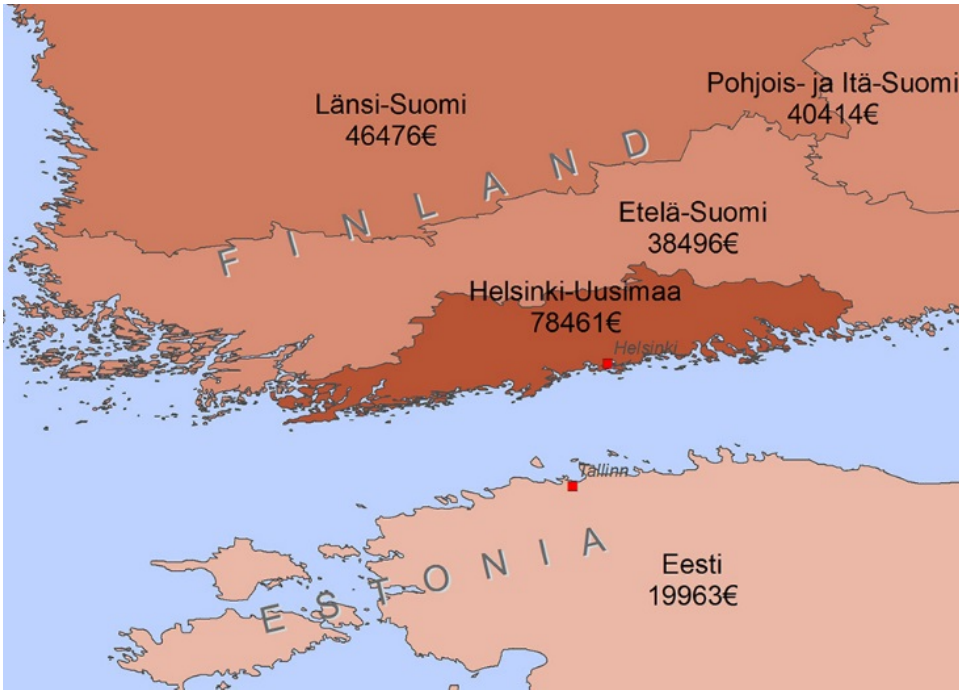


Figure 1. Regional GDP per inhabitant. Source: **IV** (Eurostat, 2013)

Based on the Finnish Traffic Agency data (**II**), there are over 8 million travellers, over 1 million cars and over 250,000 heavy good vehicles taking the journey between the Helsinki and Tallinn harbours annually. By comparison, in 1993 there were around 2 million travellers and less than 200,000 cars – the number of passengers and cars has quadrupled over the past 25 years, which has significantly increased the congestion, noise and other negative externalities in the area. This affects both travellers and residents and calls for an effective coordination of cities, especially considering that both capitals have grown by population. Both cities have decided to keep the passenger ports next to the city centres although the port sites are partially replaced with new residential buildings.

3. Methodological approach

This main body of this thesis is composed of six original peer-reviewed articles out of which **I** and **II** are classic research articles published in journals and **III**-**VI** are ranked and indexed conference papers that entail a practical component as introductions to large-scale smart-city research projects. **VII** in Appendix 1 is a conference paper, which was elaborated further into **I** (difference at least 40%). Each article is based on a separate empirical study, but all are developed for the same theoretical framework, integrated in this introductory chapter. The theoretical framework is based on a synthesis of existing research on the smart city, e-government and public administration. Most papers analyse the possible case of a Tallinn-Helsinki digital macro-region, although from different angles (**I**, **II**, **III**, **IV** and **VII**). According to Yin (1981), a case study classically investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident.

The empirical evidence in the thesis derives mainly from qualitative analysis (e.g. document analysis and interviews), with one exception: **VI** uses a quantitative model for estimating the urbanisation effect on healthcare expenditure. In most cases, the interview sample is based on the snowball sampling method. According to Tansey (2007), the snowball sampling method comprises identifying an initial set of relevant interviewees and then requesting that they suggest other potential subjects with similar characteristics/who have relevance in some way to the object of study. This second set of subjects is then interviewed and similarly requested to supply contacts for the next round of potential interview subjects. The process continues until the researcher feels the sample is large enough for the purposes of the study or until respondents begin repeating names to the extent that further rounds of nominations are unlikely to yield significant new information.

The methodological approach is the following:

- In **I**, the research framework is a case study of Tallinn's and Helsinki's digital urban services. Data was gathered through in-depth structured interviews and workshops with representatives of cities, companies and third-sector experts; altogether 21 high-level interviews were conducted in 2015 and 2016. The interviews aimed at gaining specific information about the potential of mutual digital services. Empirical information was also derived from secondary sources like published reports and documents. In the theoretical section, this paper analysed 29 interdisciplinary articles that aim to define the smart city in a systematic way. In analysing the barriers and enablers, the ATLAS.ti qualitative data-analysis software was applied.
- In **II**, data was gathered via primary and secondary sources. The primary data include non-structured focus group interviews that were conducted with city representatives (three officials from the city of Tallinn, three from the city of Helsinki and one official from the Ministry of Economic Affairs and Communications, Estonia) and companies (five Intelligent Transport Systems companies). Innovation competition process included a survey-type description of 35 international cross-border ideas, out of which 5 were selected, funded and piloted. Secondary sources include published and unpublished reports, project proposals and documents. In the theoretical section, this paper analysed 41 research papers mainly in the field of e-government with the aim to propose a theoretical framework for two-city digital innovation assessment.
- **III** compares East Asian (Singapore and Hong Kong) and Northern European (Tallinn and Helsinki) approaches to financial urban innovations. The research method is

an exploratory qualitative study using a comparative case-study approach. Empirical data collection involved primary and secondary sources, such as policy documents, project materials, strategies, reports, media articles and a few unstructured interviews.

- **IV** is based on the H2020 research and innovation project Finest Twins' second-stage proposal documents.
- **V** was initially developed for an H2020 project application in the field of Smart Energy. The paper proposes a framework for analysing and collecting energy data using the co-creation and randomised trials techniques, although the study itself has not been conducted.
- In **VI**, which analyses the potential impact of demographics as a driver of smart cities, the social budget model (SEM) of the International Labour Organisation (ILO) was applied, which uses macroeconomic, labour-market and demographic projections (the so-called cohort-based component model). With the assumption that the social-sector income and expenditure depend on economic, labour-market and demographic indicators, long-term urban health-insurance income and expenditure developments were estimated.

4. Smart city and e-government

According to **I** and **VII**, smart city covers a wide angle of "hard" domains, such as buildings, energy grids, natural resources, water management, waste management, mobility and logistics (Neirotti et al., 2014), where ICT plays a decisive role in the functions of the system and smart city has also reached "soft" domains like education, culture, policy innovations, social inclusion and government (Albino et al., 2015). Hence, it is crucial to understand that smart city is a developing concept with no mutually agreed definitional consensus. As such, it is an interdisciplinary concept with a broad range of interpretations and depends largely on the viewpoint of who uses it, see Figure 2.

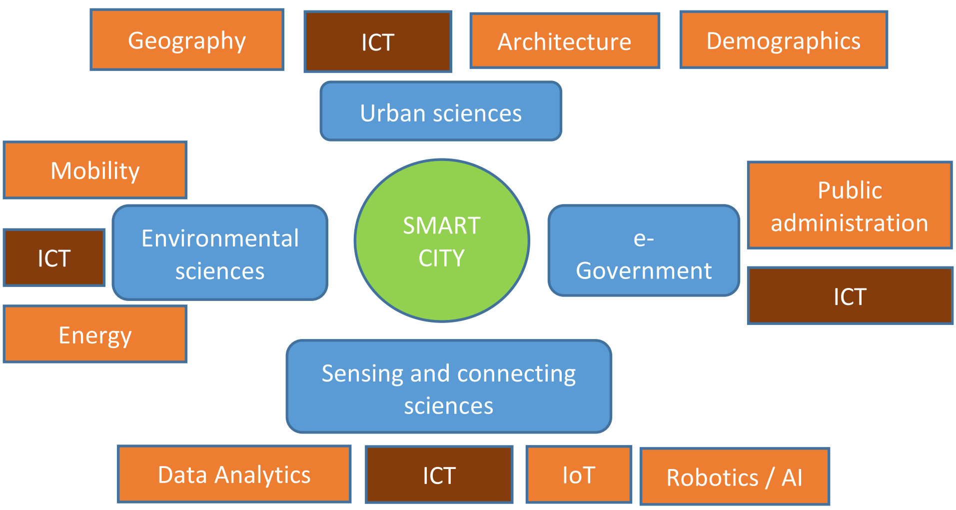


Figure 2. Smart city cross-disciplinary analysis

For example, it may be that:

- For architects, smart city represents both intelligent buildings and redesigned urban environments;
- For human geographers, smart city is analysed in the context of urbanisation and migration;
- For computer scientists, smart city represents a wide range of sensing and analytics possibilities;
- For public-administration researchers, smart city represents novel ways to reorganise the structures and management practices within cities;
- For mobility researchers, smart city is a way to optimise traffic and logistics within a city via the deployment of intelligent transport systems;
- For energy researchers, smart city represents a shift towards intelligent street lighting, smart grids and zero-energy buildings;
- For environmental scientists, smart city represents a clever way to organise urban waste management, water supply and air quality;
- For robotics and artificial intelligence researchers, smart city represents a concept with self-driving vehicles and fully automated urban industries.

Therefore, smart city is a multi-faceted concept that largely depends in its meaning on the analytical viewpoint. Nevertheless, in this varied picture, it is important to note that using Information and Communication technology (ICT), and now, one should add, data analytics, remains invariably central to understanding what a smart city is. In other words, as a lowest common denominator, smart city can be defined as "a city using ICT," or "an ICT city." Another narrowing component could be the unit of analysis – a city.

Figure 3. Smart city and e-government

This thesis is interested in how smart city can be reasoned within a phenomenon of e-government and two of its main parental disciplines, public administration and ICT (see Figure 3). All articles (**I-VII**) have been published in the quite narrow and novel sub-field of e-government that deals with smart cities. **I** is in a special issue for smart-city strategies, published in the *International Journal of E-Planning Research*. **II** has been published in a special issue of *Government Information Quarterly* on agile and adaptive governance. **III-VII** have all been published in the proceedings of e-government global conferences within their smart-city tracks (e.g. ICEGOV, CEDEM, dg.o and DTGS). Nevertheless, most papers in this thesis are cross-disciplinary, and the spillover is largely to all domains connected with smart city.

4.1. E-government as a concept

Electronic government (e-government, now also increasingly digital government) as a research field was unknown in the 1970s and 1980s but has been expanding over the past decades as there are many academic programmes, specific conferences and journals solely devoted to it (Heeks & Bailur, 2007; Bannister & Connolly 2015; Scholl 2014). As of late 2017, there were 9,901 references in the e-Gov Reference Library maintained by Hans Jochen Scholl at the University of Washington's Information School.[2] These papers consist of predominantly English-language, peer-reviewed work in the study domains of electronic government, electronic governance, and electronic democracy.

Nonetheless, it should be noted that e-government as a formal, secure and reliable research field is still far from being established, and that is the main reason why this thesis seeks for theories applicable to e-government and smart city in the domain of public administration. In a meta-analysis of 84 e-government papers, Heeks & Bailur (2007) found that e-government research derives mainly from weak or confused positivism and is dominated by over-optimistic, a-theoretical work that does little to accumulate either knowledge or practical guidance for governments. They criticise the lack of rigour (which in this context is generally understood as something good) regarding research methods alongside poor generalisation. On the other hand, the volume of research is rapidly growing, even when the quality is questionable. Heeks & Bailur (2007) also point to possible academic corruption, as their findings show that in roughly half of the papers, the author was presenting products, services, architecture or model created by the author himself. According to Yildiz (2007), e-government literature is limited by under-emphasis on the complex institutional environments that surround the processes of e-government development, and the lack of process-oriented e-government studies as opposed to output and outcome-oriented ones. In a constructive manner, he makes a threefold suggestion for dealing with this: i) observe the processes of e-government within complex political environments; ii) produce more grounded, empirical studies with new theoretical arguments, providing a better understanding of e-government policy processes and actors; and iii) tying the subject of e-government research to mainstream public-administration research (instead of staying in the periphery): the politics-administration dichotomy, intergovernmental relations, third-party government, networks and governance. The theoretical grounding of e-government has evolved over the past decade, but it is generally suggested that the field still lacks theoretical comprehensiveness (see e.g. Waller & Weerakkody 2016; Bannister & Connolly 2015).

As detailed in **II**, most researchers agree that the concept of e-government is vague (e.g. Yildiz, 2007; Aldrich et al., 2002; Bretschneider, 2003; Waller & Weerakkody 2016) and there is no single, widely agreed-upon definition (Halchin, 2004). In **II**, e-government is defined by OECD as the use of ICT, and particularly the Internet, as a tool to achieve better government (Field et al., 2003). The desired impact of e-government at the broadest level is simply better government by enabling better policy outcomes, higher-quality services, and greater engagement with citizens and by improving other key outputs identified (Field et al., 2003). A related concept is e-governance, which is sometimes said to refer to the whole system involved in managing a society, i.e. beside government institutions also companies and voluntary organisations and citizens (Grönlund & Horan, 2005), which in a way refers to the original concept of governance. Hence, in order to understand e-government and e-governance, it makes sense to recall what the concepts mean without "e". Although different definitions exist, there is a rough common understanding that governance is the steering of a specific unit in time and space, which is argued to increasingly require the participation of a range of actors,

[2] http://faculty.washington.edu/jscholl/egrl

of which government is only one, if an inevitable and the coordinating one (Drechsler, 2004).

As a novel field, triggered by the emergence of information and communication technologies or the fifth techno-economic paradigm (**IV** and Perez, 2010), the nature of e-government is dynamic in so far as the role of technology in government has largely changed and continues to do so. According to Schelin (2003), before the introduction of the Internet and the diffusion of personal computers, the main objectives of technology in government were improving the effectiveness of public administrators while increasing government productivity, e.g. the automation of mass transactions such as financial transactions using mainframe computers. Since the beginning of the Internet era, ICT is increasingly related to the way citizens and businesses interact with the government (non-tool view of technology), which then remains, of course, e-government.

II builds on this theme and supports that the next layer might be an ICT-triggered change in the government with four layers: organisational, structural, managerial and procedural, as proposed by Gong & Janssen (2012). More recently, one could add a layer based on the trend of using agile methods in government, similarly to the trends in software development, and governments being more adaptive in that sense. Agile methods, defined in **II** as fast and responsive processes (with Martini & Bosch, 2016), have been introduced rather recently both for software development in and for the public sector (e.g. Mergel, 2016) and for open government data (e.g. Mcbride et al., 2018). Adaptive governance as a concept originally stems from socio-ecological systems that can respond to rapid changes in the environment (Wang et al., 2017). With no agreed-upon definition, there seems to be consensus regarding the main characteristics of adaptive governance, introduced by Janssen & van der Voort (2016): decentralised decision-making, mobilisation of capabilities (internal/external), wider participation and adjustments to deal with uncertainty. **II** analyses how these novel concepts of agile and adaptive governance could be applied to macro-region digital-innovations analysis consisting of multiple cities.

4.2. Smart-city framework

> *The idea that cities might be computerised – that computers might enter the fabric of the city and that their software would enable an intelligence function to be established on the basis of essentially public functions, goes back a long way. It is of course part of science fiction but in a more considered sense, Alan Turing himself envisaged this in his idea of the universal machine. But it was Vannevar Bush in his prescient article "As We May Think" published in The Atlantic in July 1945 who implied that computers would eventually enter all our routine practices.*[3] *In fact it was not until 1962 that the book* A Communications Theory of Urban Growth *by Richard Meier explicitly addressed questions about information and the city (Meier, 1962), and about the same time, the notion of networks everywhere passing information socially and economically was intrinsic to Mel Webber's ideas about the non-place urban realm, which was becoming intrinsic to global society (Webber et al., 1964).*
>
> Michael Batty (2016)

[3] http://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/303881/

Therefore, the idea that cities can be digitalised goes back at least half a century. Nevertheless, according to **I** and **VII**, where smart-city definitions and its synonyms are explained in depth, most researchers agree that specifically the term smart city is a novel concept – first used in the 1990s (Albino et al., 2015) – that lacks definitional precision (Hollands, 2008; Nam & Pardo, 2011; Papa et al., 2013). Many frameworks have been proposed as typologies of the smart city, but none of them has achieved dominance in academics or in practice (Batty et al., 2012; Caragliu et al., 2011; Kuk & Janssen, 2011). The lack of mutually agreed concept and measurement poses risks as there is a self-congratulatory tendency since many cities (and even business parks) have labelled themselves as smart cities, although that can be independent from the actual level of digitalisation. According to Hollands (2008), it is often difficult to separate hype (what city does not want to be smart or intelligent?) from a real change of infrastructure or effective ICT policies.

Considering the rather blurry and even conflicting definitions, this thesis proposes its own integrative smart-city framework (see Figure 4), based on articles **I**-**VII**. This framework makes three clarifying statements: 1. smart city is driven by population growth in urban areas that poses various mobility, environmental and other challenges; 2. technology remains central as a tool in order to make cities smarter but it is not a driver itself; 3. operationally, smart city should be evaluated based on cities' digitalisation-related projects. The author of this thesis defines smart city as **"a city using ICT (incl. data analytics and sensing) for achieving mobility and environment goals dealing with urbanisation."** This attempt to conceptualise can be dynamic in time. Importantly, this smart-city framework builds on and integrates collaborative works led by Michael Batty from University College London (see Figure 5), Carlo Ratti from MIT (see Figure 6) and Rudolf Giffinger from Vienna University of Technology (Figure 8), all connected via the smart twin city project Finest Twins of Helsinki and Tallinn.

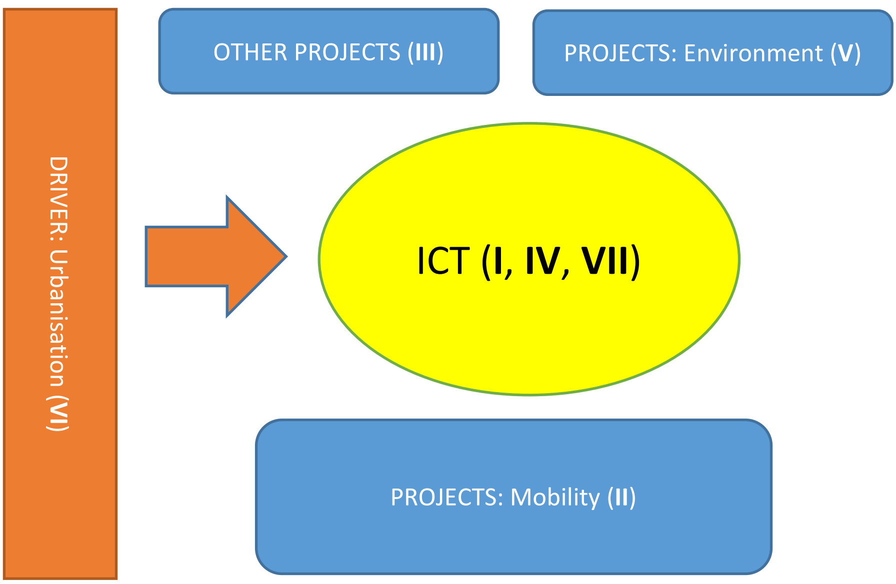


Figure 4. The smart city framework. Source: Author

Firstly, this thesis rather uniquely puts a focus on urbanisation as a key driver of smart cities. The increased density of people in cities naturally leads to mobility, environment and other challenges. According to **VI** (UN World population projections), the urban population has grown rapidly since the 1950s, from 0.7 billion to 3.9 billion in 2014. Continuing population growth is projected to add 2.5 billion people to the world's urban population by 2050, with nearly 90 per cent of the increase concentrated in Asia and Africa. As the urban population continues to grow, cities and governments are investing substantially in digitalisation as a potential solution. India has launched an initiative to build 100 smart cities[4]; in China, there are dozens of smart cities in an advanced stage of development and 200 more on the way[5]; there are several initiatives across Europe (PlanIT[6] in Portugal), the United Arab Emirates (Masdar[7]), Singapore (Tianjin[8]), South Korea (Songdo) etc.

Secondly, the argument for putting technology as the central tool is the following: without a link to ICT, there is no need to use the word "smart" in front of "city". Following the logic that "smart" in front of "phone" or "watch" indicates an advanced technology element and without it, it would just be a phone or watch, this thesis argues that the city as a phenomenon remains a crucial research domain itself, and "smart" should be put in front of it only if technological advancement is involved. Based on Batty's input in the Finest Twins project in 2016, **I**, **II** and **VII** analyse how science of cities and smart city as concepts interlink via ICT and data analytics (see Figure 5). Nevertheless, technology is seen as a tool for solving urbanisation-driven challenges in more and more populated cities, not as a driver in itself.

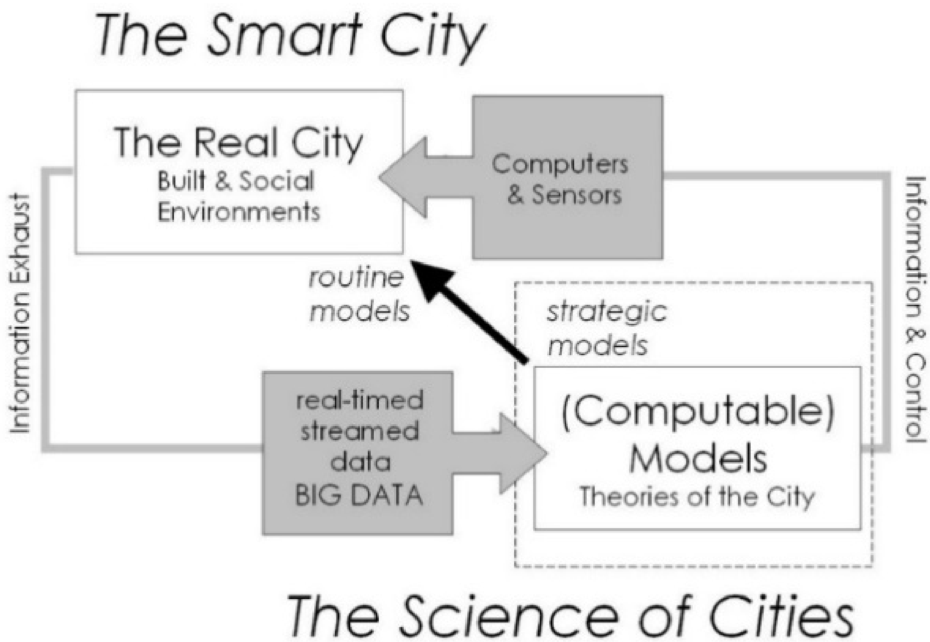


Figure 5. Batty's combined model for science of cities and smart city. Source: **I** and **VII**

[4] http://www.citymetric.com/india-s-new-government-spending-700m-new-smart-cities
[5] www.citymetric.com/skylines/can-hundreds-new-ecocities-solve-chinas-environmental-problems-1306
[6] http://www.urenio.org/2015/01/26/smart-city-strategy-planlt-valley-portugal
[7] http://www.masdar.ae
[8] https://en.wikipedia.org/wiki/Sino-Singapore_Tianjin_Eco-city

Thirdly, as the ranking of smart cities remains complicated due to the lack of agreement on concept and indicators, the smartest cities by evaluation consensus tend to be those with most digitalisation initiatives and projects that effectively deal with urbanisation-driven challenges. For example, Manville et al. (2014) selected 468 cities in the European Union with over 100,000 residents and identified cities with significant and verifiable smart-city activities, which limited their selection to 37 cities and 50 smart-city projects. This was narrowed further, and the study claimed that the most successful smart cities in the EU are Amsterdam, Barcelona, Copenhagen, Helsinki, Manchester and Vienna, as they have the most smart-city projects initiated, similarly to the framework of this thesis. Importantly, according to the results, smart-mobility and smart-environment projects outnumber other projects. It should be noted that the indicators approach has not been successful enough in comparing the digitalisation in cities, although there are first attempts to do so (e.g. Giffinger et al., 2007), but this is less established compared to e-government research, where the indicators approach is more established, but at the same time criticised, as well. For example, Yildiz (2007) claims that e-government measurement evaluation is too centred in the supply side and is mainly focused on capturing the output and outcome using different e-government indicators.

Urban Operating System

Using technology is not *per se* conditioned on using corporate-pushed locked-in solutions, as criticised by, e.g., Hollands (2008), but it can also be based on open standards and be citizen-driven, at least conceptually. A team led by MIT Professor Carlo Ratti at Carlo Ratti Associati in a collaboration with the Finest Twins H2020 project team, led by the author of this thesis, proposed to implement the digital technologies platform, an Urban Operating System (also Urban OS or UOS, see Figure 6) that aims to create a real-time sensing environment for shared services to its inhabitants and users, applicable both for single and multiple cities.

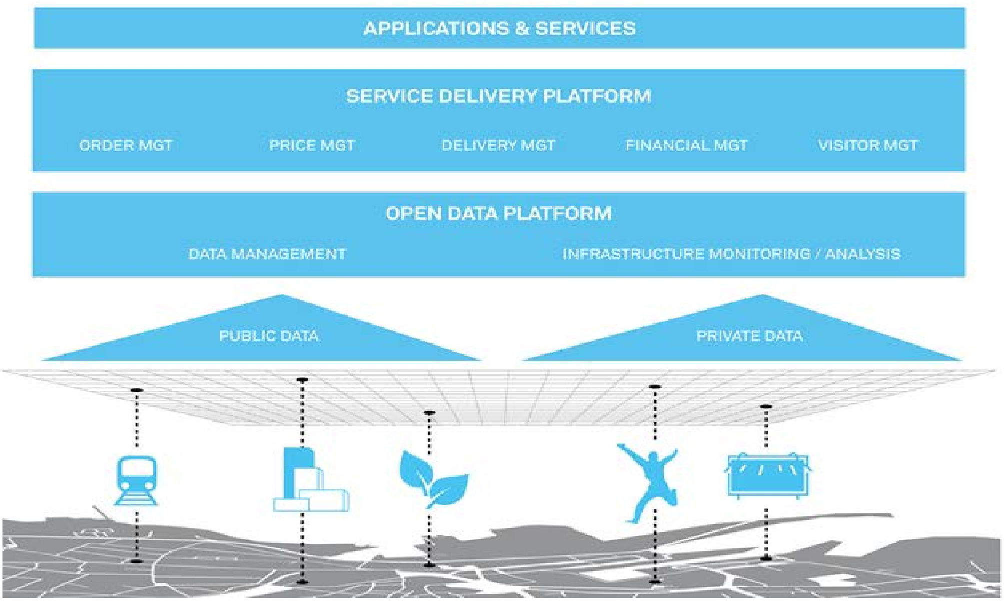


Figure 6. Urban Operating System. Source: **I**, **IV** and **VII**

Described more thoroughly in **IV**, the concept of UOS aims to deploy a network of sensors that can capture real-time data from a myriad of things occurring in the city, and connecting such sensors to an urban information system helps to better analyse and transform such data into knowledge. It is possible to create new types of urban efficiencies, products, and services for the people of the cities. In turn, they access an open-access digital services-delivery platform using anything from a smartphone or a laptop all the way to digitally enhanced infrastructures, such as responsive public spaces, intelligent transport systems or smart energy infrastructure among others (according to Ratti and Nabian (2010), each urbanite can be thought of as a human sensor, capable of reporting on their experience of the city). The city (or multiple cities) becomes a permanent platform for interaction that provides a unique mix of services to each user. Furthermore, by giving users the capabilities of developing their solutions and services, it is possible to create a more inclusive and bottom-up model of both social and economic development while jumpstarting local dynamics.

Figure 7. Urban OS for cross-border cities. Source: **I**

In the case of digital macro-regions – the topic of this analysis – the Urban OS could be applied as a platform for joint research and innovations pilots with public-sector involvement, associated companies and citizens as end-users. This combination could ensure that local companies can make cross-border smart-city solutions exportable and sell them globally, as they are developed and implemented in at least two heterogeneous environments (cities). In essence, the Urban OS aims to enable and ensure knowledge transfer between practical needs of cities, companies, citizens and researchers (see Figure 7).

Smart-city wheel

As explained earlier, this thesis groups smart city into mobility, environment and other projects, aiming to put more weight onto mobility and enviroment themes, at the same time making the "other-projects category" open and dynamic. Nevertheless, there are several attempts to decompose smart city. One of the most successful concepts is introduced by Giffinger & Haindlmaier (2010), who identified six smart-city components: smart economy, smart mobility, smart environment, smart people, smart living and smart governance (see more in **III**), although there are alterative groupings, as well (e.g. by Lombardi et al., 2012, or Nam & Pardo, 2011), as discussed in **I** and **VII**. These six characteristics make up the smart-city wheel (see Figure 8) that has been adapted by various communities (research, business, government, NGOs). For example, a modified version is promoted by Boyd Cohen (Cohen, 2014); similarly, the European Commission has adapted this as a central part of the smart-city concept, see Manville et al. (2014).

This thesis argues that urban financial digital innovations (**III**) and city demographics (**VI**) should be considered on the wheel. Electronic payment systems often appear to be an integral part of smart cities, since cash-based cities tend also to be top performers in smart-city rankings and *vice versa*. Yet, there are very few frameworks linking the two, as argued in **III**. In general, most scholars do not link smart city explicitly with demographics, and **VI** reconfirms that urbanisation through natural population increase, migration and ageing is the main driver and rationale for well-planned smart cities. To quote Wellington E. Webb, former mayor of Denver[9]: "The 19th century was a century of empires. The 20th century was a century of nation states. The 21st century will be a century of cities."

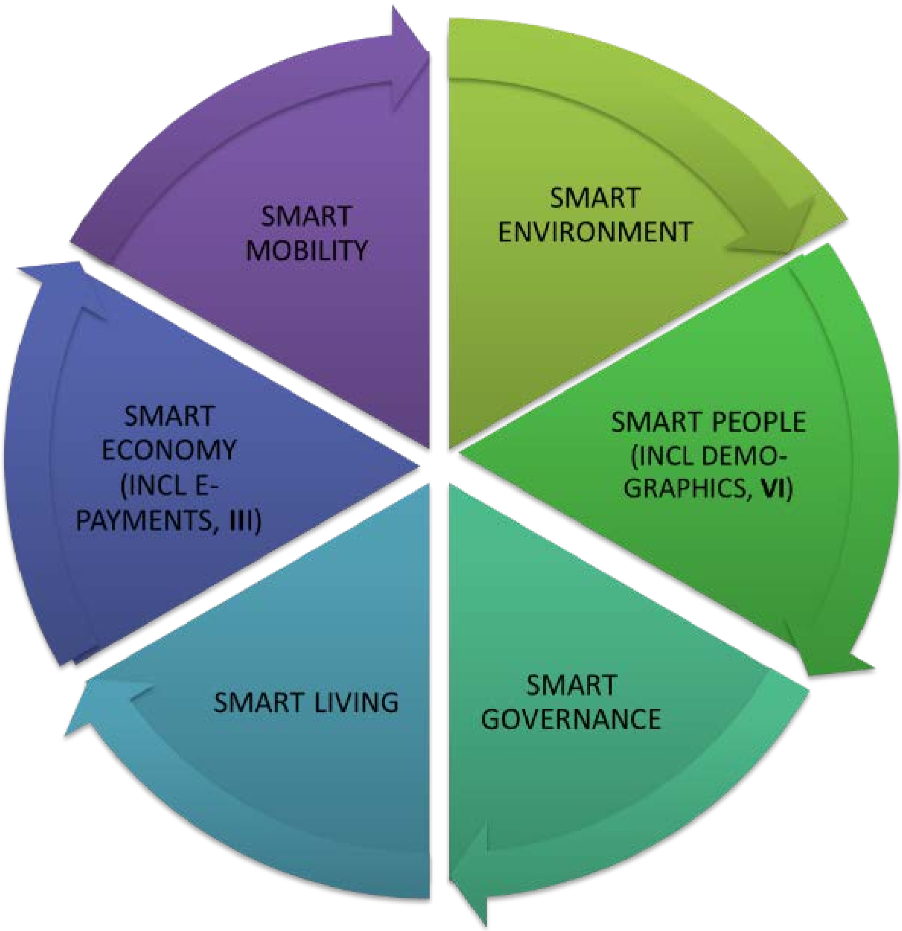


Figure 8. A modified version of Giffinger's smart-city wheel. Source: **III** and **VI**

I, **IV** and **VII** mainly deal with the governance part of the smart-city wheel, whereas **II** exemplifies a mobility case of the digital macro-region of Tallinn and Helsinki. **IV** analyses

[9] https://www.huffingtonpost.com/john-m-eger/this-is-the-decade-of-cit_b_9596524.html

the energy-data exchange layers as part of the environment component. In addition to mobility projects, environment (especially energy) remains a critical factor in the case of urbanisation. There is an ongoing discussion interconnecting sensing, cloud computing and energy provision (e.g. Hancke et al., 2013 and Yamamoto et al., 2012) and linking energy provision to smart-city platforms and testbeds (Jin et al., 2012 and Sanchez et al., 2014).

4.3. Public Value for macro-region analysis

Having the dynamic concepts of e-government and smart city analysed, the question remains which theories could be applied for multi-city analysis regarding joint ICT projects. Although there are several options, this thesis aims to cull theoretical models from the public administration (PA) literature. Modern PA relevant for the city discourse has its roots in the concept of Weberian bureaucracy. According to Weber (2016), civil servants are appointed, selected based on technical qualifications and diplomas; their salaries are graded according to rank, and the public office constitutes a career. In addition, Weberian bureaucracy set the foundations for the clear-cut separation of labour and a high degree of specialisation and civil-servant impartiality (based on the separation of political and administrative roles); it sees bureaucracy as the highest degree of efficiency (or rationalisation, Weber's key term). Thus, it should be underlined that bureaucracy (and e-bureaucracy) still exist in modern public administration.

In the light of budgetary challenges in the 1970s, new ideas evolved to contest the Weberian bureaucracy. There was a growing belief that Western states had become unaffordable and that governments should be more business-like (Pollitt & Bouckaert, 2017). The general criticism was that civil servants tend to maximise self-interest, which leads to growth of bureaus and budgets (Niskanen, 1971) – again, also present in contemporary PA – explained by a classical principal-agent problem[10] where people are opportunistic and decisions are influenced by information-asymmetry. Back then, New Public Management (NPM) seemed to provide a solution for information-asymmetry: performance management through monitoring; and introduced market incentives for the slimmer public sector: the contract state/outsourcing and privatisation. Up to the 1990s, the bureaucratic public-administration model was strongly criticised by the NPM doctrine, which promoted market-oriented governance structures (Pina et al., 2007).

It should be noted that cultural, geographical and multilevel differences are not central to this analysis, although these dimensions matter, as both Weberian bureaucracy and NPM are Western concepts (Western versus non-Western paradigms of PA are well described in Drechsler, 2013, 2015 and 2018). According to Drechsler (2005), NPM is particularly unsuitable if pushed upon transition and development countries such as Central and Eastern Europe. Hansson et al. (2016) have analysed the presence of open-government deliberative ideology in post-soviet countries and claim that post-soviet countries tend to focus more on freedom of information and accountability, and less on collaboration, diversity and innovation. To put it simply, transition (incl. Estonia) and non-transition (incl. Finland) countries are not the same.

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[10] The difficulties in motivating one party (the "agent"), to act in the best interests of another (the "principal") rather than in his or her own interests.

There are differences between local and central levels; for example, Hong & Lee (2017) claim that local governments are assumed to be more responsive to citizens.

Like previous administrative philosophies, NPM was (and to some extent still is) presented as a "one-size fits all"[11] view of the world (Alford & Hughes, 2008; Hood, 1991). According to **II**, there is a tendency to associate the concept of "traditional" administration with Max Weber, although functionally it is NPM that is now traditional. The genesis of today's Public Administration is perhaps best described by Pollitt & Bouckaert (2017) as the result of a process like geological sedimentation, where new layers overlie but do not wash away the previous ones (see Figure 10). They describe a long list of different models and approaches to public-sector management, including for our post-NPM time such 'paradigmettes' (Drechsler & Randma-Liiv, 2014) as joined-up government/whole of government, the Neo-Weberian State, and not least, the Public Value (PV). In the literature, e-government has been often linked to the NPM, as claimed by many e-government scholars (e.g. Allen et al., 2001; Heeks, 2002; Cordella, 2007; Alford & Hughes, 2008; Cordella & Bonina, 2012; Yıldız & Saylam, 2013). The classic piece by Dunleavy et al. (2006) was instrumental in debunking this myth, however, and since then, an increasing number of scholars (Alford & Hughes, 2008; Cordella & Bonina, 2012; Yıldız & Saylam, 2013) have argued for using specifically PV instead.

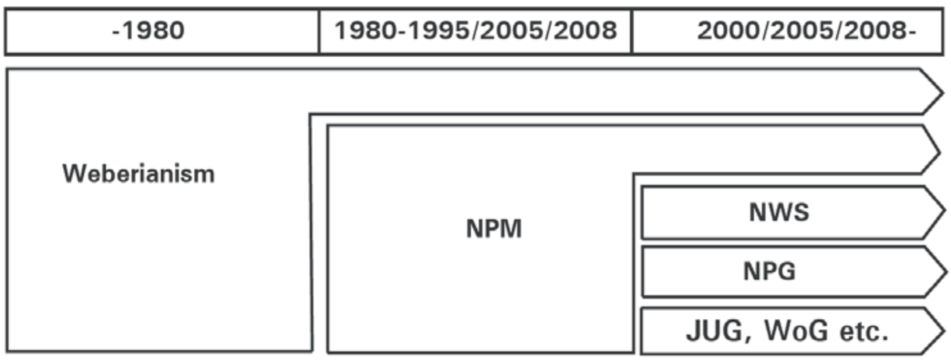

Figure 10. Public Administration philosophies. Source: Drechsler & Randma-Liiv (2014); see Pollitt & Bouckaert (2017).

In this rather complex setting, the question remains how this all fits into the understanding of digital macro-regions – the interest of this thesis. Alford & Hughes (2008) propose that the next movement in public management should be "public value pragmatism", which is principal regarding ends but pragmatic in means, in contrast to the traditional model of bureaucracy and NPM, which are seen as universal and tend to use cities or governments as their unit of analysis. According to Moore (1995), one of the core characteristics of public value is collective consumption based on collective preferences of citizens (versus aggregated individual preferences) independent of who produces it, thus also suitable for the twin and multiple city macro-region context by switching the unit of analysis from a city to a macro-region of multiple cities. Alford & Hughes (2008) link public value (there are some similarities with the public good concept

[11] Recent research suggests not to suggest universal solutions for local government analyses (Matheus & Janssen, 2017)

in economics) together with pragmatism, and they define the latter as the management approach in which everything depends on situational factors, such as the value being produced, the context, or the nature of the task.

Bonina & Cordella (2009) suggest a framework that includes analysing both managerial values derived from NPM (efficiency and effectiveness) and democratic values (fairness, equality and honesty). In a later paper, Cordella & Bonina (2012), introduce public value as a paradigm shift from NPM to address ICT-enabled public-sector reforms (see Table 1). This would change the weight of analysis of ICT implementation in the public sector from merely direct economic and management relationships in the direction of collective preferences that could also be applied for digital macro-regions of multiple cities. As an adaptive principle, public value can prioritise effective and efficient management practices, but it may also focus on values of fairness, equality and just society.

Paradigm	**Public Value**	**New Public Management**
Rationale	Public administration	Private management
Dominant focus	Relationships, politics enactment	Administrative rationalisation, results
Definition of public interest	Collective preferences	Aggregated individual preferences
Performance objective	Multiple objectives, shifting over time	Management of inputs and outputs to ensure economy and responsiveness to customers
Dominant model of accountability	Multiple accountability systems	Upward accountability via performance contracts
Preferred system of delivery	Menu of alternatives selected pragmatically	Private sector or tightly defined arms-length public agency
Means	Fulfilment of multiple objectives	Competition
Ends	Fulfilment of social expectations	"Government that works better and costs less"

Table 1. Public Value versus New Public Management. Source: **II**, based on Cordella & Bonina, 2012, adopted from O'Flynn (2007) and Stoker (2006).

