DOCTORAL THESIS

Place-Based Innovation in Place-Blind Innovation Policy Context

Jaanus Müür

TALLINNA TEHNIKAÜLIKOOL
TALLINN UNIVERSITY OF TECHNOLOGY
TALLINN 2022

TALLINN UNIVERSITY OF TECHNOLOGY
DOCTORAL THESIS
70/2022

Place-Based Innovation in Place-Blind Innovation Policy Context

JAANUS MÜÜR

PRESS

TALLINN UNIVERSITY OF TECHNOLOGY
School of Business and Governance
Ragnar Nurkse Department of Innovation and Governance
This dissertation was accepted for the defence of the degree 17/10/2022

Supervisor: Prof. Erkki Karo
School of Business and Governance
Tallinn University of Technology
Tallinn, Estonia

Opponents: Dr. Jari Romanainen
Technopolis Group

Dr. Johan Miörner
The Environmental Social Sciences department,
Swiss Federal Institute of Aquatic Science and Technology
Department of Human Geography
Lund University

Defence of the thesis: 14/12/2022, Tallinn

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.

Jaanus Müür

----
signature

European Union
European Regional
Development Fund

Investing
in your future

ISSN 2585-6898 (publication)
ISBN 978-9949-83-927-8 (publication)
ISSN 2585-6901 (PDF)
ISBN 978-9949-83-928-5 (PDF)
Printed by Koopia Niini & Rauam

TALLINNA TEHNIKAÜLIKOOL
DOKTORITÖÖ
70/2022

Kohapõhine innovatsioon kohapimeda innovatsioonipoliitika kontekstis

JAANUS MÜÜR

TALTECH KIRJASTUS

Contents

List of publications

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

I 1.1 Valdmaa, K., Pugh, R., **Müür, J.** (2021) "Challenges with strategic placed-based innovation policy: implementation of smart specialization in Estonia and Wales." *European Planning Studies*, *29*(4), 681-698. https://doi.org/10.1080/09654313.2020.1767541

II 1.1 **Müür, J.** (2022) "Intermediating Smart Specialisation and Entrepreneurial Discovery: The Cases of Estonia and Helsinki-Uusimaa." *Journal of the Knowledge Economy, 13*, 541-573. https://doi.org/10.1007/s13132-021-00757-2

III 1.1 Soe, R.-M., **Müür, J.** (2020) "Mobility Acceptance Factors of an Automated Shuttle Bus Last-Mile Service." *Sustainability, 12*(13), 5469. https://doi.org/10.3390/su12135469

IV 3.1 Bellone, M., Ismailogullari, A., **Müür, J.**, Nissin, O., Sell, R., Soe, R.-M. (2021) "Autonomous Driving in the Real-World: The Weather Challenge in the Sohjoa Baltic Project." *In*: Hamid, U.Z.A., Al-Turjman, F. (*eds*.) *Towards Connected and Autonomous Vehicle Highways*. EAI/Springer Innovations in Communication and Computing. Springer, Cham. https://doi.org/10.1007/978-3-030-66042-0_9

Appendix:

V 1.1 **Müür, J.**, Karo, E. (2023) "Learning from public sector innovation pilots: the case of autonomous bus pilots." *Innovation: The European Journal of Social Science Research*, 1-24. https://doi.org/10.1080/13511610.2023.2286438

Author’s contribution to the publications

Contributions to the papers in this thesis are:

I The author of the thesis contributed by conducting data collection and analysis of the Estonian case and summarizing the findings together with the first author. The author of this thesis also contributed to the literature review together with the first and second author and helped to revise the manuscript during the submission process together with the first and second author.

II The author of this thesis was the only author of this paper and was solely responsible for designing the study, doing the literature review, collecting the empirical data (document analysis, conducting interviews), analyzing, and summarizing the results, and going through the submission process.

III The author of the thesis put together the literature review. Together with the first author, the author of this thesis defined the research gap and summarized the findings. During the review process, both the first author and the author of the thesis were responsible for revising the paper based on the reviewers’ comments.

IV The author of this thesis was largely responsible for Section 6.3 of the article which describes the autonomous bus pilot in Tallinn which was run as part of the Sohjoa Baltic project.

V The author of this thesis developed the theoretical framework and analyzed the empirical data together with the second author. The author of this thesis also conducted the interviews for this article.

Abbreviations

CEE	Central and Eastern Europe
EC	European Commission
EDP	Entrepreneurial discovery process
EU	European Union
ERDF	European Regional Development Fund
FE	Foundational economy
HSL	Helsinki Regional Transport Authority (*Helsingin seudun liikenne*)
NUTS	Nomenclature of Territorial Units for Statistics
RDI	Research, development and innovation
R&D	Research and development
S&T	Science and Technology
S3	Smart specialization strategy
S4+	Smart specialization for sustainability
TalTech	Tallinn University of Technology

1 Focus and aim

1.1 Introduction

"[--] The greatest opportunities for growth lie in communities' recognizing their own advantages, then fostering forms of specialized innovation that rely on those advantages."
Dan Breznitz (2021), *Innovation in Real Places: Strategies for Prosperity in an Unforgiving World*

Opportunities for growth and development are something that countries, regions and cities are constantly looking for. Poor countries do it to be able to fulfil the basic needs of its citizens, catching-up countries do it to reach their full potential and the rich countries do it to not lose their position because they know there is a long line behind them.

Initially, this was pursued by countries through the development and implementation of industrial policy strategies (Rodrik 2007). Later, the emphasis shifted towards a systemic view of innovation and supportive policy mixes (Lundvall 1985). Research, development and innovation (RDI) policy strategies are by now widely adopted by different levels of government. In the European Union (EU) context, the European Commission (EC) supports regional and national governments in their RDI activities by providing financial support and policy assistance through the structural and cohesion funds with the aim to achieve economic convergence across the EU. This is done in a *place-based* manner by using the experimental governance structures of the EU (Barca 2009; Beer *et al*. 2020; Karo and Kattel 2018; Sabel and Zeitlin 2010). However, this is easier said than done. Prior research has shown how challenging it can be for the EU Member States to follow not just the formalities, but the actual spirit of the EU's regional and RDI policies which promote experimentation, coordination and collaboration between the main stakeholders, and constant policy learning (see for example Karo *et al*. 2017; Karo and Kattel 2018; Kroll 2017).

Estonia is a very good example of an EU Member State that experiences many of these policy challenges that have also been studied at length. Yet, the country also offers interesting insight into the question that has gained less attention than it deserves: how place-based RDI activities emerge in the context of largely state-led and place-blind national RDI policy? This thesis focuses on this question and attempts to fill the existing research gap. The thesis is based on case studies that open this question from two perspectives: *strategic* policy actions and context and *local* innovation dynamics.

From the strategic perspective, the thesis looks at how RDI policies in Estonia have been developed and implemented, what role the local municipalities as the lowest level administrative entities and actual physical spaces see for themselves in the context of RDI policy, and what is the role of intermediary organizations. The local perspective is used to analyze what are the opportunities and challenges related to experimental RDI activities at the local level.

The thesis shows that while the EU's smart specialization initiative (S3) has failed to spark necessary changes in the strategic governance of innovation policy that would result with place-based innovation policy, a more practical approach focusing on improving sectors of foundational economy (FE) can provide a way for the place-based

RDI activities to emerge in the largely place-blind innovation policy context. In addition, the thesis shows how cross-regional collaboration often orchestrated by intermediaries or universities from more advanced regions can spark place-based RDI activities in less developed regions and support policy learning. The thesis also points out that in the context of smart specialization for sustainability (S4+), the RDI policies must be adjusted, and greater emphasis should be put on the adoption of new solutions, which in the S3 context have received less attention.

1.2 Theoretical background

Achieving economic convergence in the EU is a rather ambitious and complex task. From the economic perspective, the EU countries and regions can have significant differences based on their productivity and distance from the technological frontier (Farole *et al*. 2011). From the governance perspective, the EU has a quasi-federal nature where in many areas, including innovation policy, the power and checks and balances are divided between the European, national and regional institutions (Karo and Kattel 2018). This has pushed the EU to embrace deliberative and dynamic experimentalist governance principles to agree on and achieve common goals by the EU as a whole (Karo and Kattel 2018; Sabel and Zeitlin 2010). According to these principles, the Member States together with the EC agree on the framework goals giving the national and regional authorities autonomy to reach them together with the obligation to provide performance reports and be the subjects of peer-review which create opportunities for experimentation and policy learning between the Member States and the EC and can also result in the revision of framework goals (Sabel and Zeitlin 2010, 3). While the experimental governance approach gives Member States much autonomy, it also puts a significant responsibility on them to achieve the framework goals. It has been a conscious choice by the EU because on some topics the Member States have been reluctant to delegate power to the EC or are doubtful whether the EC could develop the best or most optimal policies (Monar 2010; Svetiev 2010).