This thesis, based on **II**, contributes to seeking theoretical models of how local governments can jointly generate more public and social value with ICT projects. In other words, the focus is on finding a theoretical model for multi-city analysis by changing the unit of analysis from a city to a broader macro-region with multiple cities. For this purpose, PV as a concept is proposed. The main goal of PV, it has been claimed, is to examine the performance of public service from the perspective of citizens (Karunasena & Deng (2010). The most common criticism towards PV is that it suffers from definitional vagueness (Benington & Moore, 2011), as universal concepts are simpler. For example, Jorgensen & Bozeman (2007) identified 72 public values in 7 different value categories. To narrow this down, this analysis explicitly utilises the frameworks of Kearns (2004) and Karunasena & Deng (2010) to link digital macro-regions with the concept of PV. Kearns (2004) proposes three sources of PV: 1) high quality of public services (availability, satisfaction of users, perceived importance, fairness of importance, fairness of provision, cost); 2) achievement of outcomes (improvements in health, reduced poverty, environmental improvements) and 3) trust in public institutions that also includes participation.[12] Later Karunasena & Deng (2010) suggest a framework for evaluating the public values based on three drivers of public-value creation: 1) delivery of quality services; 2) operating effective public organisations and 3) achievement of socially desirable outcomes. The conceptual framework for evaluating the PV of digital macro-regions is proposed in Figure 11 and explained and validated in **II**.

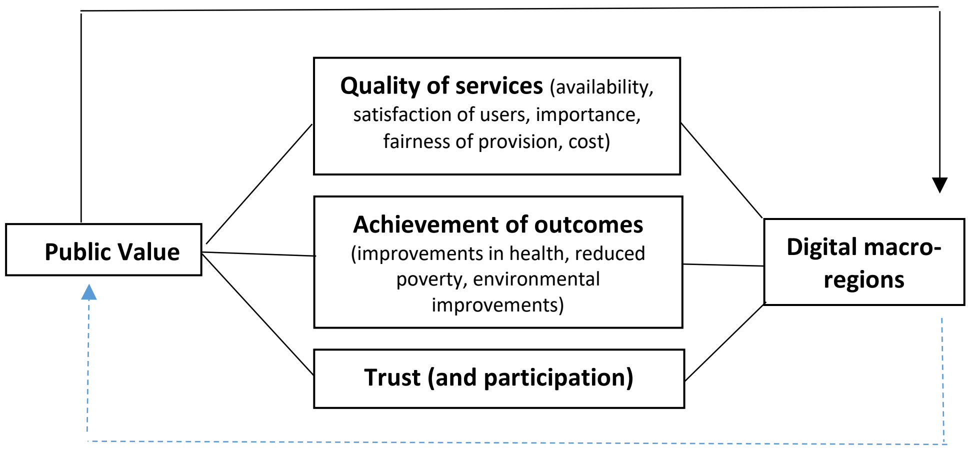

Figure 11. The Public Value theoretical framework. Source: **II**, adapted from Kearns (2004) and Karunasena & Deng (2010).

5. Data exchange platform for macro-regions

Local governments are more and more expected – even if one may ask by whom precisely – to be participatory, horizontal and collaborative with the help of digital technologies. For example, Lee & Lee (2014) criticise the provider's viewpoint whereas organisation structures are constructed for the convenience of administration, thus making the service provision vertical (e.g. departments of mobility and environment and their databases are fully disconnected). Therefore, Tallinn and Helsinki (and Estonia and Finland, respectively) are interesting as a case, as their public-sector databases are interconnected (in the case of Estonia), or there are plans to connect them (in the case of Finland), which makes inter-and intra-city data exchange possible. It should be noted that achieving this assumes change in organisations' management practices and legal setup, which is practically complex, especially when considering social and political resistance to changes, but not impossible.

Though initiated top-down, Estonia is an interesting example of horizontal exchange of data, as there is close to full interoperability between public-sector databases via the data-exchange layer called X-road, both within departments in one city and across all national cities. For example, the national population registry (which stems from the population registry of Tallinn) is fully integrated with all cities and other government

[12] Also confirmed by Picazo-Vela et al. (2015), who propose citizen participation as an important factor of value creation; Avgerou et al. (2009) claim that ICT can enforce trustworthiness (the delivery of what is expected), not trust, which for them is socially constructed.

actors in Estonia. Therefore, cities cannot keep their own population registries, as there is one live database of all residents in Estonia, and every municipality must integrate their services based on this central registry (e.g. registration of new or departing residents). It is important to note that the X-road is not extraordinary because of its technological features (there are plenty of similar-logic enterprise-service bus platforms available) but mainly because it is a case of successful implementation, both organisationally and legally. Essentially, it is a rule-based approach, and all these rules need to be defined (e.g. who can make inquiries to the population and other thousand databases and how). Essentially, it has become an institution over the past decade or two, following the logic of North (1994) that institutions define the rules of the game. In this perspective, the X-road is used as a lighthouse solution throughout this thesis, indicating how twin-cities (Helsinki and Tallinn) could conceptually benefit from it (see **I**, **II**, **III**, **IV**, **V** and **VII**). In **VII**, the Estonian data exchange layer X-road (see Figure 12) is described in a bit more detail. Briefly, in Estonia, over 3,000 government-sector (including all cities) databases are interlinked via the Internet using the transport layer.

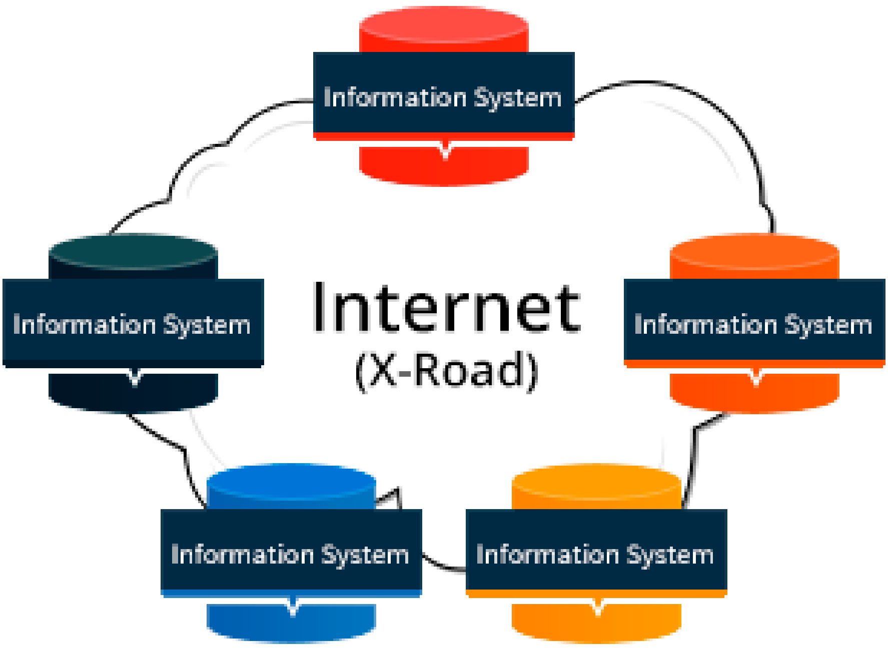

Figure 12. The X-road platform. Source: **II**, **VII**, Estonian Information System Authority

Inspired by the X-road[13], Finland is also implementing its data-exchange layer, and both countries have agreed to develop a federated solution. Recently (2017), this has resulted in a joint organisation, The Nordic Institute for Interoperability Solutions, which has the mission to develop federated e-governance solutions connecting Estonian X-Road technology with its Finnish counterpart (*Palveluväylä*). It is expected that first pilots based on these federated two-country data-exchange layers will be live in 2018 and focus

[13] http://epl.delfi.ee/news/eesti/soome-votab-kasutusele-meie-x-tee-susteemi?id=67359844 (in Estonian)

on the exchange of tax, medical and/or population data. If the federation of data-exchange layers between two countries (see Figure 13) was fully implemented, this would offer an experimental setting for joint cross-border e-services between two capitals (also applies to all cities in Estonia and Finland). Currently, the two cities still operate as digital islands but the federation of data-exchange platforms could effectively lead to joint digital services based on real-time data requests from urban and governmental databases, hence also benefiting the commuters and macro-regions. Continuing with the example of population registry: moving from Tallinn to Finland could automatically mean erasing the residence status in Tallinn and transferring it to Helsinki. Once again, the implementation of federated data-exchange layers is not only a technological challenge, but the main assumption is that this is politically desirable (multiple parties agree on how data can be exchanged and are motivated to do so, that is, create novel institutions).

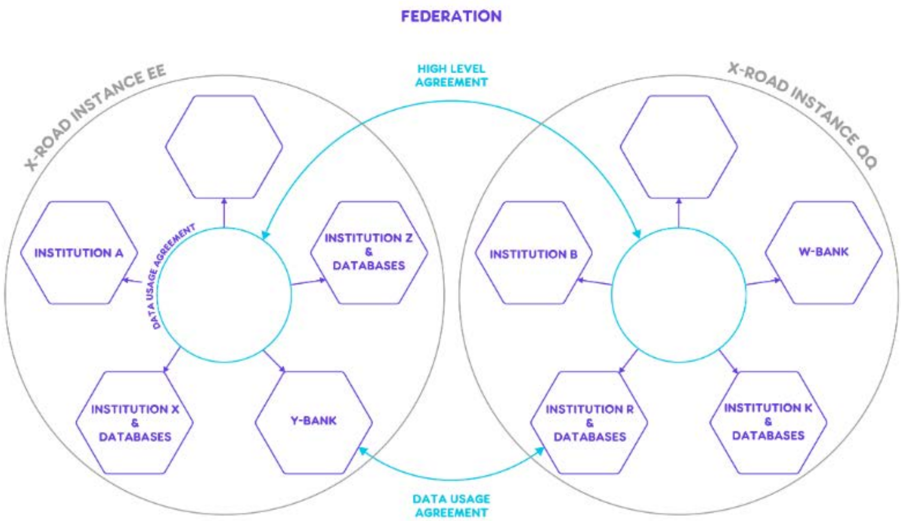

Figure 13. Federation of data platforms. Source: Estonian Information System Authority

The next step for smart cities could also be the integration of various sensor data by implementing an open and interoperable platform for connected sensors or things. That is, in addition to "citizen-based" databases, there could be interconnected registries, both public and private, for "things" like unity meters (gas, electricity, water), vehicles (cars, buses, trains etc.), home appliances, heating, lighting and waste-management systems, weather-forecast data etc. In Estonia, there is a first step towards this, namely the Estfeed platform, which connects close to 600,000 electricity users, and most end-users can trace their energy consumption via connected meters over the Internet (see more in **VI**). This platform, running on the X-road, links data sources and applications and provides a user interface for customers to see and manage their energy-consumption data and rights. For perfectly federated smart cities, such federation could be the next step, after having integrated the public registries.

6. Implications for further research and conclusion

This thesis analysed the possibility of digitally connected cities in the case of two mid-sized cities: Tallinn and Helsinki. Competing technology solutions driven by locked-in standards have a tendency to create digital islands where solutions work locally but not regionally. In this perspective, this dissertation proposed a switch from a single unit of analysis (a city) towards a macro-region unit (multiple cities), at least in the case of digitally advanced and well commuted areas. This thesis analysed smart city from four angles. Firstly, smart city as a phenomenon was defined as "a city using ICT (incl. data analytics and sensing) for achieving mobility and environment goals dealing with urbanisation." Secondly, an overarching smart-city framework was proposed with the following characteristics: smart city is driven by population growth in urban areas, which poses various mobility and environmental challenges; technology remains central as a tool in order to make cities smarter but it is not a driver itself and operationally, smart city should be evaluated based on its digitalisation-related projects. Thirdly, a way to connect smart-city services technologically and institutionally was introduced via connected data-exchange layers such as the X-road. Fourthly, as the theoretical base for both e-government and smart-city research remains weak, this thesis investigated how PA concepts (such as Public Value) could be utilised for macro-region analysis.

Conceptually, a virtually borderless twin-city is feasible, although it can take years, if not decades, to be fully functional. Nevertheless, if both cities and their respective countries label themselves as digital or smart, then moving towards a fully integrated macro area could be possible, although this remains challenging, as the two cities are heterogeneous with differences in their economic-development levels, research and innovation activities, legal set-ups, organisational practices and culture. Despite all challenges, the twin-city approach has been topical over the last 25 years and most probably continues to be so. Currently, one of the most debated questions on both sides of the Gulf of Finland is whether the modern and fast Pan-Baltic railway (Rail Baltic) should have its final stop in Tallinn or in Helsinki. If the latter is the case, this could be built via a physical tunnel approximately 100 km long that takes decades of construction time and (up to 20) billions of euros – according to the preliminary results of the FINEST Link project. On the other hand, one could argue that the connections between Tallinn and Helsinki are already relatively good and affordable now, proven by many commuters and the fact that there are at least 12 daily trips between the cities, costing around € 30 for a return trip and taking on average 2.5 hours. This thesis makes no statement regarding the feasibility of the tunnel project, but it analyses how two close cities could be linked virtually instead or parallel to the physical connection. In other words, in addition to having physical connections, there is a need for harmonised digital services which is beneficial for commuters but also local economies via an increased joint digital market. It should be stressed that both projects (virtual and physical link) are ambitious, maybe even utopian, but technologically feasible at the same time.

If the digital twin-city concept is considered a top priority, then a significant amount of further research is needed. First, there is a need for a thorough analysis how a digital twin city would affect the local economy and what would be its broader socio-economic impact (e.g. in the case of a physical tunnel, the construction sector is the main beneficiary, in the case of digitalisation, this would boost the ICT sector). In addition, the two cities, Helsinki and Tallinn, are different in their governance layers, and this should be studied further. In Finland, more power and resources are allocated towards local governments. For example, the city of Helsinki has significantly more control over the harbours, energy provision and housing. In Estonia, the decision-making and resources are more centralised. Similarly, an impact analysis of decision-making levels (local, government, supranational) could be beneficial, as currently, both central and supranational (European Union) governments play an important role in pushing toward free flow of data (e.g. data-roaming price regulation and connected data-exchange layers) and digital single market. It would be interesting to study whether local governments have a tendency to block cross-border innovations, whereas higher levels (e.g. central government) are promoting it. Further promising research and innovation projects could involve urban waste-management systems, e.g. demand-driven waste collection, where sensors indicate when to collect urban waste. Probably future trends in smart-city projects involve artificial intelligence and robots, therefore, more projects are expected in the field of autonomous urban logistics and transport and tailor-made local manufacturing. In addition, people are living longer, which drives the population growth and sets a natural demand for smart-city policies and digital applications for the elderly, e.g. in the field of healthcare. In future research, one could also adapt project evaluations for smart city research. For example, Heeks (2002) developed a model to explain high rates of failure of information systems implemented in developing countries and in the field of health care. The logic of this model is to analyse the match and mismatch between IT systems design and end-user actuality. The model derives from contingency theory and intends to explain design-actuality gaps.

Though the field of e-government is mainly influenced by PA and computer science, the evolutionary-economics point of view could be applied as well. For example, it might be important to incorporate the economics when analysing resource allocation, as IT investments can be extremely expensive. Soete & Weehuizen (2003) argue that when the purpose of ICT is to reduce costs, the consequences are crowding out of motivated employees, worse efficiency and quality performance. They zoom into the specificity of implementing ICT in the public sector and claim that dissatisfaction with ICT-based public-sector solutions has been associated with bureaucracy – the misuse of information for internal organisational power purposes, raising transaction costs, and so on. Another angle would be the role of institutions. For evolutionary economists, the level of technological competence is a fundamental factor constraining a country's productivity, and economic growth is driven by technological advance. Nelson & Nelson (2002) stress that the influence of a country's institutions on its ability to master technology is a central way how institutions affect economic performance. Therefore, technology and institutions are interrelated, and both contribute to the economic growth. As North (1994) puts it: policymakers and their decisions should be analysed within institutions, which are essentially the rules of the game.

Thus, based on the first cases, the key point in realising a winning smart-city operation is to understand that it is not a one-city game. No matter how big a city (Seoul, Rio de Janeiro), any one city is too small to create a real ecosystem of smart services and solutions. The first instalments have led to inflexible "smart cities in a box", which are ageing fast and from which the solutions do not scale elsewhere and do not apply to commuters. Instead, cities should work together to build a larger smart-city market, in which services and solutions roam from city to city with Internet-like speed.

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Lühikokkuvõte
Lugu kahest targast linnast

Käesolev doktoritöö tutvustab digitaalsete kaksiklinnade võimalikkust Tallinna ja Helsingi näitel. Siiani on kaksiklinnade analüüsi fookus olnud peamiselt sellel, kuidas linnasid paremini ühendada füüsiliselt, näiteks transpordiühenduste kaudu, ja selleks on ka mitmeid programme käivitatud. Antud töö uurib, kuidas linnasid saaks ühendada digitaalselt, eesmärgiga pakkuda ühiseid e-teenuseid ning vahetada andmeid reaalajas. Kuna IKT valdkond on tehnoloogiliselt mitmekesine, näitab senine kogemus, et isegi lähedal paiknevatel linnadel on oht muutuda digitaalseteks saarteks, kus e-teenused töötavad ainult ühe linna sees, aga mitte linnade vahel. See tähendab, kaks digitaalsete tehnoloogiate kasutamise mõttes hästi arenenud linna võivad koos moodustada mitte-digitaalse regiooni, kus kõige efektiivsemat töötavad analoogsed teenused. IKT valdkonnas on sadu erinevaid standardeid, mis võib viia piltlikult olukorrani, kus ühes linnas on kasutusel vasakpoolne liiklus, aga teises linnas parempoolne ja seega omavaheline ühendus on raskendatud kui mitte võimatu. Sellisteks näideteks võib tuua Tallinna-Helsingi kontekstis mobiilse parkimise, ühistranspordipileti ostmise ja digitaalse allkirjastamise.

Seega, antud töö keskne küsimus on, kuidas ühendada Helsingi ja Tallinn virtuaalselt, luues ühise digitaalse regiooni. Tallinn ja Helsingi, kaks Euroopa liidu pealinna, asuvad 80 kilomeetri kaugusel (eraldatud Soome lahe kaudu), nende vahel on intensiivne kaupade ja inimeste liiklus (aastas toimub üle 8 miljoni reisi) ning mõlemad linnad tutvustavad end kui eesrindlikud digitaalseid lahendusi kasutavad pealinnad. Töös tuuakse välja, et digitaalne kaksiklinn on tehnoloogiliselt võimalik, aga see ei ole isetekkeline. Teisisõnu, täielikult ühendatud digitaalne regioon eeldab väga suurt kokkulepet linnade ja riikide vahel selleks, et edukalt lahendada kõik organisatoorsed, õiguslikud, tehnoloogilised ja kultuurilised takistused ning luua efektiivseid stiimuleid ühisprojektideks. Lihtsustades, antud eesmärk on võrreldav ambitsiooniga luua Helsingi ja Tallinna vahel füüsiline ühendus tunneli näol, millest on viimastel aastatel järjest aktiivsemalt räägitud mõlemal pool Soome lahte ja mille maksumus ulatuks 18 miljardi euroni. Antud töö, omades neutraalselt positsiooni tunneli osas, väidab, et füüsilise tunneli kõrval või selle täiendusena, tuleks analüüsida ka võimalust luua hästitoimuv virtuaalne tunnel kahe linna vahel.

Kuna tark linn (*smart city*) on mõistena laialivalguv ja kasutatud sageli ka turunduslikel eesmärkidel, pakub käesolev töö välja omapoolse targa linna mõistete süsteemi: 1. ajend targaks linnaks tuleneb linnarahvastiku kasvust, mis tekitab erinevaid transpordi- ja keskkonnakorraldusealaseid probleeme; 2. tehnoloogia on oluline tööriist targa linna lahenduste kasutusele võtmisel, aga mitte eesmärk iseenesest; 3. linnade digitaliseerimise taset saab hinnata nende targa linna projektide järgi, indikaatorite asemel. Antud töös defineeritakse tark linn järgmiselt: „tark linn kasutab tehnoloogiaid (sh andmeanalüüs) selleks, et saavutada transpordi- ja keskkonnavaldkonna eesmärke keskkonnas, kus rahavastiku arv kasvab.“

Tark linn ei ole iseseisev teadusharu, vaid sõltub suuresti teaduslikust vaatenurgast. Antud töö analüüsib targa linna kontseptsiooni laiemalt, tugines nii linna-, keskkonna-, IKT kui ka juhtimisteadustele. Antud doktoritöö koos seitsme publikatsiooniga panustab e-riigi (*e-government*) kui valdkonna arengusse, mis on sümbioos IKT-teadusest ja avalikust haldusest. 2017. lõpu seisuga oli e-riigi valdkonnas avatud ligi 10 000 teaduspublikatsiooni, kuigi enamus autoreid nõustub, et valdkond on teaduslikus võtmes

veel välja kujunemata. Seetõttu analüüsib antud töö, kuidas tarka linna saab käsitleda e-riigi võtmes ning kuidas avaliku halduse teooriad saaks rakendada piiriüleste linnade digitaalsete teenuste analüüsimiseks, pakkudes välja avalike hüvede (*public value*) mudeli ning testides selle toimimist Tallinna-Helsingi näitel.

Abstract
A tale of two smart cities

This thesis proposes a novel approach to conceptualising twin-cities. To date, close-by cities are mostly analysed from the perspective of how to connect them physically, mainly providing the advancement of mobility options; there are significant local, national and supranational financial incentives for this (e.g. the EU's TEN-T programme that finances hundreds of mobility projects on all transport modes – air, rail, road, and maritime/inland). This dissertation describes that cities can also be effectively connected digitally by harmonising public services and exchanging data in real time across databases. The challenge with digitalising cities is that without joint standards and a harmonised approach, two close-by cities may become digital islands, i.e. everything is digital within the cities but not across the cities. That is, two cities can effectively produce a non-digital macro-region where the best way is to use cash and analogue services. In the field of ICT, there are hundreds of standards, and picking different ones could be compared to having one city with left-hand traffic and another one with right-hand in the most extreme cases.

The central case study focuses on connecting two Northern European capitals, Helsinki and Tallinn, virtually. The two cities are medium-sized, less than 100 km apart by sea, well commuted and label themselves as digital or smart cities. The key argument of this thesis is that virtual connection is technologically possible but not automatic. Therefore, a fully connected digital macro-area between the two cities is feasible, but this expects a high level of political priority in order to tackle the organisational, legal and cultural barriers and provide effective incentives. To simplify, a physical railroad tunnel between two capitals has been debated over the last two decades, which would be a true flagship project globally, costing up to € 20 billion. This thesis states that a virtual tunnel with a harmonised digital macro-region could also be considered, as part of discussing the physical one, or instead of it.

Creating digital or smart cities assumes real-time data exchange also within the cities, as described in the case of electricity-consumption data exchange in Estonia. As smart city as a concept remains vague with its self-congratulatory tendency, an integrative smart-city framework is proposed that focuses on understanding the phenomena, components and drivers of smart cities. This framework makes three clarifying statements: 1. smart city is driven by population growth in urban areas, which poses various mobility and environmental challenges; 2. technology remains central as a tool in order to make cities smarter, but it is not a driver itself; and 3. operationally, smart city should be evaluated based on its digitalisation-related projects. Based on cross-disciplinary examination of smart-city conceptualisation efforts, this thesis proposes to define smart city as "using ICT (incl. data analytics and sensing) for achieving mobility and environment goals dealing with urbanisation".

This thesis contributes to the evolving field of e-government that has two parental disciplines: public administration and ICT. It should be noted that e-government is not a discipline itself, although as of the end of 2017, there have been around 10,000 research papers in the field. As a novel field of research, it lacks rigour and well-grounded theoretical models. In this light, this thesis clarifies the concept of e-government, analyses how it could embed the smart city as a phenomenon and investigates which concepts and theories could be borrowed from the field of public administration. Following many scholars that propose Public Value as a model for e-government, this

thesis develops this further by offering a Public Value framework for analysing macro-regions consisting of more than one city. Nevertheless, it is important to note that that this thesis analyses the concept of smart city broadly, that is, looking for reasoning and literature in all connected domains, e.g. urban sciences, environmental sciences and sensing and connecting sciences.

Publications (Articles I-VI)

Article I

Soe, R.-M. (2018). Smart Cities – From Silos to Cross-Border Approach. *International Journal of E-Planning Research,* Special Issue on Models and Strategies toward Planning and Developing Smart Cities, 7 (2), doi: 10.4018/IJEPR.2018040105 (1.1.)

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Smart Cities:
From Silos to Cross-Border Approach

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ABSTRACT

This paper introduces a new dimension to conceptualising smart cities – a cross-border approach for heterogeneous cities. There is a mutual agreement between smart city scholars that cities are smart when they reduce silos and enable better flow of data between city functions and services. This paper focuses on the cross-border aspect of smart cities and claims that ICT in cities do not automatically lead to ubiquitous services across the cities. This can even lead to more fragmentation compared to pre-ICT area. A new model for joint digital services in the cross-border cities – the Urban Operating System – is proposed and will be evaluated in context of two Northern European cities with high commuting frequency: Helsinki and Tallinn.

KEYWORDS

Cross-Border Services, Digital Single Market, Interoperability, Public Service Provision, Smart City, Urban Operating System

INTRODUCTION

ICT deployment in cities can effectively integrate databases, functions and services, thus, create smart cities. On the other hand, it can do the opposite as well: implementation of legally and technologically locked-in solutions can drive inter-city connections apart. Isolated APIs and procurement regulations can lead to cities as technological islands instead. This can have adverse effects, transformation from interoperable to fragmented services. For example, mobile parking and public transport payments depends on local regulation and can vary across cities. What about cross-border heterogeneous cities?

This paper analyses the case of Tallinn and Helsinki, two Northern European capitals with high of commuting frequency. Millions of commutes in this relatively densely populated area demand for joint cross-border services, although public authorities often fail to provide them. Some smart city developments can even have adverse effects and can effectively lead to the situation with limited not advanced solutions for commuters.

As smart city concepts continue developing over time, this paper argues that one crucial component of smart cities is collaboration on many layers: political, business and technological. In other words, no city is smart, independent of size, when smart city solutions are developed in isolation. In the area of free movement of people and goods, smart city services need to follow actual mobility patterns. From the business point of view, digital single market is a critical component for success: best smart city services can be scaled. The problem relevant for cities within one country as well as international ones.

This paper introduces the Urban Operating System (OS) that aims to contribute to the emergence of digital single market in the urban context. The Urban OS, proposed by the Carlo Ratti Associati for the FINEST Twins project, makes bottom-up joint smart city services possible. In the digital area,

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independently developed digital services tend to be locked into specific standards making future cross-border services difficult and sometimes improbable. The Urban Operating System makes it possible, at least on the visionary level, to design ubiquitous urban services. The ubiquitous solutions not only contribute to strengthening the Digital Single Market by increasing the aggregate supply, but also mitigate digital divide and empower local communities.

ANALYTICAL FRAMEWORK

Smart City Defined

Theoretically, smart city is a novel concept that lacks definitional precision (Kuk & Janssen, 2011; Nam & Pardo, 2011b; Papa, Gargiulo, & Galderisi, 2013). A number of frameworks have been proposed as typologies of the smart city but none of them has gained dominance in academics or in practice (Batty et al., 2012; Caragliu, Del Bo, & Nijkamp, 2011; Kuk & Janssen, 2011).

On one hand, smart city covers a wide angle of "hard" domains such as buildings, energy grids, natural resources, water management, waste management, mobility and logistics (Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014) where ICT plays a decisive role in the functions of the systems. In addition, smart city has also reached to "soft" domains like education, culture, policy innovations, social inclusion and government (Albino, Berardi, & Dangelico, 2015).

In the 1990s, when the smart city term was first used, the term focused on the interplay between novel ICTs and modern infrastructure in the cities. Currently, the smart city concept is not limited to the diffusion of ICT, the focus has shifted towards a government-oriented approach that highlights the role of social capital and relations in urban development. In the everyday urban planning context, Smart city is often interpreted ideologically whereas being smarter entails strategic directions: governments label their policies "smart" in order to achieve sustainable development, economic growth, better quality of life and simply create happiness (Albino et al., 2015).

In a meta-study of smart city definitions (Hollands, 2008), smart city is a city that maximises the "utilisation of networked infrastructure to improve economic and political efficiency and enable social, cultural, and urban development." Caragliu et al. (2011) provide a boarder definition: "a city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance."

There are also narrower definitions. Smart city can be defined by its ability to develop and administrate novel services that provide information to citizens about all aspects of urban life via interactive and internet-based applications (Kuk & Janssen, 2011). Several authors criticise that current smart city definitions and components stress the provider's viewpoint and combine various lists of functional urban services whereas structures are constructed for the convenience of administration (J. H. Lee, Phaal, & Lee, 2013). Paskaleva (2011) points out the importance of open innovation and user engagement and discuss that too heavy corporate-based approach leads to risks of losing independence of governments. Many authors (Albino et al., 2015; Jung-hoon Lee & Hancock, 2012) stress the importance that smart city should be citizen-centric and citizen-driven.

From the ICT perspective, smart city is a synonym for the integrated systems and databases, smart city can be viewed (Dirks & Keeling, 2009) as an important component to integrate city's various systems (transportation, energy, education, healthcare, buildings, physical infrastructure, food, water and public safety). Similarly, a city is smart when it integrates hardware, software and network technologies in order to connect seven critical city infrastructure components and services: city administration, education, healthcare, public safety, real estate, transportation and utilities (Washburn & Sindhu, 2009), the outcome of smart city is affordable healthcare, clean environment, business opportunities and more jobs. In other words, the smart city is the use of smart computing in order to make city's infrastructure and services more intelligent and efficient that provides close to real-time awareness and advanced analytics.

In the ICT literature, smart city is sometimes conceptualised as a synonym to the Internet of Things. The Internet firstly evolved from connecting people with information (Internet 1.0) to connecting people to people (Internet 2.0). The next step is connecting objects with objects, places and everything (Internet 3.0). Balakrishna (2012) argues that this third wave aims to radically change the human interaction with the earth in the same way as the Internet has managed to revolutionise personal and business interactions. This "revolution" could be labelled in different contexts as Internet of Things, Smart City or Future Internet.

For the business sector, the technological component is mainly seen as the enabler of smart cities. This approach has been criticized by authors like Greenfield (2013) who argues that corporate-designed cities like Songdo (Korea), Masdar City (UAE), or PlanIT Valley (Portugal) avoid accumulated knowledge how cities actually function and represent "empty" spaces that try to simplify to extreme how cities operate and disregard the value of complexity, unplanned scenarios, and the mixed uses of urban spaces. Corporate-pushed and lead new planned cities are also being criticised for being mainly real estate initiatives attached with "smart" label indicating adoption of modern ICTs having less input from local populations in terms of their requests and wishes (Albino et al., 2015; Cugurullo, 2013).

According to Balakrishna (2012), the prerequisite for smart city is intelligent infrastructure and a set of cross-sectoral services (energy, sanitation, health care, transport, farming, governance, automation, and manufacturing). The infrastructure itself can be decomposed to 1) Large-Scale Instrumentation or connected objects (connect city's infrastructure with sensors, actuators, tags, readers and other sensing devices); 2) High-Speed network Infrastructure (connecting millions of devices requires significantly faster network connection) and 3) Data Management (how to exchange and make sense of data).

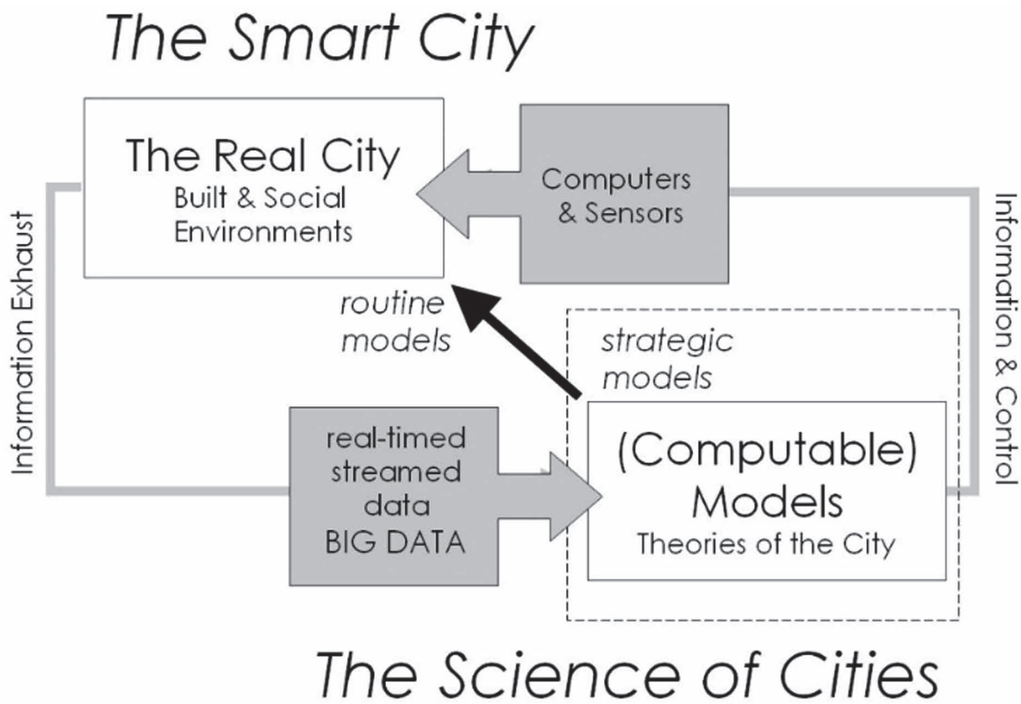
A broader concept can be found in Chourabi et al. (2011) that identified eight critical factors of smart city initiatives: management and organisation, technology (including adoption), governance (multiple stakeholders), policy context (restrictive laws and regulations), people (digital divide, participation, education, accessibility etc), economy, built infrastructure (including security and privacy and operational cost) and natural environment (resources).

One of the most comprehensive approach is offered by Batty et al. (2012) that define smart city as "a ciy in which ICT is merged with traditional infrastructures, coordinated and integrated using digital services. These technologies establish the functions of the city and also provide ways in which citizen groups, governments, businesses, and various of agencies who have an interest in generating more efficient and equitable systems can interact in augmenting their understanding of the city and also providing essential engagement in the design and planning process." (See Figure 1).

Smart city can be decomposed to industry, education, participation and technical infrastructure (Giffinger et al., 2007). This list was followed by a project by Vienna University of Technology that identified six components that are close to becoming a standard in the field (Giffinger & Haindlmaier, 2010). These components are smart economy, smart mobility, smart environment, smart people, smart living and smart governance. There is an approach to rephrase these components (Lombardi, Giordano, Farouh, & Yousef, 2012): smart economy – industry; smart people –education; smart governance – e-democracy; smart mobility – logistics and infrastructure efficiency & sustainability and smart living – security and quality. Alternatively, some authors (Nam & Pardo, 2011b) point out three core components of smart city: the technology, the people (creativity, diversity, and education), and the institutions (governance and policy).

An extensive metastudy (Manville et al., 2014) inspired by a project by Vienna University of Technology (Giffinger & Haindlmaier, 2010), a smart city addresses the following six characteristics: Smart Living, Smart Mobility, Smart Environment, Smart Governance, Smart Economy and Smart People. This current research project bases its conceptual assumptions on a European Commission meta-study that define smart city in the following way (Manville et al., 2014): "A smart city is a

Figure 1. Combined model for city science and smart city by Batty



city seeking to address public issues via ICT-based solutions on the basis of a multi-stakeholder, municipally based partnership."

Although the authors claim that this is a working definition, it is based on the meta-analysis how smart city has been conceptualised previously. There have been two main streams of smart city definitions: the first one has been focused on ICT as a technology driver and the second one has been broader including socio-economic, governance and multi-stakeholder aspects such as the use of social participation to enhance sustainability, quality of life and urban welfare. Clearly, the definition above is a combination of these two.

Smart City and Wired, Intelligent, Virtual and Ubiquitous Cities

The close terms to smart city are knowledge, wired, intelligent, virtual or ubiquitous cities (in addition, also digital, innovative and information city can be found in the literature). However, the smart city concept has become predominant among these variants, especially at city policy level, globally as well as in Europe. Wired cities (Dutton, Kraemer, & Blumler, 1987) is all about infrastructure – cables and connections; the core aim of digital cities is virtual reconstructions of cities (somewhat similar to virtual cities – see below). Knowledge cities often infer interrelations between academic knowledge and the business world (Slaughter & Rhoades, 2004).

According to Albino et al. (2015), the virtual city consists of a reality (incl physical infrastructure and inhabitants) and a parallel virtual city. A "ubiquitous city" is clearly ICT-enabled, making ubiquitous computing available to the urban elements everywhere including computer chips and sensors (Townsend, 2013). According to (Nam & Pardo, 2011), "smart" is less elitist and more user-friendly term compared to "intelligent," which is more limited to being responsive to feedback and having a quick mind. According to (Komninos, Pallot, & Schaffers, 2013), the label intelligent characterises how cities support learning, technological development and innovation in general.

This means, every intelligent city is not ICT-driven per se. smart city is often used as a synonym to intelligent city (Hollands, 2008)

Jungwoo Lee & Lee (2014) claim that these are either synonyms or predecessors or smart city and they all have in common that they imply the utilization of ICT in urban management and serving citizens. According to Albino et al (2015), the people component makes smart city unique. Smart city is clearly associated with education, learning and knowledge (Thuzar, 2011).

Urban Operating System

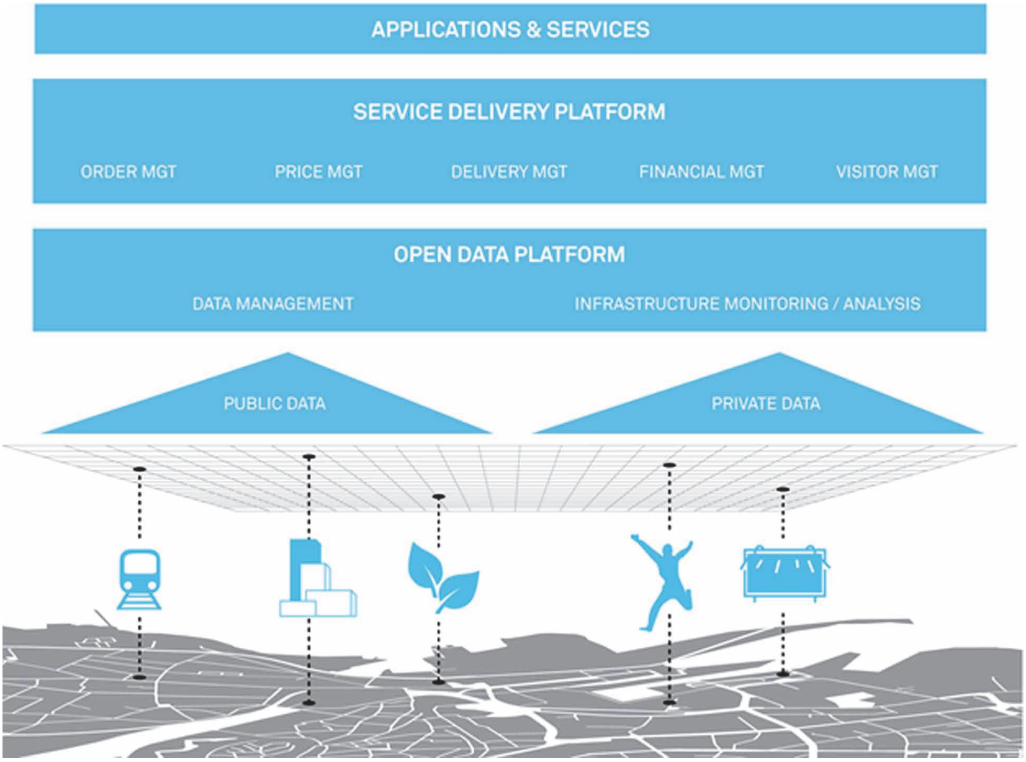
This paper suggests the design and implementation of the digital technologies platforms (an Urban Operating System or Urban OS; See Figure 2) that will enable to create a real-time cross-border sensing environment as well as to provide a new layer of shared services and opportunities to cities inhabitants and users. Rather than a top-down system supplied by an international technology leader to improve efficiency and security, the Urban OS is imagined as an open network that is able to create sustainable wealth and encourage local economy (Soe, 2017b). Through the Urban OS, the city becomes not just as a testbed but also a platform to innovate upon.