S3 is an example of an experimental governance approach in innovation-based regional policy where the framework goals (regional cohesion, smart growth, 3% R&D expenditure), autonomy to develop policies by lower levels of government (experimentation, entrepreneurial discovery process), peer review (S3 Platform), and revision of framework goals and metrics (movement from S3 to S4+) can be identified. The concept promotes experimental governance arrangements also at the lower levels as the public policy should focus on supporting the discovery and development of research and innovation domains in which a region can excel in a collaborative manner (Foray *et al*. 2009). Such an approach is in essence *place-based* as the aim is to promote development at a specific place through exogenous policy action triggering endogenous change while considering the local contextual factors which include social, cultural and institutional characteristics (Barca 2009; Barca *et al.* 2012) and is linked to a wider effort of regionalization in the EU (Loewen 2018).

1.2.1 Defining place-based innovation policy

As the term 'place' can have subjective meanings (Beer *et al.* 2020), it is important to emphasize that in the context of the current thesis it is defined as a sub-national territorial area. This is in line with how place-based policies have also been defined in the literature and is probably best reflected in the definition by Beer *et al.* (2020). Accordingly, place-based policies focus on the development of cities, localities, or regions but such an approach is more than a concentration of resources in a specific location – place-based policies also "*embody an ethos about, and an approach to, the development of economies and society that acknowledges that the context of each and every city, region and rural district offers opportunities for advancing well-being* (*Ibid*. 12)."

The opposite to the place-based policy approach is the so-called "*spatially blind"* approach which roots from neoclassical economics (Beer *et al.* 2020). It advocates development policies without explicit consideration to space as the focus is rather on people (mobility, equal access to opportunities), agglomeration (economic, population), and institutional reform (deregulation) (World Bank 2009; Barca *et al.* 2012). Spatially blind policies are often national policies which, opposite to their name, have strong effects on specific places, such as the movement of labor and capital away from rural areas and periphery to thriving agglomerations (Barca 2009).

In the context of innovation policy, the increasing importance of regions has been the result of the convergence of regional and technology policy since the beginning of the 1980s (Hassink 2020). This was related to the emergence of the innovation systems (national and regional) approach that puts innovation at the center of economic growth and emphasizes interactive learning processes between key organizations such as companies, universities, government organizations, and civil society (Asheim *et al.* 2020). The result has been an increased understanding about the division of roles and tasks between different levels of government in the context of innovation policy as it has been realized that subnational levels of territorial units are also important with their own organizational and institutional arrangements and dynamics (Marceau 2008; Barca *et al.* 2012). While it is true that certain key policies (higher education, labor market, industrial policy, science and technology) fall mostly under the responsibility of the national government, it is important to coordinate them with the regional level to incorporate the local knowledge into the design of these policies (Barca 2009; Hassink 2020).

In the EU, it was the Barca report (2009) that truly constructed the place-based narrative of cohesion policy with a strong focus on innovation (Mendez 2013). Place-based innovation policy was then manifested in the concept and frame of "smart specialization" which "*promotes integrated, place-based transformation strategies in order to focus policy support and resources on national/regional development priorities, challenges and needs, fully involving public and private stakeholders and encouraging governance innovation and experimentation"* (Solly 2016, 193).

1.2.2 Smart specialization as the EU's regional policy

The emergence and integration of smart specialization into the regional cohesion policy was a policy response to the broader critique of the European regional innovation policy. For example, Foray and Van Ark (2007) argued that too many regions in Europe try to copy the most successful regions of the world, which has often resulted in overemphasizing high-tech research that is not in line with the local economic needs. This is an issue that has recently also been highlighted by Breznitz (2021), although the initial suggestion by Foray and Van Ark (2007) was rather opposite to the place-based approach as they supported the agglomeration of research and development (R&D) resources in Europe so that true centers of excellence would emerge. Similarly, Tödtling and Trippl (2005) pointed out that regions (metropoles, peripheral, and old industrial regions) differ based on innovation activities, firms and regional clusters, knowledge generation and diffusion, knowledge transfer, education/training, and networks and therefore a "tailor-made" innovation policy approach addressing specific challenges of a region is needed. As a solution, Foray *et al.* (2009) suggested the smart specialization concept based on the entrepreneurial discovery process (EDP) where the public policy should focus on supporting the discovery of research and innovation domains in which a region can excel.

From the evolutionary perspective on regional resilience, we can witness how smart specialization has moved from promoting adaptation to promoting adaptability (Boschma 2015; Pike *et al*. 2010). Initially it was a rather sectoral approach (adaptation) arguing that focus should be put on existing economic sectors which would most likely benefit from adopting new technologies. In addition, taking into account that entrepreneurs will search for opportunities within their domain, it was argued that the size of the domain should be large enough (range of relevant sectors and activities), and connectedness with other domains should be high enough (Foray and Van Ark 2007; McCann and Ortega-Argilés 2015). Later, the question of granularity gained more attention. The conclusion has been that smart specialization policies should support diversification through specialization (adaptability) where policy activities target concrete companies and activities that have the potential to transform existing sectors through related variety or establish new ones (Foray 2018; McCann and Ortega-Argilés 2013a; McCann and Ortega-Argilés 2013b).

Such an approach also requires flexibility and willingness to experiment as not every targeted company and activity will be a success and therefore choices need to be regularly reviewed (Foray 2018). Although the entrepreneurs have a central role in the EDP, the search processes of companies and activities should ideally happen in the form of network, association or partnership, including also local research institutions and public sector organizations as the EDP is based on the knowledge about science, technology, engineering, market growth potential, possible competitors, and inputs and services required for launching new activities (Foray 2014; Foray *et al.* 2011).

Over the last decade and more, these conceptual ideas of smart specialization were integrated into the EU's cohesion policy. As McCann and Ortega-Argilés (2015) argue, smart specialization is a concept which helps to think about local knowledge-enhancement and learning-enhancement systems and therefore it was well-suited to be adopted as a local and regional place-based development policy approach. As already mentioned, smart specialization is an example of an experimental governance approach in innovation-based regional policy with framework goals and directions. In fact, the development of regional smart specialization strategies (S3) through which regions set their growth areas (preferably based on their existing strengths) to achieve these goals became a precondition for accessing RDI-related European Regional Development Funds (ERDF) under the cohesion policy while the development of exact policy measures remained to be the responsibility of national and regional governments.

The conceptual idea itself and how it has been integrated into the EU's regional policy framework have also received significant criticism. Pugh (2018) argues that the systemic approach (see for example Edquist and Chaminade 2006) which is the foundation of smart specialization makes it conceptually ambiguous and therefore less normative and prescriptive. Reaching sustainability goals (see below) adds additional ambiguity. The idea of specialization has also caused confusion and misinterpretation as policies developed as part of smart specialization are often not aiming at diversification through specialization but target existing sectors as a whole or are focused on "trendy" sectors or technologies that have little presence in the region (Pugh 2018; Hassink and Gong 2019). It has also been pointed out that it is not clear whether focus on the regional territorial level is the most proper one nor is it clear what should be the basis for defining a region (Pugh 2018). Marques and Morgan (2018) discuss that smart specialization is based on assumptions and ideas that often do not hold in practice, or have actually been disproven, such as policymaking based on the linear innovation model; the existence of necessary governance capacities in the region or country (see also Karo and Kattel 2015); the existence of local elites who are committed to innovation; the existence of already functional triple-helix coalitions; and good coordination across different levels of government.

1.2.3 Smart specialization and the European Green Deal

The place-based innovation policy approach in the form of smart specialization also plays a vital role in the context of the European Green Deal and the transition towards a sustainable society. McCann and Soete (2020) argue that the European Green Deal is both the EU's Moonshot mission and a place-based innovation policy for sustainability. The latter also means movement towards newly-focused smart specialization for sustainability or S4+ (*Ibid*.). As described by the European Commission, the movement from S3 to S4+ refers to „ [--] *Smart Specialisation Strategies which ex-ante aim at improving sustainability and inclusiveness through an innovation-driven policy*."[1] It can also be argued that S4+ is an attempt to direct the EU regions towards improving their resilience in two ways. First, to direct their industrial, technological and institutional structures towards a sustainable growth path (see also Boschma 2015). The second aim of S4+ is to improve the environmental resilience of regions and achieve climate neutrality.

The importance of places in the context of the European Green Deal is well described by McCann and Soete (2020, 12) who provide an overview of the experimental governance logic of the European Green Deal. According to them, the EU-level is the most appropriate for setting the green direction for development (mobilizing and attracting large-scale funding, EU regulations, global level activities), which is reinforced by national level activities that position their industries on emerging markets of sustainable products and services and aim at connecting local and regional innovation dynamics to national and EU-wide networks. However, it is the regional and local level where the actual implementation of the European Green Deal happens as the different policy initiatives should address the local challenges in the form of S4+ (*Ibid*. 12). As regions differ based on their innovation activities and innovation policy (Tödtling and Trippl 2005), so do they also differ based on environmental impacts they experience (type and severity), available resources to address these impacts, relevant groups of actors, networks and institutions that can drive or oppose transition, visions, priorities, *etc* (Kelemen 2020). From the innovation perspective, it is the concrete places (regions) where the new technological but also social solutions emerge that enable sustainability transition (Kelemen 2020; **Article II**).