There is a natural demand for interoperable city functions and services in the cross-border areas. In heterogeneous cities like Helsinki and Tallinn with high commuting frequency, citizens demand for joint and interoperable services, which ICT deployment can effective offer, but it can do the opposite as well. In the case of frequent mobility services, there can be two-speed development from the users' perspective: services are more advanced for city-internal use, at the same time more complicated for the cross-border usage. In this project, such examples were mapped in the field of public transport and parking tickets within cities and cross-border.

1. **Public Transport Ticket:** Cities of Helsinki and Tallinn have replaced cash-based systems with RFID cards. Helsinki has still a few ticket machines available whereas Tallinn has none of them left. On the other hand, RFID cards are based on different standards and cannot be used in both cities. This means, for cities where approximately 10% of people commute regularly, smart solutions have produced more burdens: a commuter needs to have two RFID cards and follow rather complex charging and identification instructions. On the other hand, cash-based options are expensive. In Tallinn, a single journey purchased with cash is € 2, whereas RFID-based ticket costs for one hour € 1.1. and for one day € 3.
2. **Parking Payment Options:** In Tallinn, the city government has implemented text-message based parking tickets already a decade ago that has effectively reduced the number of public parking ticket machines. On the other hand, there is no roaming with foreign numbers, non-Estonian mobile numbers cannot pay for the parking. This has led to areas where foreigners (e.g. Finns often travelling to Tallinn) cannot pay for the public parking unless they purchase a local SIM card. On the Helsinki side, the most common parking payment is mobile application (easyPark, Parkman) with limited parking machines available, although the number is decreasing. Therefore, an Estonian commuting to Helsinki needs to download a mobile application, tie it with credit card and start using it. In reality, many Estonians have not done it, either because they seldom commute, they are used to text message-based solutions instead of mobile applications or they do not have a credit card. This has led to the situation when a significant number of foreign parked cars just do not pay for the ticket.

The concept of Urban OS, proposed by the Carlo Ratti Associati for the FINEST Twins project, is simple: deploying a network of sensors that can capture real-time data from a myriad of things occurring in cross-border cities, and connect such sensors to an urban information system helps to analyse better and transform such data into knowledge. We can create new types of urban efficiencies, products, and services for the people of the cross-border cities. In turn, they access an open-access digital services delivery platform using anything from a smartphone or a laptop all the way to digitally

Figure 2. Urban operating system by Carlo Ratti Associati



enhanced infrastructures such as responsive public spaces, intelligent transport systems or smart energy infrastructure among others. The cross-border cities become a permanent platform for interaction that provides a unique mix of services to each user. Furthermore, by giving users the capabilities of developing their solutions and services we create a more inclusive and bottom-up model of both social and economic development while jumpstarting local dynamics.

This paper proposes the following path: the creation of an Urban Operating System that is available for local and cross-border solutions. Such an approach follows from strategic plans developed by European Innovation Partnership on Smart Cities and Communities. Equally importantly, this will utilise open software and platform standard solutions developed in the context of FIWARE Smart Cities and Open and Agile Smart Cities (OASC) initiatives in order to ensure replicability and more importantly, scalability. In Estonia, public ICT infrastructure based on open standards – x-road and electronic Identity which means that all cities within the Estonia can exchange information in real time because all city databases are connected with each other over the Internet.

In practice, the Urban OS is a platform for joint R&I pilots with public sector involvement, associated companies and citizens as end-users. This combination will ensure that companies can make cross-border smart city solutions exportable and sell them globally. In essence, the Urban OS enables and ensures knowledge transfer between practical needs of cities and companies, and researchers (see Figure 3).

An important tool for the Urban OS is the twin-city Living Lab. The figure below explains how joint cross-border pilots will take place in the cross-border cities and how these pilots can push two cities towards shared identity, can help to harmonise data and make it interoperable, and provide means for co-working and for trial legislation (see figure 4).

Figure 3. Urban OS for cross-border cities developed by the FINEST Twins team (Sami Lehto)

EMPRIRICAL PART

Research Method

The research method is a case study of Tallinn and Helsinki digital urban services from the Estonian perspective. Data was gathered through in-depth structured interviews with representatives of cities, companies and third sector experts, altogether 21 high-level interviews were conducted in 2015 and 2016. The interviews, conducted by the FINEST Twins project members (Ralf-Martin Soe and Johann Peetre), aimed at. gaining specific information about the potential of mutual digital services. Empirical information was also derived from secondary sources like published and reports and documents.

The results of the interviews will be presented in the following way:

- Summary of all interviews are divided into three groups (private, public and third sector). This is shortened and edited text that highlights most important aspects of the interview data. The list of interviewed experts in provided in the annex 1.
- Text-analysis using the Atlas.ti software in order to map the enablers and barriers of cross-border smart cities based on Helsinki and Tallinn in three dimensions: private sector, public sector, third sector (associations and ngos), see the coding Table 1 below.

The purpose of ATLAS.ti qualitative data analysis software is to systematically analyse complex phenomena hidden in unstructured data (text, multimedia, geospatial). The program provides tools that let the user locate, code, and annotate findings in primary data material, to weigh and evaluate their importance, and to visualize the often-complex relations between them. ATLAS.ti consolidates large volumes of documents and keeps track of notes, annotations, codes and memos that require close study and analysis of primary material consisting of text, images, audio, video, and geo data. In addition, it provides analytical and visualization tools designed to open new interpretative views on the material.

Smart city is an emerging and rapidly changing field of study and therefore, the theories have to be adjusted to the changing environment. On the other hand, especially in the case of novel topics, there is a lack of approaches and overwhelming theories that could be empirically evaluated. To address it, the interviews have a goal to go beyond theory and linkages found in the current literature.

Tallinn-Helsinki Case Study

Tallinn and Helsinki (two Northern-Europe capitals of Estonia and Finland, respectively) are selected for the following reasons: proximity (two cities are just 80 km apart by sea); high-level commuting

Figure 4. Urban OS toolbox: Smart-twin-city living-lab model developed by the FINEST Twins team (Sami Lehto)

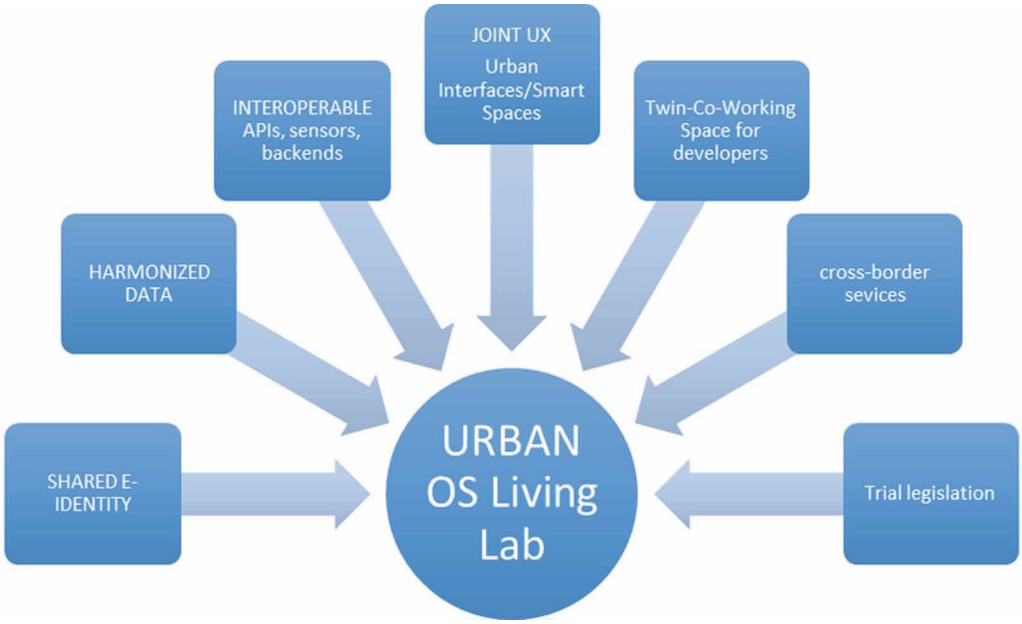


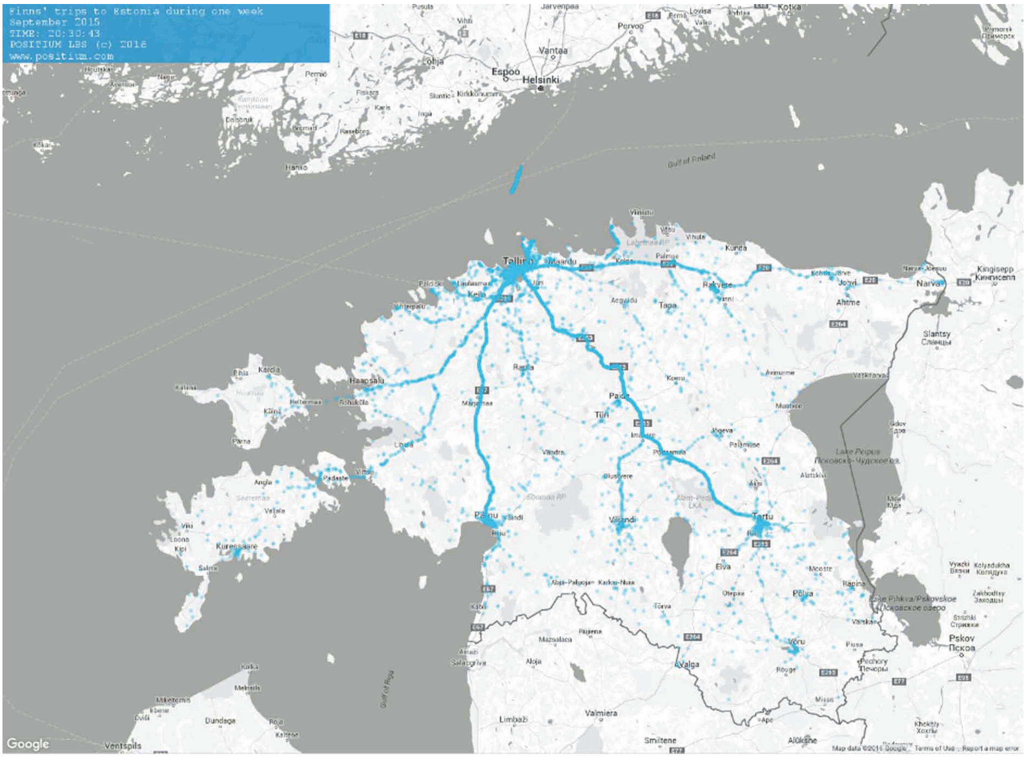
Table 1. The coding strategy of interview transcripts

	Enablers of cross-border smart city (code 1)	Barriers of cross-border smart city (code 2)
Private Sector	quotations (20): co-operate, coordinate, export, communicate, communication, cross-border, enter, scalable, flexibility, comfort, standard, access, participatory, grant, horisontal, agile, inclusive, agreement, integrate, mutual	quotations (20): passive, waiting, legacy, un-coordinate, dogma, fear, fragment, suffer, slow, bureaucracy, weak, block, silo, vertical, closed, cheap, limited, problem, frustrate, avoid
Public Sector		
Third Sector		

frequency (there were 8 million commuters between Tallinn-Helsinki in 2016) and high-level of digitalisation of public services. Economically, the cities are on the different levels: Tallinn is a post-soviet city trying to catch up whereas Finland is a well-developed western city. Tallinn GDP per capita is roughly 2.5 times smaller than Helsinki GDP (Soe, 2017a). Between two medium-sized cities, there is a high commuting frequency. The combined population of Estonia and Finland is just 7 mln. Approximately every 15-20th Estonian lives in Finland and commutes back to Estonia on a regular basis (see Figure 5). For Finland, Estonia is the most popular investment and tourism destination, every fifth Finn stays overnight in Estonia each year. The two countries speak rare Finno-Ugric languages, and there is a feeling of kinship between the countries. In terms of innovation, both countries are particularly strong in digital innovations.

The on-going collaboration between the public administrations of the cities of Helsinki and Tallinn is both strong and growing. For example, the cities have agreed on a memorandum of understanding to structurally develop the “twin city” in various domains, from social issues to specific smart-city topics, including open data harmonisation and public-transport-system interoperability. The Helsinki region and Tallinn form a pair of two similar-size NUTS2-level regions, which sometimes

Figure 5. Commuting frequency between Estonia and Finland (source: Positium Ltd)



are defined as small "macro-region" by themselves. There is a large amount of ERDF (European Regional Development Fund) targeted to the cohesion of this macro-region through Central Baltic and Baltic Sea Region Interregs as well as national structural funds. For example, there is a Southern Finland-Estonian sub-programme in Central Baltic Interreg that much resembles the project regions. Also, there is a large amount of collaboration of the public authorities on these levels. Notably, the Helsinki region RIS3 and the Estonian RIS3 (smart specialisation strategies) are aligned. Smart city domains are in the focus of the Helsinki region RIS3, and ICT and digital industries are in the focus of the Estonian RIS3 planning work.

There are also several ERDF-funded projects for the smart twin-city collaboration on the public-administration level. As an example of these, the following two projects were decided to be funded from the Central Baltic Interreg ERDF on 14.6.2016, starting 1.9.2016:

- **FinEstSmartMobility** (1,8M€, 2016-2019)), which will plan and procure 4 smart (ICT-based) solutions to improve the traffic flows that go through Helsinki and Tallinn via the ferry and airplane connection.
- **FinEst Link** (2016-2019, feasibility study € 1.3 mln), which will execute planning towards a fixed link ("the railway tunnel" or another connectivity link) between Helsinki and Tallinn. This project is expected to lead to a very large-scale transport investment project (e.g. CEF; the pre-feasibility study estimates an investment size of 14B€ between 2020 and 2030).

On the national levels, Estonia and Finland are considered as frontrunners of digital innovations. Two small European countries are the birthplaces of Nokia and Skype, respectively, and they have an overall strong digital focus in many aspects of life. Finland is considered a good place for innovative ideas, especially in the field of digitisation. Estonia is renowned for having one of the most innovative e-governments in Europe. No other nation has equipped each of its citizens with a secure digital identity and no other nation has connected all public databases over the Internet, using a secure transport layer (the X-road). Helsinki is considered among the top 6 most successful European smart cities.

The Helsinki City is part of several networks that aim to make cities work together for developing joint smart-city solutions. Helsinki coordinates the 6Aika project, which harmonises smart-city solutions for the six biggest cities in Finland (Helsinki, Espoo, Vantaa, Tampere, Turku and Oulu). They also initiated and coordinated the CitySDK project, which offered open and scalable smart-city solutions for 8 cities in Europe: Amsterdam, Barcelona, Helsinki, Istanbul, Lamia, Lisbon, Manchester and Rome. The CitySDK was then transformed to Open and Agile Cities which connects 89 cities from 19 countries in Europe, Latin America and Asia-Pacific.

SWOT Analysis of Two Cities

In accordance with two cities SWOT analsyses,[1]2 the Table 2 summarizes the prospects for a sustainable smart city and region strategy of cross-border Tallinn-Helsinki Region. The Tallinn-Helsinki Region is well positioned as a model of a Smart Region for the push it gives to development of new technologies within a multi-levelled infrastructure and towards the creation of new business sectors. Many elements needed to create, develop, test and market new ideas and new technologies are present. However, there are also weaknesses and challenges to be addressed, such as the lack of diversity in technology base, and the peripheral position of the cross-border Tallinn-Helsinki Region in Europe. That is one of the reasons behind the strong political and economic will in strengthening of the cooperation between Helsinki and Tallinn.

RESULTS

Summary of Interviews

The Urban OS between two urban areas aims to connect various cross-border stakeholders with an aim to jointly provide mutual services for commuting citizens. In this paper, we have analysed the potential and barriers for Helsinki-Tallinn (and Estonia-Finland) joint digital services from three viewpoints: Private Sector, Third Sector and Public sector.

Private Sector

From the private sector, there is a strong willingness to offer cross-border services, although there are clear obstacles that block this. Many company managers claim that these are not technological but related to legislation and cultural aspects (managers of Port of Tallinn, SpinTek, Positium and Cityntel). The street-lights provider Cityntel has reshaped its target market from the Nordics to Asia, for example. “We have quit trying to enter the Finnish market. Too little possibilities and everything moves very slowly, legacy prevents innovation,” claims the chief executive of this company. This view is commonly shared, entering the market really require the references.

In addition, there are real market entry obstacles as well which make it complicated for companies to introduce cross-border solutions. As an executive from Spin Tek puts it: “smaller municipalities would like to implement our solution, but will not until Helsinki city has approved the idea also. But Helsinki is waiting until the software is implemented in some smaller municipalities first.” On top of that, insourcing smart city solutions require higher analytical capabilities of public servants.

Most interviewees point out the lack of clear responsibilities (e.g. no-one is responsible for improving cross-border transit) and claim that the Public Sector is not coordinated, stuck in old dogmas (legislation may lag 20 years in some cases), fragmented and is too afraid to take risks. In addition, also larger companies are not very willing to invest in smart city solutions, at least in Estonia. “Big

Table 2. SWOT analysis of Tallinn and Helsinki

Strengths	Opportunities
• Strong, innovation oriented clusters • Good level of collaboration government – business - universities • Prominent role of user driven, open innovation (Helsinki) and test-site mind-set (Tallinn) • Effective innovative policy instruments • Gateway for companies entering Nordic, Russian and European markets	• Strong innovation driven collaborative networks • Push for creation of new business sectors • Emerging entrepreneurial ecosystem • Strong national and regional policy cohesion • Geographical location as basis for new entrepreneurial opportunities • Unused opportunities of the Internet for business and citizens and for smarter cities and regions
Weaknesses	**Threats and Challenges**
• Strong ICT sector but lack of diversity • Limited human capital base • Limited scale • Enterprises operating mostly in domestic markets • Too few growth oriented innovative SMEs • Somewhat peripheral position in Europe • Gap between basic research and business	• Ageing population impacting labour shortage and conditions for SMEs • Increasing international competition; globalisation pushing expertise and companies to look for global opportunities • Industrial structure largely depending on large companies and few industries · Dependency on mobile technology, lacking diversity

companies do not take the risks to fund smart city activities, development expenditure and risks are too high," claims a representative from a small research-based company, Positium.

The bottom-line is strongly linked with the access to funds. Each municipality, by nature, prefers local companies. Some Estonian companies even claim (e.g. Goswift) that it is easier to enter the Finnish market through European Union projects compared to the foreign procurement process. Procurement is a key in any case, as one of the biggest water and sewage construction company representative puts it: "the real challenge is how to overcome the slowness of the procurement process at the same time keeping it legally correct (avoid corruption)."

Another view on smart city was given by the CEO of Ericsson, a Finn working in Estonia. He pointed out that the base of smart city lays in training. "For twin cities, there is a need for new nano degrees to train people in an effective way to adapt the demand of the labour market. Joint job-related training can really contribute to the joint digital market."

Third Sector (NGOs and Associations)

The Enterprise Estonia, Rakvere City (a small town in Estonia) and a cluster of companies have invested into the Rakvere Smart House Competence Center – a real physical demonstrator of near-0-energy buildings. The executive of this lab states that this project could be scalable and applied abroad but this is difficult within the current standardisation legislation. "The legislative system and its differences from country-to-country is the main block in implementing the best practices in another country. The slowness of bureaucracy is also slowing down the adoption of new solutions."

A smart city cluster developer from Tallinn, who helps companies to export abroad, points out that the most crucial aspect is a state as a smart procurer: "under the normal procurement procedures, you will get the cheapest solution, which is probably outdated. If the procurer is smart and has written a good initial task, then the supplier must have the ability to provide it. In a smart city, you want to procure a solution in the early stage of development." This is seconded by the Tartu Science Park Project Manager: "…cities do not know most up-to-date Smart solutions. City officers are busy and when they plan to innovate through procurement, they use search engines and find thousands of solutions. But which ones does work? If you approach the company directly, they try to sell their product. Therefore, there is a need for neutral and trustworthy advice."

A development head of the Tartu Smart City Lab, a regional cluster in the southern part of Estonia, pointed out three keywords for successful implementation of scalable smart city solutions: 1. willingness to take risks, 2. openness to innovation and 3. technological know-how. The main problem is that innovation is risky and cities have very low risk-tolerance.

A Senior Research Fellow at the Swedish Environment Institute states that smart city research projects should be more applicable, there is a need for real impact. Another problem is related to the organisational set-up in cities, namely the isolated departments (silos). It is also very important, as stated by an enthusiast in the Urban Lab, to focus on the governance part of smart cities, that is, how to involve citizens in the decision-making process.

Public Sector

The Public Sector has a slightly different viewpoint on the take-up of smart city innovations, both domestic and cross-border. As the head of the Transport Investment Department at the Ministry of Economics and Communications in Estonia puts it: "Most of the innovations are still incomplete, it is not cost-effective to implement them on a larger scale. "On the other hand, public service representatives agree that the smart city projects are held back by the public authorities – problems with bureaucracy and conservativeness of officials. "In order for smart city functions to be implemented, either many public officials have to be replaced or retrained…" stated one Ministry-level representative.

In the public sector, most smart city related projects are co-funded and most funds are external. Many interviewees point out that they are a very clear need for smart budgeting: business needs to have an open access to information on city budgets. Still, many public servants do not agree that there should be joint budgeting for the cross-border solutions. "Finnish-Estonian cooperation is about sharing experience and best-practices. 1 + 1 = 3," stated an executive in the Ministry of Economics and Communications of Estonia. Another executive from the same ministry, responsible for the IT development, agreed by stating that technology itself cannot be the goal itself, it is always the means. "Still, projects, both internal and external, need external funding, though, not every project is a start-up success story." This view is not shared by all public servants. Experts from the Ministry of Finance in Estonia working on the regional development and the smart cities measure, indicate that cities should not depend only on external financing in the development projects. "The support that cities get from the EU structural funds is objectively big, but in comparison with their actual budget, that is spent on developing the city, then the fiscal support is small. So actually cities should be able to finance their own smart city projects, if they wanted to," was pointed out.

National and local governments have different views on responsibilities of the cities. An ICT advisor to the Prime Minster underlines the importance of capabilities and priorities of local governments. In his view, the challenge in the smart city is not about technology but bringing different parties together by making agreements. Smart city adoption is more the question of local government cooperation than state-level policies. The problem is that the local governments are passive, do not cooperate and could be more innovative. In Estonia and Finland, there is a very good ICT infrastructure (authentication, security protocols), it is very important for cities to use it actively. The City Secretary of Tallinn (capital city of Estonia) does not agree and states that the government should cover more of local governments IT costs. The logic is the following: "Tallinn is a lighthouse for other local governments: if Tallinn implements something, others will follow. It would be more efficient if the state would finance it (in any case, this is taxpayers money). There are also cases when the government takes over information systems developed by the Tallinn City (e.g. Population Registry or Social Info System STAAR)."

Many interviewees claim that there is a too heavy focus on local and national solutions, compared to cross-border ones. „Most Tallinn city transport should have the Finnish link as well because 15-20% of transport from Port of Helsinki moves to Tallinn. The best cooperation would be Tallinn-Helsinki-St. Petersburg: divergent systems, different people and habits and much greater market potential," states a chief civil servant at the Ministry of Economics and Communications of Estonia. He adds that this should be coordinated by a Central Agent for all three regions, in the top-down perspective. On the other hand, an executive from Tallinn City likes the idea of cross-border services but claims that in reality, Helsinki and Tallinn are competitors (in terms of tax income). „If there are better kindergartens and access to schools for Estonians in Helsinki, this does not bring the children back to Tallinn."

Most interviewed participants agreed that there is a need for joint cross-border services between Tallinn and Helsinki. For example, all interviewees agreed that both m-parking and x-road should be cross-border already now. "We should not be stuck on hypotheticals, we should thrive towards actually realising our crazy ideas," stated the head of IT department of the Ministry of Economics and Communications of Estonia.

A Tallinn City civil servant, responsible for transport investments, claims that there is a real need for joint teams and joint budgets. "If there is an ambition for high-level projects (e.g. tunnel), this has to work in real co-operation between the cities. In practice, this does not work that there is a team in Estonia and Finland, there should be one mutual cross-border team for high-level projects."

Text-Analysis Results

In this project, 21 translated interview transcripts were analysed using the Atlas.ti qualitative data analysis software. The aim of text-analysis was to compare the difference between barriers and enablers of cross-border smart cities in three sectorial dimensions. For this purpose, both barriers and enablers were coded, 20 words were selected for each coding (see Table 3 for codes). As a supporting tool to complement the main descriptive analysis (part 4.1.), no strong difference between barriers and enablers were found, both as totals and across sectors. Nevertheless, it should be noted that the public sector and the third sector (associations and ngos) focused more on offering solutions (enablers) instead of indicating the problems (barriers). The private sector, on the other hand, pointed out more critical components to be solved. This indicates that companies experience market barries to cross-border services directly whereas public administrators see it from the distance.

In this project, two codes (barriers and enablers) are used as classification devices in order to create sets of related information units for the purpose of comparison. Each code has 20 quataitons, created manually by the researcher (in textual documents, a quotation is an arbitrary sequence of characters ranging in length from a single character, to a word, a sentence, or a paragraph, even up to the entire data file). Quatations were analysed on the sentence levels, which means that the entire sentence that contains the indicated markers - quatations, will be a subject to the analysis. In other words, when a matched quatation is found in the text, the size of the segment to be coded is specified as a sentence surrounding the matched quation. This strategy allows to map and analyse the entire sentences as barriers-sentences or enablers-sentences and thus, involve other common quatations to the analysis as well, see the results on the comparitative Figures 6 and 7.

IMPLICATIONS

Merging public urban services of close cross-border cities (e.g. Helsinki and Tallinn; San Diego and Tijuana; Seattle and Vancouver; Hong Kong and Shenzhen; Singapore and Johor City) enhances

Table 3. Code-document table

	Barriers	Enablers	Totals
Private sector	25	17	42
Public sector	20	33	53
Third sector	13	16	29
Totals	**58**	**66**	124

Figure 6. Text-analysis of enablers

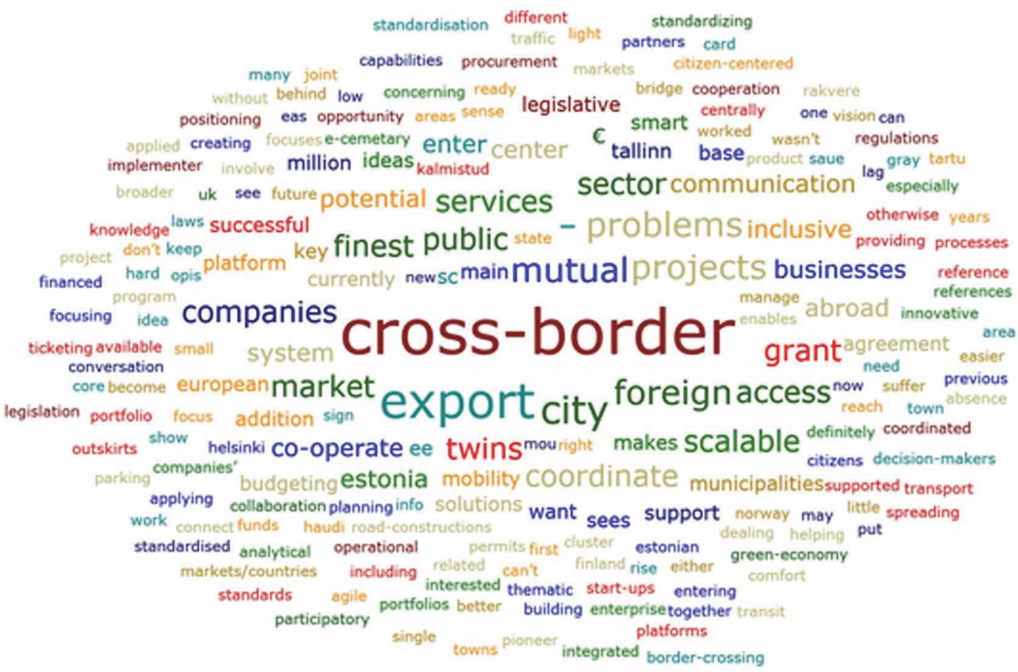
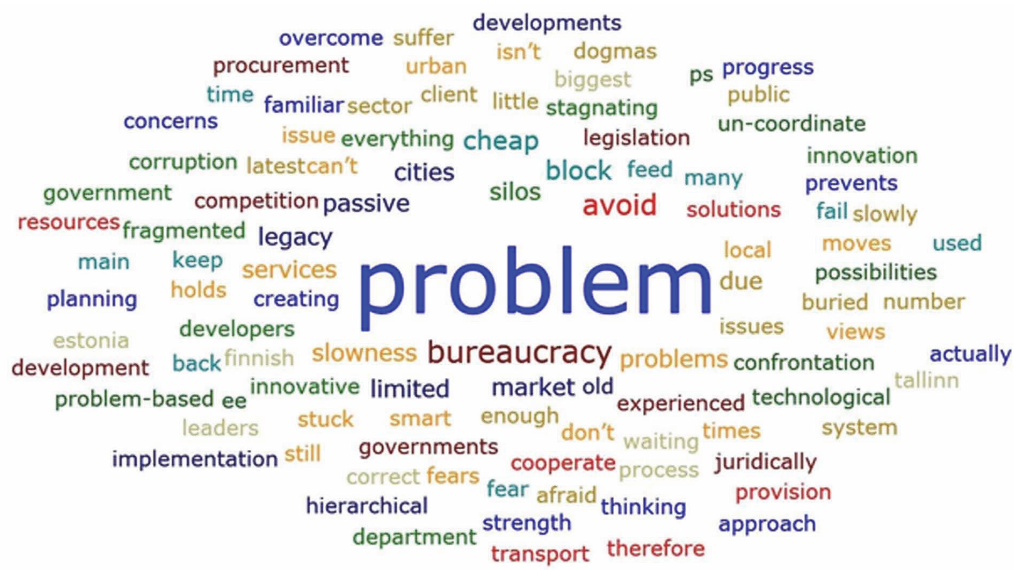


Figure 7. Text-analysis of barriers



everyday living and working of hundreds of thousands of commuting citizens. Despite very close economic and social connections, currently cities have very few joint digital servicnes for commuting citizens. This clearly indicates that even very close ICT savvy municipalities lack capabilities how to offer joint services, in spite of high-level technological readiness and frequently commuting citizens' natural demand. The main challenge is not technological but related to making agreements with stakeholders and bringing different parties together.

There is a need to start from simple and widespread urban services through collaborative joint cross-border hands-on pilots (e.g. public transportation tickets and mobile parking for heterogeneous cities) and practice joint procurements for innovative solutions. Standardisation is also the key to cross-border urban services. The real threat is that if local municipalities do not manage to innovate from bottom-up jointly with neighbouring cities (both national and international), then all the cross-border solutions will be enforced top-down or aggressively linked to global business vendors. In both cases, the local stakeholders are not involved effectively.

CONCLUSION

This paper introduced the need for collaboration in developing smart city services. In the theoretical section, most authors agree that a city is smart when it connects various services and functions, therefore, reducing silos. On the other hand, there is a research gap in the inter-city perspective, papers do not focus on the cross-border need for heterogeneous cities, based on actual commuting patterns. This is one of the first papers to focus on the cross-border aspect of smart city claiming that two ubiquitous cities do not automatically lead to ubiquitous services within these cities. This can actually lead to more fragmentation, for example, in the case of parking and public transport tickets between Tallinn and Helsinki.

As one possible conceptual solution, this paper proposed a framework for joint cross-border digital services (the Urban OS) and analysed how the concept is perceived in the capital cities of Estonia and Finland. The Urban OS is a collaboration platform for joint digital services between two heterogeneous urban areas and an important driver of the Digital Single Market. Thus, the concept is flexible and does not follow one-size-fits-it-all approach. The main argument of the Urban OS is that cities need to collaborate on technological, policy and political layers, if they wanted to offer better services for commuters and tourists and make locally developed smart city solutions globally scalable.

The empirical part, looking from the Estonian side, clearly states the reasons for the lack of joint services: business sector claims that there are market barriers, NGOs that there is a lack of funding and the public sector argues that innovations are not ready. What is clear, there are clear expectations errors, from all sectors perspective. Most experts agreed that cross-border services are the main enabler of intercity collaboration whereas legacy, lack of coordination and closed digital border are the main barriers. From the positive perspective, the cities of Tallinn and Helsinki have recently initiated joint digital projects based on the Memorandum of Understanding.

ACKNOWLEDGMENT

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ENDNOTES

1 http://www.uudenmaanliitto.fi/files/14178/Helsinki_Smart_Region_Paper_2014_2nd_Edition_15.9.2014.pdf

2 http://www.tallinn.ee/est/g739s1671 (in Estonian)

APPENDIX 1.

List of Interviewed People:
Private Sector:

1. Hele-Mai Metsal, Port of Tallinn, Infrastructure Department, Head of Development Department
2. Mari Pultsin, SpinTek, Board Member
3. Alar Võrk, Cityntel, CEO
4. Seth Lackman, Ericsson Estonia, CEO
5. Madis Sassiad, GoSwift, Board Member
6. Nils Kändler, Infragate, Board Member
7. Erki Saluveer, Positium, CTO

Public Sector:

1. Toomas Haidak, Ministry of Economic Affairs and Communications of Estonia, Head of Transport Investment Department
2. Kaur Sarv, Ministry of Economic Affairs and Communications of Estonia, Chief Expert
3. Janek Rozov –Ministry of Economic Affairs and Communications of Estonia, Head of IT Development Department
4. Liis Palumets, Ministry of Finance of Estonia, Regional development and the Smart Cities measure, Chief Expert
5. Eedi Sepp, Ministry of Finance of Estonia, Regional development and the Smart Cities measure, Chief Expert
6. Siim Sikkut, Government Office of Estonia, ICT Policy Advisor to the Prime Minster
7. Toomas Sepp, Tallinn City, Head of City Administration (City Secretary)
8. Liivar Luts, Tallinn City, Lead Transport Specialist

Third Sector (Associations, NGOs, Academia)

1. Kalle Karron – Rakvere Smart House Competence Centre, CEO
2. Eero Pärgmäe – Tehnopol, Development Manager
3. Hannes Astok, Tartu Smart City Lab, Development Manager
4. Mari Jüssi, Swedish Environment Institute in Tallinn, Senior Fellow
5. Teele Pehk, Foundation Estonian Cooperation Assembly, Head
6. Vaido Mikheim, Tartu Science Park, Project Manager

Ralf-Martin Soe (M) is at the Head Predictive Governance Lab at Tallinn University of Technology. During the last three years, he has been focused on initiating and coordinating new large-scale Smart City Research and Innovation projects with strong export potential. He has previously worked at the United Nations University's Innovation Centre of Excellence, UNU Merit (Holland), for the UK Government and in PwC as a Financial and Economic Consultant. Mr Soe has two master degrees in the speciality of financial management (MSc, Maastricht University, and MBA, University of Tartu) and is a PhD Research Fellow at Tallinn University of Technology (focusing on smart cities).

Article II

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Agile local governments: Experimentation before implementation

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A B S T R A C T

This paper discusses how local governments can team up for joint service provision, be more adaptive towards new technological and organisational changes and introduce novel services following main industry trends (e.g. predictive analytics, autonomous vehicles and artificial intelligence). The conceptual approach is to use Public Value (PV) as the framework for the organisation and management of government performance, one of the most important successor 'paradigmettes' of the New Public Management (NPM). Based on the PV concept, the 'adaptive model' for local governments is introduced according to which each procured ICT solution is preceded by agile, open, bottom-up and experimental trial. This model is corroborated via recent empirical evidence from the case of Helsinki and Tallinn which was obtained by observing how city governments collaborate on joint innovation-lab-type structures and conduct agile trials in the field of smart mobility before traditional procurement.

1. Introduction

This project is interested in how ICT adds public value via agile methods. According to the modern-classic essay by Dunleavy, Margetts, Bastow, and Tinkler (2008), government information systems are a big business (costing up to 1% of GDP a year), for instance, the United Kingdom spends around £ 14 billion annually to public-sector IT operations. At the same time, not all government IT projects deliver public value (Luna-Reyes, Picazo-Vela, Luna, & Gil-Garcia, 2016). In this light, there is a logical need to analyse and propose digital government models, both theoretical ones and through best practices. These models are becoming more complex and they have to solve the challenges how (local) governments can become more experimental, adaptive and agile at the same time delivering public and social value through digital government projects.

In this paper, we argue that a Public Management concept that, after the fall of the New Public Management (NPM), is particularly suitable to frame this phenomenon is Public Value (PV), as it offers a high degree of freedom for innovative solutions and has great potential for establishing open ecosystems that are pronounced as important by the e-Government side itself (inspired by the classic essay on the death of NPM-long live digital-era Governance by Dunleavy, Margetts, Bastow, & Tinkler, 2006). Empirically, we will look at a novel process for introducing Intelligent Transport System solutions tested in two EU capitals, Helsinki and Tallinn. This process is unique as the typical one-city procurement is preceded by open, agile and cross-border trials with state-of-art technologies introduced via setting up two-city pop-up innovation structures for twelve months prior the procurement. The early empirical evidence indicates that it is possible for local governments to launch their own ICT solutions by having a higher level of technology, cross-border solutions and cooperation. We will analyse organisational, structural, managerial and procedural changes required to sustain and replicate this.

In order to achieve adaptive governance as proposed by Janssen and Voort (2016), organisations need to be able to deal with the changes and introduce more decentralised and bottom-up decision-making structures via mobilising more talents and participants. The main purpose of a private firm is to generate profit, but this is already inherently different in the public sector (Drechsler, 2005), which is crucial when evaluating the impact of ICT use in the public sector. Hence the focus on PV, which according to Moore (1995), is a broader understanding of a return or benefit than private value, adapted to the public sector for strategic management purposes. In other words, the aim of private managers is to create private (often monetary) value, whereas the aim of public managers it to create public (social) value (Luna-Reyes et al., 2016).

An increasing number of e-Government researchers (Cordella & Bonina, 2012; Karunasena & Deng, 2010; Kearns, 2004; Yıldız & Saylam, 2013; Yu, 2008) therefore recommend using PV in e-Government analysis, similarly to Public Administration scholars (e.g. O'Flynn, 2007). Nevertheless, the question remains how to do so, as PV as a theory remains necessarily fuzzy, or critically put, vague (Benington &

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Moore, 2011). This paper will offer one approach how to operationalise PV in e-Government research by building on the PV framework for e-Government by Kearns (2004) and Karunasena and Deng (2010) and deconstructing PV into high-quality services, achievement of outcomes and trust in public institutions. It does so by analyzing the cross-border setting of two European capitals (Helsinki and Tallinn) in depth by closely observing the agile approach for procuring ICT solutions for cross-border commuters. The sources of data for the qualitative case study include policy documents, project materials and interviews.

2. Literature review

Electronic government (or e-Government) is still a relatively novel concept. The term was widely unknown two decades ago but now is booming as there are academic programs on e-Government, specific conferences and journals solely devoted to this (Heeks & Bailur, 2007). On the other hand, the nature of e-Government is not static. According to Schelin (2003), before the introduction of the Internet and diffusion of personal computers, the main objectives of technology in government were improving the effectiveness of public administrators while increasing government productivity, e.g. the automation of mass transactions such as financial transactions using mainframe computers. After the Internet era, ICT is increasingly related to the way citizens and businesses interact with the government (non-tool view of technology). The next layer is an ICT-triggered change in the government on four layers: organisational, structural, managerial and procedural, as proposed by Gong and Janssen (2012). In parallel, agile methods, here defined as fast and responsive processes (Martini & Bosch, 2016), are introduced both for software development (e.g. Mergel, 2016) and for Open Government Data (e.g. Mcbride, Aavik, Kalvet, & Krimmer, 2018).