It is understandable why movement towards greater sustainability is desirable. However, attaching an additional dimension can make the concept of smart specialization less understandable. Hassink and Gong (2019) argue that using smart specialization strategies to achieve sustainability transition will lead to situations where the question of economic competitiveness contradicts other aspects of social well-being

[1] Homepage of the European Commission's S3 platform. Available at: https://s3platform.jrc.ec.europa.eu/s4

such as environmental cleanness and ecological integrity. To some extent the smart specialization policies have already drifted away from the concept (Radosevic 2017) or in other words: the policy has run ahead of the theory (Foray *et al.* 2011; Foray 2014). An additional dimension can also increase coordination challenges due to a wider circle of interest groups. This can interrupt the existing social and political balance of power and is further amplified by differences of understanding what sustainability itself means (Pike *et al*. 2010). As the aim is to improve sustainability through innovation, greater focus must also be directed towards the adoption of new technologies, which itself can be challenging (**Article V**).

1.2.4 Challenges related to place-based RDI policies in the Central and Eastern European context

As already briefly indicated above, innovation and regional policy literature streams have listed a number of challenges related to the development and implementation of place-based RDI policies in the EU Member States. Crucially for the focus of this thesis, it has been pointed out that in most Central and Eastern European (CEE) countries a functional regional government level is often missing (Loewen 2018). While previously the EU pushed for further regionalization in the new CEE Member States, the growing need to consolidate the nation-state and the EC treating the national governments as their main counterparts further strengthened the centralization processes in CEE (Campbell and Coulson 2006; Loewen 2018).

These centralization processes in CEE have further led to *nationally coordinated* and *place-blind* RDI policy, which is also linked to the increased use of EU funds to finance innovation activities (**Article I**; Karo *et al*. 2017; Karo and Kattel 2018). These developments together with a strong emphasis on procedural accountability, speed of distributing EU funds, and performance management based on *ex-ante* output indicators (Karo and Kattel 2018) contradict the experimental governance principles and the place-based logic of smart specialization (although framework goals and indicators are also important in the experimental governance context). *Organizational thinness* is another challenge that refers to the limited availability of critical organizations such as research institutions or intermediaries (**Article II**; Grillitsch and Trippl 2016; Trippl *et al*. 2020). *Policy capture* by incumbent stakeholders can similarly hamper the efforts of developing and implementing place-based and experimentalist policies (Foray 2018). For example, the strong influence of academia in a place-blind innovation policy context can lead towards overemphasizing high-tech themes that have little connection to the local economy – something that smart specialization was meant to avoid – and prevent the development of more locally suitable policies (Karo *et al*. 2017). *Coordination issues* refer to difficulties with developing, implementing and, if needed, renewing RDI policies in collaboration and partnership between the public sector, entrepreneurs, academia, and other relevant stakeholders due to centralized top-down governance, skepticism towards bottom-up processes or lack of policy capacity and understanding of each stakeholder's role (Estensoro and Larrea 2022; Capello and Kroll 2016; Karo and Kattel 2015; Kroll 2015). For some regions, implementing place-based policies aimed at improving their position in global value chains can be challenging due to their reliance on the presence of local subsidiaries of *multinational enterprises,* over which the local policy makers have little control (Capello and Kroll 2016; Karo and Kattel 2018).

Theoretical discussions do exist that focus on necessary policy changes so that place-based RDI policy would emerge. Karo and Kattel (2018) suggest taking steps towards the Schumpeterian entrepreneurial state through incentivizing the finance sector to invest into productive sectors, pursuing EU-wide and domestic innovations in the public sector, and encouraging long-term investments into green and future technologies. Similarly, Morgan (2019) and Coenen and Morgan (2019) suggest that the lagging regions should direct their policies towards prioritizing innovation in the normally unfashionable FE sectors that keep us 'safe, sound and civilized' and would include a broader list of sectors and therefore larger number of jobs compared to a small band of sectors covered by the Science and Technology (S&T) approach. These FE sectors cover goods and services that constitute the foundation of our everyday life, are often funded or provided by the state, such as healthcare, transportation, telecoms and education, and are ignored by industrial or RDI strategies due to their mundane nature (Bentham *et al*. 2013; Morgan 2019; Thompson *et al*. 2020, 1177). The proposal of supporting innovation in the FE sectors is a step further from the idea of Thompson *et al*. (2020) who argue that city-regions should not only refocus their strategies "*on more controllable and locally embedded 'accelerators' of growth balanced by 'stabilizers' of provision of essential services*," but this growth should be based on local small and medium-sized enterprises, social enterprises and entrepreneurs who innovate. While Thompson *et al*. (2020) separate accelerators of growth from the FE sectors that act as stabilizers, Coenen and Morgan (2019) argue that all FE sectors are extensively technology-using and knowledge-intensive sectors.

1.3 The aim and contributions of the thesis

Estonia is a very good example of an EU Member State that experiences many of the policy challenges listed above. Yet, Estonia is also a paradoxical case as the country also offers interesting insight into the question that has gained less attention than it deserves: how place-based RDI activities emerge in the context of a largely state-led and place-blind national RDI policy? This thesis focuses on this question and attempts to fill the existing research gap. The thesis is based on case studies that open this question from two perspectives: *strategic* policy actions and context and *local* innovation dynamics.

Estonia is a country with a state-led and place-blind national RDI policy that has largely been under the responsibility of the Ministry of Education and Research (Karo *et al.* 2017; Karo *et al.* 2014; Karo and Kattel 2015). With the exception of a couple of policy measures, the state-led approach has largely neglected the regional/local needs and differences inside the country (**Article I**). Such an approach has been defended with explanations referring to efficiency and the smallness of the country (Karo *et al*. 2017) and is also linked to the two-tier centralized governance system (Loewen 2018; Sootla and Kattai 2020). In Estonia – which is one of the least corporatist countries among the developed economies (Jahn 2016) – the development of RDI policies as part of the EU-wide effort to adopt the smart specialization principles has shown significant coordination challenges. The involvement of the private sector has rather taken the form of formal consultation, although there is also evidence that only a few companies and sectors were interested in the S3 discussions while the majority of companies were rather concerned about the social tax level and labor supply (**Article II**; Karo et al. 2017). As a result of the limited involvement of the private sector, the Estonian RDI policy has long been tilted towards the interests of the academia, which do not necessarily match with those of the private sector due to the heavy focus on the S&T fields (Karo *et al*. 2017).

At the same time, a growing number of place-based RDI activities are emerging at the local government level, often independent from the national RDI policy, with the aim to develop practical technological solutions to improve public services and solve local urban challenges related to transportation, planning or air quality, which are sectors covered by FE thinking. These initiatives are also tilted towards the S&T, as among them we can find the development of (autonomous) mobility solutions, sensor solutions, mobile applications, different geo-solutions (digital twin of the city, 3D mapping of underground communications), *etc*. Such developments are place-based in nature and create new promising local businesses that have developed their own innovative products and have the potential for further growth and development.

The aim of this thesis is to look at the preconditions for the emergence of place-based RDI activities in the context of state-led and place-blind national RDI policy. The thesis mostly focuses on the local municipality level, which in Estonia has long been an unused institutional and physical space in the context of RDI policy. The discussions are mostly about Tallinn as the location of most of such place-based RDI activities to date. More specifically, the thesis looks at how such activities are rationalized and how the cooperation networks behind these RDI activities have emerged and how they function. The latter is done by looking at the role of organizations that function as local level intermediaries. These organizations can play a crucial role as they support local cooperation through building and maintaining networks between the key stakeholders in the region. They can also initiate practical collaboration between the stakeholders through different initiatives or projects. Intermediaries can be considered to be organizations that operate between the users and producers of knowledge with the aim to transfer knowledge (Smedlund 2006; Shohet and Prevezer 1996). Smedlund (2006) adds that intermediaries "[--] *orchestrate collaboration between the key actors in the region*." Such collaboration can be focused on a specific topic or technology (Janssen and Frenken, 2019), or it can be focused on representing the interests of a certain group (David *et al.* 2009). Clark (2014) distinguishes between labor market, supply-chain, and innovation intermediaries and also includes research and education institutions as intermediaries, the latter point showing that other institutions can also take the role of an intermediary organization, which is also addressed in **Article II**. The thesis argues that such organizations can be crucial for innovation activities at the local level (see more in **Article II**).

Such innovation activities supported or even orchestrated by local intermediaries do not only help local companies to develop new technologies and business models, but they also help local municipalities to take part in the sustainability transition. More specifically, by getting involved in different projects, municipalities themselves can learn more about the potentials and shortcomings of new technologies (**Article V**), including how citizens perceive these technologies (**Article III**) or how the technology copes with specific local conditions, such as weather conditions (**Article IV**). This can further help the local decisionmakers to address their place-specific issues (e.g. pollution, transportation) and develop public services and place-based innovation initiatives.

We can also witness cross-border policy learning that such organizations can facilitate through joint projects. This is one of the main aims of experimental governance in Europe. However, an important difference seems to emerge. While in the EU policies and models, it is assumed that such learning takes place through peer review and mandatory reporting, it has been pointed out that CEE countries have seen S3 just as a formal *ex-ante* conditionality without focusing on the exact rationales and governance implications of the concept (Sabel and Zeitlin 2010; Karo and Kattel 2018). The thesis shows that practical collaboration at the local level between usual triple/quadruple-helix participants in RDI activities from more advanced and less advanced regions has a better chance of spurring place-based innovation and policy learning than the formal experimental governance structures of the EU. This argument is based on the observations that look at the collaboration between such organizations from Tallinn and the Helsinki-Uusimaa region.

The research papers of this thesis address the following research questions related to (some of the) preconditions for place-based innovation activities to emerge in the context of state-led and place-blind innovation policy, the role of place-based intermediaries, and the opportunities and challenges of place-based innovation:

- In the context of a place-blind national innovation policy, what role do the larger local governments see they could play in the development and implementation of innovation policy and why (**Articles I, II**)?
- How can intermediary organizations spark place-based innovation activities and orchestrate entrepreneurial discovery processes at the local level (**Article II)**?
- The discussions on the benefits and challenges related to local innovation experiments are addressed through the following two research questions:
  - How experimental innovation pilots help technology providers and potential service providers to learn about the specifics of a technology **(Article III** on how potential users perceive the new technology and **Article IV** on how specific local conditions, such as the weather, impact the functioning of the technology)?
  - How the set-up and design of the pilots and the institutional context support or hinder the process of learning about a new technology and its eventual adoption (**Article V**)?

Article I, co-authored with Dr. Kaija Veskioja (previously Valdmaa) and Dr. Rhiannon Pugh, looks at the implementation of smart specialization in Wales and Estonia. The article shows how in both countries the development and implementation of smart specialization has not taken place in a bottom-up manner. Instead, the regional priorities have been chosen at the national level in a top-down manner with limited directionality. In the context of Estonia, the article looks at the reasons why the place-based perspective was abandoned, and why the local governments were largely left out from the implementation of S3 and what role they could play in innovation policy.

Article II is a single-authored article that analyzes what role intermediary organizations can play in the development and implementation of the smart specialization strategy. The empirical part of the paper analyses the cases of Estonia and Helsinki-Uusimaa in Finland, which are both Nomenclature of Territorial Units for Statistics level 2 (NUTS-2) regions at the EU level. The article shows how different intermediary organizations are actively participating in the RDI policy in Helsinki-Uusimaa bringing together a variety of stakeholders (through formal and informal means), which helps to co-shape a common understanding about the direction of development. In addition, these organizations launch different initiatives such as experimental innovation projects and innovation procurements in a living lab setting (city-as-a-platform). Although we can find different intermediary organizations in Estonia, the article shows that their focus is not on building networks and establishing a common understanding of the direction of economic development. The article concludes that while the literature of smart specialization has long emphasized the importance of multi-stakeholder cooperation and coordination in the context of EDP, it has provided little insight about how such coordination is organized or how should it look like. Looking at intermediaries could provide valuable lessons for weaker regions in this matter.

Article III is co-authored with Dr. Ralf-Martin Soe, and it looks at a specific technology pilot as part of smart city innovation policies and more specifically analyzes the mobility acceptance factors of an automated shuttle bus last-mile service. The article is based on a survey that was conducted when the automated shuttle bus pilot was running in Tallinn as part of the Sohjoa Baltic project. The specific pilot is a perfect example of how local municipalities can participate in the RDI policy. The pilot did not only help to build local know-how about the technology (mostly in TalTech and Modern Mobility), but it also provided an opportunity for the local government to find out how its citizens perceive such technology, which can be a useful information for later adoption.

Article IV is a book chapter co-authored with Dr. Mauro Bellone, Azat Kuitunen (previously Ismailogullari), Oscar Nissin, Dr. Raivo Sell, and Dr. Ralf-Martin Soe. The chapter describes weather-related challenges that affect autonomous driving. The empirical part is based on autonomous bus pilots that were organized as part of the Sohjoa Baltic project.

Article V is co-authored with Dr. Erkki Karo, and it studies how the explorative lessons from technology pilots become exploited and routinized by local actors. The article develops a holistic framework combining knowledge exploration and exploitation practices, which takes into account the different types of learning activities that testing and adoption of the technology may require. The aim of the article is to discuss how the set-up and design of the pilots supports or hinders the process of learning about the new technology and its eventual adoption (exploitation). We later use the framework to analyze autonomous bus pilots in three cities: Helsinki, Tallinn and Kongsberg. We show that the design and contextual fit of real-life pilots, especially the cooperation structure and the division of roles between pilot partners, together with knowledge dissemination practices, influence the ability of local public sector authorities to learn from such pilots and develop capabilities necessary for integrating new technologies into public services.

2 Methodology

This work is a cumulative thesis that is the result of working on different EU-funded research and innovation projects (Sohjoa Baltic, Smart-up BSR, Sohjoa Last Mile) that have enabled to analyze place-based innovation dynamics from two different perspectives: *strategic* policy actions and context and *local* innovation dynamics. Hence, the papers have followed different methodological approaches. The thesis is extensively based on case studies, which is a well-suited method for investigating “how” and/or “why” a social phenomenon works and for describing that phenomenon (Yin 2018).

First, the strategic perspective tries to look at how innovation policy has been developed and implemented in Estonia, but also in neighboring Helsinki-Uusimaa which is a valuable case for comparison that has also played an important role in the emergence of place-based RDI activities in Estonia. This perspective is covered through two case study articles (**Article I** and **Article II)** that help to get an overview of how innovation policy in general and S3 specifically have been developed and implemented in Estonia and analyze what role do the local governments see they could play in the development and implementation of innovation policy in the context of smart specialization.

Second, the local perspective looks at placed-based innovation dynamics from the angle of innovation pilots that have emerged largely separate from the national innovation policy. This is covered with **Article III**, **Article IV** and **Article V**. The aim of this is to analyze more deeply how private companies, public institutions and research institutions can benefit from the opportunities that local innovation activities and pilots can provide. This is done by studying innovation pilots focusing on autonomous vehicles. The articles rely on survey-based analysis of a single technology pilot and extensive comparative case study analysis of different technology pilots.

In **Article I**, a cross-case policy comparison approach was used. Information was collected through desktop research, policy observations and semi-structured interviews (34 in total) to build up a picture of innovation policy practices in Wales and Estonia. Desktop research included the analysis of strategic and other official documents related to RDI policy, different reports, studies by other scholars, *etc*. The interviews were conducted in 2011-2013 (Welsh case) and in 2019 (Estonian case) with policy makers and key actors in the innovation system to collect information about how S3 was developed and what the interviewees see as the main obstacles in implementation. The article is a discussion that looks at the key insights related to the elements of smart specialization.

While the aim of **Article I** was to give a macro-level overview about the development and implementation of S3 in Wales and Estonia, **Article II** goes more down to the micro level as it focuses on the role of intermediary organizations in developing and implementing RDI policy. **Article II** follows the holistic comparative case study approach as it compares how smart specialization is implemented in Helsinki-Uusimaa and Estonia, specifically looking at the role of intermediary organizations. The study is based on secondary sources such as strategic documents, action plans, public information on the websites, and prior research. In addition, 13 semi-structured interviews were carried out between February and September of 2019.

Article III looks at a specific technology pilot as part of smart city innovation policies and more specifically analyses the user-feedback from one of the autonomous bus pilots in Tallinn. The pilot took place as part of the Sohjoa Baltic project, funded by Interreg Baltic Sea. The aim of the project was to research, promote and pilot automated driverless electric minibuses as part of the public transport chain, especially for the first/last mile connectivity.[2] Data used in **Article III** was gathered through various methods. Users of the autonomous bus had the opportunity to fill in an online questionnaire. A total of 3877 passengers were served between August and December 2019, of which 152 answered to the questionnaire. The results were compared with the control group of 55 people who had not used an autonomous bus before. Regression analysis was applied to analyze the answers of the questionnaire. In addition, a group interview was conducted with the operators of the autonomous bus and the daily conversation log with the operators was analyzed to get more information related to the daily operations of the autonomous bus. **Article III** is a concrete example of an analysis that provides valuable information to technology developers (private companies, universities) and potential operators (cities, public transport providers) about technical and design-related shortcomings of such vehicles and about user perception.