Nonetheless, most e-Government researchers agree that the concept of e-Government is vague as well (e.g., Aldrich, Bertot, & McClure, 2002; Bretschneider, 2003; Yildiz, 2007). There is no single, widely agreed upon definition (Halchin, 2004). In the current paper, e-Government is defined as “the use of ICTs, and particularly the Internet, as a tool to achieve better government” (OECD, 2003). The impact of e-Government at the broadest level is simply better government by enabling better policy outcomes, higher quality services, greater engagement with citizens and by improving other key outputs identified (Field, Muller, & Lau, 2003). A related concept is e-Governance which refers to the whole system involved in managing a society, including beside government institutions, also companies and voluntary organisations and citizens (Grönlund & Horan, 2005).

Similarly, digital government can be defined as the use of IT applications in government (Luna-Reyes et al., 2016). Yet by and large, and seeing how the word is actually used, it is just a newer, more fashionable synonym for e-Government. Adaptive governance originally stems from socio-ecological systems that can respond to rapid changes in the environment (Wang, Medaglia, & Zheng, 2017). With no agreed-upon definition, there seems to be consensus regarding the main characteristics of adaptive governance, introduced by Janssen and van der Voort (2016): decentralised decision-making, mobilisation of capabilities (internal/external), wider participation and adjustments to deal with uncertainty. Wang et al. (2017) introduced three types of adaptive governance: polycentric, agile and organic, in other words, claiming that agile governance is a part of adaptive governance. In the ICT domain, agile software development aims to make development processes fast and responsive, minimising the time between identification of a customer need and delivering a solution (Martini & Bosch, 2016).

The concepts of digital government, adaptive governance and agile governance are usually (if often implicitly) interlinked but not the same (see Fig. 1). This paper assumes that digital governance is the broadest concept while agile government the most narrow, although this is debatable. Zhang and Kim (2016) point out that digital government's causal relationships are troubled by uncertainty. In reality, wicked problems also stand for adaptive and agile governance and largely influence their relationships. In other words, Fig. 1 is not static but dynamic and can be redrawn numerous times, with different scales and from different standpoints.

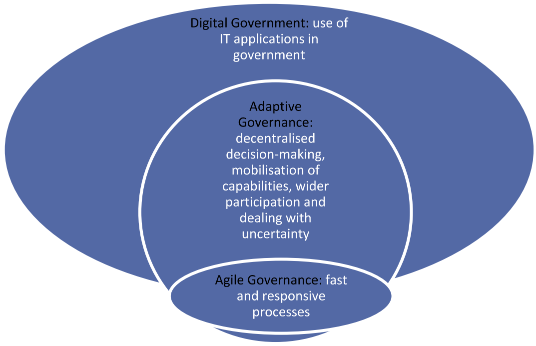


Fig. 1. Main concepts: digital government, adaptive and agile governance.

It has become commonplace to argue, according to authors such as Janowski, Pardo, and Davies (2012), that governments can no longer achieve public goals by themselves alone, but that they have to work through networks of state and non-state. Arguably, this was never different, and already Max Weber regards this as a truism (Kattel, Drechsler & Karo, 2018), the argument has currently entered the front of the state once again, and it is true that ICTs help to connect actors to the network and to build, manage and sustain relationships between them (Janowski et al., 2012).

One often associates the concept of “traditional” administration with Max Weber (although now, functionally it is NPM that is traditional). But the genesis of today's Public Administration is perhaps best described by Pollitt and Bouckaert (2017), as the result of a process like geological sedimentation, where new layers overlie but do not wash away the previous one. They describe a long list of different models and approaches to public sector management, including for our post-NPM time such ‘paradigmettes’ as joined-up government/whole of government, the Neo-Weberian State, and not least, the PV.

The question is how all this fits into the understanding of e-Government. In the literature, it has been often linked to the NPM, as claimed by many e-Government scholars (Alford & Hughes, 2008; Allen, Juillet, Paquet, & Roy, 2001; Cordella, 2007; Cordella & Bonina, 2012; Heeks, 2002; Yıldız & Saylam, 2013). The classic piece by Dunleavy, Patrick; Margetts, Helen; Bastow, Simon; Tinkler (2006) was instrumental in debunking this myth, however, and since then, an increasing number of scholars (Alford & Hughes, 2008; Cordella & Bonina, 2012; Yıldız & Saylam, 2013) argue for using specifically PV instead.

NPM is often presented as a “one-size fits all” view of the world (Alford & Hughes, 2008; Hood, 1991) that should not be suggested for local governments (Matheus & Janssen, 2017). Alford and Hughes (2008) propose that the next movement in public management should be “Public Value Pragmatism,” which is principle-bound regarding ends but pragmatic in means, in contrast to NPM which is seen as universal. Cordella and Bonina (2012) introduce PV as a paradigm shift from NPM to address ICT-enabled public sector reforms. According to them, this would change the weight of analysis of ICT implementation in the public sector from merely direct economic and management relationships in the direction to collective preferences (see also Table 1). In principle, PV can prioritise effective and efficient management practices but it may also focus on values of fairness, equality and just society.

Table 1
Public value versus new public management.

Paradigm	Public Value	New Public Management
Rationale	Public administration	Private management
Dominant focus	Relationships, politics enactment	Administrative rationalisation, results
Definition of public interest	Collective preferences	Aggregated individual preferences
Performance objective	Multiple objectives, shifting over time	Management of inputs and outputs to ensure economy and responsiveness to customers
Dominant model of accountability	Multiple accountability systems	Upward accountability via performance contracts
Preferred system of delivery	Menu of alternatives selected pragmatically	Private sector or tightly defined arms-length public agency
Means	Fulfilment of multiple objectives	Competition
Ends	Fulfilment of social expectations	"Government that works better and costs less"

Source: Cordella & Bonina, 2012 (adopted from O'Flynn (2007) & Stoker (2006)).

Once again, public sector and private sector management goals and aims are not strongly correlated, therefore, private sector management tools and practices should not be implemented without understanding the differences: private sector managers' aim to generate private/monetary value whereas the public sector managers' ultimate goal is improvement of the public/social value. This is the core reason why PV could be taken as the successor to NPM best-suited for e-Government, which has the same intentions and projections as well. In addition, also operations and applications are not the same between the two sectors (for example, Bertot, Estevez, & Janowski, 2016 split public and private sector applications and claim that policy and governance innovations are unique to the public sector exclusively).

Geographical and multilevel differences are not central to this analysis, although these dimensions matter. Hansson, Talantsev, Nouri, Ekenberg, and Lindgren (2016) have analysed the presence of open government deliberative ideology in post-soviet countries (including Estonia) and claim that post-soviet countries tend to focus more on freedom of information and accountability, and less on collaboration, diversity and innovation. There can also be the difference in adaptive governance on the local and central levels. Hong and Lee (2017), for example, claim that local governments are assumed to be more responsive to citizens, thus being more adaptive.

3. Research design and methods

3.1. Conceptual framework of PV for digital government

In this paper, we propose a way to organise and manage e-Government within the framework of PV. To use PV that way is not novel but has been done, e.g., by the World Economic Forum (World Economic Forum, 2011).

The main goal of PV, it has been claimed, is to examine the performance of public service from the perspective of citizens (Karunasena & Deng, 2010). The most common criticism towards PV is, as previously mentioned, that it suffers from definitional vagueness (Benington & Moore, 2011). Jorgensen and Bozeman (2007) identified 72 public values in 7 different value categories. To narrow this down, this project explicitly utilises the frameworks of Kearns (2004) and Karunasena and Deng (2010) to link e-Government with the concept of PV. This also matches, by and large, with definition of Good Governance by OECD, problematic though the latter may be (Drechsler, 2004).

Previous studies analysed for this project have claimed that there is an impact of e-Government on service quality (Kearns, 2004), mainly through an increased amount of information available to citizens, but questions areas such as take-up and fairness. There is mixed evidence on cost-reduction, but this might derive from time lag. In the case of desired social outcomes in important areas such as health, education or transportation, the results are inconsistent, although there is a positive story to tell in every aspect (Kearns, 2004). The relationship between e-Government and trust remains weak. Avgerou, Ganzaroli, Poulymenakou, and Reinhard (2009) claim that ICT can enforce trustworthiness (the delivery what is expected), not trust, which is for them socially constructed.

Kearns (2004) proposes to link public value in relation to e-Government using three sources: 1) high quality of public services (availability, satisfaction of users, perceived importance, fairness of importance, fairness of provision, cost); 2) achievement of outcomes (improvements in health, reduced poverty, environmental improvements) and 3) trust in public institutions that also includes participation, inspired by Picazo-Vela, Gutiérrez-Martínez, Duhamel, Luna, and Luna-Reyes (2015) who propose citizen participation as an important factor of value creation. Karunasena and Deng (2010) suggest a framework for evaluating the public values of e-Government in Sri Lanka based on three drivers of public value creation: 1) delivery of quality services; 2) operating effective public organisations and 3) achievement of socially desirable outcomes. The conceptual framework for evaluating the PV of Government is proposed in Fig. 2.

3.2. Research design and method

This paper analyses the set-up of cross-border agile trials in Tallinn and Helsinki as part of the project FINEST Smart Mobility (FESM),[1] especially the design and implementation of open and agile innovation trials as part of the procurement process. This project was selected for the following reasons:

1. It meets the PV concept: open and collaborative approach
2. Real-life experimentation via agile trials
3. Cross-border set-up makes the model replicable in other cities
4. Focus on key PV aspects: aims to improve high-demand mobility services (quality of services) and reduce CO_2 emissions (achievement of social outcomes)
5. Access to recent primary and secondary data

The project summary is the following:

The connection between Helsinki West Harbour and Tallinn Old City Harbour is one of the busiest in the world with over 8 million annual passengers. The FESM project aims to tackle this ever-increasing challenge through intelligent traffic solutions. The project provides more fluent integration of different transport modes of this inter-city and cross-border traffic with piloting and planning ICT-driven solutions. As an outcome transportation time for both passengers and cargo are expected to be reduced. The better flow of people and good results in less CO_2 emission and noise in the port area as well as in the cities are expected. Through cross-border approach, end-to-end and user-centric experience are ensured and better cross-border mobility planning achieved. The project is funded through Interreg Central Baltic programme (EU Structural funds) with a total budget of 1.8 million euros. Project partners are City of Helsinki, City of Tallinn, ITL Digital Lab,

[1] www.finestsmartmobility.com

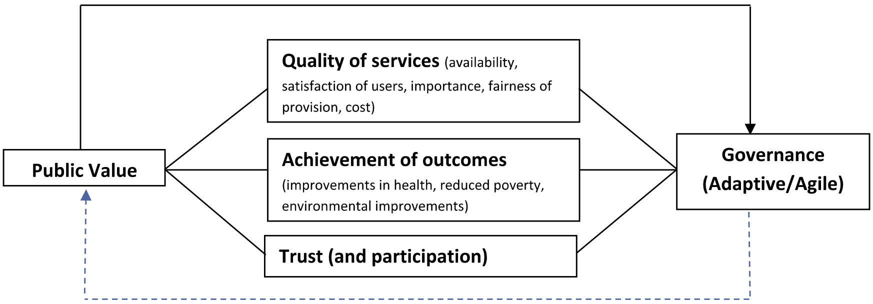


Fig. 2. The Public Value theoretical framework.

City of Vantaa, Estonian Road Administration and Forum Virium Helsinki.

The research method is a case study of Tallinn and greater Helsinki (cities of Helsinki and Vantaa) pursuing to implement digital urban transport solutions. Data was gathered through in-depth analysis of open-innovation living-lab trials via joint procurement between Tallinn and Helsinki. The data collection can be divided into two parts: 1. Preparatory phase and 2. Competition phase (see Fig. 3 below).

In the preparation phase (mid 2015–mid 2016), data was gathered via primary and secondary sources. The primary data include non-structured focus group interviews that were conducted with the city representatives (three officials from the city of Tallinn, three from the city of Helsinki and one official from the Ministry of Economic Affairs and Communications, Estonia) and companies (five Intelligent Transport Systems companies). In addition, the Estonian Association of Information Technology and Telecommunications also participated in both focus group interviews. Secondary sources include published and unpublished reports, project proposals and documents.

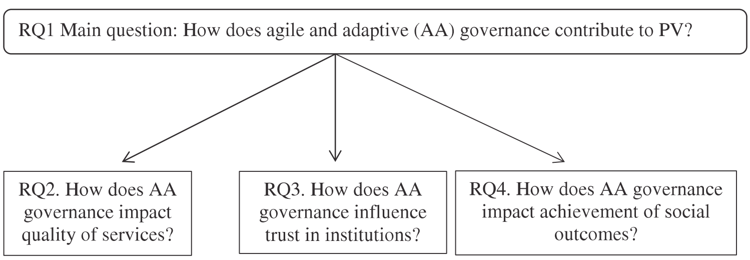
The competition phase includes a punctual description of the two-city procurement process. We observed the design and implementation of the agile piloting phase via access to procurement documents and companies' bids and participated the evaluation meetings. The most important evaluation consensus meeting took place on 19 December 2016 and had nine participants (four from the city of Helsinki, two from the city of Vantaa, one from the city of Tallinn, one from Ministry of Economic Affairs and Communications and one from the Estonian Association of Information Technology and Telecommunications).

3.2.1. Competition phase: agile pilots programme implementation and evaluation

The agile trials programme was set-up by two innovation labs, Forum Virium and ITL Digital Lab. Compared to the detailed and specific city-level procurements, the agile trials programme was open for everybody to participate. The prize fund was € 67,500 and participants were instructed to bid in the range of € 2000 – € 15,000. The call was introduced in October 2016 and disseminated through various channels (e.g. websites, direct contact with companies, advertisement in national workshops and seminars but also in international ones like Barcelona Smart City Expo). The application form published on the website[2] had simple and easy-fill-in structure and with no restrictions set for participants (e.g. size of a company, previous experiences, country of origin etc.). The applicants had to give their basic contacts and provide a brief answer to the following questions (see also Appendix 1):

- A brief description of the fast innovation trial: How would you use the money?
- Who would execute the trial in your organisation?
- Your proposed price of the trial (in EUR, including VAT)
- What are the tasks and deliverables, and their schedule
- How do you think your proposal would help plan better smart mobility solutions?
- What would you need from the consortium in order to execute the trial?
- Do you give the consortium right to use the deliverables in the project next stage planning and promotion?
- Public two-paragraph text presentation of your trial

The application process, a wide and open participation process with no restrictions, attracted much interest towards the agile trials programme. In total, there were 35 international applications submitted, from which five trials were selected (success rate of 14%). Most applicants were SMEs, although there were a few start-ups, two big local players with more than thousand employees and one global technology



[2] http://www.finestlink.fi/smartmobility

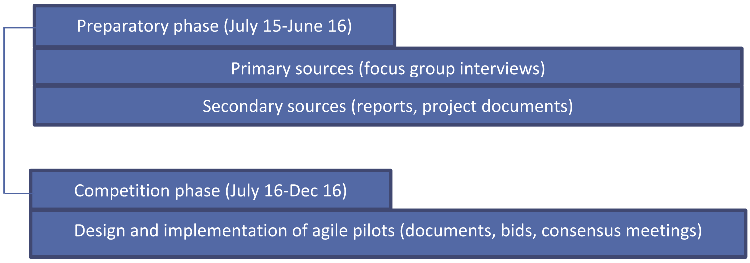


Fig. 3. Research design in two phases.

company. Typically, filling in the application form took half an hour to one day (feedback from winning proposals) which can be considered as low bureaucracy. As a selective process, the proposals introduced various state-of-art solutions like machine-learning, autonomous cars, robots in ports, artificial intelligence, 3D virtual models, smart city sensors and LoRa application.

The proposals were evaluated by nine experts from partner's organisations (Forum Virium, ITL Digital Lab, Road Administration and cities of Helsinki, Vantaa and Tallinn) as well as one associated partner (Ministry of Economic Affairs and Communications in Estonia). All participants had to evaluate each proposal following the four evaluation criteria, each ranked from 1 to 5 (see Table 2). After individual votes, there was a consensus meeting that analysed the first 20 proposals and generated the list of five winning proposals and five second-best proposals. The winners were announced late December 2016 and trials started in January 2017.

4. Analysis and results

4.1. Setting the scene: Tallinn-Helsinki cross-border area

Two European capitals, Helsinki and Tallinn, are in a unique situation. Between the two small nations (combined population of seven million), there is a high commuting frequency. According to the national statistics, approximately every 15–20th Estonian lives in Finland and commutes back to Estonia on a regular basis (see also Fig. 4 – based on the mobile positioning data). For Finland, Estonia is the most popular investment and tourism destination; every fifth Finn stays overnight in Estonia each year. The two countries speak unique Finno-Ugric languages. In terms of innovation, both countries are relatively strong in digital innovations.

On the national levels, Estonia and Finland have a reputation of being frontrunners of digital innovations. Two very small European countries are the birthplaces of Nokia and Skype, respectively. Estonia is renowned for having one of the most innovative e-Governments in Europe.[3] No other nation has equipped each of its citizens with a secure digital identity and no other nation has connected all public databases over the Internet, using a secure transport layer (the X-road). Helsinki, on the other hand, is considered among the 6 most successful European smart cities.[4]

4.1.1. Digital infrastructure in the region

From the ICT architecture, there are two cornerstones of the ICT deployment in Estonia: widely used electronic identity and secure exchange of data over the Internet. In the first case, most residents of Estonia (93%) have a personal ID card that is used in the digital environment for authentication and electronic signatures (Soe, 2017). Secondly, all government-sector databases (over 3000) are linked with each other via the Internet using the secure transport platform called x-road (see Fig. 5). The x-road is an open-standard transport layer that connects various databases with each other, independent from the vendors (potential for full interoperability).

The public infrastructure applies to Finland and two capital cities as well. The Estonian ID card is taken over by Finland and Finland is the second country to implement the X-road. This offers an experimental setting for digital cross-border services.

4.2. The mobility challenge in the region

The ferry connection between Helsinki West Harbour and Tallinn Old City Harbour is one of the busiest in Europe with over eight million annual passengers. The North Sea-Baltic TEN-T Core corridor meets Scandinavian-Mediterranean TEN-T core corridor at Helsinki, thus being a key node in the transport networks of northern Europe. Already the current traffic creates substantial congestion, noise and other negative externalities at both ports and at both cities. There has been no common mobility planning and there are no cross-border Intelligent Transport System (ITS) solutions.

According to the Finnish Traffic Agency, there are over 8 million travellers (see Fig. 6), over a million private cars and 0.25 million trucks taking the mobility journey between Helsinki Harbours and Tallinn Old City Harbour annually. The total mobility has been growing and has been projected to grow. Both cities have decided to keep the ports next to the city centres and are building new residential areas immediately next to the port sites. In both ports, the amount of space reserved for truck parking is decreasing. Already with the current traffic level to/from ports, the congestion, as well as noise and other negative externalities, is substantial. This affects both the travellers as well as local residents. For example, the peak driving times for the first kilometre out from the port has been measured to be over 50 min.

The rush hours of loading and unloading the ferries and the interference of the port traffic with the daily commuting traffic create peak congestion events that escalate the problems. Better management of these interferences is possible with smart solutions, and with better mobility planning. More so, the mobility users see the ferry leg of their journey just as one part of their trip and the modality changes at both ports as a single entity. The cross-border approach is needed to ensure a smooth end-to-end user experience.

The lack of intelligent transport systems has been listed as one of the main missing links for the North-Sea Baltic corridor by the European Union.

4.3. FESM initiative objectives for providing public value

The Finest Smart Mobility project aims to provide more fluent integration of different transport modes of inter-city and cross-border traffic via the planning and piloting of ICT-driven solutions, in order to reduce time in transportation for both passengers and cargo, that is, to provide better public value. The better flow reduces both time vehicles

[3] http://www.europarl.europa.eu/RegData/etudes/etudes/join/2013/507481/IPOL-IMCO_ET(2013)507481_EN.pdf

[4] www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdf

Table 2
Evaluation of agile trials.

Criteria for evaluation	Evaluated in scale 1–5
Innovativeness of the trial	• A genuinely new service idea or product • The experiment generated new practices/ solutions/aspects to a specific challenge
Potential for a scalable service	• Usability of the service • The functionality of the business model • The potential for long-term solution • Can be put in practice in Helsinki and Tallinn capital regions early 2017
Teams and resources	• Skills and know-how of the executive team • Other resources of the executive team (e.g. funding, collaboration) • Potential to continue developing the service after the experiment • Executed by a consortium of more than one organisation or company
Smart, agile and user-driven	• Service/product utilises ICT-technology or data • Use of agile development methods • Service responds to the needs of users

spend in port areas as well as the fluency of the traffic flow. This will also reduce CO_2 emissions and noise. The cross-border approach is needed in order ensure the end-to-end user-centric experience of the mobility as well as better planning: same or similar tools for the commuters on both ports, tools for the ferry operators, urban planners, and data.

The FESM project is piloting smart solutions that will reduce the travel time. The project contributes to these targets also indirectly: by contributing to open data and open source enablers for further innovations, and by mobility planning that further enables and drives towards travel time reduction in the mobility. The FESM aims to create also market references for smart port solution provider companies.

The FESM project plans to create pragmatic improvements and enablers that directly enhance the mobility flows and have a direct impact on mobility planning for local governments. Smart mobility solutions - ICT-based solutions - are aimed to be a potential and cost-effective way to increase and improve the mobility flows. They are also potentially a tool to integrate services on both ports and cities in order to enhance the user experience, and use of sustainable options. The project aims to solve specific, highly visible mobility challenges with smart solution pilots.

The project plans to improve the mobility flows arriving and leaving the Helsinki West Harbour and Tallinn Old City Harbour. It will optimise and smoothen the mobility journeys of people, public transport, private cars and trucks arriving and leaving the ports. It addresses both local and transit traffic. It does this

i) by implementing ICT solutions ('pilots') which improve the efficiency and enable smart management of mobility, and
ii) by creating a mobility plan that addresses the international mobility aspects.

As the traffic is heavily congested at peak hours, coherent mobility management together with smart ICT solutions is planned to lead to a reduction of travel times, which contributes both to transport flows of people and transport flows of goods. More fluent mobility flow and faster travel times will also lead to fewer CO_2 emissions per person/per tonne, less noise and other emissions at residential areas next to the ports. Congestion escalates these negative externalities, for example, repeated stops and starts of the trucks create more emissions than fluent driving.

The smart solutions can substantially contribute to successful

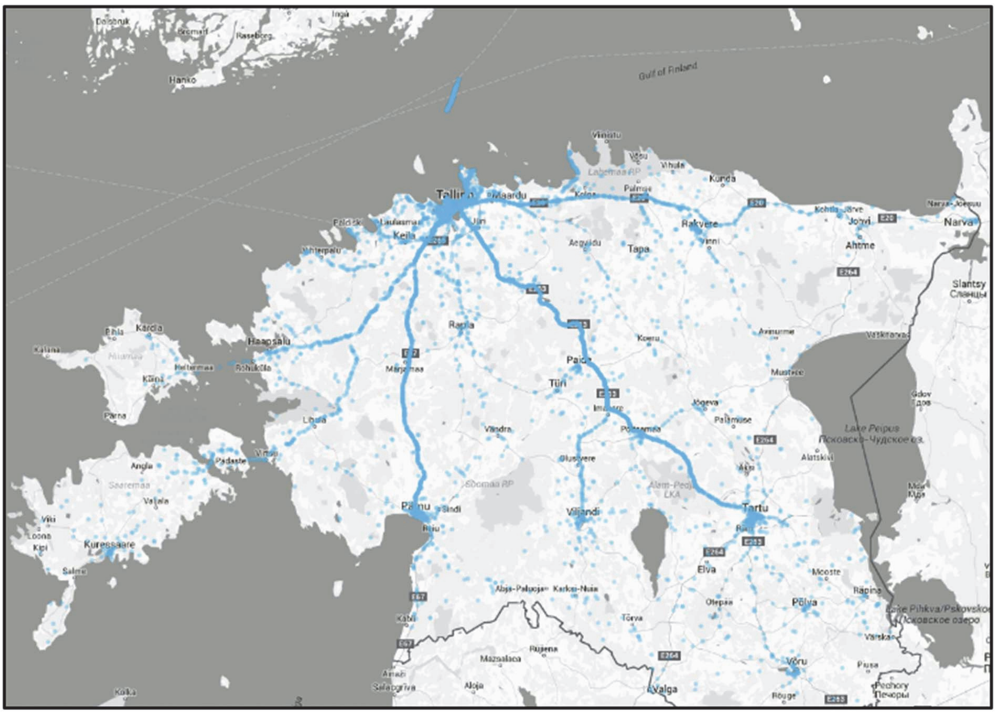


Fig. 4. Commuting frequency between Estonia and Finland.

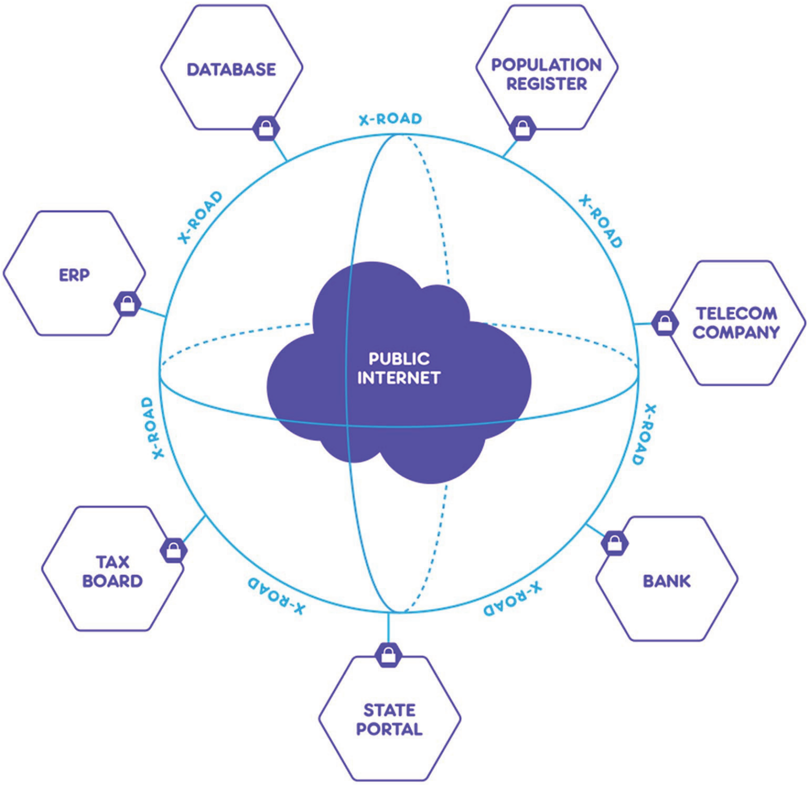


Fig. 5. The X-road. Source: Information System Authority of Estonia

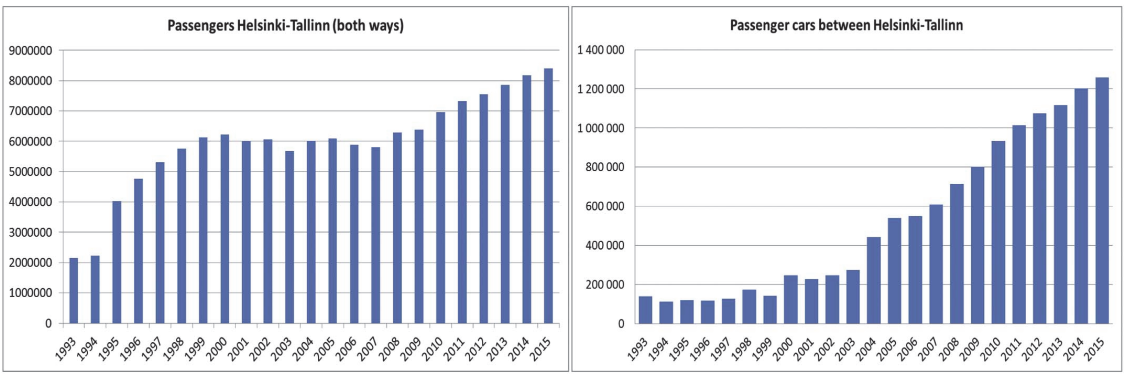


Fig. 6. Passengers between Tallinn-Helsinki.
(Source: Finnish Traffic Agency, 2016)

management of the closure of the truck parking areas near the ports. From the users' perspective, the smart solutions can provide a smooth integration of the different modalities, and easy to use information about the public transport options. This could further drive the modal shift towards public transport, easing the congestion by choosing sustainable transport modes.

4.4. FESM piloting programme

The FESM project will conduct five pilots to be implemented in 2017–2019:

- **PILOT 1**: Just-in-time logistics for Heavy Good Vehicles, based on truck parking at the ring-roads and mobile application that directs them to the boarding. This is expected to reduce the time-in-city with an estimate of 5–10% per truck. This is also a key tool to manage the closure of the truck parking at ports.
- **PILOT 2**: Smart management outbound traffic, with dynamic mobility management with signage and integration to navigators and possibly to smart traffic lights. This integrates the unloading traffic

to city traffic better, improving also other traffic.

- **PILOT 3**: Smart Park&Ride for ferry passengers with private cars to increase the use of public transport for the port entry/exit. This includes easy real-time information and ordering of the Park&Ride and public transport options. This is expected to reduce the number of private cars to the ports by 5%.
- **PILOT 4**: Smart traffic solution pilot in order to increase the modal split of public transport for travellers from Estonia to Helsinki Airport with a ferry connection.
- **PILOT 5**: a feasibility study with a pilot regarding the Tallinn ring-road to improve the management of both commuting and international transit traffic flows with ITS solutions.

The focus of the project is to pilot and invest to new types of solutions to optimise the flow of people and goods. Solutions will be used and developed also after the project, and are projected to be replicable to other environments. For example, queuing systems for ports will be extended to ensure smoother and less congested traffic flow. As ports are currently developed and Heavy-Goods-Vehicles (HGV) waiting areas will be closed, it is clear that there is a need for a “smart” queuing system. The same applies for out-going traffic, which easily creates congestion in cities, with smart guiding systems the congestion can be avoided. In Vantaa, the objective is to integrate the cross-border public transport and ferry options, which will lead to increased use of public transport for various passenger groups. In Tallinn, at least one of the intersections on Reidi tee (the new road to the main port) will be equipped with self-learning adaptive streetlights; this improves vehicles' permeability and reduces traffic congestion and also CO_2 emissions. The City of Tallinn has the intention for developing a “smart” intersection solution, using more real-time analysis in the main novel road to the Old Harbour, which could be extended later to other main intersections. It is certainly wise to continue developing of Smart Park & Ride (P&R) after the end of the project and currently, Tallinn is trying to find ways to expand the system even more (new P&R terminals, new smart services, etc.). The feasibility study of dynamic traffic management will be in a key role to plan and implement real ITS technology investments on ring road corridor which is connector road to main ports. Cross-border solutions developed during this project can be expanded to similar solutions to other EU countries.

4.5. Agile trials for cross-border regions

To ensure the pilots' quality from the user perspective, and the best exploitation of emerging technologies, the project engages the planners, mobility users and technology stakeholders in the process of co-designing the use cases: descriptions of journeys on ‘how things could be’, including agile trials of emerging technologies (€ 67,500 in value). The project then executes the large pilots (€ 1,000,000 in value) through a public procurement. The take-up of smart solutions will affect the real-life mobility journeys and travel time. Smart solution pilots will primarily be integrated features into existing user interfaces e.g. car navigators, route planners and ferry applications. This is accomplished with open data and open APIs.

This FESM is unique for introducing open and agile trials before procuring the pilots that will be developed into long-lasting solutions (see Fig. 7). This set-up is experimental and if proven successful, could be a trigger for change how local governments procure novel ICT solutions. Conceptually, this is a shift towards bottom-up and decentralised local government that implements up-to-date technologies including a large group of stakeholders in the first stages. On the other hand, this also means higher initial investment. There are very few examples of local governments doing experimental trials before real ICT procurement. The next chapter will describe the trials in depth.

4.6. Organisation change: creating public value via innovation ecosystem

In order to develop the traffic flow between regions, it is vital to involve all parties. This project involves relevant organisations from Tallinn and Helsinki, and it creates a common understanding how seamless travel can be achieved. A substantial share of the traffic in the macro-region consists of cross-border traffic between Helsinki and Tallinn. The traffic planning regarding one city/port directly affects the other. To enable optimal mobility planning and optimal solutions, a common approach is needed. The core partnership structure is created naturally from the challenge addressed: public sector organisations responsible for the management and planning of take-up of smart solutions in the Tallinn Old City Harbour - Helsinki West Harbour connection. These are teamed-up with innovation labs and operate in a close collaboration with ports of Tallinn-Helsinki.

Core partners of the FESM:

- **City of Helsinki** (capital of Finland) is the local authority over mobility related issues in Helsinki. City of Helsinki (Economic Development division) coordinates the whole project. City of Helsinki (City Planning Department; West Harbour Project) will provide expertise for the harbour mobility planning for the pilots. **Responsible for pilots**.
- **The city of Vantaa** is the location of Helsinki Airport. **Responsible for pilots**.
- **City of Tallinn** (capital of Estonia) is the local authority over mobility related issues in Tallinn and consequently a partner in the project pilots. **Responsible for pilots**.
- **Estonian Road Administration** is a government agency which performs the implementation of state policy and development programmes, management functions, state supervision, and applies the enforcement powers of the state in the field of road management, traffic safety, public transport and the environmental safety of vehicles. **Responsible for pilots**.
- **The Estonian ITL Digital Lab** is a non-profit and non-governmental organisation dedicated to uniting companies in the ICT sector. **Responsible for agile trials**.
- **Forum Virium** is a limited company fully owned by the City of Helsinki. **Responsible for agile trials**.

All pilots start with a one-year planning stage done together by all partners. This consists of expertise planning with mobility experts and authorities, detailed market analysis, and user-centric solutions/requirements planning with the real mobility users (public transport operators, private car travellers, truck drivers, truck companies). Small agile trials to probe and validate new technology opportunities are part of the planning stage. After the planning stage, the pilots will be executed in the implementation stage in 2017–2018. Procurement with competitive dialogue procedure will be used as the tool to execute the pilots. The pilots will end with a transition period that will integrate the piloted solutions into cities' normal operations. The preparation also includes identification and involvement of the key stakeholders and partners, defining the development process and scope of the plan.

In total, five agile trials and five pilots will be executed by external providers (companies). The specifications for pilots will be developed after conducting trials, that is, real hands-on demonstrations in real-life for approximately one week. There are clear elements of organisational, structural, managerial and procedural changes: trials are designed and conducted by innovation labs (Forum Virium and ITL Digital Lab) whereas the real pilots and solutions will be procured by ‘mature players’, the cities of Helsinki, Vantaa and Tallinn. The core reason for linking innovation labs to this process is to be adaptive and agile compared to the assumed established bureaucratic structures of cities (although this is a bit of a cliché, Kattel, Drechsler & Karo, 2018). The trials took four months from project kick-off to real implementation of these, see the Fig. 8.

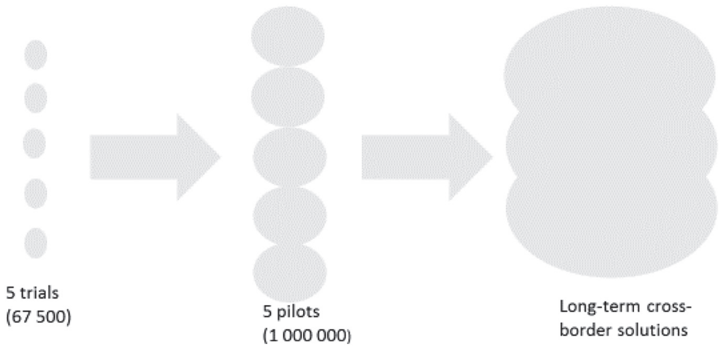


Fig. 7. Overview of the FESM project concept.

5. Results

This paper contributes to seeking the novel theoretical models how governments, especially local ones, can generate more public and social value with ICT projects. First, PV as a concept is proposed for evaluation in the (local) digital government research. Secondly, this paper contributes linking public value with emerging concepts of adaptive and agile governance. Thirdly, a modified conceptual framework is proposed (see also Table 3). Therefore, the main theoretical contribution is linking adaptive and agile governance with the PV concept. In addition, this paper argues that digitalisation is challenging the closed-unit conceptualisation of governments: there is a need for cross-border models as digital tools can effectively work across the borders.

Empirically, the aim of agile trials programme was to make a public and open call for prototypes in the field of planned five pilots. The specifications for the larger pilots will be adjusted according to the results of the trials. The initial pilots were designed by three cities and Road Administration officials two-three years ago which is a typical time lag from project planning to project implementation in the public sector. For city-administrations, agile trials are considered as a market test, to understand what kind of novel technologies are available. Therefore, trials introduce agile and adaptive feedback mechanism into the standard procurement process: through open and wide calls for trials, local governments can test the market and experiment with new solutions. After the trials are concluded, the specifications for real pilots and therefore also long-lasting ICT solutions can incorporate more state-of-the-art solutions.

There were five winning proposals financed by the innovation labs in the consortium. Two proposals were from Finland and three from Estonia. There is a clear pattern of success: the winning trials are the experimental ones with easy-to-implement real-life autonomous trials with limited or no integration of databases and systems of partners needed for trials. The following winning agile trials were implemented in 2017:

- **Goswift**: as the port traffic is growing and the amount of truck parking around the port is reduced, a smart service solution is required. City Port Arrival Management (CPAM) will provide heavy goods vehicles with a specific arrival route and time to start the journey. It will be an improvement for all stakeholders: truck drivers will know their reliable route to the port, ferry operators will know that the vehicles arrive on time and the city will have the possibility to limit congestion, noise and pollution.
- **Positium** will develop a service prototype whose purpose is to better understand cross-border movements in twin-cities using mobile phone location data. Movements of people travelling between Helsinki and Tallinn and their journeys in destinations are analysed and visualised. Ferry companies are able to identify passenger flows between harbours but have little information about further movement after leaving the ferry. This service prototype will add a new dimension: Positium will analyse the mobility flows that pass through ports and map the movements in both urban areas after arriving in port (Estonians in Helsinki region and Finns in Tallinn regions). As a result, we will be able to map popular tourist stops, as well as the most common routes taken at the destination. Knowing tourists' activity spaces, better urban planning can be undertaken, creating a pleasant environment for both the tourists and the locals.
- **Jiffi** is the world's first hands-free mobile ticketing system for public transport that utilises Bluetooth Low Energy communication protocol and micro-location technology to detect when passengers enter and exit the transit vehicle. This will streamline ticketing process, thus speeding up the time of travel. Jiffi's system would be installed on the trams servicing West Terminal in Helsinki for a limited piloting period so that a selected group of passengers arriving from Tallinn would be able to test the system and give valuable feedback about the accuracy and pleasantness of the new innovative solution.
- **FLOU**: Successfully managed open ecosystems enable new and existing companies to act as Sherpas combining existing services to create better service levels for FinEst (Finland and Estonia) passengers as well as motivating them to reduce external costs of their transportation. The aim of the FinEst Sherpa challenge is to look at new service models, project the benefits to different stakeholders and find a way to enable the ecosystem.
- The **TownHall24** trial with a 24/7 accessible smart container and a digital service platform provides carless alternatives to local transport and logistics needs. Passengers and locals can rent equipment to complement their own or shared public transport options such as city bikes, share second-hand goods and receive deliveries to reduce shopping trips and errands or have heavy luggage delivered to the port by other drivers while taking public transport themselves.