Similar to **Article III**, **Article IV** provides information about weather-related challenges that affect autonomous driving. The chapter provides an overview of most recent technologies for sensors and intelligent driving, and data sets used for the development of autonomous driving with references to weather-related issues. In addition, the chapter describes the weather-related challenges experienced during the three autonomous bus pilots (Tallinn, Helsinki, Kongsberg) organized as part of the Sohjoa Baltic project.

Article V is the third article that looks place-based innovation policy from the local perspective and focuses on how learning from innovation pilots takes place and how it influences the adoption of technology. The article uses a comparative case study approach and looks at how the specific design of pilots and local contextual factors have impacted the ability of Tallinn (Estonia), Helsinki (Finland), and Kongsberg (Norway) to explore and exploit autonomous driving technology. A total of 13 autonomous bus pilots conducted in the aforementioned three cities were analyzed. The analysis was based on desktop research and 12 semi-structured interviews with 13 experts involved in organizing the pilots.

[2] Homepage of the Sohjoa Baltic project. Available at: https://www.sohjoabaltic.eu/

3 Main findings

This section highlights the main findings of the thesis. The findings are presented in the order of the research questions presented in the *Focus and aim* section of the thesis and are based on the articles. This helps to present the main findings in a coherent manner.

In the context of a place-blind national innovation policy, what role do the larger local governments see they could play in the development and implementation of innovation policy and why?

Estonia is a good example of a country with a place-blind and nationally coordinated RDI policy. This topic is opened in **Article I** and it complements previous literature on the matter. In this literature, several reasons have been pointed out why the Estonian RDI policy has largely been place-blind. These include the smallness of the country, emphasis on policy efficiency which itself is linked to smallness, and lack of private sector demand for research and innovation (Karo *et al.* 2017; Karo and Kattel 2015).

Article I adds that the lack of regional perspective can also be due to the high number (over 200) of mostly small local municipalities that existed prior to the local municipality reform in 2017. Arguably, it was questionable whether most of the local municipalities would have understood the smart specialization concept as local municipalities in Estonia are largely not responsible for economic policy. In addition, the fact that Estonia has only two medium-sized universities (University of Tartu and Tallinn University of Technology) with regional centers has been also highlighted as one of the reasons for abandoning regional focus.

At the same time, we see evidence of place-based innovation initiatives taking place where significant role is played by large local municipalities (mostly Tallinn, to a lesser extent also Tartu and slowly also other larger cities) and the universities (including their regional centers). Especially Tallinn and Tartu and their respective universities have been involved in several activities described in the literature such as building and maintaining collaboration networks, providing consultancy services to new businesses, building science and industrial parks, conducting public procurements for innovation and participating in different innovation pilots (**Article II**; Bakici *et al.* 2013; Lember *et al.* 2011; Zelenbabic 2015). The Estonian case provides particularly interesting insight as the local governments have largely been excluded from economic and RDI policy as they have mostly been considered service providers but are slowly taking a more proactive role (**Article I**).

The cities of Tallinn and Tartu have established their own administrative units responsible for economic development and have developed their own S3 strategies. Tartu, together with surrounding municipalities, has even tried to copy the Brainport Eindhoven model, although, with limited success (**Article I**; related to Brainport see also Morisson and Doussineau 2019). Compared to other areas in Estonia, these two municipalities also enjoy the status of being local agglomerations as they are the two largest municipalities (Tallinn serving as the capital) and serve as locations of the main campuses of all the Estonian universities and most of the Estonian businesses. As brought out in **Article II**, these municipalities seek for a bigger role in the national RDI policy context, both in the development and implementation phases. The argument here is that the local governments are much closer to other key stakeholders such as private companies and universities and can more easily find and organize different bottom-up collaboration projects. For example, cities can act as test platforms for innovation projects.

Several aforementioned activities, such as innovation procurements or innovation pilots, can effectively be used by cities, as they are responsible for a large number of services that represent FE sectors and offer numerous possibilities. These include services such as transportation (and mobility in general), education, health, social services, and urban planning in general. In Tallinn, we can see evidence that supporting innovation in these FE sectors is rationalized with the adoption of the Smart City narrative. The new *Tallinn 2035 Development Plan* includes a Smart City Program as one of the five action programs under the activities related to business environment (City of Tallinn 2020). The Smart City Program explicitly mentions the use of innovation procurements, demo projects and public service design to support local innovation. This narrow operationalization is interesting because the smart city concept itself is much broader and covers topics such as smart economy, smart people, smart governance, smart mobility, smart environment, and smart living (Giffinger *et al.* 2007). Interestingly, many of such projects are not initiated by the City of Tallinn (this is also the case in the City of Tartu). Rather, the city has been asked to join these projects by other local (oftentimes universities) and foreign partners. In the case of Tallinn, the author of the thesis identified 16 innovation projects in the city's externally funded projects database[3] where the goal is to test and/or develop new technology. Only 4 of these were initiated by the City of Tallinn. At the same time, 8 projects had a lead partner from Finland (7 of them from Helsinki-Uusimaa region) and for 3 projects the lead partner was TalTech. This leads us to the next research question.

How can intermediary organizations spark place-based innovation activities and orchestrate entrepreneurial discovery processes at the local level?

Regarding collaboration with foreign partners, we can identify active collaboration between Tallinn and the organizations from Helsinki-Uusimaa. The Finnish region is considered one of the lead innovators in the EU (**Article II**). The importance of such collaboration is also explicitly emphasized in the Smart City Program of the *Tallinn 2035 Development Plan* (City of Tallinn 2020, 23). Finland is well known for its experimental culture which is also present in the City of Helsinki and in its sub-organizations (Ornston 2012; Breznitz and Ornston 2013; **Article II**). Most notable of such organizations is Forum Virium Helsinki. As shown in **Article II**, the City of Helsinki has adopted the city-as-a-platform approach to support different experimental activities to improve public services and urban infrastructure. Many of such experimental activities are organized as part of different, mostly EU-funded innovation projects.

It is important to think about and analyze the conditions on the Finnish side that have led to such collaboration. This thesis emphasizes the role of intermediary organizations. As **Article II** shows, in Helsinki-Uusimaa, which is located in strongly corporatist Finland (see also Ornston 2012; Jahn 2016), we can find a large number of intermediaries which function at the local, regional, and the national levels. These organizations bring together companies (private, state-owned, municipality-owned), research organizations, and

[3] The database does not contain projects where the city-owned companies are partners. There has also been a number of innovation pilots in Tallinn where the city government has provided important support but without budget and being an official partner. These projects are also not in the aforementioned database.

various public organizations from all government levels. While some of these intermediaries mobilize stakeholders under a certain topic (e.g. Smart & Clean Foundation, Health Capital Helsinki), others are more generic (e.g. Forum Virium Helsinki, Helsinki Business Hub).

Many of these organizations, including intermediaries, were also involved in the development of the Helsinki-Uusimaa region's S3 strategy. These intermediaries help to maintain a common understanding among the local stakeholders regarding the direction of development, which in addition to the regional S3 strategy has been framed through several other strategies addressing topics such as climate change, energy efficiency, carbon neutrality, protection of nature, circular economy and sustainable urban development. This is done through formal membership and partnership (other organizations as members/partners of a particular intermediary) or through different projects, including RDI projects. Such collaboration is a good example of the entrepreneurial discovery process in a place-based context.

The fact that the City of Tallinn is participating in a number of such experimental projects, often coordinated by Finnish partners, has given the former the opportunity to see the benefits of such initiatives. As mentioned, the City of Tallinn is now supporting experimentation with its most important and recent strategic document *Tallinn 2035 Development Plan* with several activities already taking place, such as continuous participation in experimental projects, running of innovation competitions (Tallinnovation) or use of innovation procurements. Such projects and initiatives where the aim is to develop and experiment with new technologies have already given a chance to local companies to come out with their own products (**Article V**; Juuse and Karo 2021). Therefore, it is possible to argue that such collaboration has created a spillover in the form of place-based innovation and generated policy learning, both rationalized through the adoption of the smart city narrative.

Although Estonia is a less corporatist country than Finland (Jahn 2016), a number of intermediary organizations can be identified here as well. These include national government agencies (providing funding), cluster organizations (bringing together companies and educational institutions), technology parks, technology competence centers (R&D support), and county-level development centers (business and project funding consultation). Yet, as **Article II** shows, compared to the Helsinki-Uusimaa region, these organizations are not focusing much on building networks between different organizations to develop and maintain a common understanding regarding the direction of economic development and supportive policies as part of EDP, which actually should be their aim according to the experimental governance logic of the RDI policy in the EU. As has been emphasized by previous literature, the main priority has rather been the distribution of Cohesion Funds without rethinking the overall governance logic of the RDI policy and its goals (Karo and Kattel 2018).