6. Discussion and implications

The key point to understand a winning smart solution is to understand that this is not a one-city nor one-country game. Even megacities (Tokyo, Sao Paulo) are arguably challenged when having to create a real ecosystem of cutting-edge agile and adaptive governance solutions (predictive analytics, Internet of Things and Big Data technologies). The first instalments have led to inflexible “smart cities in a box” or “smart countries in a box,” which are ageing fast, and from which solutions do

Fig. 8. The timeline of agile trials.

Table 3
Main theoretical contribution.

Main contribution	Theoretical building blocks
1.Using Public value for digital government research	Benington and Moore; Cordella, Bonina and Willcocks; Luna-Reyes, Picazo-Vela, Luna & Gil-Garcia,
2.Establishing a link between public value and adaptive and agile governance	Bertot, Estevez, Janowski; Hong and Lee; Janssen and van der Voort; Mergel; Wang, Medaglia & Zheng
3.Public Value framework for digital government including adaptive and agile governance	Karunasena and Deng; Kearns

not scale elsewhere. This paper observed closely a case of cross-border cities (Helsinki, Tallinn and Vantaa) co-operation in the search for joint solutions for end-users as proofs that local governments can be agile and adaptive by implementing new methods (experimental trials) and working closely with innovation labs with different organisational culture than centuries-old traditional local governments.

6.1. Theoretical implications

Citizens in cross-border regions are interested in local governments' ability to provide public value through quality of services, real outcomes against societal challenges that combined creates trust in institutions – a conceptual framework suggested for e-Government research in this paper. What should the cities do if 1/15 of the population commutes to the neighbouring city in a different country? The NPM, rooted in protecting a single entity's financial interests, did not provide a solution for this, as the foundation of the NPM is that cities have to compete with each other, e.g. for the tax revenues. The PV concept is proposed as it is not focused on drawing strict borders between the cities but is focused on cooperation and openness instead. When comparing ICT solutions offered by local governments with successful technology companies, one key factor stands out: solutions offered by technology companies go over the borders, solutions offered by local governments typically end where the borders of that city end. For example, Uber works the same way in all cities unless banned but there are hundreds of interoperable smart transport cards introduced by local governments and locked-in to specific cities only.

6.2. Practical implications

There is limited evidence how local governments can be more adaptive to a changing environment and introduce agile methods, and this project provides practical advice for local governments on how to design and implement agile trials. This paper has observed a new model how local governments (and also central governments) can be more “innovative” by using agile tools in an open collaboration with neighbouring local governments, innovation labs and SMEs. This project monitored closely how local governments can introduce open and agile trials before ICT procurement and implementation. Typically, the public sector is not fully open to implementing agile methods when the solution is outsourced as it is typically locked-into the procurement regulations that require all products and services to be specified in depth prior the procurement. In other words, it is not possible to develop a purchased bicycle into e-bike or motorcycle once the technology approves. Therefore, the local governments can either increase in-house development or, alternatively, introduce more agile methods to get the best specifications for the procured solutions. One tool, described in this paper, is to introduce agile trials before full-scale procurement. Agile trials are bottom-up and decentralised (see also Table 4), attract the state-of-the-art technologies, and have the potential to generate more public value.

Table 4
Agile trials (PV) versus traditional approach (NPM) to procurement (based on Table 1).

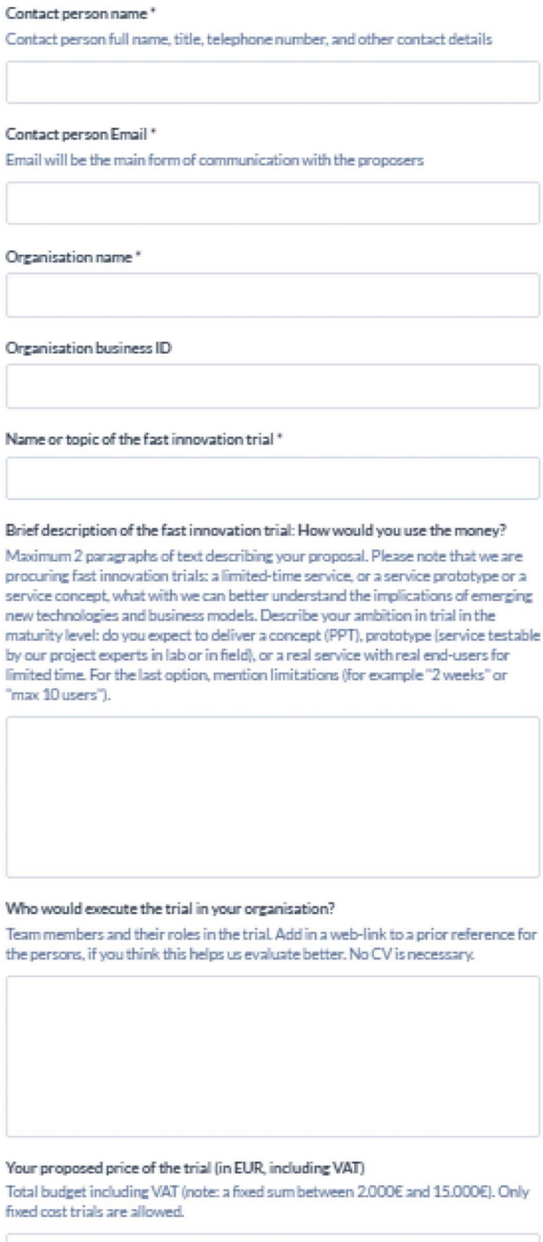
	Agile trials (PV)	Traditional approach (NPM)
Level of centralisation	Bottom-up, decentralised	Top-down, centralised
Level of technology	Up-to-date	Time-lagged
Involvement of stakeholders	Open approach	Closed approach
First stage cost	Higher initial investment	Lower initial investment
Public value added in		
Quality of services	High	Medium
Achievement of outcomes	High	Medium
Trust in institutions	Medium to High	Low to Medium

There is limited empirical evidence how agile trials work. This paper analysed the implementation of agile trials in two capital areas in in the Northern Europe. Although the project Finest Smart Mobility that included fast trials before procurement started only in late 2016, there is already the first evidence that this allows local governments of Tallinn, Helsinki and Vantaa to gain a better understanding of new technologies and attract more local companies to experimenting with new solutions for the public use.

7. Conclusions

This paper proposes a new way to manage government performances within the framework of PV with novel dimensions: adaptive and agile governance. The main research question (RQ1) was interested how agile and adaptive governance contributes to public value and it was replied by three sub-questions. The sub-questions were focused on the interplay between agile and adaptive governance and three domains of PV: quality of services, trust in institutions and achievement of social outcomes. These questions were analysed via recent empirical evidence in the case of cities of Helsinki and Tallinn. As the results of this particular case study, city governments can effectively improve the design mobility services (quality of services – Research Question 2), reduce CO2 emissions (achievement social outcomes- Research Question 3), and create trust in institutions (Research Question 4) while at the same time being adaptive and agile.

Appendix 1. Agile pilots online application form



Contact person name *

Contact person full name, title, telephone number, and other contact details

Contact person Email *

Email will be the main form of communication with the proposers

Organisation name *

Organisation business ID

Name or topic of the fast innovation trial *

Brief description of the fast innovation trial: How would you use the money?

Maximum 2 paragraphs of text describing your proposal. Please note that we are procuring fast innovation trials: a limited-time service, or a service prototype or a service concept, what with we can better understand the implications of emerging new technologies and business models. Describe your ambition in trial in the maturity level: do you expect to deliver a concept (PPT), prototype (service testable by our project experts in lab or in field), or a real service with real end-users for limited time. For the last option, mention limitations (for example "2 weeks" or "max 10 users").

Who would execute the trial in your organisation?

Team members and their roles in the trial. Add in a web-link to a prior reference for the persons, if you think this helps us evaluate better. No CV is necessary.

Your proposed price of the trial (in EUR, including VAT)

Total budget including VAT (note: a fixed sum between 2.000€ and 15.000€). Only fixed cost trials are allowed.

What are the tasks and deliverables, and their schedule

Maximum one line of text per task and per deliverable. Mention delivery month of the deliverable, and the IPRs for each deliverable. The default will be that all of the IPR ownership of all deliverables remains with you - we buy service trials limited in time. But we will require to have free, open usage rights for any general insights we learned regarding the technology or the business model, as well as a public presentation material about the trial.

How do you think your proposal would help us plan better smart mobility solutions?

Does it give any insight in the future procurement of smart mobility solution? Does it give us new ways to think about mobility planning or management? Are the proposed technologies or business models innovative enough?

What would you need from us in order to execute the trial?

Do you expect us, or someone else than you, participate in the execution or planning of the trial? How, when, and how much? What else would you expect? Have you identified critical external interfaces you need in order to deliver the trial?

Do you give us right to use the deliverables in the project next stage planning and promotion? *

I give my permission to use our pilot and project results as a reference material in communication of FinEst Smart Mobility project.

- Yes
- No

Public two paragraph text presentation of your trial

The public introduction of the innovation trial will be published in the project page. Maximum 500 characters.

Lähetä / Send

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Article III

Soe, R.-M., & Mikheeva, O. (2017). The Combined Model of Smart Cities and Electronic Payments. In P. Parycek & N. Edelmann (Ed.), *7th International Conference for E-Democracy and Open Government (CeDEM)* (pp. 194-205). Krems (Austria): IEEE Computer Society, doi: 10.1109/CeDEM.2017.11 (3.1.)

2017 International Conference for E-Democracy and Open Government

Combined model of smart cities and electronic payments

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Abstract — **Typically, smart city innovations are considered in the field of mobility, energy and built environment whereas the financial dimension is neglected or plays a rather marginal role. This paper goes beyond this classification and analyses explicitly the link between the smart city and electronic payments by looking into the two groups of cases – East Asian, comprised of Singapore and Hong Kong, and Northern European, comprised of Tallinn and Helsinki. The two regions with high level of urban digitalization were selected in order to analyse the level of electronic payments systems in these cities inspired by the research question: can the level of electronic payments be used as a proxy for smart cities? By presenting empirical analysis along these lines of research, the study further argues that incorporating financial services provision – particularly electronic payment systems – into existing concepts of smart city (e.g. proposed by Batty or Giffinger) would help to move from a rather abstract notions of smart economy and smart living towards more concrete technological and policy initiatives.**

Keywords: smart city, electronic payment systems, ICT, interoperability, East Asia, Northern Europe

I. INTRODUCTION

The smart city initiatives touch upon various aspects of urban living – from infrastructure and sustainable environment programmes to electronic governance. Emerging smart city policy initiatives and related scholarly discussions have primarily dealt with financial aspects of how to finance smart city programmes: from public-private partnerships and 'smart' bonds to guarantee schemes provided by national development banks (such as German KfW) and attracting international institutional investors, which makes large-scale city projects compete globally. Interestingly, developments and innovations in financial sector *per se*, both as part of related smart city projects and as an independent development, have received less attention. The former is predominantly represented in electronic payment systems, which are increasingly labelled as smart payment systems.

Cities handle large money flows as well as various fines, fees and use payments, which make payment systems an important target for modernisation [28]. Digitization of payments is perceived as favourable due to enhanced efficiency (i.e. handling cash is more expensive), increased transparency and possibility of greater oversight over city's finances. Nevertheless, it is not only the city administrations that are subject to financial innovations, the digitization of payments affects the entire ecosystem in cities, especially the interaction between businesses and customers. In a city environment, integration of payment mechanisms aims at enabling a sought after convenience of interoperability. In addition, electronic means of payments are perceived as facilitators of financial inclusion (e.g. prepaid cards for unbanked citizens - City ID prepaid debit card was first launched in Oakland, US, in 2013) while prepaid benefits cards and virtual cards are meant to both strengthen the transparency and increase operational efficiency. In other words, transparency and cost-efficiency are the two major arguments in favour of digitization of payments. At the same time, challenges include issues of connectivity, appropriate levels of security [18] [19], use of cloud computing to store and use the data securely, visibility and higher expectations of ROI (return-on-investment) as well as citizens' demands for greater personalization of services [28]. Moreover, electronic payments could also contribute to the digital divide, that is, support those who are tech-savvy while disadvantaging those with limited digital and financial literacy (e.g. no bank account).

To explore electronic payment systems in relation to smart city, current study poses the following research question: "can the development of electronic payment systems reflect the perceived smartness of cities". To answer this question, the study compares two different regions and four urban areas that are known for a high level of digitalization: East Asian on one hand

[1] Both authors are corresponding authors and have contributed to this paper on the 50-50 basis

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(Singapore and Hong Kong) and Northern European on the other hand (Tallinn and Helsinki). All four cities (Tallinn, Helsinki, Singapore and Hong Kong) are tech-savvy and have been known for high levels of urban digitalization (see table 1) with some of them scoring high on smart city rankings, although there is no systematic and dominant ranking framework of smart cities. From empirical perspective, by identifying respective policy initiatives, where relevant, and actual implementation of digital payment solutions, the study allows to juxtapose the experiences of the two East Asian city-states, which have been at the forefront of smart city solutions as well as e-payments, to more recent developments in the two Northern European cities, where smart city initiatives and e-payment solutions have been rapidly emerging. From conceptual perspective, the aim of the study is to see whether and in what way electronic payment systems could be incorporated into existing concepts that dominate discussions on smart cities. For this, a conceptual framework for smart cities that includes electronic payments will be proposed. Current study contributes to the emerging conceptual discussion on how to determine which cities are smart cities and how to rank them. Another, rather supportive layer in paper's analysis, is to compare electronic payments in policy driven smart cities (Singapore and Hong Kong) to more bottom-up smart city eco-systems like Helsinki and Tallinn. In other words, the aim of the paper is twofold: 1) to gather empirical data regarding the use of electronic payment systems in selected cases, and 2) to discuss the notion of electronic payments and their potential relevance to existing concepts of smart city.

TABLE I. CASE SELECTION

City	*Region*	*Policy-Driven/ Bottom-Up*	*Level of urban digitalization*	*Level of integrated payment systems*
Tallinn	Northern Europe	Bottom-up	High level of urban digitalization (smart city services via X-road and electronic Identity)	To be analysed (cross-border approach)
Helsinki	Northern Europe	Bottom-up	High level of urban digitalization (Helsinki is ranked as top 6 European Smart City)	To be analysed (cross-border approach)
Singapore	East Asia	Policy-driven	High level of urban digitalization (Singapore is ranked as top 1 smart city)	To be analysed
Hong Kong	East Asia	Policy-driven	High level of urban digitalization (labels itself as a global leading smart city)	To be analysed

The research method is an exploratory qualitative study using comparative case study approach. Empirical data collection involved primary and secondary sources, such as policy documents, project materials, strategies, reports, media articles, unstructured interviews and unstructured panel meetings with experts. When confronted with lack of respective policy initiatives, the study relied on description of existing e-payment solutions and their rationales. By presenting empirical analysis along these lines of research, the study further argues that incorporating financial services provision – particularly electronic payment systems used in retail – into existing concepts of smart city would help to move from a rather abstract notions of 'smart economy' and 'smart urban living' towards more concrete technological and (potential) policy initiatives. The structure of the paper is as follows: next comes an overview of dominant concepts of smart city with the focus on payments and its role therein; then empirical cases are presented and discussed; the final part consists of conclusion and suggestions for future research.

II. SMART CITY AND ELECTRONIC PAYMENTS

Electronic payment systems often appear to be an integral part of smart cities since cash-based cities are not in the top performers in smart city rankings and vice versa. Yet, there are very few frameworks linking the two. First, empirical and conceptual frameworks that do link electronic payment systems (e.g. standards developed by International Telecommunication Union (ITU), corporate indexes and smart city conceptual frameworks) are analysed, and second, an integrative framework is proposed. In other words, this section analyses smart city theoretical frameworks that include financial innovations, namely electronic payments. Typical smart city concepts and empirical cases focus on mobility, construction and energy tied with Information and Communication Technology (ICT). Most smart city concepts do not include electronic payment systems. On the other hand, most authors agree that smart city is a relatively novel concept that lacks definitional precision [7] [26] [27]. Several frameworks have been proposed for conceptualising the smart city but none of them has gained significant dominance [3] [4] [21].

Although, attempts have been made to bring the notion of standardization to the field – e.g. an ongoing work by the British Standard Institute, commissioned by the UK government, on defining business cases, models, forms of funding and other aspects of economic assessment of smart city projects; recently issued ISO (International Organisation for Standardization) standards in 2014 and 2016 for cities and communities respectively. A new ISO standard issued for smart cities includes 17 thematic KPIs (key performance indicators) with Finance being one of them: it consists of one core indicator – debt service ratio (debt service expenditure as a percent of a municipality's own source revenue) – and three supporting indicators – capital spending as a percentage of total expenditures, own-source revenue as a percentage of total revenues, and tax collected as a percentage of tax billed (ISO 37120:2014[2]) thereby emphasizing how financially sustainable a city is or should be. Meanwhile, a set of standards developed by the Focus Group on Smart Sustainable Cities at the International Telecommunication Union (ITU) includes electronic payments and financial services [17] while financial institutions are also identified as important

[2] http://www.iso.org/iso/37120_briefing_note.pdf

stakeholders in ICT development programmes [16]. In other words, ITU identifies financial services and payment systems as an integral part of smart city projects while ISO focuses on financial performance only. Among existing sets of KPIs and index systems for smart cities the following agencies included financial service provisions in their policy documents: China's Ministry of Housing and Urban-Rural Development (smart payments, smart finance), Ericsson in its 'Networked Society Index' (electronic and mobile phone payments), IBM in its 'Smarter City Assessment' (access to finance), PwC in its 'Cities of Opportunities Index' (financial and business services employment) [16]. Although, in its latest technical report ISO also acknowledges the role payment systems (micro, electronic) should play in smart city models [15].

In the 1990s, when the Smart City term was first used, the term focused on the interplay between novel ICTs and modern (physical) infrastructure in cities [29]. A smart or ubiquitous city is ICT-enabled, making ubiquitous computing available to urban elements everywhere including computer chips and sensors [30]. The smart city concept is not limited to the diffusion of ICT, and the focus has shifted towards a government-oriented approach that highlights the role of social capital and relations in urban development [2]. In a meta-study of Smart City definitions, Hollands [7] summarises that a smart city maximises the "utilisation of networked infrastructure to improve economic and political efficiency and enable social, cultural, and urban development." Caragliu et al. [4] developed this further and claim: "a city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance." In other words, none of the concepts above mentions financial innovations like electronic payments as part of the smart city (or its synonyms: electronic city, wired city, intelligent city etc) concept. In this light, current study's approach is to analyse how to complement two smart city frameworks (Batty's science of cities and Giffinger's six smart city characteristics) with financial services, particularly by including electronic payments.

A research group led by the Vienna University of Technology [6] identified six components of the smart city: smart economy, smart mobility, smart environment, smart people, smart living and smart governance. A large smart city meta-study conducted by the European Commission, led by Manville et al. [22] developed this further and mentioned that a smart city should address one or more of the following six characteristics:

Smart Living:

- ICT-enabled lifestyles, behaviour and consumption;
- Healthy and safe living in a culturally vibrant city with diverse cultural facilities;
- Good quality housing and accommodation;
- Smart Living is also linked to high levels of social cohesion and social capital.

Smart Mobility:

- ICT supported and integrated transport and logistics systems.
- For example, sustainable, safe and interconnected transportation systems can encompass trams, buses, trains, metros, cars, cycles and pedestrians in situations using one or more modes of transport.
- Smart Mobility prioritises clean and often non-motorised options.
- Relevant and real-time information can be accessed by the public in order to save time and improve commuting efficiency, save costs and reduce CO_2 emissions, as well as to network transport managers to improve services and provide feedback to citizens.

Smart Environment:

- Smart energy including renewables, ICT-enabled energy grids, metering, pollution control and monitoring, renovation of buildings and amenities, green buildings, green urban planning.
- Principals: resource use efficiency, re-use and resource substitution.
- Examples: street lighting, waste management, drainage and water resource systems that are monitored to evaluate the system, reduce pollution and improve quality.

Smart Governance:

- Services and interactions which link and integrate public, private, civil and EC organisations so that they can function as one organism.
- Smart Governance objectives include transparency and open data by using ICT and e-government in participatory decision-making and co-created e-services (apps).
- Transversal factor.

Smart Economy:

- E-business and e-commerce via increased productivity;
- ICT-enabled and advanced manufacturing and delivery of services;
- ICT-enabled innovation: new products, new services and business models.

Smart People

- E-skills, ICT-enabled working;
- Access to education and training, human resources and capacity management;
- Inclusive society that improves creativity and fosters innovation;
- Enable people to input, use, manipulate and personalise data, for example through appropriate data analytic tools and dashboards, to make decisions and create products and services.

The European Commission's in-depth meta-study [22] has clarified Giffinger's Smart Economy concept by adding e-business / e-commerce, which could be complemented, as current study suggests, with an additional dimension: namely electronic payments (Fig. 1).

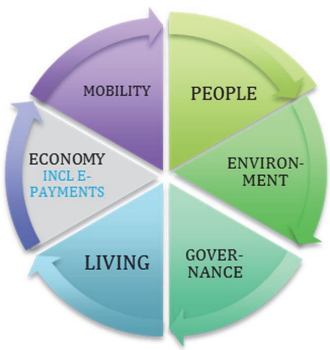

Figure 1. Modified Smart City concept of Giffinger (e-payments added)

Batty et al. [3] define Smart City as "a city in which ICT is merged with traditional infrastructure, coordinated and integrated using digital services. These technologies establish the functions of the city and also provide ways in which citizen groups, governments, businesses, and various types of agencies who have an interest in generating more efficient and equitable systems can interact in augmenting their understanding of the city and also providing essential engagement in the design and planning process." The study sketches the research agenda for Smart Cities and point out that research should develop new forms of urban governance and organisation (in other words, re-engineering cities).

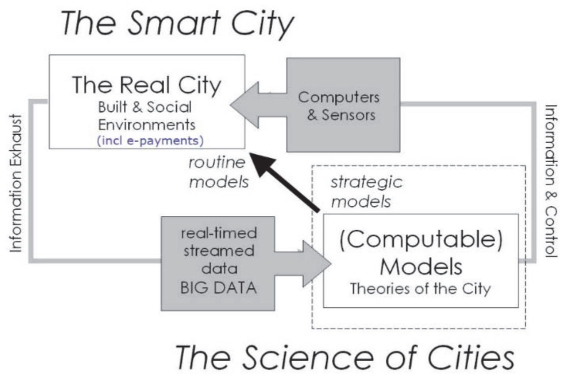

Figure 2. Modified Smart City concept of Batty et al (e-payments added)

According to Batty et al [3], Fig. 2 above provides a useful focus for understanding what smart city research and innovation actions should entail:

●Improving Mobility: Minimising Disruption, Producing Better Quality Travel Experiences, Minimising Energy Consumption

●Improving the Use of Resource such as Energy: Smart Sensors and Grids

●Enabling Integrated Design of Built Environments: Through ICT, Local Networks, WLAN, Cloud Services
●Providing Access to Public Information: Open Data and Transparency
●Improving Citizen Participation: Engaging Wider Circles of Citizens in Relevant Decisions
●Improving Democratic Decision-Making: Through New Methods of Information Delivery to Citizens and Methods for Online Engagement
●Improving Retailing/Commerce: Delivering Better Information and Access to Consumers and Producers in Real and Online Environments
●Enabling Better Housing Choices: through Access to Capital, Information about Supply
●Delivering Better Information to Urban Management: Through a Variety of Media such as Dashboards and Other Interfaces
●Providing Services for Building Integrated ICT Platforms: Providing Integrated IS at Different Scales
●Providing Integrated Data Services: Adding Value to Data, Opening Data.

Some of these activities overlap as one might expect but this is a broad range of functions that demand some very different skills and perspectives [29]. Moreover, many of them relate to other organisations which have urban mandates such as utility services, local governments, financial services, and a variety of formal and informal agencies which operate in cities. Batty et al [3] have also pointed out that Smart City research and innovation actions should improve retailing/ commerce and offer better access to capital. These two points provide the basis for linking the concepts of smart city with smart payment systems. In other words, the "real city" on the illustration above can also represent financial services as seen in Fig. 2 above. In other words, the two prominent conceptualisations of smart cities, one by Batty and another by Giffinger, provide an opportunity to integrate electronic payment systems into smart city frameworks. Moreover, an emerging field of standardisation of 'smartness' demonstrates that to certain extent digital payments are indeed regarded as integral to smarter urban living, as suggested by ITU. This brings forth the need for empirical studies to map actual developments and implementation of digital payment solutions. The comparative analysis of the four cases selected for current study that will be described below.

III. SMART CITIES: SELECTED CASES

Four cities exhibit continuity in digitisation of payments, yet of various intensity and with various actors being in charge: from explicit and centrally planned policy initiatives to more bottom-up developments by innovative business actors. Further, in some cases diffusion of e-payment solutions crosses national borders owing to increasing standardisation and certain demand factors, as will be shown below. The latter is exemplified by two Northern European cities Tallinn and Helsinki. Due to the novelty and high relevance of cross-border e-payment solutions to current study, Tallinn-Helsinki region will be analysed jointly, as the two capitals are close and well commuted, thus, the level of cross-border services is an integral part of both urban areas. Overall, Estonia and Finland have been at the forefront of e-governance developments. The use of similar ICT infrastructure, which facilitates the development of inter-regional solutions, makes the two cities a relevant comparison. Both countries score high in the use of ICT and online banking. Moreover, similarities in cultures, language, attitudes and close proximity, which involves intensive collaboration in trade, communication, transport and finance, act as a somewhat demand factor for designing innovative cross-border services (e.g. mobile parking ticketing is currently being developed).

In another pair of cases, both Hong Kong and Singapore have been serving as regional financial centres since the times of spice trade (given the scope of the article, administrative autonomy of Hong Kong is considered sufficient to put it with Singapore into a single category of city-states). In contemporary city-states, financial industry continues playing a pivotal role in economic development and in addition to a large offshore financial sector, the national financial industry keeps thriving. Despite the fact that both city-states are governed by national-like authorities and therefore any generalisation should be treated with caution, yet developments in electronic payment systems deserve an attention. Both city-states score high in regional and global rankings of smart cities (e.g. by Boyd Cohen) and both Hong Kong and Singapore have been continuously investing in financial infrastructure.

A. Hong Kong

Hong Kong has been ranked among the top smart cities due to early and far-reaching developments in electronic payments and an effective urban transportation. Hong Kong has been the pioneer in smart cards: the Octopus Smart Card (Fig. 3), first introduced in 1997, was emulated by London's Oyster Card and in other cities around the world, allows to make both online and offline payments for all public transport and parking as well as in supermarkets and fast-food restaurants with over 13 million transaction processed a day (as of 2015). Over 28 million Octopus cards are in circulation; over 99% of people aged between 15 and 64 are using Octopus; more than 15 000 retail outlets from over 6 000 service providers accept payment by Octopus; more than 70 000 Octopus card readers have been installed; over 13 million Octopus transactions are processed a day (transactions are valued at over HK$150 million [2]). In addition, e-payments have been an essential part of modernization in cargo industry through collaboration between government and cargo firms [2].

Figure 3. Octopus Smart Card in Hong Kong (source: hong-kong-traveller.com)

Another two prominent developments in e-payments are EPS and PPS systems: both combine credit cards with payments for various public services. The largest electronic payment system, which is run by the consortia of 22 banks registered with the EPS Company, was designed in 1985 and is currently active in Hong Kong, Macao and Shenzhen. The system also allows withdrawing cash upon a purchase thereby eliminating the need to use the ATM. In addition, payments of various fees (utilities, government charges, telecom services, education services, charities) can be done either by phone or online – a venture run jointly by the EPS Company and HK Telecommunications.

At the same time, e-commerce lies at the core of SME programmes and development grants. Provision of high-tech financial infrastructure facilitating electronic transactions was made a policy priority with subsequent lines in the annual budget in 1995/96 by the Financial Secretary [9]. Hong Kong's Monetary Authority has been active in promoting financial services via effective regulatory framework and by launching retail payment initiatives through consortia of banks and local retailers (e.g. among most recent are e-Cheque, Electronic Bill Presentment and Payment (EBBP), Store Value Facilities (SVFs) and Retail Payment Systems (RPSs) [8]. Altogether, these policy initiatives should be viewed within the context of an International Financial Center, which Hong Kong exemplifies. At the same time, various agencies are in charge of various smart city programmes thereby creating fragmentation of policy implementation and administration. Central Policy Unit (CPU) [2] recognises this as an impediment to further progress by comparing Hong Kong with the experience of Singapore where strategy formulation and policy implementation are more streamlined and centralised with a separate agency (IDA, currently IMDA) dedicated to Info-communications development and integration.

B. Singapore

Owing to Singapore's long-standing commitment to become another International Financial Center in Asia, in addition to Hong Kong, and a regional financial hub, Singapore's officials emphasise a unique policy orientation taken by the Monetary Authority (MAS) to transform the city-state into a 'smart' financial centre[3]. According to Channel News Asia, Singapore's financial sector has been the dominant investor in ICT with Development Bank of Singapore (DBS) alone now spending some S$600 million on technology every year[4] as compared with S$2.8 billion that Singapore's government spent on ICT tenders during the fiscal year 2016[5]. Electronic payments first featured as a part of e-economy and were seen as part of projected e-infrastructure [10]. In 2002, IDA (Info-communications Development Authority) and MAS were reported to be developing a few initiatives, including the nationwide contactless Smart Card standard for retail and transport sectors, while a consortium of local Telecommunication companies started developing a nationwide mobile payments platform [11].

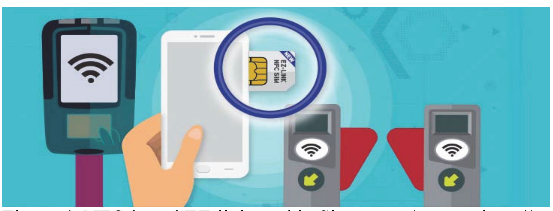

Figure 4. NFC-based EZ-link card in Singapore (source: http://www.channelnewsasia.com and IMDA)

[3] http://www.channelnewsasia.com/news/business/singapore/singapore-well-poised-to/1829460.html

[4] http://www.mas.gov.sg/Singapore-Financial-Centre/Smart-Financial-Centre.aspx

[5] https://www.imda.gov.sg/infocomm-and-media-news/buzz-central/2016/6/investing-in-ict-for-smart-nation-growth

More precisely, the 4th Infocommunications Technology Roadmap [11] refers to the development of an EZ-Link card (Fig. 4 depicts an upgraded version integrated with SIM-card and enabled through Near Field Communication technology, launched in 2016), a contactless pre-paid card for public transport, which would be later considered for use in micro-payments (following Hong Kong's experience with Octopus card); and NETS Cash Card that has been implemented and moving towards multi-application type of cards. Payment infrastructure utilising smart chip cards characterises 'smart space' [12] and the development of nationwide electronic and mobile payment infrastructure was recommended by the iN2015 sub-committee in 2006. [12] [13] The latest, 6th Infocommunications Technology Roadmap also stresses the potential of e-payments as part of Money 2.0, which characterises new digital economy [14].

Most recently, electronic payments were made a key sector in Financial Technologies, which overall has been put high on government's agenda as Singapore is to become an 'electronic payment society'. (MAS managing director's speech in August 2016[6]). In the recent report, commissioned by MAS, KPMG [20] refers to the high level of cash and SVFs used for transactions: the later accounts for 59% of total transactions while 2/3 of non-SVF payments are made in cash. The amount of cash in circulation stands at high 8.8%, compared to 4.4% in Australia and 2.2% in Sweden, which involves the need for ATMs and self-service kiosks that altogether add to the cost of handling cash (0.5% of GDP or about S$ 2mln per year). Following the electronic payments roadmap, suggested by KPMG, MAS started a series of public consultations on both regulation and governance of payment systems. The major areas of reform involve the following two:

- Streamlining existing regulations via the creation of a payment framework, which would be activity- and risk-based;
- Consolidating governance structures in a to-be-established National Payment Council (following similar experience of Australia and the UK) to govern, develop and promote interoperable payment solutions, national payment strategies and implement key projects [23].

Electronic payments are one of the three sub-sectors in financial services – along with trade finance and insurance – which Infocommunications & Media Development Authority, IMDA (a successor of IDA since October 2016) promotes, in close collaboration with MAS. What comes to the actual use of e-payment systems, the field remains underutilized given the possibilities of established infrastructure (e.g. real-time interbank transfer system (Fast and Secure Transfers or FAST) has been in operation since 2014), as well as fragmented with more than one standards currently in use: both EZ-Link card and NETS card have been in use. IDA has been previously tasked with developing an interoperable solution although Land Transport Authority (LTA) has recently announced its joint pilot with MasterCard, which enables cardholders to pay for transport fares and getting charged directly from their debit/credit accounts.[7] Further, MasterCard ventures into closer collaboration with banks in providing cardless payments in taxies through MasterPass and respective app[8].

C. Tallinn-Helsinki

Two European capitals, Tallinn and Helsinki, are only 80 km apart and therefore, will be grouped in this section. Between the two small nations (combined population of 7 million), there is a high commuting frequency [29]. Approximately every 15-20th Estonian lives in Finland and commutes back to Estonia on a regular basis (Fig. 5). For Finland, Estonia is the most popular investment and tourism destination, every fifth Finn stays overnight in Estonia each year. The two countries speak Finno-Ugric languages.

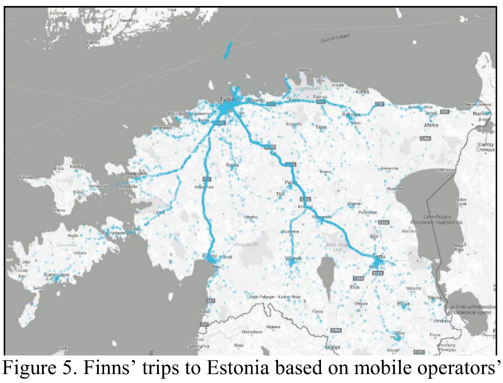

Figure 5. Finns' trips to Estonia based on mobile operators' data in September 2015 (source: Positium LBS)

[6] http://www.mas.gov.sg/News-and-Publications/Speeches-and-Monetary-Policy-Statements/Speeches/2016/An-Electronic-Payments-Society.aspx
[7] www.lta.gov.sg/apps/news/page.aspx?c=2&id=115768bb-0ca6-4cb5-a2b2-984e4a0c8384
[8] http://newsroom.mastercard.com/asia-pacific/news-briefs/innovative-masterpass-in-app-first-to-launch-with-comfortdelgro-taxis-in-singapore/

On the national levels, Estonia and Finland have a record of being frontrunners of digital innovations [29]. Two small European countries are the birthplaces of Nokia and Skype, respectively, and they have an overall digital focus in any aspect of life. Estonia is renowned for having one of the most innovative e-governments in Europe (The Digital Economy and Society Index 2016). No other nation has equipped each of its citizens with a secure digital identity and connected all public databases over the Internet, using a secure transport layer (the X-road, see Fig. 6). Helsinki, on the other hand, is considered among the top 6 most successful European smart cities [22] and there is a real-time economy competence centre in Aalto University.

There are two cornerstones of the ICT deployment in Estonia: widely used electronic identity and secure exchange of data over the Internet [29]. In the first case, most residents of Estonia (93%) have a personal ID card that is used in the digital environment for authentication and electronic signatures. Secondly, all government-sector databases (over 3000) are linked with each other via the Internet using the secure transport platform called X-road. The X-road is an open-standard transport layer that connects various databases with each other, independent from the vendors (ensuring full interoperability for the provision of local urban services).

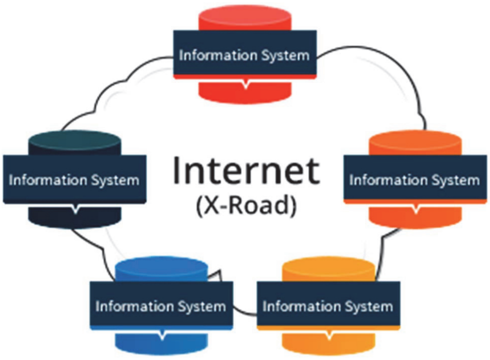

Figure 6. The X-road platform (source: Estonian Information System Authority)

The public infrastructure applies to Finland and two capital cities – Tallinn and Helsinki - as well [29]. Estonian ID card is taken over from Finland and Finland is the second country to implement the X-road. This offers an experimental setting for cross-border services. Our core interest is, what is the role of financial policies and level of adoption in this.

According to the European Central Bank, Nordic countries (including Estonia and Finland) are more advanced in the level of card payments. In 2014, card payments accounted for 46% of all transactions in the EU. There is a clear pattern that the Nordic countries have a higher level of non-cash payments. The top 6 is the following: Denmark (73.2), Portugal (67.3), Sweden (67.2), Estonia (65), UK (61.2) and Finland (60.5), see Fig. 7.

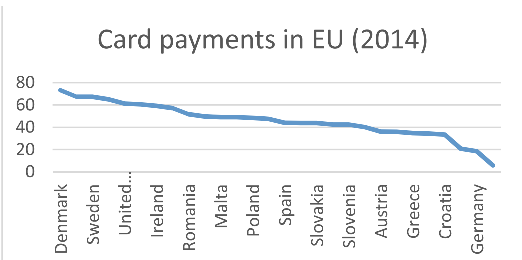

Figure 7. Card payments in the EU in 2014. Source: ECB

According to comparative surveys (e.g. by billentis.com), Estonia and Finland hold leading positions globally in the implementation of e-invoices (40 percent of invoices are sent electronically in both countries). In 2003, only 3.2% of all sent invoices were e-invoices and the proportion grew above 40 % by 2013, which means that Estonia and Finland along with other Nordic countries are pioneers in the field of e-invoicing globally (Fig. 8), which can be considered as the back-office of e-payments.

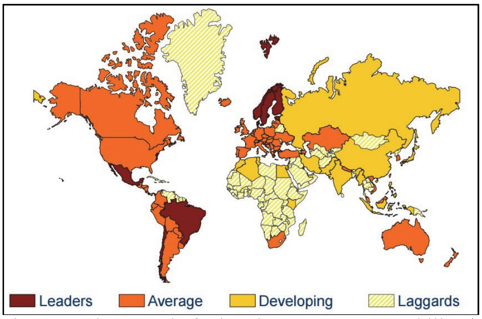

Figure 8. The spread of e-invoices 2016. Source: billentis.com

A local example of utilisation of NFC technology is a joint Estonian-Finnish private sector initiative following an m-wallet concept, developed by three large companies: Omniva, Telia and Tieto. The logic of the m-wallet is that a customer can pay with a mobile phone, including for such services as parking and transport. In addition, the m-wallet makes it possible to receive a receipt on a mobile phone in real time against mobile payment. The integrated concept is depicted below (Fig. 9). The m-wallet solution is downloadable from the Apple Store and Google Play (mTasku). This concept is developed jointly by regional financial service providers while the co-operation started in 2011 and is currently in the testing phase (e.g. in canteens of Tallinn University of Technology). The uniqueness of this e-payment solution is its cross-border applicability.

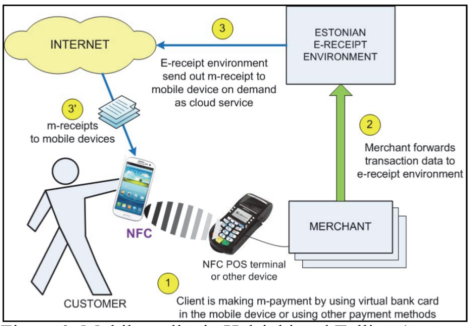

Figure 9. Mobile wallet in Helsinki and Tallinn (source: digital receipts consortium /Telia)

In the m-wallet environment, following customer's purchases of goods or services against the receipt with a bankcard or smartphone, or by using a customer card, the receipts are then sent automatically to the portal. This environment has already been developed by Omnia and Telia and is integrated with 4400 Point-of-Sales terminals (Fig. 10) but this needs to be harmonised with other partners' solutions for cross-border usage through successful market-entry. The Telia m-wallet solution is downloadable from the Apple Store and Google Play (mTasku).