At the local level, the role of intermediary organizations is partially played not only by Finnish organizations, but also by local universities and science parks that are actively looking for RDI projects that bring together various stakeholders. Such cooperation is mostly limited to single projects, educational cooperation, or to bringing together different companies that serve the interests of universities and science parks. However, during the last two years there have been some positive developments as well, such as increased activities from the Tallinn City side mentioned before and the establishment of the Green Tiger cooperation platform[4] that seeks to envision a balanced economic model for Estonia in cooperation between businesses, individuals, the public, and the third sector.

How experimental innovation pilots help technology providers and potential service providers to learn about the specifics of a technology?

Taking part of and providing opportunities to run different experimental projects can play a crucial role in the context of S3, the Green Deal and S4+. The experimental projects do not only help to develop new technologies, but also to learn about technologies that have the potential to improve public services, infrastructure and overall sustainability (**Article V**). In addition, one important characteristic of the public sector is that once some new policies are adopted, they are likely to remain in place (Tassey 2014). This is also the case with technology (type and providers) and public services resulting in lock-in situations (see for example Hornnes *et al.* 2010; Ampe *et al.* 2020; Marquardt and Nasiritousi 2022). Experimental pilots can diminish risks related to lock-in situations where inferior solutions are scaled up.

These aspects are addressed in **Article III** and **Article IV**. Such pilots can help to gather feedback from the potential users during the time when the technology is used to provide the service either as how it will look like or close to it. For example, **Article III** is based on an autonomous bus pilot that provided last-mile transportation service in Kadriorg Park located in Tallinn. However, the service was not provided in the final form (fully autonomous service) as an operator was always in the bus. The feedback can include where and for what they would use the new solution, how they perceive it (e.g. safety, security, reliability) or what improvements should be made. **Article IV** describes how the local weather conditions influenced autonomous driving during the three pilots organized as part of the Sohjoa Baltic project. Such information can later be used for technology and service development purposes, but it can also make some service providers cautious as that information can also be considered evidence that shows the immaturity of the technology. This has been the case with the regional public transportation authority HSL in Helsinki (**Article V**).

How the set-up and design of the pilots and the institutional context support or hinder the process of learning about a new technology and its eventual adoption?

Learning from the pilots can be divided into cognitive, relational and normative learning (McFadgen and Huitema 2017), each of which provides opportunities to gain organizational and/or technical knowledge related to the technology. As is shown in **Article V**, the aforementioned types of learning are in turn linked to different tasks carried out during the preparation and running of experimental pilots (in the case of self-driving last-mile buses). As such experimental pilots are often conducted in collaboration between several organizations (e.g. quadruple and triple-helix collaboration or what Schot *et al.* (1994) call technology nexuses), the division of tasks between project partners responsible for preparing and running the experimental pilot will determine which types of learning each organization is exposed to.

[4] The homepage of Green Tiger: https://rohetiiger.ee/en/

The division of tasks can play an important role in future experiments and the eventual adoption of the technology. If public organizations responsible for providing public services and infrastructure are only responsible for tasks which provide organizational and not technical knowledge, then it creates a danger that these organizations are not able to adopt and scale up new technologies. This can impact the region's ability to achieve the sustainability goals set at the EU level. **Article V** provides some insight on this matter by analyzing autonomous bus pilots in Helsinki, Tallinn and Kongsberg. Although the technology of autonomous driving is not mature yet, many cities in Northern Europe are interested in running pilots with autonomous buses because of the novelty and potential of the technology. This has provided an opportunity to see how learning from such technology pilots takes place.

Although Helsinki, Tallinn and Kongsberg have run a number of pilots with autonomous buses, only Kongsberg managed to move from the experimentation phase to limited adoption. A number of reasons for this can be identified. Compared to the other two cities, Kongsberg has taken a more holistic view on the pilots. While the pilots in Tallinn and Helsinki are run as technology experiments, the stakeholders in Kongsberg have from the start tried to think about the possible business and service development opportunities. This is due to the bigger involvement of public transportation authorities and the service provider. In addition, the stakeholders in Kongsberg have been included in a larger number of different activities related to the preparation and operation of the pilots. Most importantly, it is the local public transport authority Brakar and the current service provider Vy who have largely been responsible for running those pilots. The latter has taken a step even further and has launched a new autonomous public transportation line with a regular-sized bus in Stavanger which is first of its kind in Europe.

Meanwhile, in Tallinn and Helsinki, the role of public transport authorities and service providers has been limited or non-existent. In Tallinn, the local public transportation authority has been responsible for activities that provide opportunities for mostly relational learning and organizational knowledge and in Helsinki the local public transportation authority has only provided support while not being officially involved in any of the pilots. In both cities, most of the technical knowledge gained through cognitive and relational learning has ended up in organizations that have little influence over service delivery. However, we can identify the important role of intermediary organizations such as Forum Virium Helsinki in organizing autonomous pilots in Helsinki and also to some extent in Tallinn. In addition, in Tallinn and Helsinki the responsibility for different activities has been more divided.

At the same time, we can find local companies from all three cities that have benefited from participating in these pilots as it has enabled them to develop solutions linked to autonomous mobility (vehicles, mobility management software, sensor technology, smart infrastructure solutions, *etc*). Such achievements are in line with S3 and partially with S4+ concepts. But as mentioned before, S4+ is about improving sustainability through innovation-driven policy. In the context of adopting new technologies, the responsible public organizations have to take a more active role while participating in experimental pilots.

4 Discussion

The findings provide several important discussion points related to preconditions for place-based innovation policy to emerge and smart specialization in Europe. S3 was integrated into the EU's regional policy with the assumption that the Cohesion Funds will be used together with the adoption of experimental governance principles of the smart specialization concept. Yet, this has been rather challenging in the CEE (Karo and Kattel 2018).

This has especially been the case in small states such as Estonia where a tendency exists to consider the small state as a unified place and where national-level policy implementation has been perceived as a more efficient governance arrangement than regional or local place-based approaches. It has also helped to avoid thorough discussions on the shortcomings of the place-blind policy approach. This tendency has been further amplified by the EU polices where statistical regions of the NUTS-2 level that are the targets of Cohesion Funds cover several countries, including Estonia, as a whole, and this further strengthens the centralization of the administration and allocation of EU funds in these countries.

Yet, even in a small state like Estonia, the national government is not always capable of identifying the needs of specific localities in the country, nor the opportunities that the involvement of local municipalities could provide. Local municipalities have mostly been considered as service providers and not policy developers. This is especially the case in the context of economic and RDI policy where they have long been an unused institutional and physical space, although the fact that municipalities are responsible for delivering public services provides many opportunities in the RDI policy context. In addition, the smallness of a country does not automatically result in improved collaboration between the key stakeholders. This is shown by the previously mentioned failure of the Estonian central government to involve local municipalities in the RDI policy and difficulties experienced by the central government to develop meaningful collaboration between the state, the private sector and the academia.

However, this thesis argues that while S3 has failed to spark necessary changes in the overall strategic governance of innovation policy that would ideally result in place-based innovation policy, a more practical approach focusing on improving FE sectors could potentially provide a way for place-based RDI activities to emerge in place-blind innovation policy context if several preconditions are met. First, the Estonian case shows that the local municipalities have to have an understanding of their potential (**Article II**). Based on Coenen and Morgan (2019), this is not always the case. Otherwise, FE sectors would not be ignored to such extent. In addition to this understanding, there must also be the will to act. However, the will is often constrained by the availability of financial resources and the public sector's general tendency to avoid risks, while the experimental RDI activities are characterized by uncertainty. Although S3 has failed in bringing the necessary changes to innovation policy governance in the CEE, the case of Estonia shows that the availability of different EU funds such as Horizon and Interreg has helped to support place-based innovation as they encourage and enable public organizations to take more risks (**Article II**; **Article V**).

The findings of this thesis also point out that cross-regional collaboration can be crucial for sparking place-based experimental RDI activities. They also show that it is more likely for such collaboration to be coordinated by intermediaries or universities from more developed regions due to their long experience in participating in the development and implementation of RDI policy and/or greater organizational thickness compared to the less advanced regions (see also **Article II**; Kroll 2017; Tödtling and Trippl 2005). Most importantly, such cross-regional collaborations between the cities and key organizations have the potential to spark policy learning, which is one of the main aims of the experimental governance model where peer-review and mandatory reporting should fulfill this role. We can witness how such policy learning has taken place in the City of Tallinn as it now tries to follow in the steps of Helsinki City. Similar to Helsinki, Tallinn has increased its focus to support local innovation both in writing (Tallinn 2035 Development Strategy) and in practical terms (experimental RDI activities). Such policy learning shares similarities with the twinning approach that was used to help CEE candidate states build capacities in specific areas not covered by *acquis* with the support by the EU Member States (Sabel and Zeitlin 2010; Tulmets 2010).

The aforementioned place-based experimental RDI activities have created opportunities for companies to develop new technologies but also for all the relevant stakeholders to gain technical and organizational knowledge related to that new technology that can support its future adoption. This is especially the case with all the entities responsible for FE sectors, including local municipalities. However, the question of adoption has attracted less attention in smart specialization discourse than it should. Some change in this matter can be identified as the European Green Deal and S4+ emphasize addressing local sustainability challenges through the development and adoption of new technologies.

It also means that the tasks of EDP have to change as well. Until now, EDP has focused on identifying domains where RDI activities could complement the region's productive assets (Foray 2014). A more specific aim has been to identify technologies and groups of companies that have the potential to bring forth a wider transformation in the local economy and develop policy measures to support them (Foray 2018). The updated task of EDP in the S4+ context is to synchronize RDI activities, the region's productive assets and the local sustainability challenges. Finding the right balance between the three will be a challenge itself due to contradictions between issues related to economic development and environmental sustainability and increasing coordination challenges (see also Hassink and Gong 2019).

More specifically, addressing the sustainability challenges also means that the question of adopting new technologies and solutions should already be addressed during the EDP process. One should not look at the question of adoption linearly as something that takes place after the technology becomes market-ready. As this thesis shows (see **Article V**), the adoption of a new technology is a matter that needs to be addressed already during the development and piloting phases. In practical terms, it means that the design of policy interventions that support the development of new technologies such as experimental RDI activities should provide opportunities for future users to gain technical and organizational knowledge about the specific technology which would ease later adoption. Ignoring this could lead towards experimental lock-in situations where experimental RDI activities are carried out without adoption in mind. The cases of Tallinn and Helsinki in **Article V** can be described as such instances. Companies still benefit from such initiatives as they are able to develop their products, but the development is not directed towards solving local challenges.

The case studies of this thesis again show how important governance in RDI policy is. More specifically, the thesis provides if not a complete, then at least a partial blueprint on how to set up a policy system that supports place-based innovation and how the development of cooperation networks and the design of pilots plays a vital role in achieving S4+ goals through place-based innovation.

Based on the main findings and the discussion, several policy recommendations can be suggested which can improve the implementation of place-based RDI policy. First, as **Article II** shows, larger municipalities want to have a more active role in the Estonian RDI policy. In addition, there are good examples of place-based RDI activities which have resulted in locally developed technologies. During the 2014-2020 funding period, a limited number of measures existed that had a place-based focus and could benefit local governments, such as the innovation procurement measure, county-level development centers and regional competence centers (**Article I**). As sustainability challenges are very often local in nature (Kelemen 2020), it is important to have increased involvement of local municipalities in the development and implementation of RDI policy to support the development of solutions suitable for the local context. Local municipalities can prevent designing policy measures that are not suitable for them or include extended amount of red tape. One of such questions is related to the mandatory co-funding and its rate. A high co-funding rate can prevent not only small but also larger municipalities from using such measures (**Article II**). In addition, a separate measure to cover co-funding could encourage smaller municipalities to participate in international innovation projects. Increased attention to supporting innovation in FE sectors at the municipality level could be a viable option based on the success stories of the previous years.

Second, in addition to supporting the local development of new technologies and solutions, the adoption of such solutions needs separate attention. The former was the focus of S3 which aimed at identifying the opportunities for growth and development that a region has while taking into account the local socio-economic challenges.[5] S4+ requires place-based innovation policy activities to address the local environmental and sustainability-related challenges. Therefore, a bigger emphasis has to be put on mastering and scaling up the new solutions. This is also the case with the public entities such as local governments and national and regional agencies responsible for developing and providing different services and infrastructure. As oftentimes such solutions are first tested as part of different innovation pilots, the design of such pilots must improve. This includes involving the most relevant organizations in pilots, especially service providers, and dividing the tasks in a way that enables service providers to gain organizational and technical knowledge related to a particular solution. As **Article V** shows, this is not always the case.

Third, as the Finnish example shows (**Article II**), intermediary organizations can play an important role in building collaboration networks necessary for EDP. Establishing and supporting novel organizations such as Green Tiger should be further encouraged in Estonia. Larger municipalities or groups of municipalities could consider establishing Forum Virium-type organizations that aim at running projects with local and external actors who have the potential to provide opportunities for local companies and improve public services and infrastructure. Similarly, county-level development centers or municipality associations could be used in this role as these organizations have a good understanding about the profile and needs of local municipalities, companies, and entrepreneurs located in a specific county.

[5] European Commission's Smart Specialisation Platform, available at: https://s3platform.jrc.ec.europa.eu/what-we-do

These policy recommendations would help to adjust the Estonian RDI policy more to the local needs currently not grasped enough by the central government and bring it closer to a place-based approach (Beer *et al.*, 2020). It would also mean a departure from the state-led entrepreneurial discovery process dominated by the academia to a more balanced representation of interests (Foray 2014; Karo *et al.* 2017).

It is also clear that the experimentalist governance toolbox has not helped CEE countries to learn from their more developed peers, as for them peer-review and mandatory reporting are just formal procedures that need to be complied with to get funding (see Karo and Kattel 2018). While these tools serve a purpose for more advanced economies, a more suitable tool for the CEE context should be promoted. This thesis shows that practical cross-regional collaboration between more advanced and less advanced regions resembling twinning could be this tool. The implementation could be a challenge due to innovation policy being a "shared" policy domain, meaning that such collaboration cannot be made mandatory. On a positive note, the EC funding bodies are already recommending such collaboration by preferring projects carried out by partners representing both more advanced and less developed regions (e.g. Interreg). However, further research is needed to analyze what has been the impact of such project funding preferences.

5 Avenues for future research

The aim of this thesis is to look at the preconditions for the emergence of place-based RDI activities in the context of state-led and place-blind national RDI policy. In the light of this thesis, several topics emerge that need further research.

First, further observations on cross-border collaboration between the key institutions from regions and countries at different levels of development and different RDI policy would be valuable. The thesis shows that experimental innovation pilot projects linked to FE sectors organized in collaboration between an advanced region with a place-based RDI policy setting and a less advanced region with a spatially blind RDI policy setting can create a spillover where place-based innovation activities emerge in the latter region. Identifying and investigating other examples of such collaboration would provide valuable information that could be used as a blueprint in actual policymaking. Is such collaboration viable only between bordering regions or is it more important to have a shared interest in developing certain FE sectors are some of the questions that would require further investigation.

Second, there is plenty of literature focusing on smart specialization that emphasizes the importance of multi-stakeholder collaboration in the context of EDP (Foray 2014; McCann and Ortega-Argilés 2016). Although right in their conclusions, they often fail at providing practical guidance, which is also one of the critiques by Pugh (2018). **Article II** was written in the spirit of providing some concrete examples how such collaboration can work in real life. Further cases such as Helsinki-Uusimaa in Finland should be identified and described for both academic and policy purposes.

Third, collaboration and coordination questions will become even more challenging in the S4+ context. However, environmental and sustainability questions touch every aspect of our society. As Trippl *et al.* (2020) have argued in the context of S3, not only organizational thinness, but also organizational thickness can be a challenge as regions have to decide whom to include in policy processes. Sustainability as an additional dimension will increase the number of organizations that are interested participating in the RDI policy process and interrupt the existing social and political balance of power (Pike *et al*. 2010). Further research is needed to see how the EU regions and countries attempt to balance the oftentimes contradictive interests of economic development and sustainability and the relevant actors who represent these interests. In addition, as the European Green Deal and S4+ open up access to RDI policy processes, we can also expect competition between the new participants regarding whose niche ideas (Schot and Geels 2008) will get more support.

References

AMPE, K., PAREDIS, E., ASVELD, L., OSSEWEIJER, P., BLOCK, T. (2020) "A transition in the Dutch wastewater system? The struggle between discourses and with lock-ins." *Journal of Environmental Policy & Planning, 22*(2), 155-169. https://doi.org/10.1080/1523908X.2019.1680275

ASHEIM, B. T., ISAKSEN, A., TRIPPL, M. (2020) "Chapter 1: The role of the Regional Innovation System approach in contemporary regional policy: is it still relevant in a globalised world?" In González-López, M., Asheim, B. T. (*eds.*) *Regions and Innovation Policies in Europe: Learning from the Margins*, 12-29. Edward Elgar Publishing. https://doi.org/10.4337/9781789904161

BAKICI, T., ALMIRALL, E., WAREHAM, J. (2013) "The role of public open innovation intermediaries in local government and the public sector." *Technology Analysis & Strategic Management, 25*(3), 311-327. https://doi.org/10.1080/09537325.2013.764983

BARCA, F. (2009) "An Agenda for A Reformed Cohesion Policy: A Place-Based Approach to Meeting European Union Challenges and Expectations," Independent Report, Prepared at the Request of the European Commissioner for Regional Policy, Danuta Hubner, European Commission, Brussels.