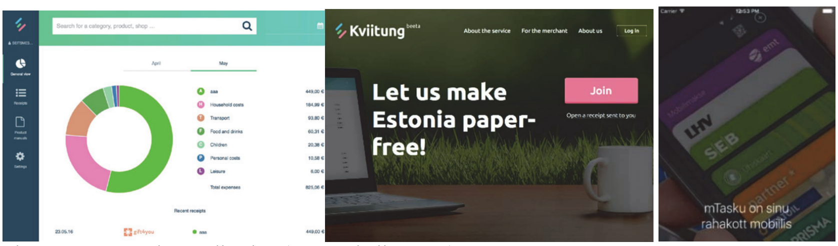

Figure 10. E-Receipt application (source: kviitung.ee).

In terms of actors and standardisation process, the development of e-payment solutions, including above mentioned, involves private sector actors with national and local governments acting as facilitators, as compared to significantly more proactive approach taken by policy-makers in Hong Kong and Singapore. Electronic payments are mentioned somewhat in Finland's Roadmap for Network Technologies and Services [1] while Finnish Digital Agenda for 2011-2020 states that "payment and billing services [should be incorporated] as widely as possible as part of digital services and processes [25]." Meanwhile, the overall focus of Estonian policy-makers has been on e-governance solutions, as exemplified by Estonia's Digital Agenda 2020 [24], with no explicit reference to digitization of payments. Although the widespread use of online banking, cashless transactions, and recent innovative solutions in e-payments, mentioned above, suggest that e-payment systems in Estonia are most likely implicitly regarded as part of broader e-governance initiatives.

In other words, Estonia and Finland can be considered as having a more bottom-up approach to developing e-payment solutions, driven by associations of Finance/Accounting and ICT companies. While developing a joint m-wallet standard, the Finnish input has been coordinated under the TARU project in a broad collaboration with government representatives, POS providers, retailers, banks and accountants (participants: Nordea, SOK, Solteq, Valtiokonttori, Tieto, Tikon, Fennoa, Administer, Nets, Hawcon, Taitoa, Arkkeo). In Estonia, the process was coordinated by Association of ICT that drafted the technical standard jointly with the government's e-invoice working group (Ministry of Finance, Ministry of Economics and Communications, Tallinn City), Association of Estonian Accountants, Estonian Traders Association and Estonian Banking Association. The working groups of both countries have had routine joint workshops on harmonising the two concepts and it is very important that the two concepts are digitally interoperable.

IV. KEY FINDINGS

Following cross-case comparison, certain features pertaining to the cases can be identified (summarised in table 2):

- Singapore has been moving towards making payments as a key sector in overall Financial Technologies agenda; with the two main regulating and implementing agencies in charge – Infocommunications Media Development Authority (IMDA) and Monetary Authority of Singapore (MAS) – 'smart payments' have been placed and promoted within the 'Smart Nation' agenda.
- Hong Kong exemplifies more decentralised approach with multiple agencies in charge of 'smart city' initiatives, although Honk Kong Monetary Authority has been similarly proactive alike its Singaporean counterpart, and it scores high on electronic payment systems and is a way ahead of Singapore.
- Despite differences, the two East Asian cities can be characterized by relatively explicit policy attitude towards Financial Technologies with electronic payments being either part of it (Hong Kong) or rather at the core (Singapore); advanced development of supporting infrastructure (financial and telecom services, development and penetration thereof, financial literacy) and an explicit top-down approach with active engagements by public agencies.
- The two Northern European cities can be, in turn, characterised by the weak presence of relevant policy agenda (incl. Digital Agenda for Europe [5]), a multitude of private sector actors with regulators learning from them without explicitly prohibiting new innovative financial products.
- An existing infrastructure is effectively utilised and the extent of standardisation enables to extend it further towards regional solutions, between Tallinn and Helsinki. In terms of coordination, the Northern European cases represent a bottom-up approach with strong private stakeholders.
- In addition, Estonian setting suggests that electronic payments are perceived as an extension of wider e-governance agenda and integral to e-society.

TABLE II. CROSS-CASE COMPARISON

City	*Region*	*Policy-Driven / Bottom-Up*	*Level of urban digitalization*	*Level of integrated payment systems*
Tallinn	Northern Europe	Bottom-up, digital payments as part of e-governance agenda / solutions	High	High
Helsinki	Northern Europe	Bottom-up, digital payments are recognized as part of digital economy	High	High
Singapore	East Asia	Policy-driven and centralized, 'smart finance' is part of 'smart nation'	High	High
Hong Kong	East Asia	Policy-driven but somewhat fragmented, early mover and among top smart cities	High	High

V. CONCLUSION AND SUGGESTIONS FOR FURTHER RESEARCH

As follows from the description of the four cases – Hong Kong, Singapore, Tallinn and Helsinki – high levels of urban digitalization co-exist with similarly significant developments in electronic payment systems, achieved through various approaches, summarized above. Although the link between smart cities and electronic payments needs further investigation, current preliminary analysis postulates that the level of e-payments could be a useful proxy for analysing the level of 'smartness' in cities. More precisely, digitization of payments is not sufficient and yet a necessary condition for a smart city. Further work ought to be done in tracing the development of e-payment solutions and actors involved therein. The paper also suggested an integrative framework of smart cities that includes electronic payments, which, if combined with comparative empirical studies, would enable to better operationalize various layers in a wide and multi-faceted concept of a smart city.

As seen from the empirical examples, authorities are in charge of shaping trajectories of urban infrastructure, including in financial domain, although payment systems are not generally regarded (at least explicitly) as an integral part of smart communities, with minor exceptions such as Singapore and possibly Hong Kong. Yet, doing so might provide an additional window of opportunity for local policy-makers to bring in private companies on board through public procurement tenders as well as public-private partnerships (PPPs): even if not regarded as part of smart finance, digitization of payments involves multiple stakeholders, sophisticated infrastructure, which requires continuous maintenance and development. Meanwhile, global players in financial services are moving towards closer collaboration with banks (which operate payment systems) to provide innovative payment solutions that might not require any physical infrastructure: MasterCard serves as the most recent example.

Current study aimed to outline the various approaches to digitization of payments within the context of smart urban living. Even without an active policy approach towards financial technologies, policy-makers are confronted with rapidly developing applications of technology in financial domain. Further research on the subject should include interviews with the stakeholders – public agencies, in both ICT and financial sectors, as well as private actors and end users – in order to have a better overview of collaboration and networks put in place while developing e-payment solutions. This would also enable to see to what extent solutions developed are linked to the 'smart city' agenda, both in case government agenda explicitly says so (East Asian cases) or where public agents act as enablers and facilitators (Northern European cases).

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Article IV

Soe, R.-M. (2017). FINEST Twins: platform for cross-border smart city solutions. In In C. C. Hinnant & A. Ojo (Ed.), *dg.o '17: Proceedings of the 18th Annual International Conference on Digital Government Research* (pp. 352−357). New York: Association for Computing Machinery (ACM), doi: 10.1145/3085228.3085287 (3.1.)

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FINEST Twins: platform for cross-border smart city solutions

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ABSTRACT

The FINEST Twins aims to build a smart-city Center of Excellence (CoE) based in Estonia capable of mobilising all leading actors and stakeholders in Estonia and establish a solid long term partnership with their Helsinki region counterparts, capitalising on the macro region's scientific knowledge, innovativeness and entrepreneurship. The smart city CoE will focus on mobility, energy and built environment glued together by governance and urban analytics & data and aims to match leading smart city research centers globally. The FINEST Twins develops the cross-border knowledge transfer infrastructure (Urban Operating System) through real-life pilots capable of attracting international expertise and investment, as well as acting as a springboard for the exportation of Finnish-Estonian knowledge and combined service solutions on a global scale.

CCS CONCEPTS

• **Social and professional topics → Computing technology policy → Government Technology Policy**

KEYWORDS

smart city, digital single market, interoperability, cross-border services, public service provision

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1. INTRODUCTION

The FINEST Twins looks into how to achieve digital single market in the urban context. By fact, most digital services are local and by large, most of them are developed in isolation from the neighbouring local governments, either national or international. In the digital area, this is a huge challenge, as independently developed digital services tend to be locked-in to specific standards making future cross-border services challenging.

Information-and Communication technologies (ICTs) are aggressively reformulating the borders between the countries, at least the virtual ones. ICT breakthroughs like Facebook, Skype, Google and LinkedIN have clearly changed the understanding of the world map: if you can get online, there are no borders, at least in online communications services.

On the other hand, the picture is different if we zoom into the regional levels where each municipality tailors its own electronic services: local services are often developed in isolation with small or little attempts to co-design the services jointly with neighbouring cities in order to offer the cross-border services area for their citizens. Digital urban services are still developed and analysed from the "closed-borders" perspective, disregarding every-day commuters and the fact that, at least technologically, services can be easily scaled over the borders.

Tallinn and Helsinki (two Northern-Europe capitals) are selected for the following reasons: proximity (the two cities are just 80 km apart by sea); high-level commuting frequency (there were 8 million passengers between Tallinn-Helsinki in 2016 whereas Estonia's entire population is just 1.3 million) and digitalisation (Finland has very strong digital industry, strongly rooting from Nokia. (E-)Estonia, on the other hand, is highly appreciated for its electronic government). Economically, the cities are not the "in the same league:" Estonia is a post-soviet country still trying to catch up whereas Finland is a well-developed western country. Estonia's GDP is 2.5 times smaller than Finland's.

2. FINEST TWINS INITIATIVE

The FINEST Twins focuses on developing new Smart City state-of-the-art solutions and testing them in the cross-border environment. It is a partnership between Tallinn University of Technology, Forum Virium Helsinki (Helsinki City), Aalto University and the Ministry of Economic Affairs and Communications of Estonia.[1]

Smart City, an ICT-enabled city, has a huge market potential across the world. As the urban population continues to grow, cities and governments are investing heavily into digitalisation. India has recently launched an initiative to build 100 smart cities,[2] in China, there are dozens of smart cities in an advanced stage of development and 200 more on the way,[3] there are several initiatives across the Europe (PlanIT[4] in Portugal), Arab Emirates (Masdar[5]), Singapore (Tianjin[6]), South Korea (Songdo) etc. Some of these initiatives reach to tens of billions of euros, making the full market potential in hundreds of billion euros.

The aim of the FINEST Twins is to establish a smart city Center of Excellence, based in Tallinn. Clearly, both Finland and Estonia

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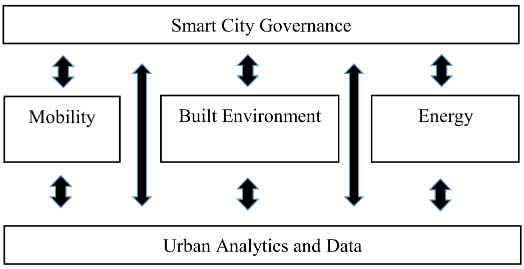
[1] See also: www.smarttwincities.eu
[2] http://www.citymetric.com/india-s-new-government-spending-700m-new-smart-cities
[3] http://www.citymetric.com/skylines/can-hundreds-new-ecocities-solve-chinas-environmental-problems-1306
[4] http://www.urenio.org/2015/01/26/smart-city-strategy-planlt-valley-portugal
[5] http://www.masdar.ae
[6] https://en.wikipedia.org/wiki/Sino-Singapore_Tianjin_Eco-city

have strong digital industry but this is less and less capitalised in the financial terms. The Finest Twins postulates that the smart city is “the next big thing” for Finnish, Estonian, European and global digital industry. The bottom-line is a top global knowledge base through research actions that will be actualised through real innovation activities and standards. In Finest Twins, researchers will be working with the companies. Out of funds (estimated € 5 mln annually), approximately 60-70% will be for research activities and 30-40% would go directly to innovation pilots.

The main focus areas are Mobility, Built Environment and Energy. Supportive layers are Data Architecture and Smart City governance (see figure 1). In other words, the Finest Twins will pilot **new mobility solutions** such as Mobility as a Service, mobile positioning data, twin ports, intelligent street crossings, automatic vehicles etc (some pilots in the preparatory phase), **new built Environment solutions** (zero-energy houses, new generation heating solutions, planning of large-scale real estate projects) and **new energy solutions** (smart grids, optimisation of energy demand to avoid peaks, connected meters and sensors), see also figure 2.

Figure 1. Finest Twins focus areas



The FINEST Twins CoE will also contribute to the emergence of Digital Single Market in the urban context. By fact, most current digital public services are local and by large, most of them are developed in isolation from neighbouring governments, either local, national or international. In the digital area, this is a huge challenge, as independently developed digital services tend to be locked into specific standards making future cross-border services improbable. Clearly, frequently commuting citizens and travellers prefer cross-border smart city services, but public authorities fail to provide such systems. The FINEST Twins guarantees to change this by effectively designing truly ubiquitous urban services and effectively testing them on cities all around world and also globally. The ubiquitous solutions not only contribute to strengthening the Digital Single Market by increasing the aggregate supply, but also mitigate digital divide and empower local communities.

Figure 2. Finest Twins R&I pilots

The roots of this project lay in Finland and Estonia. In Estonia, the societal use of ICT is the most developed globally exemplified by widespread take-up of innovative mobile and e-applications. The strong scientific and technological capacities of Finland match well with the Estonian entrepreneurship dynamics, especially in ICT. The FINEST Twins model will capitalize on these initiatives aggregating current research, innovative services and solutions into integrated service solutions capable of creating additional added value to its users all around the world. The FINEST Twins attracts international expertise and investment, as well as, act as a springboard for the exportation of Finnish-Estonian knowledge and service solutions on a global scale.

3. TALLINN-HELSINKI CHALLENGE

Two European capitals, Helsinki and Tallinn, are in a very unique situation. Helsinki, the capital of Finland, belongs to one the wealthiest region in the EU. Tallinn, the capital of Estonia, is among the catching-up regions. There is approximately three times wage difference between the two capitals while being physically only 80 km apart (see the figure 3). A talented PhD student from Tallinn can earn more taking on a cleaning position in Helsinki compared to continuing to pursue an academic career at home; a skilled construction worker in Helsinki earns more than an average professor in Tallinn. Between the two small nations (combined population of 7 million), there is a high commuting frequency. Approximately every 15-20th Estonian lives in Finland and commutes back to Estonia on a regular basis. For Finland, Estonia is the most popular investment and tourism destination, every fifth Finn stays overnight in Estonia each year. The two countries speak unique Finno-Ugric languages, and there is a strong feeling of kinship between the countries. In terms of innovation, both countries are particularly strong in digital innovations. Despite being one of the better performers in scientific excellence among the Eastern European countries, having one of the most advanced e-governments[7] and enjoying fast catch-up towards the European averages, Estonia still lags behind Finland in widespread research excellence.

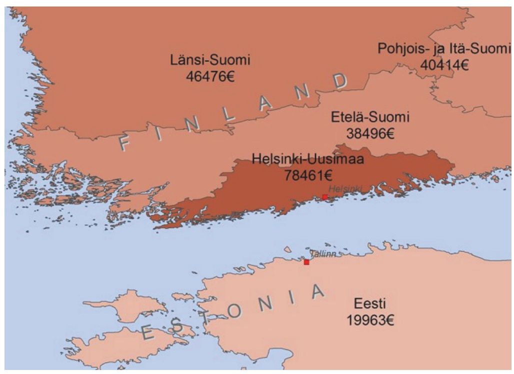


Figure 3. GDP per inhabitant, 2013 (source: Eurostat)

Finland has one of the most envied education systems globally on all levels and the second highest public Research and Innovation (R&I) intensity of all EU Member States.[8] Finland is among the top 5 countries globally for academic citations per capita, above the UK and the US.[9] Estonia, a low-performer, has 3.3 times less citations per capita, the aggregated country-level h-index difference is 2.7 times. In terms of disciplines of FINEST Twins

[7]http://www.bloombergview.com/articles/2015-03-04/envying-estonia-s-digital-government

[8]https://ec.europa.eu/research/fp7/pdf/country-profiles/finland/country_profile_and_featured_projects.pdf

[9]http://academia.stackexchange.com/questions/18767/research-publications-per-capita

(Computer Science, Energy, Engineering and Social Sciences), the biggest lag in citations and h-index is in Computer science and Engineering, the smallest one in Energy and Social Sciences, see the table 1 below.

In the case of access to research funding, the picture is very similar. Finland ranks fifth in the EC Innovation Output Indicator whereas Estonia is 19th (out of 28, in 2014). In volumes, Finland received € 867 mln from FP7, compared to Estonia with € 89 mln,[10] the per capita difference is 2.4 times. In the comparison of our two core partner universities, TUT received € 11 mln against Aalto's € 76 mln. When controlling for size (Aalto is roughly 2 times bigger[11]), Aalto received 3.8 times more from FP7 than TUT.

1996-2014	EE citations per capita	FI citations per capita	difference	EE h-index	FI h-index	difference
All fields	0,24	0,79	3,3	162	443	2,7
..in Computer Science	0,0017	0,0053	3,1	41	138	3,4
..in Engineering	0,0030	0,007	2,4	48	144	3,0
..in Energy	0,0007	0,0008	1,2	31	71	2,3
..in Social Sciences	0,0018	0,0025	1,4	40	106	2,7

Table 1. Estonian and Finnish citations per capita.[12]

In addition, the Estonian ICT deployment has not been leveraged in commercial. The IT sector that Estonia is renowned for does not generate significant export revenues. IT services exports in 2014 constituted only 1.3 % of total export revenue. The reason for this is that so far Estonia's e-government solutions have lacked international scalability. This has various reasons: first, lack of policy initiatives directed at ICT exports; second, labour shortage in the ICT sector; and third, perhaps most importantly, lagging interdisciplinary R&I activities that would utilise ICT solutions in other sectors of the economy as well. The CoE will directly alleviate the latter via concentrated research efforts and teaming up with the key Finnish R&I players.

4. VISION AND KEY OBJECTIVES

VISION: The FINEST Twins project's vision is to build an ICT-driven Smart City Centre of Excellence (CoE) based in Estonia capable of mobilising all leading actors and stakeholders in Estonia and establish a solid long term partnership with their Helsinki region counterparts, capitalizing on the macro region's scientific knowledge, innovativeness and entrepreneurship, and act as a reference and hub for cross-border scientific and innovation cooperation projects and ventures. The FINEST Twins CoE will be a true joint venture between the metropolitan region of Helsinki-Uusimaa[13] (onwards referred to as Helsinki region) and Estonia, establishing the EU cross-border Smart City solutions and a demo lab capable of attracting international expertise and investment, as well as, acting as a springboard for the exportation of Finnish-Estonian knowledge and combined service solutions on a global scale.

[10] http://ec.europa.eu/research/fp7/index_en.cfm?pg=country-profiles

[11] weighted difference between academic staff and students

[12] www.scimagojr.com

[13] http://ec.europa.eu/enterprise/policies/innovation/policy/regional-innovation/monitor/base-profile/helsinki-uusimaa/helsinki-uusimaa-region

Key objectives

1. Scientific, innovation and business related co-operation between Helsinki and Estonia in the Smart City fields of living, mobility and environment. Promoting efficient exchange of knowledge, building a joint research portfolio, supporting faster cross-border take-up of Smart City innovations.
2. Joint-production of cross-border services in order for both regions to benefit (economies of scale, better added value services, et al.). The CoE will bring together all main public and private actors, facilitating communication, networking and the building of long-term cooperation and true partnerships in macro-region.
3. Developing FINEST Twins cities (macro-region) as one integrated Smart City open "living laboratory" acting as a test bed for new innovations, and focusing on close-to-market innovations, city-driven innovations and open engagement of local innovator ecosystems.

5. SELECTED DOMAINS

"A Smart City is a city seeking to address public issues via ICT-based solutions on the basis of a multi-stakeholder, municipally based partnership."

The above definition is part of a 2014 study published by the European Parliament [1]. Although the authors claim it to be a working definition, it is based on the meta-analysis how Smart City has been conceptualised previously. The FINEST Twins Smart City vision encompasses not ICT as a technology driver in a broader scope including socio-economic, governance and multi-stakeholder aspects such as the use of social participation to enhance sustainability, quality of life and urban welfare. The key point in the continuous and successful development of a Smart City is to understand, that it is not a one-city game. It is a combination of not only multiple stakeholders from municipalities, research, businesses and citizens, but also partner cities, regions and nations. The future FINEST Twins Smart City CoE will mainly focus on the following three Smart City areas: Living, Mobility and Environment. These three areas are aligned with Helsinki region key strengths both in terms of research and innovation outputs, as it can be demonstrated by the numerous publications and pilot actions currently in place across the region, and are also a key priority for Estonia.
There are as many 'Smart City' definitions as there are 'Smart City' projects. The following figure 4 illustrates a common view on Smart cities focus areas and impact measurement indicators.

The thematic areas, in accordance with the most recent study on Smart Cities published by the European Parliament[14], are the following:

Smart Living:

- ICT-enabled life-styles, behaviour and consumption
- Healthy and safe living in a culturally vibrant city with diverse cultural facilities
- Good quality housing and accommodation
- Smart Living is also linked to high levels of social cohesion and social capital.

Smart Mobility:

- ICT supported and integrated transport and logistics systems.

[14] http://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdf

- For example, sustainable, safe and interconnected transportation systems can encompass trams, buses, trains, metros, cars, cycles and pedestrians in situations using one or more modes of transport.
- Smart Mobility prioritises clean and often non-motorised options.
- Relevant and real-time information can be accessed by the public in order to save time and improve commuting efficiency, save costs and reduce CO2 emissions, as well as to network transport managers to improve services and provide feedback to citizens.

Smart Environment:

- Smart energy including renewables, ICT-enabled energy grids, metering,
- Pollution control and monitoring,
- Renovation of buildings and amenities, green buildings,
- Green urban planning,
- Principals: resource use efficiency, re-use and resource substitution
- Examples: street lighting, waste management, drainage and water resource systems that are monitored to evaluate the system, reduce pollution and improve quality

Figure 4. The Smart city wheel by Boyd Cohen

6. KNOWLEDGE TRANSFER INFRASTRUCTURE: URBAN OS

Currently, globally leading smart city solutions follow two distinct patterns: first, building entire cities or parts of cities from the ground up based on smart city technologies; or, second, incrementally adding layers of sensors, opening up data for existing services. For regions aiming to catch up, neither alternative is satisfactory: the former demands enormous resources not available and the latter follows too slow a pace to advance public service reforms, digital common market and competitiveness. For catching up purposes, FINEST Twins proposes the following path: the creation of an Urban Operating System that is available for local and cross-border solutions. Such an approach follows from strategic plans developed by European Innovation Partnership on Smart Cities and Communities. Equally importantly, FINEST Twins will utilise open software and platform standard solutions developed in the context of FIWARE Smart Cities and Open and Agile Smart Cities (OASC) initiatives in order to ensure replicability and more importantly, scalability. Estonia's public ICT infrastructure based on open standards – x-road[15] – has brought Estonia and Finland globally to the cutting edge of e-government solutions and offers a unique opportunity to develop an Urban OS. This allows us to build an integration architecture for connecting sensors, the x-road for things.

The Urban OS is a crucial research infrastructure needed for the smart city CoE. The aim is to add the things layer to the x-road by developing an open and interoperable platform for connected sensors. In practice, the Urban OS is also a platform for joint R&I pilots with public sector involvement, associated companies and citizens as end-users. We have teamed up with recognised companies that are willing to invest into joint smart city pilots, and build on top of the excellence research the centre will produce. This combination will ensure that partner companies can make CoE developed research-intensive smart city solutions exportable and sell them globally. In essence, the Urban OS enables and ensures knowledge transfer between practical needs of cities and companies, and research streams.

The FINEST Twins CoE has pre-agreements with renowned ICT-focused companies (F-Secure, Tieto, TeliaSonera and Siemens) for initial joint pilots in the fields of smart city. In the case of our partner companies, F-Secure is interested in cyber security aspects of smart cities; Tieto's and TeliaSonera's interests are tied to Data Architecture development; Siemens is interested in the Built Environment solutions. In addition, there are negotiations in process with Ericsson and Telia for joint 5G pilots (Telia Estonia is planning to invest for 5G stations in Tallinn already in 2018), both plan to co-operate with FINEST Twins, although the terms are not yet finalised. In addition to the current pre-agreement with Siemens, they are also interested in Smart Energy pilots.

In addition to working with large companies, we have a very strong connection to all smart city related clusters in Estonia (e.g., ICT Cluster, Smart City Lab, Tehnopol Science Park and Rakvere Smart House Competence Center) which facilitates the creation and development of direct relationships between academia and private and public sectors as well as between local firms and some of the global smart city market value chain leaders..

Technological change in the world economy is constant but not continuous; it occurs in massive surges of change [2]. Over the last 200 years the Western countries have experienced five successive waves of revolutions centred on the technologies with pervasive application potential. The most widely accepted theoretical framework for discussing technological change and the creative destruction they generate is the techno-economic paradigm shifts approach by Chris Freeman and Carlota Perez, which is based on Schumpeter's business cycles and Kondratieff's long wave theory [3]. The theory states that in order to realise the full potential of the new wave of technological revolution, the clusters of technologies should be coupled with sets of best practices and a stable socio-institutional framework for supporting their creation, take-up and diffusion. This highly contested societal embedding of new technologies has historically resulted in large-scale economic, political, cultural, spatial and psychological changes, both intended and unintended, beneficial and harmful. Since the 1970s, the world economy has witnessed

[15] https://www.ria.ee/en/x-road.html

the emergence of a cluster of information and communication technologies, which is interpreted as the fifth techno-economic paradigm.

According to Carlota Perez, we are currently entering the phase of deployment in which the fusion of new technologies, best practices and the supporting institutional framework enables the realisation of the full gains of the paradigm. In order to make use of the emergent paradigm various technological, organisational and institutional rearrangements are required.

As the rapid rise of sharing economy shows, habitation (city) itself will be the era-defining business model through which ICT paradigm spreads. Accordingly, digital layers of cities will be fundamental to the socio-economic development of coming decades. The CoE will create such a digital layer through research and innovation actions via building the Urban OS.

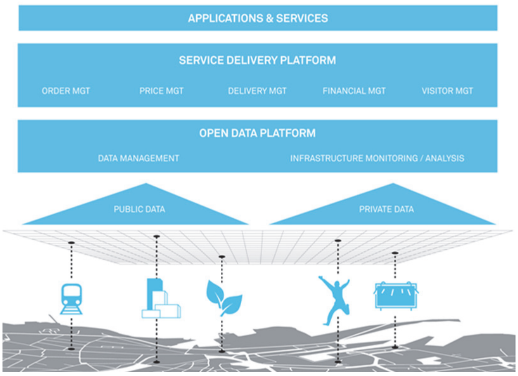


Figure 5. Urban Operating System

The concept of Urban OS is simple (see the figure 5): deploying a network of sensors that can capture real-time data from a myriad of things occurring in the city, and connect such sensors to an urban information system helps to analyse better and transform such data into knowledge. We can create new types of urban efficiencies, products, and services for the people of the cities. In turn, they access an open-access digital services delivery platform using anything from a smartphone or a laptop all the way to digitally enhanced infrastructures such as responsive public spaces, intelligent transport systems or smart energy infrastructure among others. The city becomes a permanent platform for interaction that provides a unique mix of services to each user. Furthermore, by giving users the capabilities of developing their solutions and services we create a more inclusive and bottom-up model of both social and economic development while jumpstarting local dynamics.

Urban OS Architecture

The data management layer provides standardisation and storage function for the platform facilitating analysis of long-term sensor data. Urban OS would be the primary conductor of various data streams used by the various digital services between two cities.

Integrating data streams

Ubiquitous sensors and sensor networks are increasingly providing data sources of different contents, formats, and qualities. Integrating diverse data sources allow developing applications that would not be possible by using single sensor network. When integrating data from heterogeneous sources, syntactic, schematic, and semantics diversities of the data schemas are challenging problems. Through an Operating System, data from diverse sources is translated into a common language and visual interface.

Data processing functionality

The Urban OS will offer businesses, citizens, and governments the ability to combine real-time data from across some data streams to create and up-to-the-minute picture of urban material flows and dynamics. In addition carrying data from providers to consumers, the Urban OS will allow clients to process quickly, manipulate and visualise the data of data streams. Through the platform, applications can also be published and shared among users.

Scalability and flexibility

Agile development processes have dramatically changed the way technology is being implemented. Shorter cycles allow to constantly adapting to changes or new conditions. The OS platform will be designed to meet current needs without compromising the ability of future generations to meet theirs. At the moment we can assume hundreds of data streams, with individuals contributing this number easily into the thousands. Taking into account the overall input load and the numbers of potential clients, and doing a quick approximation, we could easily end up with up to one million messages per second. The OS platform will be designed to deal with, initially, a small load, but at the same time, it will need to be designed to scale to hundreds of machines to deal with the additional load.

Inhabitants as actuators

Truly smart cities will emerge as inhabitants and their many electronic devices are recruited as real-time sensors of daily life, agents for sensing and reporting their individual experience. Offering a real-time view of how human, material, digital and financial resources travel through the landscape of their daily lives will perceptually expand each citizen's sphere of responsibility from the domestic space to the space of the city - the city becoming the smart meter of all these factors. In a digitally augmented smart city, civic zones can be transformed into responsive environments through technological mediation. This would change the passive inhabitants of the city to active participants of spatial scenarios, and the public spaces from areas of transit to urban destinations.

During the last decade, there have been large investments in smart city research, innovation and systems uptake in Europe and globally. The European Innovation Partnership on Smart Cities and Communities (EIP SCC) forecasts the market for smart city solutions in 2020 to be € 1.3 trillion, with current market-size estimates being at € 200-400 mln annually. Many of the CO^2 reduction targets require further smart city R&I activities to be realistically achievable. Also, the public funding for smart cities has been vast: just the Future-Internet PPP (FIWARE)[16] programme consists of only € 300 mln of EU funding with many of its application domains being in the context of cities. This is the societal context and the market and public sector demand for the FINEST Twins R&I.

The Urban OS builds on the previous R&I investments and the existing collaboration on this domain: it brings in the "best pieces, knowledge and middleware that are pragmatically needed" to execute state-of-the-art smart city R&I in a real-life cross-border ("Digital Single Market") setting. The approach follows closely and contributes to the developments of:

[16] https://www.fiware.org/tag/smart-cities

- EIP SCC Urban Platform[17] (project partner FV-Helsinki – Helsinki City Innovation company – has 3 commitments to EIP SCC; project partner University of Tartu representatives are in the EIP SCC "sherpa group");
- Open and Agile Smart Cities Initiative,[18] which links to FIWARE and the development of common standards by cities (project partner FV-Helsinki is founding member of OASC)
- EIT Digital[19] development in the smart spaces, urban life and mobility action lines (project partner Aalto hosts EIT Digital node in Helsinki and project partner FV-Helsinki is associate partner in EIT Digital);
- CitySDK[20] is a "service development kit" for cities and developers that aims at harmonising application programming interfaces (APIs) across cities. CitySDK APIs enable new services and applications to be rapidly developed, scaled and reused through providing a range of tools and information for both cities and developers (the project was led by FV-Helsinki with 8 cities as partners: Amsterdam, Barcelona, Helsinki, Istanbul, Lamia, Lisbon, Manchester and Rome).
- SELECT for Cities[21] is a R&I pre-commercial procurement led by Helsinki together with Antwerp and Copenhagen, which will develop a number of platform prototypes, capable of integrating the current cities OS, IoT and all Smart eco-systems and data, for transforming cities into large scale IoT Living Labs. FV-Helsinki is the coordinator.

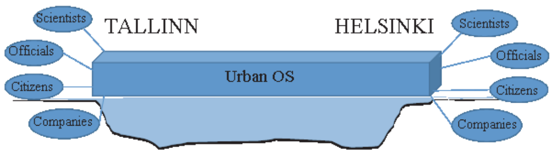


Figure 6. The Urban OS model for cross-border R&I collaboration

The urban OS is a digital layer of cities that functions in real time, is both public and private, integrates diverse data streams and offers data processing functionality and scalability/flexibility. Within the urban OS, companies can create new products and services, the public sector can enhance existing and create new services, and citizens can be empowered to be more actively involved in cities' socio-economic developments. The FINEST Twins proposes to create the urban OS for the Helsinki-Tallinn region, which is a great test-environment for teaming with strong scaling potential to other cross-border regions. The FINEST Twins aims to be the first Cross-Border test-site for two-city joint digital services (see the figure 6) by connecting all the key actors in the region through joint R&I pilots. This is well supported by the joint take up of x-road for the real-time data exchange between Estonia and Finland and our plan to develop the sensors exchange layer on it, the x-road for things.

Critical to the CoE R&I initiatives will be the design and implementation of the digital-technologies platforms that will enable it to create a real-time cross-border sensing environment as well as to provide a new layer of shared services and opportunities to its inhabitants and users. Rather than a top-down system supplied by an international technology leader to improve efficiency and security, the Urban OS is imagined as an open network that is able to create sustainable wealth and encourage local economy. Through the Urban OS, the city becomes not just a R&I testbed but also a platform to innovate upon.

7. CONCLUSIONS

This paper gave an overview of how cross-border cities can offer joint services via open ecosystem (Urban OS). The cities of Tallinn and Helsinki are very different on the economic level and therefore, joint platform for smart city services can effectively serve as a knowledge transfer mechanism from more advanced region (Helsinki) to the catching-up region (Tallinn). A strong common element of both cities is strong digital infrastructure and potential for interoperability of services.

The key point to understand a winning smart city is to understand that this is not a one-city nor one-country game. No matter how big a city (Tokyo, Sao Paulo), any local government is too small to create a real ecosystem of cutting-edge agile and adaptive governance solutions (predictive analytics, Internet of Things and Big Bata technologies). The first instalments have led to inflexible "smart cities in a box" or "smart countries in a box," which are ageing fast, and from which solutions do not scale elsewhere.

There is a need to start from simple and widespread urban services through collaborative joint cross-border hands-on pilots (e.g. public transportation tickets and mobile parking for heterogeneous cities) and practice joint procurements for innovative solutions. Standardisation is also the key to cross-border urban services. The real threat is that if local municipalities do not manage to innovate from bottom-up jointly with neighbouring cities (both national and international), then all the cross-border solution will be enforced top-down or aggressively linked to global business vendors.

8. ACKNOWLEDGEMENTS

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Article V

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Data-based Energy Provision for Smart Cities

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Abstract. This project will demonstrate how ICT-based solutions can contribute to saving energy by motivating behavioural change of energy end-users. The project will demonstrate how energy service providers can be more open (involvement of end-users and other energy market participants) and innovative (open living lab concept for co-creation and co-design practices) in the development of smart energy solutions. This project will develop an effective intervention to change the behaviour of above-average energy users via training them to use smart tools and coaching them throughout the process. The aim is to increase knowledge of the energy market, change thinking patterns, initiate smarter decisions and through this create actual change in consumers' behaviour – in pilot test group energy consumption is expected to decrease by 5-10%. This project will integrate at least seven third party digital energy tools with the Estfeed platform that connects over 600 000 energy users in Estonia. Therefore, we expect to deliver and popularise smart tools for minimum of 100 000 of energy-users, with slightly stronger focus on the large-scale users (both individuals and corporate/public).

Keywords: smart energy platform, smart applications, DSO, digital tools for energy users, aggregator, living labs, open innovation, social sciences, ICT, randomised trials

1 Introduction

The project aims to demonstrate how ICT-based solutions can contribute to saving energy by motivating and supporting behavioural change of energy end-users (mainly electricity but also gas and heating) in the case on Estonia as a Large Pilot, Slovenia and Denmark as mini-pilots and Germany as a close follower.

Estonia is chosen as the main pilot country for the following reasons:

1. All electricity meters are being replaced with smart meters (during 2012-2016, 630 000 meters were replaced, the total investment was 100 mln Euros)
2. A consortium of companies are developing an open data exchange platform and app store called Estfeed, operated by the main Estonian Government-owned electricity and gas Transmission System Operator (TSO). This platform links data sources and application, and through this makes smart meters' data from the TSO´s owned data hubs (electricity and gas at the moment) available over the Internet for end-users but also app developers, close-to-real-time (one hour delay). The platform also provides an app-store where equal visibility for all energy efficiency applications integrated with the platform are presented to customers on equal basis.

3 The Estfeed plafrom runs on the open X-road[1] data exchange layer, which connects all public sector databases in Estonia over the Internet. The X-road is the corner-stone of the Estonian e-government, which is evaluated as the best in Europe according to the EC Digital Economy and Society Index (DESI). In essence, it is a platform that can link whatever data sources with the main ICT infrastructure of Estfeed and through the authentication, authorization and mandates functions, it provides a legal basis for third parties to use this data for processing, testing and developing applications for energy efficiency.

4 Estonia's CO2 emissions per population are one of the highest in the EU: there is a need for real change.

2 Concept

"A Smart City is a city seeking to address public issues via ICT-based solutions on the basis of a multi-stakeholder, municipally based partnership."

The above definition is part of a 2014 study published by the European Parliament (Manville et al., 2014). Although the authors claim it to be a working definition, it is based on the meta-analysis how Smart City has been conceptualised previously. The key point in the continuous and successful development of a Smart City is to understand, that it is not a one-city game. It is a combination of not only multiple stakeholders from municipalities, research, businesses and citizens, but also partner cities, regions and nations. In this paper, the Energy is part of the Environment domain and classified in the following way:

- Smart energy including renewables, ICT-enabled energy grids, metering,
- Pollution control and monitoring,
- Renovation of buildings and amenities, green buildings,
- Green urban planning,
- Principals: resource use efficiency, re-use and resource substitution of buildings and amenities,
- Examples: street lighting, waste management, drainage and water resource systems that are monitored to evaluate the system, reduce pollution and improve quality

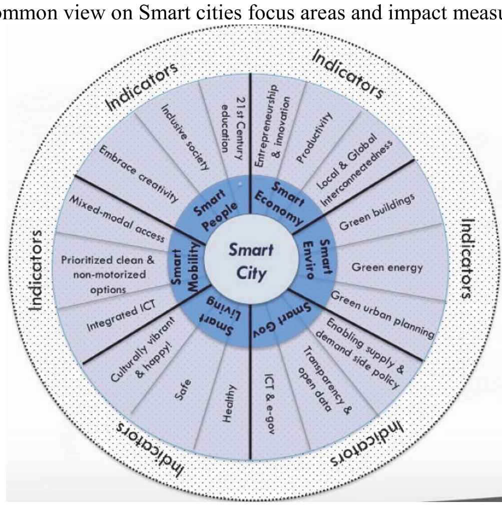
Smart Energy is considered an integral part of the main smart city frameworks (Neirotti, Marco, Cagliano et al., 2014; Batty, Axhausen., Giannotti et al., 2012; Giffinger and Haindlmaier, 2010; Soe and Mikheeva, 2017; and Lugaric Krajcar S and Simic, 2010). There is also discussions regarding the connection between sensing, cloud computing and energy provision (e.g. Hancke, Silva and Hanke, 2013 and Yamamoto, Nakamura and Matsumoto, 2012) and connecting energy to Smart City IoT platforms and testbeds (Jin, Gubbi, Luo, et al, 2012 and Sanchez, Muñoz, L, Galache et al., 2014).

Dirks & Keeling (2009) view Smart City as an important component to integrate city's various systems (transportation, energy, education, health care, buildings, physical infrastructure, food, water and public safety). Balakrishna (2012) argues that the

[1] https://www.ria.ee/x-road/

prerequisite for Smart City is intelligent infrastructure and a set of cross-sectoral services (energy, sanitation, health care, transport, farming, governance, automation, and manufacturing).

There are as many ‘Smart City’ definitions as there are ‘Smart City’ projects. The following figure below by Boyd Cohen based on Manville et al. (2014) illustrates a common view on Smart cities focus areas and impact measurement indicators.



From the methodological perspective, this project will demonstrate how energy providers can be more innovative and open by using the open living lab concept to implement co-creation and co-design practices of the development of smart energy solutions. The open lab will help to better design smart solutions by both providing competences and access to real user co-design contexts, as well as providing the enabling smart energy environment (including the smart data exchange platform, the energy infrastructure, open APIs and IoT platforms) which serves as a starting point for future innovations. Next generation open living laboratories are also tools for speeding up the take-up of new innovations in an iterative and user-centric, yet managed manner. One of these tools is conducting co-creation workshops with a purpose to involve end-users into the development process, which will also be leveraged on.

In this project, co-creation workshops will be experimental, based on the randomized trials method. That is, we will run two types or workshops:

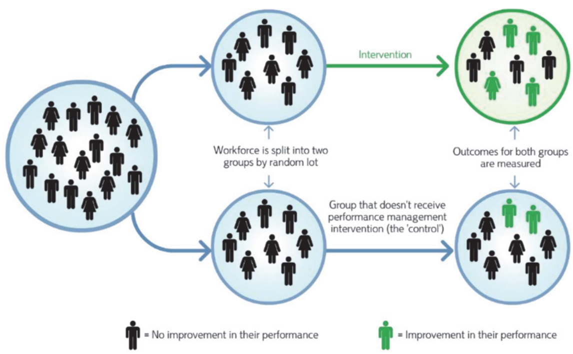
1) In the first case (intervention group), we will explain the benefits of energy savings and coach participants throughout the process how to use smart consumption tools offered by the consortium, in addition to co-creating the solutions with end-users;

2) We will invite the control group only for co-creation purpose, with no guidance on how to save on energy consumption.

This Open Living Lab method aims to involve end-users of energy services in the development process via the living lab model. The aim of the Open Living model is to facilitate the co-creation between the local developers, people (end-users) and ICT systems with specific challenges defined by the public authorities.

2.1 Co-creation workshops

The co-creation workshops would provide two outcomes:
1) We will fully involve at least 60 selected end-users (e.g. people with above average energy consumption: house-owners with electrical heating and industrial users) to the smart solutions development process.
2) We will develop an effective intervention to change the behaviour of above-average energy users via training them to use smart tools and couching them throughout the process. Later on, we will compare the results of the intervention group with their previous energy consumption and the control group. As the outcome, we will measure the two group's energy savings during the time of workshop and also 6 months later. If there are statistically relevant differences between the two groups, we can conclude our intervention to be successful. This could mean that it really makes sense to replicate this intervention (smart solutions and training) for the larger population, both in partner countries but also in Europe generally.
In addition to energy savings, the impact of indoor climatic conditions on personal health, productivity and comfort will be also researched.



3 Project Objectices

The project has three objectives:
1) Cost-effectiveness: we aim to prove that smart connected meters do provide at least 10% of savings for large-scale energy users: homes with electricity heating and industrial customers. In terms of cost-effectiveness, the idea is also to link customers with data exchange platforms that provide a variety of different energy effi-

ciency ICT tools (app stores) were customers are encouraged to try many different applications for different home appliances and functions and through this also generate increased savings and stronger fit with client needs;

2) Connect installed smart meters with end-users via third party applications in order to improve interoperability. We will award innovation vouchers for the best solutions. In our main pilot country, Estonia, close to all electricity meters are replaced, partially also smart gas meters and heating meters are installed. This project will integrate third party solutions (e.g. aggregator) and other smart IoT devices to this platform that collect and process data and communicate directly with end-users, this also promotes new data- and platform based business models.

3) Focus on "smart" saving potential: this project aims to smoothen the energy demand by providing suggestions for energy consumption based on analysed data and energy market behavioural patterns: e.g. suggestions for kindergartens/public offices to switch off their water heaters and refrigerators during the evening peak hours when nobody is in the building anyways.

This project will make this platform available for all third party developers with efficient business plans, independent of their size.

This project consortium has strong capabilities in technology (ICT and Energy) and is coordinated by the eGovernment unit within the Tallinn University of Technology (TUT). The role of TUT is to provide latest insights from social and behaviour sciences in order to understand factors influencing consumer choices and impact on consumer behaviour within such an energy system. In addition to TUT, the consortium involves two EU technology-research centers of excellence (Fraunhofer and Danish Technology Institute), Estonia's government-owned TSO Elering, a Nordic software company with proven Energy record Tieto and an SME for the app-centred pilot in Slovenia (Internet Institute). We have also involved University of Leipzig for Energy expertise. In total, there are 7 partners from 4 countries. The developed solutions will be deployed in a variety of building types (private and public) and the value of the energy services exposed to the end users.

3.1 Estonian Pilot

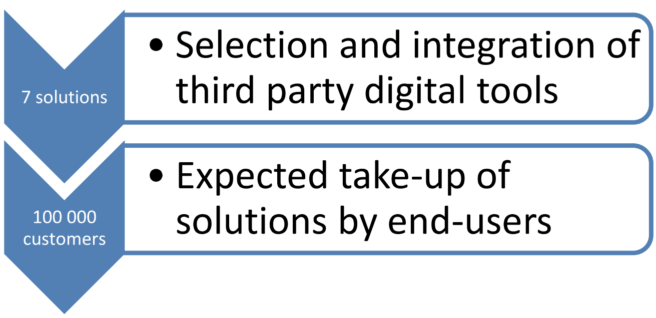
The Estonian Pilot is targeted at the large-scale electricity users, both private and corporate. In the case of the private customers, only those with electricity heating will be selected. With cold winters reaching as low as minus 25, electricity bills can be remarkable – up to 15%- 30% of the average wage, thus the savings potential is the greatest and there is a real need for smart advice. In addition, a selection of corporate buildings will be selected in collaboration with the State Real Estate Ltd. The State Real Estate Ltd is the biggest government-owned real-estate owner with over 1 000 public buildings in the portfolio (e.g. schools, ministries, hospitals etc.). There is potentially larger impact on the smart solutions targeted for large-scale users.

The aim of the Estonian pilot is to develop, test and gather customer feedback to the Estfeed data exchange platform and its energy efficiency applications. Until the beginning of 2017 the main focus has been on developing and building the unique platform that is able to link all different kinds of data sources and applications. Under this pilot the focus is to increase the content quality and user experience of this platform, develop content, services and applications for the client portal, which serves as the user interface of Estfeed. To have a variety of applications and data sources available, this project aims to link the Elering platform with hundreds of thousands of connected smart meters/devices through the Estonian public data transport layer X-road with third party applications like:

1) Right Amphere (With the help of this application you can find out how large the main fuse needs to be where you use energy).
2) Aggregator (the aggregator helps you to decide how many consumers should band together so as to buy electricity at lower prices).
3) Virtual Power Plant (A virtual power plant helps you decide which renewable energy sources would make most sense where you use energy).
4) Head Monitor (The heat monitor is able to track energy losses related to your consumption).

Two different kinds of test groups will be formed: the pilot group who receives information, gets access and is educated how to use the platform and its applications and is involved in the development of the platform; and the reference group who will not get any information, training nor access to platform and apps. In addition, pilot data can be compared with their last year's consumption data. Groups of at least 30 + 30 members can prove statistically if our intervention (change in behaviour) has an effect or not.

The outcome of the Estonian Pilot is a Smart Energy platform with at least seven third party smart solutions co-designed and fully integrated to this platform. The integrated solutions will run for at least one year, will be clearly selected, defined and monitored. This platform will utilise the knowledge already gathered on the data exchange layer of the X-Road, an open-source and free-to-use software system, which is successfully used by the governments of Estonia and Finland. The critical requirement for the European Digital Single Market (DSM) is open and secure energy data exchange for the EU-wide consumption. According to the Digital Economy and Society Index 2016, Estonia is ranked as number one in digital government services[2], the cornerstone of this is a successful implementation of the X-road.

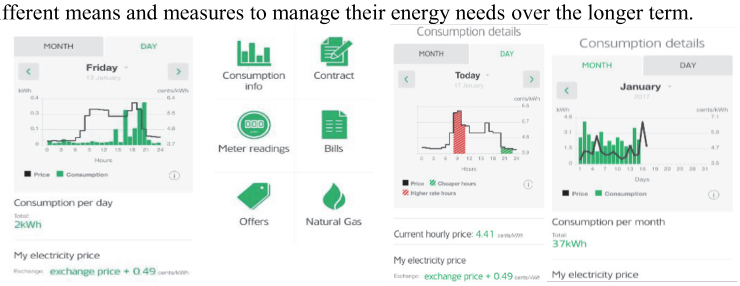


[2] https://ec.europa.eu/digital-single-market/en/digital-public-services-desi-dimension-5

For this purpose, we will target developer communities but also start-ups, universities and SMES in order to co-develop digital solutions. The selection criteria for these solutions is the maximum reach of customers and savings potential. When complemented with awareness-raising activities, we assume to target 100 000 end-users in Estonia with these new solutions. The technical work (integration with Elering and X-road) will be done by Tieto.

3.1.1 Data Exchange Layer Estfeed

The activities are focused on the development and integration of state-of-the art digital tools and applications and their connection with close-to-real-time-data from smart meters and potentially also from other smart devices. The solutions will empower end-users (building owners, residents, housing associations, public actors etc.) to engage and collaborate in achieving energy savings and allowing them to explore different means and measures to manage their energy needs over the longer term.



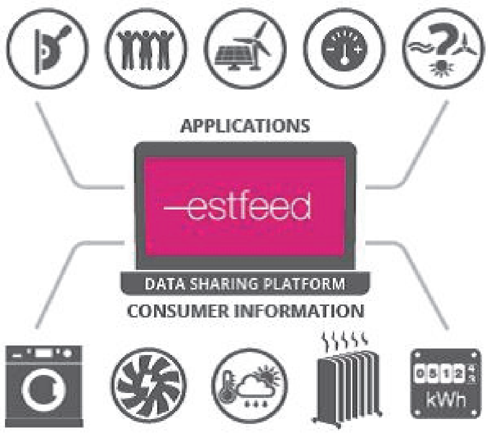
One example is “MyEnergy” application in Estonia, offered by state-owned Energy company Eesti Energia. This application connects smart meter data with end-users by offering 1) consumption data, 2) electricity price predictions, and 3) demand-based suggestions for smart energy consumption. See the snapshots from the application below. The application can be downloaded here.[3]

The Estfeed energy data exchange platform is developed by the main TSO Elering, partner this project and uses X-road for data communication. This platform links data sources and applications and provides a user interface for customers to see and manage their energy consumption data and rights. In other words, the platform supports services such as authentication, authorization and mandates that enable to give rights to process and manage the data of customers by third parties, e.g. energy efficiency applications but also tenants who would otherwise have no access to consumption data and therefore also less incentives for smarter consumption management.

The Estfeed brings together data sources and applications for energy flexibility management, energy efficiency, customer involvement, audit and benchmarking. Data sources can range from electricity, gas and district heating smart meter readings to weather forecast and energy day-ahead prices (currently Elering focuses on gas and electricity). It also can be consumption information from individual devices in indus-

[3] www.energia.ee/en/tark-tarbimine/mobiiliapp

try, offices, and households. Data source can also be e-invoices and other machine-readable documents. Estfeed is a portal that gives developers a chance to access this information flow. By interpreting and combining data, they can create useful applications for themselves or their customers (end consumers). The aim of the applications is to create efficiency, either for cost optimization or for end consumers. Estfeed is integrated part of Estonian public information exchange platform called X-Road. This means highest security standards. X-Road enables access to all kind of public data sources that may be of relevance for the developers of Estfeed applications. In that sense this R&D project is the first one of its kind in Europe were a public stock company uses a government developed ICT platform and develops it further in line with the needs of a specific sector, the energy industry and consumers. Estonian electricity and gas transmission system operator (TSO) Elering is the operator of Estfeed and as a neutral party, it is well placed to provide data sharing service to public in reliable and independent way.



3.2 Minipilots in Denmark and Slovenia

Complementing the large pilot in Estonia, a mini pilot will be implemented in Slovenia and Denmark, the aim of which is to test and validate consumer applications from an end-user perspective, hence providing insights about the design of tools and services exposed by smart energy environments towards consumers.

More specifically, the mini pilot focuses on the investigation and validation of mobile apps for energy monitoring and efficiency from various perspectives, including quality of experience, efficiency of use of the available services, transparency of energy-related data and the created incentives for a more energy-conscious user behaviour. Validation workshops will be organised to engage end-users in testing of selected smart energy apps and quantitative and qualitative feedback will be collected to gather and analyse end-users' design insights.

The mini pilot will target involvement of small groups of invited end-users to facilitate a dynamic co-creation and co-design exercise. A validation methodology and key observed metrics will be prepared in alignment with the methodology implemented in the large pilot in Estonia. During the piloting phase, only simulated data will be used.

4 Excepted Results

The aim is to increase knowledge of the energy market, change thinking patterns, initiate smarter decisions and through this create actual change in consumers' behaviour – in pilot test group energy consumption is expected to decrease by 5-10% in the intervention group.

This behavioural change will be initiated through:

1. providing information and training about available smart meters and other measuring devices and sensors, energy efficiency solutions/application and energy data exchange platforms;
2. providing access to ICT solutions and platforms and involving end-users, consumers, clients and their feedback into the continuous development cycle of the platform and its applications, and through this involvement increasing the usability of the devices, applications and platforms;
3. training consumers and clients how to use the energy data exchange platform and its applications.

This project will integrate at least seven third party energy digital tools with the Estfeed platform that connects over 600 000 energy users in Estonia. Therefore, we expect to deliver and popularise smart tools for minimum of 100 000 of energy-users, with slightly stronger focus on the large-scale users (both individuals and corporate/public).

In more detail, proposed actions of the project will demonstrate the impacts listed below:

- Final energy consumption will decrease by 5-10% in the pilot group prompted by the use of innovative energy efficiency and platform applications introduced and developed throughout the project, e.g. increase of knowledge about changes in energy prices during the day and suggestions how to use energy in a more sustainable way through the platform and apps.
- Wider deployment and adoption of user-friendly ICT solutions prompting behavioural change and energy efficiency will be accelerated through the pilots. After the end of the project the platform and its applications will stay available for end users and application developers for further development and increase of usability.
- Number of energy end-users changing their behaviour will increase, documenting why and how changes are an effect of particular measures taken, as well in terms of the sustainability of the behavioural change.

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Article VI

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The role of demographics in cities

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ABSTRACT

In general, most smart city researchers agree that population growth is driving the need for smart cities but there is very limited, if any, conceptual and empirical cases that explain the role of demographics (and ageing) as a driver of smart cities and its effect on future urban healthcare costs. This research paper proposes a new conceptual framework that incorporates demographics into the most common smart city concepts (e.g. Giffinger's) as a driver for populations' change in cities. The main research question is the following: how does cities getting older or younger affect healthcare costs and policies. This conceptual framework is validated in the City of Tallinn by proposing a conceptual model for estimating and predicting healthcare costs in urban areas.

CCS CONCEPTS

• **Applied Computing → Law, social and behavior sciences → Economics**

KEYWORDS

smart city, demographics, ageing, smart solutions, life expectancy, healthcare expenditure

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1. INTRODUCTION

According to the UN World Population Projections, the urban population has grown rapidly since the 1950s, from 0.7 billion to 3.9 billion in 2014. Asia, despite its lower level of urbanisation, is home to more than 50% of world population. Continuing population growth and urbanisation are projected to add 2.5 billion people to the world's urban population by 2050, nearly 90 per cent of the increase concentrated in Asia and Africa.

It is clear that urbanisation is driving the need for smart cities. As the urban population continues to grow, cities and governments are investing substantially into digitalisation. India has recently launched an initiative to build 100 smart cities; in China, there are dozens of smart cities in an advanced stage of development and 200 more on the way; there are several initiatives across Europe (PlanIT in Portugal); Arab Emirates (Masdar); Singapore (Tianjin); South Korea (Songdo) etc. From the demographic aspect, there are three drivers of urban population growth: rate of births, rate of deaths and migration. When factoring in the change in life expectancy, it is clear that ageing is one of the main drivers of the population growth, seconded by migration to and from the cities. According to the UN World Population Prospects, the global life expectancy at birth rose by 3 years between 2000-2005 and 2010-2015, that is, from 67 to 70 years. Globally, life expectancy at birth is projected to rise from 70 years in 2010-2015 to 77 years in 2045-2050. People are living longer which drives the population growth and sets a natural demand for smart city policies and smart applications for the elderly.

On the other hand, smart city scholars fail to incorporate demographics as part of the story explaining the phenomenon. By investigating some smart city scholars (e.g. Batty, Garagliu, Gigginger, Gil-Garcia, Hollands, Janssen, Lee, Manville, Nam Ratti, Townsend etc), none of them have integrated demographics to their smart city concepts and none of them have investigated the role of demographics empirically, e.g. in designing the smart city strategies.

2. THEORY

In general, most scholars do not link smart city with demographics nor ageing, although most authors agree that smart city is a novel concept that lacks definitional precision [4] [7] [8]. A number of frameworks have been proposed as typologies of the smart city but none of them has dominance in academics or in practice [1] [2] [5]

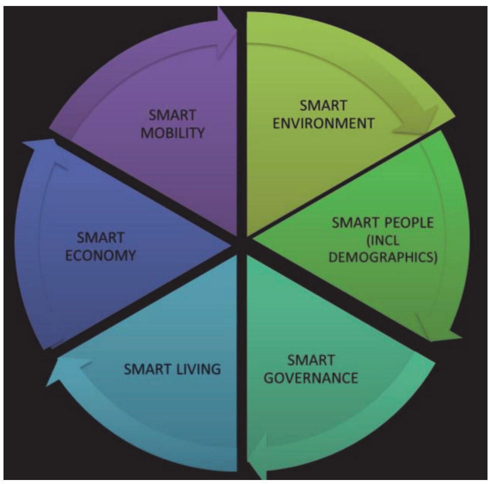

Figure 1. Modified Smart City concept of Giffinger (added demographics)

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In the 1990s, when the Smart City term was first used, the term focused on the interplay between novel ICTs and modern (physical) infrastructure in the cities. Currently, the smart city concept is not limited to the diffusion of ICT, and the focus has shifted towards a government-oriented approach that highlights the role of social capital and relations in urban development [2]. In a meta-study of Smart City definitions, Hollands [4] summarises that a smart city maximises the "utilisation of networked infrastructure to improve economic and political efficiency and enable social, cultural, and urban development." Caragliu et al. [2] developed this further and claim: "a city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance." In other words, none of the concepts above mentions ageing nor demographics as part of the smart city (or its synonyms: electronic city, wired city, intelligent city etc) concept. We will approach it by analysing how to complement two smart city frameworks (Giffinger's six smart city characteristics) with demographics.

A research group led by the Vienna University of Technology [3] identified six components of the smart city: smart economy, smart mobility, smart environment, smart people, smart living and smart governance. A large smart city meta-study conducted by the European Commission, led by Manville et al. [6] developed this further and mentioned that a smart city should address one or more of the following six characteristics: Smart Living, Smart Mobility, Smart Environment, Smart Governance, Smart Economy and Smart People. We propose to complement Smart People dimension also with demograhics (see figure 1 below) in Giffinger's in-depth meta-study [6]

3. METHOD: POPULATION PROJECTION

In creating the healthcare costs prognosis methods for cities, the logic of the social budget model (SEM) of the International Labour Organisation (ILO) was used, which is a frame-model based on a top-down method, that uses macroeconomic, labour market and demographic projections (so called cohort-based component model). With the assumption that the social sector income and expenditure depend on the economic, labour market and demographic indicators, the long-term health insurance income and expenditure developments were simulated.

Below are presented the main data sources, assumptions and other important aspects about the healthcare prognosis model.

3.1. Population Prognosis

The population prognoses are made in one year gender-age groups until the year 2060. The population starting position is taken from Statistics Estonia. The population prognosis of the health insurance model is built on the flow principle (see figure 2).

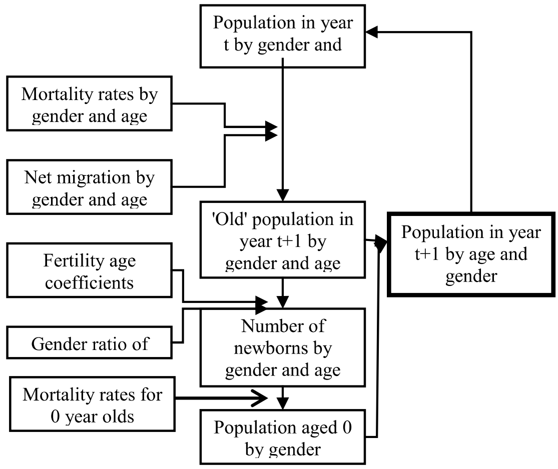


Figure 2. Logical scheme of population prognosis

The population prognosis (i.e. fertility, mortality and migration) is considered as set in regard to health insurance, i.e. it is assumed that the health insurance doesn't affect fertility, population health or migration.

The number of men and women at a given age in a given year equals the number of people who were a year younger in the previous year, who are also alive in the next year plus the net migration for the given age.

$$\text{Numberof people}[\text{sex, age, year}] = \text{Numberof people}[\text{sex, age-1, year-1}] \times (1 - \text{mortalityrate}[\text{gender, age-1, year-1}]) + \text{Net migration}[\text{sex, age, year}]$$

For the number of zero year old people the formula is bit different:

$$\text{Numberof people}[\text{sex, age=0, year}] = \text{Newborns}[\text{sex, year-1}] \times (1 - \frac{\text{mortalityrate}[\text{sex, age=0, year-1}]}{2}) + \text{Net migration}[\text{sex, age=0, year}]$$

The mortality rate is divided by two for zero year old children (as children are born all year round the mortality rate for the given year is halved compared to those who live the whole year). The upper age limit is 100 years, because it is assumed that nobody will live longer than that.

Fertility prognosis

The number of newborns in a given year is predicted by using the number of all women of childbearing age (15-49) for the given year and the given fertility age coefficient.

$$\text{Births}[\text{year}] = \sum_{\text{age}=15}^{49} \text{Number of women}[\text{age},\text{year}] \times \text{fertility age coefficient}[\text{age},\text{year}]$$

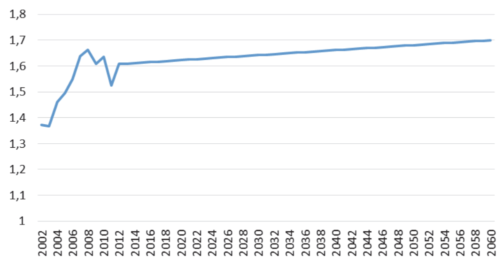


Figure 3. Past values and prognosis of the total fertility rate

The prognosis of the number of women comes from the population prognosis. The fertility age coefficient is predicted in 5 year age groups and then converted to 1 year age coefficients by using polynomials for evening out the results. The conversion is done with formulas that are presented in the sample version of the ILO social budget (ILO 1999). The fertility age coefficient for each year is predicted by two components:

1) The given total fertility rate (TFR) for a certain final year. In the model TFR 1.7 is taken as the base assumption for 2060, this has been also assumed by the Eurostat prognosis base scenario for Estonia (see figure 3).
2) The proportions of the given fertility age coefficient in the final year. The child bearing pattern in 5 year age groups for 2060 is taken as a base scenario from the Finnish data of 2002. As a result, the age of the average woman giving birth increases by *circa* three years in 40 years - from 29.5 years (in 2012) to 32.5 years (in 2060). 1.06 has been taken as the boys to girls ratio among newborns (the average of the years 2003-2012).

For the intervening years the fertility rate is found by linear interpolation.

$$\text{Age factor}[\text{age},\text{year}] = \text{Fertility age factor}[\text{age, initial year}] * \left(1 - \frac{\text{year - initial year}}{\text{final year - initial year}}\right) + \text{Fertility age factor}[\text{age, final year}] * \left(1 - \frac{\text{year - initial year}}{\text{final year - initial year}}\right)$$

Knowing the fertility age coefficient for each year for women of all ages and the number of women in all ages, it us possible to derive the number of children born each year, which is proportionally divided between boys and girls.

$$\text{Number of births}[\text{year}] = \sum_{\text{age}=15}^{49} \text{Fertility age factor}[\text{age},\text{year}] * \text{Number of women}[\text{age},\text{year}]$$

The number of women in a year is the average of the number of women at the beginning of the given year and at the beginning of the next year. Figure 4 shows the fertility age coefficient and reference fertility.

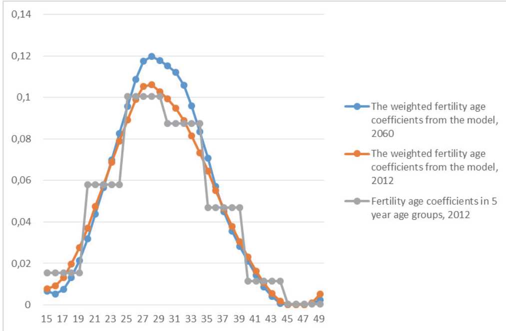


Figure 4. Fertility age coefficients in 2012 and on the final year of the prognosis (2060)

Mortality prognosis

The following data is used for predicting mortality:

1) mortality rate and life expectancy at the initial year (Europop 2010);
2) mortality rate and life expectancy at the reference year (Europop 2050);

According to the models base scenario, the life expectancy at birth will increase to 81.5 years for men and to 87.8 years for women by 2060. There are given initial and reference coefficients for mortality rates, in this case Europop 2010 and Europop 2050 indicators. Then, by using linear interpolation separately for individual ages of men and women, the approximate mortality rates are found for each life expectancy. The mortality rates of initial years are interpolated linearly until the reference year, whereupon it's assumed that the life expectancy no longer increases.

According to demographic assumptions, the mortality rates are decreasing proportionally more for men aged 20-40, to achieve the predicted life expectancy. For women the mortality rates are decreasing proportionally the most in ages 10-25.

Migration

Migration is not predicted in the base scenario of the health insurance model, because there are no detailed predictions based on gender-age about migration. The immigration and emigration of the working-age population impacts the revenue as well as the expenditure of the health insurance system, therefore migration sensitivity analysis options have been added to the model.

Population prognosis results of the model

Based on the aforementioned assumptions, the population predictions in the health insurance model are made up to the year 2060.

Labour market prognosis

The labour market predictions are based on the labour market status of the population, as defined by the International Labour Organisation (ILO). The employed, inactive and unemployed are predicted separately (see figure 5). The prognosis is made for 5 year gender-age groups and it is assumed that the current employment rates will grow in the long term and will, by 2030, achieve the rates at which they will stay until 2060. It's also assumed that the unemployment rates will converge to their lowest level by the year 2030 and will stay there until 2060.

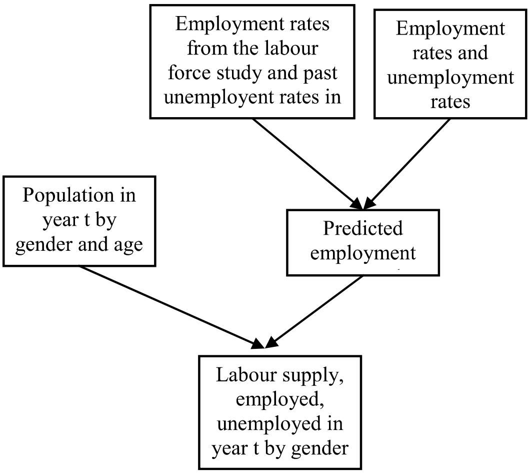
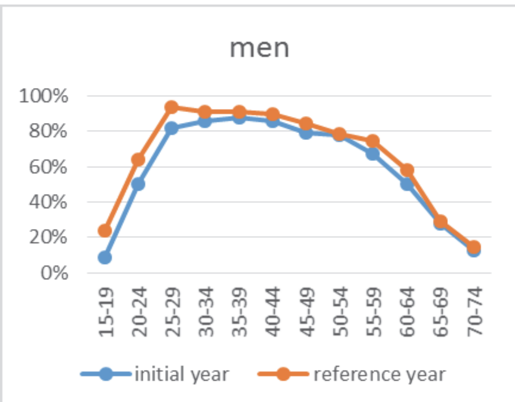


Figure 5. Prognosis of labour market indicators

Figure 6 describes the employment rates based on gender and age in 2012 (initial year) and 2030=2060 (reference year). A larger employment rates increase can be expected for women, because their retirement age increases more. In the long term it can be assumed that the employment rates for the elderly are equal, because they have been similar in pre-retirement age (in age groups 55-59) and because the retirement age become equal in 2016.

It must be noted that the employment rate development, used in figure 6, represents an optimistic scenario, where employment rates are approaching the historically highest values thus far and, in regard to the elderly, they even reach a level that hasn't been reached so far. Also the convergence of employment rates is stable and in the base scenario it is assumed that business cycles do not occur.



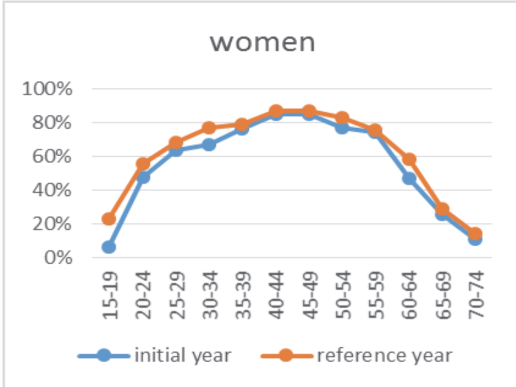


Figure 6. Actual and assumed employment rates by gender and age groups

Macroeconomic prognosis

The following economic indicators are used as input: the gross domestic product (GDP), consumer price index (CPI) and the average gross wages, which change similarly with labour productivity. The changes in prices and average wages were assumed to be independent from the developments of the population, labour market and health insurance itself. The possible effect of health insurance on the development of fundamental economic indicators, such as productivity or prices, is not assessed separately. A new economic crisis or economic boom (i.e. increase in unemployment, wage growth) is not assumed in the long-term base scenario, although the model enables the assessment of the effect of various economic cycles through sensitivity analysis.

Long-term macroeconomic indicators are taken in accordance with the long-term prognosis of the Ministry of Finance, which have been adjusted by a short-term prognosis. Important variables in the prognosis are the following:

1) GDP at current prices
2) CPI change,
3) change of average monthly wages.

Regarding social security tax proceeds, it is assumed that the real (effective) tax rates from the past will persist.

Prognosis of health care revenue and costs

The focus of the health care revenue and costs analysis are the services and compensations funded by the Estonian Health Insurance Fund (henceforth health insurance fund), because firstly they constitute the largest part of the health care costs and secondly, additional health care costs depend on the state budget or local government budget and the health care expenditures that are made by the people themselves also depend on which services the solidarity-based health insurance, that is organised by the health insurance fund, covers or does not cover. The resources of the health sector from the state budget and local government budget, where the estimated revenue equals the cost of services offered, are not predicted in the base scenario.

The primary source on the health insurance revenue side is the health insurance portion of the social security tax. The cost side is affected by population ageing, through changes in usage and prices of services. The number of treatment cases for the health insurance fund health care services is predicted by using the extent of health care costs and services used per capita by gender and age in 2012 and it is assumed that the respective ratios will remain the same until the end of the prognosis period. In health care funding, the possible developments in revenue and costs of the health insurance fund are predicted separately until the year 2060. Figure 7 describes the formation of the health insurance budget; it sums up the population and labour market chapters (above) and leads in the health care costs chapter (below).

In the long run, the organisation of healthcare can change or new technologies and services can be implemented and thus the costs can also change, but it would be too complicated to consider them in the base scenario of the prognostic model.

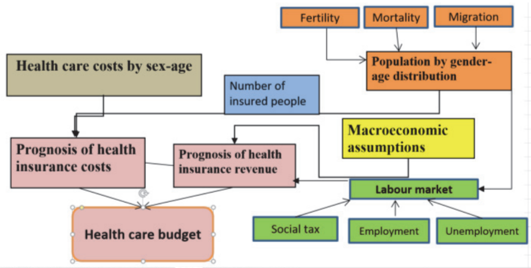


Figure 7. The logic of predicting health insurance revenues and costs

Health care costs

Health care costs are predicted based on the following relations:

$$q_{g,a,t,h} = \frac{q_{g,a,2012,h}}{pop_{g,a,2012}} pop_{g,a,t}$$

where

$q_{g,a,t,h}$ = number of service h treatment cases for people of gender g and age a in year t,

$q_{g,a,2012,h}$ =number of service h treatment cases for people of gender g and age a in year 2012,

$q_{g,a,2012,h}$ =number of people of gender g and age a in year 2012 according to the data of the Population Register,

$pop_{g,a,t}$ = number of people of gender g and age a in year t.

To predict the health care service unit price, the base year revenue is related to the price index of the respective year.

$$c_{g,a,t,h} = c_{g,a,2012,h} pi_{t,h}$$

where

$C_{g,a,t,h}$ = average cost of health care service treatment cases for people of gender g and age a in year t,

$C_{g,a,2012,h}$=cost for person of gender g and age a in year 2012

$pi_{t,h}$ = value of health care services h price index in year t.

The cost S $_{g,a,t,h}$ = by gender, age and service is derived for each year by multiplying the number of services with the service unit price:

$$S_{g,a,t,h} = c_{g,a,t,h} q_{g,a,t,h}$$

In the long-term, the health care costs in the base scenario change for all services at the same rate as the average wage, i.e. faster than the CPI. This is mainly because labour costs account for about 50% of health care costs (*ca* 65% of general medical care costs, *ca* 70% of prevention work, *ca* 45% of specialised medical care, *ca* 56% of nursing care and *ca* 62% of dental care). Also a large part of the other costs (pharmaceuticals, equipment, instruments) will increase, due to technological development, at a faster rate than the general price level in the economy. It is also assumed that the price of health care services will develop equally for all gender-age groups. However, the health care service prices are, in the short-term, adjusted differently from the average wages to ensure consistency with the short-term predictions of the health insurance fund price changes (2013-2017).

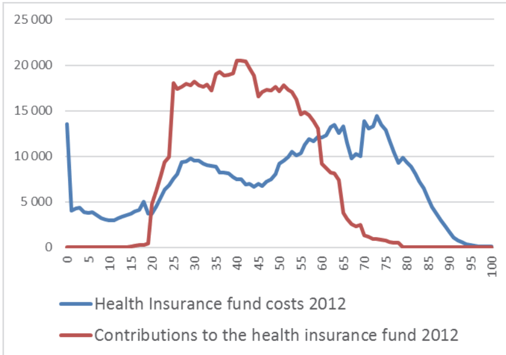


Figure 8. Health insurance fund costs and social security tax proceeds to the fund by age groups, in thousands of Euros, 2012

Figure 8 describes the solidarity in funding Estonia's health insurance and a possible sensitivity in regard to the age structure of the population, and shows what the health care costs of the health care services funded by the health insurance fund for people of a certain age are and what is the health insurance portion per capita of the social security tax proceeds. It shows clearly that the highest costs per capita are during infancy and in old age and most monetary contributions to the system are made during working age.

4. RESULTS

When comparing the social security tax income and health insurance fund costs on the city level as a percentage of the GDP, we see that, according to the base scenario, the costs exceeds the revenue for the next 20 years (see figure 9) and beginning with 2030 the deficit starts to increase rapidly, because by then the employment rates have reached their maximum level and would not rise any further and the ageing population starts to increase the costs. This in turn decreases the health insurance fund reserves, which in this case will become negative, from which point on the need for additional monetary sources increases to retain the existing level of spending. It should be noted that this model assumes zero migration.

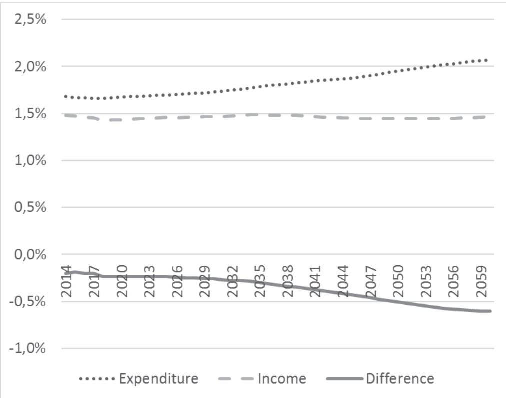


Figure 9. Revenue, costs and difference of City of Tallinn health insurance in 2012-2060, percent of GDP

5. CONCLUSIONS

This paper is interested in the link between demographics, smart cities and healthcare expenditure. In the theoretical section, we argue that most smart city researchers neglect demographics as a key driver of urbanisation which also creates demand for smart cities. In other words, smart cities are a result of urbanisation and technology. Urbanisation, on the other hand, is also driven by demographics (ageing), thus, it should be incorporated to the smart cities research. This research paper proposes a conceptual framework that incorporates demographics into the most common smart city concepts (e.g. Giffinger's).

This model is tested in the City of Tallinn for estimating and predicting healthcare costs in urban areas – a demonstration why demographics in the urban areas should not be ignored. In the case of Tallinn, a combination of demographic, economic and labour force simulations indicate that health care expenditure is increasing in the long run.

It should be noted that this model is based on simplified assumptions and should be used only as a support for making decisions under uncertainty. In reality, the change in mortality and fertility is very difficult, if not impossible, to predict and the change of employment is not linear over the long run, therefore, the model ignores economic fluctuations (e.g. recessions). In addition, it also ignores advances in the medical technology.

6. ACKNOWLEDGMENTS

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Appendix 1

Article VII

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Smart Twin Cities via Urban Operating System

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ABSTRACT

This paper looks into how cities can offer joint digital services in the cross-border areas. By fact, most digital services are local and by large, most of them are developed in isolation from the neighbouring local governments, either national or international. In the digital area, this is a huge challenge, as independently developed digital services tend to be locked-in to specific standards making future cross-border services challenging. We propose a model for joint digital services in the cross-border cities – the Urban Operating System. The model will be validated in two Northern European cities with high commuting frequency: Helsinki and Tallinn.

CCS Concepts

• Applied computing~E-government

Keywords

Smart city; digital single market; interoperability; cross-border services; public service provision

1. INTRODUCTION

Information and Communication technologies are aggressively reformulating the borders between the countries, at least the virtual ones. ICT breakthroughs like Facebook, Skype, Google and LinkedIn have clearly changed the understanding of the world map: if you can get online, there are no borders, at least in online communications services. On the other hand, the picture is different if we zoom into the regional levels where each municipality tailors its own electronic services: local services are often developed in isolation with small or little attempts to co-design the services jointly with neighbouring cities in order to offer the cross-border services for their citizens. Digital urban services are still developed and analysed from the "closed-borders" perspective, disregarding everyday commuters and the fact that, at least technologically, services can be easily scaled over the borders.

This paper analyses the definitional framework of smart city, proposes a new model for cross-border cities –the Urban Operating System – and analysis it based on two cities: Tallinn and Helsinki. There is great potential for joint urban services for citizens of Tallinn and Helsinki – at least all the components are there: proximity, commuters and digitalisation. Frequently commuting citizens and travellers of two cities prefer mutual smart city services.

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Currently, the urban digital services are being developed in isolated silos, although there is effective ongoing co-operation between the city officials and there is also a high-level political willingness to develop mutual services. There has been extensive political hype since Estonia's re-independence in the early 90s claiming the area (Tallinn and Helsinki) to become a "twin-city," there are even two names for this: Talsinki and Hellinn. Even now the tunnel project between Helsinki and Tallinn remains topical. Clearly, the assumption of twin-cities is that there are mutual services, including joint digital services.

2. ANALYTICAL FRAMEWORK

2.1 Smart City defined

Theoretically, Smart city is a novel concept that lacks definitional precision [12] [19] [21]. A number of frameworks have been proposed as typologies of the smart city but none of them has gained dominance in academics or in practice [3] [4] [13].

On one hand, Smart city covers a wide angle of "hard" domains such as buildings, energy grids, natural resources, water management, waste management, mobility and logistics (20) where ICT plays a decisive role in the functions of the systems. In addition, Smart city has also reached to "soft" domains like education, culture, policy innovations, social inclusion and government [1].

In the 1990s, when the smart city term was first used, the term focused on the interplay between novel ICTs and modern infrastructure in the cities. Currently, the smart city concept is not limited to the diffusion of ICT, the focus has shifted towards a government-oriented approach that highlights the role of social capital and relations in urban development. In the everyday urban planning context, Smart city is often interpreted ideologically whereas being smarter entails strategic directions: governments label their policies "smart" in order to achieve sustainable development, economic growth, better quality of life and simply create happiness [1].

In a meta-study of Smart city definitions [12], smart city is a city that maximises the "utilisation of networked infrastructure to improve economic and political efficiency and enable social, cultural, and urban development." Some authors [4] claim that "a city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance."

There are also narrower definitions. Smart city can be defined by its ability to develop and administrate novel services that provide information to citizens about all aspects of urban life via interactive and internet-based applications [13].

Several authors criticise that current smart city definitions and components stress the provider's viewpoint and combine various lists of functional urban services whereas structures are constructed for the convenience of administration [14]. Some authors [22] stress the importance of open innovation and user engagement and discuss that too heavy corporate-based approach leads to risks of losing the independence of governments. Many authors [1] [16] stress the importance that smart city should be citizen-centric and citizen-driven.

From the ICT perspective, smart city is a synonym for the integrated systems and databases, smart city can be viewed [7] as an important component to integrate city's various systems (transportation, energy, education, healthcare, buildings, physical infrastructure, food, water and public safety). Similarly, a city is smart when it integrates hardware, software and network technologies in order to connect seven critical city infrastructure components and services: city administration, education, healthcare, public safety, real estate, transportation and utilities [24], the outcome of smart city is affordable healthcare, clean environment, business opportunities and more jobs. In other words, the smart city is the use of smart computing in order to make city's infrastructure and services more intelligent and efficient that provide close to real-time awareness and advanced analytics.

In the ICT literature, smart city is sometimes conceptualised as a synonym to the Internet of Things. The Internet firstly evolved from connecting people with information (Internet 1.0) to connecting people to people (Internet 2.0). The next step is connecting objects with objects, places and everything (Internet 3.0). Some authors [2] argue that this third wave aims to radically change the human interaction with the earth in the same way as the Internet has managed to revolutionise personal and business interactions. This "revolution" could be labelled in different contexts as Internet of Things, Smart City or Future Internet.

The prerequisite for smart city is intelligent infrastructure and a set of cross-sectoral services (energy, sanitation, health care, transport, farming, governance, automation, and manufacturing) [2]. The infrastructure itself can be decomposed to 1) Large-Scale Instrumentation or connected objects (connect city's infrastructure with sensors, actuators, tags, readers and other sensing devices); 2) High-Speed network Infrastructure (connecting millions of devices requires significantly faster network connection) and 3) Data Management (how to exchange and make sense of data).

A broader concept can be found in [5] that identified eight critical factors of smart city initiatives: management and organisation, technology (including adoption), governance (multiple stakeholders), policy context (restrictive laws and regulations), people (digital divide, participation, education, accessibility etc), economy, built infrastructure (including security and privacy and operational cost) and natural environment (resources).

One of the most comprehensive approach is offered by Batty [3] that define smart city as "a city in which ICT is merged with traditional infrastructures, coordinated and integrated using digital services. These technologies establish the functions of the city and also provide ways in which citizen groups, governments, businesses, and various of agencies who have an interest in generating more efficient and equitable systems can interact in augmenting their understanding of the city and also providing essential engagement in the design and planning process." The authors sketch their research agenda for smart cities and one out of seven points is that smart city research should develop new forms of urban governance and organisation (in other words, re-engineering cities).

Embedding technologies into the fabric of the built environment relate to the narrower concept of the smart city. In the last 10 years, devices have been produced that can be located at very fine scales in the urban environment. These devices can be used to roam the environment where they are linked to movable objects used by humans as many kinds of mechanical devices: in short computers and related sensors now exist everywhere either fixed to physical objects in the environment or contained as parts of mobile smart phones, and related computational interfaces. An immediate product of such devices is data, and as much of this is now being streamed in real time, this data can be, and usually is, voluminous, hence big. Big Data is largely unstructured and is part of the "exhaust" of the smart city. Computers and computation have also been used for many years, almost since their inception, to enable and extend the science we use for thinking about the structure and organisation of cities. This science is at arm's length from ideas about the smart city. It developed in the form of spatial economic and transportation models relating to how cities function from the 1950s onwards and has moved through many variants as computers have become bigger, faster, more visually accessible and so on. Today, various models and methods exist which are highly visual and accessible. These models and methods enable data, some of it big, to be easily incorporated into the functions of smart city models. This wave of applications which is increasingly called "The Science of Cities," is not the same as the narrower domain of "Smart Cities" but they are complementary to one another [3]. Collectively a synthesis of each is sometimes referred to by the term "City Science" or "Urban Science" but it is important to be aware of all these differences. The diagram below suggests how we might clarify these distinctions:

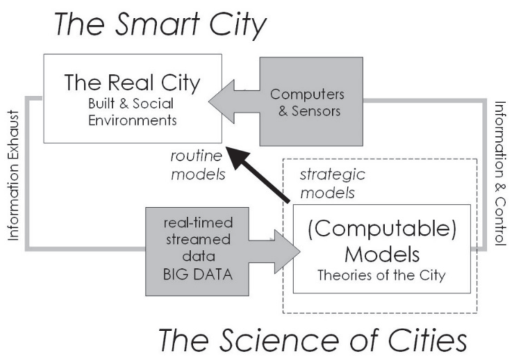

Figure 1. Combined model for City Science and Smart City by Batty

The figure 1 provides a useful focus for understanding what smart city R&I actions should entail:

- **Improving Mobility**: Minimising Disruption, Producing Better Quality Travel Experiences, Minimising Energy Consumption
- **Improving the Use of Resource such as Energy**: Smart Sensors and Grids
- **Enabling Integrated Design of Built Environments**: Through ICT, Local Networks, WLAN, Cloud Services
- **Providing Access to Public Information**: Open Data and Transparency

- **Improving Citizen Participation**: Engaging Wider Circles of Citizens in Relevant Decisions
- **Improving Democratic Decision-Making**: Through New Methods of Information Delivery to Citizens and Methods for Online Engagement
- **Improving Retailing/Commerce**: Delivering Better Information and Access to Consumers and Producers in Real and Online Environments
- **Enabling Better Housing Choices**: through Access to Capital, Information about Supply
- **Delivering Better Information to Urban Management**: Through a Variety of Media such as Dashboards and Other Interfaces
- **Providing Services for Building Integrated ICT Platforms**: Providing Integrated IS at Different Scales
- **Providing Integrated Data Services**: Adding Value to Data, Opening Data

Some of these overlap as one might expect but this is a broad range of functions that demand some very different skills and perspectives. Moreover, many of them relate to other organisations which have urban mandates such as utility services, local governments, financial services, and a variety of formal and informal agencies which operate in cities. This suggests that a suitable mediator would have such a pivotal role in bringing many diverse agencies, personal skills, and technologies together.

Smart city can be decomposed to industry, education, participation and technical infrastructure [8]. This list was followed by a project by Vienna University of Technology, led by Giffinger, that identified six components that are close to becoming a standard in the field [9]. These components are the smart economy, smart mobility, smart environment, smart people, smart living and smart governance. There is an approach to rephrase these components [17]: smart economy – industry; smart people –education; smart governance – e-democracy; smart mobility – logistics and infrastructure efficiency & sustainability and smart living – security and quality. Alternatively, some authors [19] point out three core components of smart city: the technology, the people (creativity, diversity, and education), and the institutions (governance and policy).

An extensive metastudy [18] inspired by a project by Vienna University of Technology [9], a smart city addresses the following six characteristics: Smart Living, Smart Mobility, Smart Environment, Smart Governance, Smart Economy and Smart People.

This current research project bases its conceptual assumptions on a European Commission meta-study that defines smart city in the following way [18]:

"**A smart city is a city seeking to address public issues via ICT-based solutions on the basis of a multi-stakeholder, municipally based partnership**."

Although the authors claim that this is a working definition, it is based on the meta-analysis how smart city has been conceptualised previously. There have been two main streams of smart city definitions: the first one has been focused on ICT as a technology driver and the second one has been broader including socio-economic, governance and multi-stakeholder aspects such as the use of social participation to enhance sustainability, quality of life and urban welfare. Clearly, the definition above is a combination of these two.

2.2. Smart City Clusters

Definitions of a smart city are of course rather versatile since the concept is not yet matured and contexts of definitions vary. However, things and terms, or, domains referred in those definitions are quite focused. If we take notions of ICT and public services somewhat given in the context, there are four main clusters that are typically referred. In the order of typicality, they are

1. Sustainability and protection of natural resources
2. Efficiency of traditional/existing infrastructure plus information systems
3. Citizen and quality of life and their relation to learning, creativity, and human or social capital
4. Economy in a sense of growth and new job opportunities

Based on growth perspective and emphasis on technology versus human activities, the clusters can be also divided into four fields (see table 1).

Table 1. Four clusters of smart city definitions

Emphasis in the SC definitions		Technology	Human
Growth	Calm down	Sustainability, Protection of natural resources	Citizen/Quality of life ⇔ Learning, Creativity, Human/Social capital
	Efficient	(Efficiency of) traditional infrastructure	Economy/growth/jobs

Thinking of the main argument, there are two main types of definitions of the concept of a smart city. First, also in the order of time, there were mostly technology-oriented definitions taking new ICT solutions, sensors and data sources, in some cases infrastructure of them, as a starting point that would then improve (mostly) public services and quality of life in general. Among other things, there was a strong corporate interest in this technology based utopias, since "for corporations such as IBM, Cisco systems, and Siemens, the technology component is the main component" [1].

Another main type of a smart city definition is having a somewhat critical or compensatory relation to the earlier one. It emphasises a governance-orientation, that is, human and social capital, and urban development in general. These include a huge variety of themes such as (governance of) learning, happiness, quality of life, growth, the flow of information, and competitiveness.

2.3. Urban Operating System[1]

This paper suggests to design and implement the digital technologies platforms (an Urban Operating System or Urban OS) that will enable to create a real-time cross-border sensing environment as well as to provide a new layer of shared services and opportunities to cities inhabitants and users. Rather than a top-down system supplied by an international technology leader to improve efficiency and security, the Urban OS is imagined as an open network that is able to create sustainable wealth and encourage local economy. Through the Urban OS, the city becomes not just as a testbed but also a platform to innovate upon.

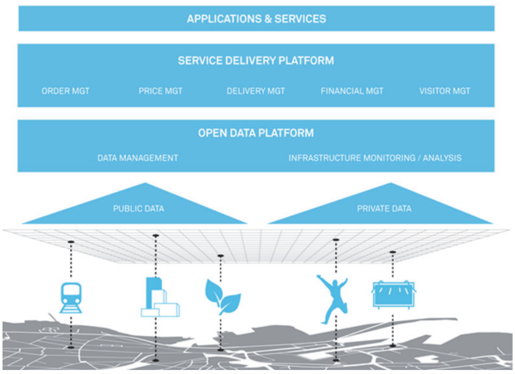

Figure 2. Urban Operating System

The concept of Urban OS is simple: deploying a network of sensors that can capture real-time data from a myriad of things occurring in cross-border cities, and connect such sensors to an urban information system helps to analyse better and transform such data into knowledge. We can create new types of urban efficiencies, products, and services for the people of the cross-border cities. In turn, they access an open-access digital services delivery platform using anything from a smartphone or a laptop all the way to digitally enhanced infrastructures such as responsive public spaces, intelligent transport systems or smart energy infrastructure among others. The cross-border cities become a permanent platform for interaction that provides a unique mix of services to each user. Furthermore, by giving users the capabilities of developing their solutions and services we create a more inclusive and bottom-up model of both social and economic development while jumpstarting local dynamics.

Urban OS Architecture

The data management layer provides standardisation and storage function for the platform facilitating analysis of long-term sensor data. Urban OS would be the primary conductor of various data streams used by the various digital services between two cities.

Integrating data streams

Ubiquitous sensors and sensor networks are increasingly providing data sources of different contents, formats, and qualities. Integrating diverse data sources allow developing applications that would not be possible by using single sensor network. When integrating data from heterogeneous sources, syntactic, schematic, and semantics diversities of the data schemas are challenging problems. Through an Operating System, data from diverse sources is translated into a common language and visual interface.

Data processing functionality

The Urban OS will offer businesses, citizens, and governments the ability to combine real-time data from across some data streams to create and up-to-the-minute picture of urban material flows and dynamics. In addition carrying data from providers to consumers, the Urban OS will allow clients to process quickly, manipulate and visualise the data of data streams. Through the platform, applications can also be published and shared among users.

Scalability and flexibility

Agile development processes have dramatically changed the way technology is being implemented. Shorter cycles allow to constantly adapting to changes or new conditions. The OS platform will be designed to meet current needs without compromising the ability of future generations to meet theirs. At the moment we can assume hundreds of data streams, with individuals contributing this number easily into the thousands. Taking into account the overall input load and the numbers of potential clients, and doing a quick approximation, we could easily end up with up to one million messages per second. The OS platform will be designed to deal with, initially, a small load, but at the same time, it will need to be designed to scale to hundreds of machines to deal with the additional load.

Inhabitants as actuators

Truly smart cities will emerge as inhabitants and their many electronic devices are recruited as real-time sensors of daily life, agents for sensing and reporting their individual experience. Offering a real-time view of how human, material, digital and financial resources travel through the landscape of their daily lives will perceptually expand each citizen's sphere of responsibility from the domestic space to the space of the city - the city becoming the smart meter of all these factors. In a digitally augmented smart city, civic zones can be transformed into responsive environments through technological mediation. This would change the passive inhabitants of the city to active participants of spatial scenarios, and the public spaces from areas of transit to urban destinations.

This paper proposes the following path: the creation of an Urban Operating System that is available for local and cross-border solutions. Such an approach follows from strategic plans developed by European Innovation Partnership on Smart Cities and Communities. Equally importantly, this will utilise open software and platform standard solutions developed in the context of FIWARE Smart Cities and Open and Agile Smart Cities (OASC) initiatives in order to ensure replicability and more importantly, scalability. In Estonia and Finland, public ICT infrastructure based on open standards – x-road and electronic Identity – has brought two countries globally to the cutting edge of e-government and smart city solutions and offers a unique opportunity to develop an Urban OS.

In practice, the Urban OS is a platform for joint R&I pilots with public sector involvement, associated companies and citizens as end-users. This combination will ensure that companies can make cross-border smart city solutions exportable and sell them globally.

[1] The concept of Urban Operating System is co-developed with the Carlo Ratti Associati.

In essence, the Urban OS enables and ensures knowledge transfer between practical needs of cities and companies, and researchers (see figure 3).

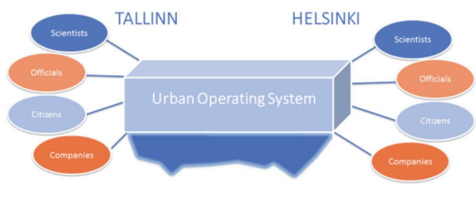

Figure 3. Urban OS for cross-border cities

An important tool for the Urban OS is the twin-city Living Lab. The figure below explains how joint cross-border pilots will take place in the cross-border cities and how these pilots can push two cities towards shared identity, can help to harmonise data and make it interoperable, and provide means for co-working and for trial legislation (see figure 4).

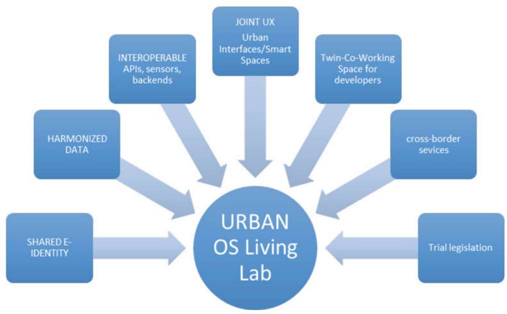

Figure 4. Urban OS toolbox: smart-twin-city living-lab model

The importance of participation processes lies in the role of citizens as actively engaged protagonists in the conception and construction of their city and not merely recipients of public services. Thus, digital means will foster inclusiveness and accessibility, enabling an on-going and real-time exchange of information, outreaching a wider range of actuators. In order to generate discussion spaces that allow for the development of science, technology and innovation in cross-border cities, a crowdsourcing platform will be built in order to allow for the real-time interaction of relevant communities in the project, in a free and open manner. Such a platform has the capacity to transform itself into a project bank formulated by the community, allowing for the identification of strategic projects to encounter institutional support and become a reality. The public space could be used for a multitude of propositions that vary according to the basic needs of the population. Such a platform will be an essential part of pilots through living labs tools described above.

Currently, globally leading smart city solutions follow two distinct patterns: first, building entire cities or parts of cities from the ground up based on smart city technologies; or, second, incrementally adding layers of sensors, opening up data for existing services. For cross-border solutions, neither alternative is satisfactory: the former demands enormous resources not available and the latter follows too slow a pace to advance public service reforms, digital common market and competitiveness.

The first phase of the smart city often focuses on the deployment of hard infrastructure related to connectivity and sensors, capable of registering one or more quantifiable aspects, and is followed by initiatives that address various dimensions of a city's life and operations. Once populated with a large number of sensors, a city can register changes in its context, better responding to emerging conditions and adapting to the needs of its inhabitants. In addition to developing new infrastructures, cities can leverage systems already in place that have been developed for other reasons but can function as a source of information on how our cities operate. A great example is the cellphone network: each time a text message or email is sent, a phone call made, Facebook profile updated or photo uploaded or tagged in Flickr, an entry with time and location of this action is added to the dataset. When cross-referenced with the geographical terrain, data harnessed at this scale offer a means to understanding and responding to, the urban dynamics of the city in real-time. Whether extracted from existing telecommunications networks or from highly customised sensors embedded for the purpose of monitoring urban flows, the end goal should be to democratise access to the information thinking long term in real-time and ultimately reducing the inefficiencies of present day urban systems.

In general, the literature on big data classifies sources under three broad categories: opportunistic sensing, purposely sensing and crowd sensing. Opportunistic sensing leverages data running on existing systems, such as a telecommunication network, but can be used to better understand different systems. In other terms, data is collected for one purpose and used for another. This approach to data collection is made possible largely by the fact that mobile phones have become so ubiquitous – citizens replace the need for purpose-built sensors, contributing real-time data through their portable devices. Other typical data providers include credit card companies recording user transaction, taxi fleets reporting vehicle GPS, smart parking solutions, and so on.

In contrast to opportunistic sensing, purposely-sensed datasets are derived from ad hoc sensor networks configured to study a specific phenomenon. Thanks to advances in microelectronics sensors and computation are becoming increasingly affordable and distributed, a phenomenon often referred to as "smart dust"; hence networks of remote sensing agents can now be embedded in the city fabric to extract large amounts of information. This data is channelled to central control stations where it is aggregated, analysed and used to make decisions on how the monitored terrain should be regulated and actuated. Here, the resulting datasets tend to be more uniform, and the stated use and actual end-use scenarios are better aligned to decode various flows within the city.

In every city, the complete story cannot be told by figures and data alone. To adequately assess a situation, the voice of the citizen must be heard. Each urbanite can be thought of as a human sensor, capable of reporting on his/her experience of the city through content sharing platforms such as Flickr, Twitter, Facebook or Wikipedia [23]. These actions offer a unique view on how citizens navigate their environment, bringing clarity to points of attraction or spontaneous migrations. This approach describes the third data source known as crowd sensing. The crowd becomes a distributed network of sensors that allows understanding the dynamic patterns of the city and the experiences of its citizens at a quasi-real-time rate. In the absence or failure of top-down sensor networks, this grassroots approach to sensing leverages the millions of newly cyber-connected citizens to coordinate human activity on the unprecedented scale. Integrated cities perform with unparalleled efficiency (whether resources, transportation, or infrastructure), enabled by digitally-controlled circuitry and virtual operating systems, ultimately transforming urban space into an open living lab.

The next generation of knowledge districts will project their influence far beyond their physical boundaries. Implementing a PPP approach to investment projects can result in the transfer of knowledge and expertise from the private partner to the public entity. PPP also facilitates lead-market creation with export potential where public sector can act as a demanding first customer for new technologies while sharing financial and technology risks with other partners.

3. EMPIRICAL PART

3.1. Research Method

The research method is a case study of Tallinn and Helsinki digital urban services from the Estonian perspective. Data was gathered through in-depth structured interviews with representatives of cities, companies and third sector experts, altogether 30 high-level interviews were conducted in 2015 and 2016. The interviews aimed at gaining specific information about the potential of mutual digital services. Empirical information was also derived from secondary sources like published and reports and documents.

Smart city is an emerging and rapidly changing field of study and therefore, the theories have to be adjusted to the changing environment. On the other hand, especially in the case of novel topics, there is a lack of approaches and overwhelming theories that could be empirically validated. To address it, the interviews have a goal to go beyond theory and linkages found in the current literature.

3.2. Tallinn-Helsinki case study

Two European capitals, Helsinki and Tallinn, are in a relatively unique situation. Between the two small nations (combined population of 7 million), there is a high commuting frequency. Approximately every 15-20th Estonian lives in Finland and commutes back to Estonia on a regular basis (see figure 5). For Finland, Estonia is the most popular investment and tourism destination, every fifth Finn stays overnight in Estonia each year. The two countries speak rare Finno-Ugric languages, and there is a feeling of kinship between the countries. In terms of innovation, *both countries are particularly strong in digital innovations.*

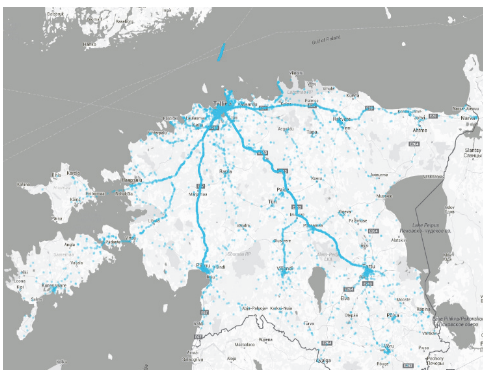

Figure 5. Commuting frequency between Estonia and Finland

The on-going collaboration between the public administrations of the cities of Helsinki and Tallinn is both strong and growing. For example, the cities have agreed on a memorandum of understanding to structurally develop the "twin city" in various domains, from social issues to specific smart-city topics, including open data harmonisation and public-transport-system interoperability.

The Helsinki region and Tallinn form a pair of two similar-size NUTS2-level regions, which sometimes are defined as small "macro-region" by themselves. There is a large amount of ERDF (European Regional Development Fund) targeted to the cohesion of this macro-region through Central Baltic and Baltic Sea Region Interregs as well as national structural funds. For example, there is a Southern Finland-Estonian sub-programme in Central Baltic Interreg that much resembles the project regions. Also, there is a large amount of collaboration of the public authorities on these levels. Notably, the Helsinki region RIS3 and the Estonian RIS3 (smart specialisation strategies) are aligned. Smart city domains are in the focus of the Helsinki region RIS3, and ICT and digital industries are in the focus of the Estonian RIS3 planning work.

There are also several ERDF-funded projects for the smart twin-city collaboration on the public administration level. As an example of these, the following two projects were decided to be funded from the Central Baltic Interreg ERDF on 14.6.2016, starting 1.9.2016:

- **FinEstSmartMobility** (1,8M€, 2016-2019)), which will plan and procure 4 smart (ICT-based) solutions to improve the traffic flows that go through Helsinki and Tallinn via the ferry and airplane connection.
- **FinEst Link** (2016-2019, feasibility study € 1.3 mln), which will execute planning towards a fixed link ("the railway tunnel" or another connectivity link) between Helsinki and Tallinn. This project is expected to lead to a very large-scale transport investment project (e.g. CEF; the pre-feasibility study estimates an investment size of 14B€ between 2020 and 2030).

On the national levels, Estonia and Finland are considered as frontrunners of digital innovations. Two small European countries are the birthplaces of Nokia and Skype, respectively, and they have an overall strong digital focus in many aspects of life. Finland is considered a good place for innovative ideas, especially in the field of digitisation. Estonia is renowned for having the most innovative e-governments in Europe.[2] No other nation has equipped each of its citizens with a secure digital identity and no other nation has connected all public databases over the Internet, using a secure transport layer (the X-road). Helsinki is considered among the top 6 most successful European smart cities.[3]

The Helsinki City is part of several networks that aim to make cities work together for developing joint smart-city solutions. Helsinki coordinates the 6Aika project, which harmonises smart-city solutions for the six biggest cities in Finland (Helsinki, Espoo, Vantaa, Tampere, Turku and Oulu). They also initiated and coordinated the CitySDK project, which offered open and scalable smart-city solutions for 8 cities in Europe: Amsterdam, Barcelona, Helsinki, Istanbul, Lamia, Lisbon, Manchester and Rome. The CitySDK was then transformed to Open and Agile Cities which connects 89 cities from 19 countries in Europe, Latin America and

[2] https://ec.europa.eu/digital-single-market/en/digital-public-services-desi-dimension-5

[3] www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdf

Asia-Pacific.

3.3. ICT Infrastructure

There are two cornerstones of the ICT deployment in Estonia: widely used electronic identity and secure exchange of data over the Internet. In the first case, most residents of Estonia (93%) have a personal ID card that is used in the digital environment for authentication and electronic signatures. Secondly, all government-sector databases (over 3000) are linked with each other via the Internet using the secure transport platform called x-road. The x-road is an open-standard transport layer that connects various databases with each other, independent from the vendors (close to full interoperability).

Nevertheless, the successful ICT deployment has not been leveraged in commercial terms. The IT sector that Estonia is renowned for does not generate significant export revenues. IT services exports in 2014 constituted only 1.3 % of total export revenue. The reason for this is that so far Estonia's e-government solutions have lacked international scalability. This has various reasons: first, lack of policy initiatives directed at ICT exports; second, labour shortage in the ICT sector; and third, perhaps most importantly, lagging interdisciplinary R&I activities that would utilise ICT solutions in other sectors of the economy as well.

Joint data exchange layer X-Road

Established in 2001, the X-Road is the backbone of the Estonian ICT architecture as it equally offers a combined solution for infrastructure and standardisation. The X-Road data exchange layer connects all databases and information systems of the public sector (more than 3000). By implementing the X-Road, the aim to store each data item only once could potentially be achieved, an important prerequisite to acceptance in the field of data protection issues in Estonia. The open SOAP (Simple Object Access Protocol) architecture of X- Road allows the implementation of all kinds of web services for the use of citizens and enterprises in Estonia. The X-Road environment was expanded to send all kinds of XML-format electronic documents securely over the Internet as it is at the same time a public key infrastructure (PKI).

One of the key elements of ICT deployment in Estonia is that its databases are decentralised. The technological platform is technically maintained by the government. Government agencies or businesses can choose from the he offered solutions, and services can be added one at a time. X-Road is the connection between databases of government institutions and enterprises offering public service or business solutions. All Estonian public e-solutions that use multiple databases use the X-Road.

The X-Road can be used not only for making queries to the different databases, but also to write to multiple databases, transmit large data sets, and perform searches across several databases. In a larger sense, the X-Road can be described as an early example of a "public cloud" offered to all public authorities, businesses, and citizens. Close to 1000 organisations, public registers and databases are connected to X-Road today. The X-Road services have been used more than 30 million times.

Implementation and maintenance of the X-Road structure which is the central basis for security, functionality, and ease-of-use aspects is given to a government agency with support from a university research institution, the Estonian Informatics Centre (RIA), a subdivision of the Ministry of Economic Affairs and Communications. They are supported by service providers, consumers associations, application service providers and authentication service providers. X-Road may be also described as an early example of a 'platform-as-a- service' cloud service in as much as application developers can develop and run their solutions on the X-Road; however, information is kept in a particular database of each organisation, independent from the X-road (which is a communication layer). The technical environment is kept open to perpetual modifications and can keep pace with changing demands, for example, if the need for a specific service ends (see figure 6).

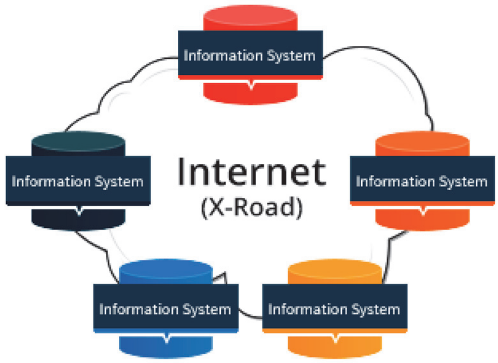

Figure 6. The X-road platform

Authentification via Electronic Identity

In 2001 the Parliament established ID-card as a compulsory identity document to replace the identification through passport. The first ID-cards were issued to Estonian citizens in 2002. By 2005, over 50% of the Estonian population owned an ID-card. The ID-card project uses the digital signature, which was established in 2000. The certification of the ID-card includes a personal identification code, which enables identification of the user. This identification feature can be used to do online transactions, e.g. in the field of banking or shopping. Furthermore, a certificate, which enables the user to sign documents with the same legal implications as a handwritten signature, is inserted in the ID-card chip. Both certificates inserted in the ID-card can be applied in the public sector as well as between enterprises and between individual private users.

As the bank sector promoted the e-ID card from the beginning, it offers real advantages in usage for almost everyone. Full bank transfer service, for example, is most conveniently done with e-ID security. Users of telephone banking, code-cards or branch services have to accept reduced features. In 2007, the banking sector significantly reduced all activities to develop other identification schemes besides the e-ID on its own. Although Estonia is not the inventor or originator of e-ID (the initial R&D came from Finland), experts emphasise how in the Estonian society and economy the functionality of the card is used to its fullest (over 90% of citizens have the ID card and over 30% use it in the online environment). A citizen pays around 25 euro for an e- ID Card. There are no per-use fees. The initial e-ID implementation as a whole was tax-funded. The respective service providers bear the costs per transaction.

In 2007, the mobile-ID was introduced that offers eID services (identification and digital signature) via the SMS protocol. In 2014, the e-Residency project was kicked-off by the government that offers eID services for non-residents of Estonia (Estonia has over 15 000 e-residents in 2016)

The public infrastructure applies to Finland and two capital cities as well. The Estonian ID card is taken over from Finland and Finland is the second country to implement the x-road. This offers a unique setting for cross-border services**.**

4. RESULTS

The Urban OS between two urban areas aims to connect various cross-border stakeholders with an aim to jointly provide mutual services for commuting citizens. In this paper, we have analysed the potential and barriers for Helsinki-Tallinn (and Estonia-Finland) joint digital services from three viewpoints: Private Sector, Third Sector and Public sector.

4.1. Private Sector

From the private sector, there is a strong willingness to offer cross-border services, although there are clear obstacles that block this. Many company managers claim that these are not technological but related to legislation and cultural aspects (managers of Port of Tallinn, SpinTek, Positium and Cityntel). The street-lights provider Cityntel has reshaped its target market from the Nordics to Asia, for example. "We have quit trying to enter the Finnish market. Too little possibilities and everything moves very slowly, legacy prevents innovation," claims the chief executive of this company. This view is commonly shared, entering the market really require the references.

In addition, there are real market entry obstacles as well which make it complicated for companies to introduce cross-border solutions. As an executive from Spin Tek puts it: "smaller municipalities would like to implement our solution, but will not until Helsinki city has approved the idea also. But Helsinki is waiting until the software is implemented in some smaller municipalities first." On top of that, insourcing smart city solutions require higher analytical capabilities of public servants.

Most interviewees point out the lack of clear responsibilities (e.g. no-one is responsible for improving cross-border transit) and claim that the Public Sector is not coordinated, stuck in old dogmas (legislation may lag 20 years in some cases), fragmented and is too afraid to take risks. In addition, also larger companies are not very willing to invest in smart city solutions, at least in Estonia. "Big companies do not take the risks to fund smart city activities, development expenditure and risks are too high," claims a representative from a small research-based company, Positium.

The bottom-line is strongly linked with the access to funds. Each municipality, by nature, prefers local companies. Some Estonian companies even claim (e.g. Goswift) that it is easier to enter the Finnish market through European Union projects compared to the foreign procurement process. Procurement is a key in any case, as one of the biggest water and sewage construction company representative puts it: "the real challenge is how to overcome the slowness of the procurement process at the same time keeping it legally correct (avoid corruption)."

Another view on smart city was given by the CEO of Ericsson, a Finn working in Estonia. He pointed out that the base of smart city lays in training. "For twin cities, there is a need for new nano degrees to train people in an effective way to adapt the demand of the labour market. Joint job-related training can really contribute to the joint digital market."

4.2. Third Sector

The Enterprise Estonia, Rakvere City (a small town in Estonia) and a cluster of companies have invested into the Rakvere Smart House Competence Center – a real physical demonstrator of near-0-energy buildings. The executive of this lab states that this project could be scalable and applied abroad but this is difficult within the current standardisation legislation. "The legislative system and its differences from country-to-country is the main block in implementing the best practices in another country. The slowness of bureaucracy is also slowing down the adoption of new solutions."

A smart city cluster developer from Tallinn, who helps companies to export abroad, points out that the most crucial aspect is a state as a smart procurer: "under the normal procurement procedures, you will get the cheapest solution, which is probably outdated. If the procurer is smart and has written a good initial task, then the supplier must have the ability to provide it. In a smart city, you want to procure a solution in the early stage of development." This is seconded by the Tartu Science Park Project Manager: "cities do not know most up-to-date Smart solutions. City officers are busy and when they plan to innovate through procurement, they use search engines and find thousands of solutions. But which ones does work? If you approach the company directly, they try to sell their product. Therefore, there is a need for neutral and trustworthy advice. "

A development head of the Tartu Smart City Lab, a regional cluster in the southern part of Estonia, pointed out three keywords for successful implementation of scalable smart city solutions: 1. willingness to take risks, 2. openness to innovation and 3. technological know-how. The main problem is that innovation is risky and cities have very low risk-tolerance.

A Senior Research Fellow at the Swedish Environment Institute states that smart city research projects should be more applicable, there is a need for real impact. Another problem is related to the organisational set-up in cities, namely the isolated departments (silos). It is also very important, as stated by an enthusiast in the Urban Lab, to focus on the governance part of smart cities, that is, how to involve citizens in the decision-making process.

4.3. Public Sector

The Public Sector has a slightly different viewpoint on the take-up of smart city innovations, both domestic and cross-border. As the head of the Transport Investment Department at the Ministry of Economics and Communications puts it: "Most of the innovations are still incomplete, it is not cost-effective to implement them on a larger scale." On the other hand, public service representatives agree that the smart city projects are held back by the public authorities – problems with bureaucracy and conservativeness of officials. "In order for smart city functions to be implemented, either many public officials have to be replaced or retrained," stated one Ministry-level representative.

In the public sector, most smart city related projects are co-funded and most funds are external. Many interviewees point out that they is a very clear need for smart budgeting: business needs to have an open access to information on city budgets. Still, many public servants do not agree that there should be joint budgeting for the cross-border solutions. „Finnish-Estonian cooperation is about sharing experience and best-practices. 1+1=3," stated an executive in the Ministry of Economics and Communications. Another executive from the same ministry, responsible for the IT development, agreed by stating that technology itself cannot be the goal itself, it is always the means. “Still, projects, both internal and external, need external funding, though, not every project is a start-up success story.” This view is not shared by all public servants. Experts from the Ministry of Finance working on the regional development and the smart cities measure, indicate that cities should not depend only on external financing in the development projects. “The support that cities get from the EU structural funds is objectively big, but in comparison with their actual budget, that is spent on developing the city, then the fiscal support is small. So actually cities should be able to finance their own smart city projects, if they wanted to,” was pointed out.

National and local governments have different views on responsibilities of the cities. An ICT advisor to the Prime Minster underlines the importance of capabilities and priorities of local governments. In his view, the challenge in the smart city is not about technology but bringing different parties together by making agreements. Smart city adoption is more the question of local government cooperation than state-level policies. The problem is that the local governments are passive, do not cooperate and could be more innovative. In Estonia and Finland, there is a very good ICT infrastructure (authentication, security protocols), it is very important for cities to use it actively. The City Secretary of Tallinn (capital city of Estonia) does not agree and states that the government should cover more of local governments IT costs. The logic is the following: “Tallinn is a lighthouse for other local governments: if Tallinn implements something, others will follow. It would be more efficient if the state would finance it (in any case, this is taxpayers money). There are also cases when the government takes over information systems developed by the Tallinn City (e.g. Population Registry or Social Info System STAAR). ”

Many interviewees claim that there is a too heavy focus on local and national solutions, compared to cross-border ones. „Most Tallinn city transport should have the Finnish link as well because 15-20% of transport from Port of Helsinki moves to Tallinn. The best cooperation would be Tallinn-Helsinki-St. Petersburg: divergent systems, different people and habits and much greater market potential,” states a chief civil servant at the Ministry of Economics and Communications. He adds that this should be coordinated by a Central Agent for all three regions, in the top-down perspective. On the other hand, an executive from Tallinn City likes the idea of cross-border services but claims that in reality, Helsinki and Tallinn are competitors (in terms of tax income). „If there are better kindergartens and access to schools for Estonians in Helsinki, this does not bring the children back to Tallinn.“

Most interviewed participants agreed that there is a need for joint cross-border services between Tallinn and Helsinki. For example, all interviewees agreed that both m-parking and x-road should be cross-border already now. “We should not be stuck on hypotheticals, we should thrive towards actually realising our crazy ideas,” stated the head of IT department of the Ministry of Economics and Communications.

A Tallinn City civil servant, responsible for transport investments, claims that there is a real need for joint teams and joint budgets. “If there is an ambition for high-level projects (e.g. tunnel), this has to work in real co-operation between the cities. In practice this does not work that there is a team in Estonia and Finland, there should be one mutual cross-border team for high-level projects. “

5. CONCLUSIONS

This paper proposed a framework for joint cross-border digital services (the Urban OS) and analysed how the concept is perceived in the capital cities of Estonia and Finland. The Urban OS is a collaboration platform for joint digital services between two heterogeneous urban areas and an important driver of the Digital Single Market.

Merging public urban services of close cross-border cities (e.g. Helsinki and Tallinn) enhances everyday living and working of hundreds of thousands of commuting citizens. Despite very close economic and social connections, currently Helsinki and Tallinn have very few joint digital servicnes for commuting citizens. This clearly indicates that even very close ICT savvy municipalities lack capabilities how to offer joint services, in spite of high-level technological readiness and frequently commuting citizens’ natural demand. The main challenge is not technological but related to making agreements with stakeholders and bringing different parties together.

The empirical part, looking from the Estonian side, clearly states the reasons for the lack of joint services: business sector claims that there are market barriers, NGOs that there is a lack of funding and the public sector argues that innovations are not ready. What is clear, there are clear expectations errors, from all sectors perspective.

There is a need to start from simple and widespread urban services through collaborative joint cross-border hands-on pilots (e.g. public transportation tickets and mobile parking for heterogeneous cities) and practice joint procurements for innovative solutions. Standardisation is also the key to cross-border urban services. The real threat is that if local municipalities do not manage to innovate from bottom-up jointly with neighbouring cities (both national and international), then all the cross-border solutions will be enforced top-down or aggressively linked to global business vendors. In both cases, the local stakeholders are not involved effectively.

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- Implementation of autonomous shuttle buses in Tallinn Public Transport
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Finest Twins (Project Manager, 2015–2016) www.finesttwins.eu

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2013– **NGO ITL Digital Lab**, R&D Manager

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Finest Smart Mobility (Project Partner, 2016–2019) www.finestsmartmobility.com

- Cross-border Intelligent Transport Systems Pilots between Helsinki, Vanttaa and Tallinn
- Gross budget: € 1.2 million
- Contractual Partners: Helsinki City, Forum Virium Helsinki, ITL Digital, Road Administration and Tallinn City

Cross-sectoral product development (single-led project, 2017–2019)

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- Gross budget: € 61,000, mainly financed from Enterprise Estonia

Real-time Economy (Project initiator, 2014–) www.itl.ee/index.php?page=359

- Contractual Partners: ITL Digital, Technology Industries Finland (TIF), ICT Cluster of Latvia (LIKTA), TIETO, Omniva and Telema
- Business X-road integration with Peppol (e-invoices)
- Grant € 800,000 EUR. Financed by CEF and Interreg

e-Receipt (Project Partner, 2014–2016) www.kviitung.ee

- Environment Friendly IT solutions for e-receipts
- Gross Budget: € 905,250, net grant from Innovation Norway: € 577,097
- Contractual Partners: Omniva, EMT, Authente (Norway), Helesinine, ITL Digital & Trinidad

TestLab (Project Manager, 2013–) www.smartlab.ee

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