BARCA, F., MCCANN, P., RODRIGUEZ-POSE, A. (2012) "The Case for Regional Development Intervention: Place-Based Versus Place-Neutral Approaches." *Journal of Regional Science, 52*(1), 134-152. https://doi.org/10.1111/j.1467-9787.2011.00756.x

BEER, A., MCKENZIE, F., BLAŽEK, J., SOTARAUTA, M., AYRES, S. (2020). "What is Place-Based Policy?" *In*: BEER, A., MCKENZIE, F., BLAŽEK, J., SOTARAUTA, M., AYRES, S. (*eds.*) *Every Place Matters: Towards Effective Place-Based Policy (1st ed.)*. Routledge, 11-22. https://doi.org/10.4324/9781003110118

BENTHAM, J, BOWMAN, A, DE CUESTA, M, ENGELEN, E., ERTÜRK, I., FOLKMAN, P., FROUD, J., JOHAL, S., LAW, J., LEAVER, A., MORAN, M., WILLIAMS, K. (2013) "Manifesto for the Foundational Economy." *CRESC Working Paper*, *131*. Manchester: Centre for Research on Socio-Cultural Change.

BOSCHMA, R. (2015) "Towards an Evolutionary Perspective on Regional Resilience." *Regional Studies*, *49*(5), 733-751. https://doi.org/10.1080/00343404.2014.959481

BREZNITZ, D., ORNSTON, D. (2013) "The Revolutionary Power of Peripheral Agencies: Explaining Radical Policy Innovation in Finland and Israel." *Comparative Political Studies, 46*(10), 1219-1245. https://doi.org/10.1177/0010414012472466

BREZNITZ, D. (2021) *Innovation in real places: Strategies for prosperity in an unforgiving world*. Oxford: Oxford University Press.

CAPELLO, R., KROLL, H. (2016) "From theory to practice in smart specialization strategy: emerging limits and possible future trajectories." *European Planning Studies, 24*(8), 1393-1406. https://doi.org/10.1080/09654313.2016.1156058

CITY OF TALLINN (2020) "Tallinn 2035 Development Strategy." Available: https://www.tallinn.ee/eng/strateegia/Arengustrateegia-Tallinn-2035-avalikustamine

CLARK, J. (2014) "Manufacturing by design: the rise of regional intermediaries and the re-emergence of collective action." *Cambridge Journal of Regions Economy and Society, 7*(3), 433-448. https://doi.org/10.1093/cjres/rsu017

COENEN, L., MORGAN, K. (2019) "Evolving geographies of innovation: existing paradigms, critiques and possible alternatives." *Norsk Geografisk Tidsskrift – Norwegian Journal of Geography*, *74*(1), 13-24. https://doi.org/10.1080/00291951.2019.1692065

DAVID, T., GINALSKI, S., MACH, A., REBMANN, F. (2009) "Networks of Coordination: Swiss Business Associations as an Intermediary between Business, Politics and Administration during the 20th Century." *Business and Politics, 11*(4), 1-38. https://doi.org/10.2202/1469-3569.1269

EDQUIST, C., CHAMINADE, C. (2006) "Industrial policy from a systems-of-innovation perspective." *EIB Papers, 11*(4), 108-132.

ESTENSORO, M., LARREA, M. (2022) "Facilitation of Entrepreneurial Discovery Processes by Policymakers: an Actionable Definition of Roles and Challenges." *Journal of the Knowledge Economy*. https://doi.org/10.1007/s13132-022-00906-1

FAROLE, T., RODRÍGUEZ-POSE, A., STORPER, M. (2011) "Cohesion Policy in the European Union: Growth, Geography, Institutions." *Journal of Common Market Studies*, *49*(5), 1089-1111. https://doi.org/10.1111/j.1468-5965.2010.02161.x

FORAY, D. (2014) *Smart Specialisation: Opportunities and Challenges for Regional Innovation Policy (1st ed.)*. Routledge. https://doi.org/10.4324/9781315773063

FORAY, D. (2018) "Smart specialization strategies as a case of mission-oriented policy-a case study on the emergence of new policy practices." *Industrial and Corporate Change, 27*(5), 817-832. https://doi.org/10.1093/icc/dty030

FORAY, D., DAVID, P. A., HALL, B. (2009). "Smart specialisation – The concept." *Knowledge Economists Policy Brief No. 9*.

FORAY, D., DAVID, P.A., HALL, B.H. (2011) "Smart specialization: From academic idea to political instrument, the surprising career of a concept and the difficulties involved in its implementation." *MTEI Working Paper*, *2011–001*.

FORAY, D., VAN ARK, B. (2007). "Smart specialization in a truly integrated research area is the key to attract more R&D to Europe*." Knowledge Economists Policy Brief No. 1*.

GIFFINGER, R., FERTNER, C., KRAMAR, H., KALASEK, R., MILANOVIĆ, N., MEIJERS, E. (2007) "Smart cities - Ranking of European medium-sized cities."

GRILLITSCH, M., TRIPPL, M. (2016) "Innovation policies and new regional growth paths: A place-based system failure framework." *Papers in Innovation Studies, No. 2016/26.*

HASSINK, R., GONG, H. (2019) "Six critical questions about smart specialization." *European Planning Studies, 27*(10), 2049-2065. https://doi.org/10.1080/09654313.2019.1650898

HASSINK, R. (2020) "Chapter 2: Advancing place-based regional innovation policies," *In*: González-López, M., ASHEIM, B. T. (*eds.*) *Regions and Innovation Policies in Europe: Learning from the Margins*. Edward Elgar Publishing, 30-45. https://doi.org/10.4337/9781789904161

HORNNES, E., JANSEN, A., LANGELAND, Ø. (2010) "How to Develop an Open and Flexible Information Infrastructure for the Public Sector?" *In:* WIMMER, M. A., CHAPPELET, J.-L., JANSSEN, M., SCHOLL, H. J., (*eds.*) *Electronic Government*. EGOV 2010. Lecture Notes in Computer Science, *vol 6228*. Berlin, Heidelberg: Springer, 301-314.

JAHN, D. (2016) “Changing of the guard: trends in corporatist arrangements in 42 highly industrialized societies from 1960 to 2010.” *Socio-Economic Review, 14*(1), 47-71. https://doi.org/10.1093/ser/mwu028

JANSSEN, M. J., FRENKEN, K. (2019) “Cross-specialisation policy: rationales and options for linking unrelated industries.” *Cambridge Journal of Regions Economy and Society, 12*(2), 195-212. https://doi.org/10.1093/cjres/rsz001

JUUSE, E., KARO, E. (2021) “New Emerging Industries and Alternative Pathways into Global Value Chains: the Case of Estonian Automated Mobility and Delivery Industry.” *Unpublished manuscript, currently under review*.

KARO, E., KATTEL, R. (2015) “Economic development and evolving state capacities in Central and Eastern Europe: can “smart specialization” make a difference?” *Journal of Economic Policy Reform, 18*(2), 172-187. https://doi.org/10.1080/17487870.2015.1009068

KARO, E., KATTEL, R. (2018), “Innovation (Policy) and Transformative Change in the European Union.” *In*: VIHALEMM, P., A. MASSO, A., OPERMANN, S. (*eds*.) *The Routledge International Handbook of European Social Transformation*. Abingdon: Routledge, 239-249. https://doi.org/10.4324/9781315612942

KARO, E., KATTEL, R. & CEPILOVS, A. (2017) “Can Smart Specialization and Entrepreneurial Discovery be Organized by the Government? Lessons from Central and Eastern Europe.” *In*: RADOSEVIC, S., CURAJ, A., GHEORGHIU, R., ANDREESCU, L., WADE, I. (*eds*.) *Advances in the Theory and Practice of Smart Specialization*. Academic Press, 269-292.

KARO, E., KATTEL, R., LEMBER, V., UKRAINSKI, K., KANEP, H., VARBLANE, U. (2014) “Nutika spetsialiseerumise võimalused ja väljakutsed Eestis teadus-, arendus- ja innovatsioonipoliitika kujundamisel ja juhtimisel 2014-2020.” *TIPS poliitikaanalüüs*.

KELEMEN, A. (2020) “Supporting sustainability transitions under the European green deal with cohesion policy: Report on a Toolkit for National and Regional Decision-Makers.” European Commission, Directorate-General for Regional and Urban Policy.

KROLL, H. (2015) “Efforts to implement smart specialization in practice – leading unlike horses to the water.” *European Planning Studies*, *23*(10), 2079–2098. https://doi.org/10.1080/09654313.2014.1003036

KROLL, H. (2017) “The challenge of smart specialisation in less favoured regions.” *Working Papers Firms and Regions*, *No. R1/2017*, Fraunhofer ISI.

LEMBER, V., KALVET, T., KATTEL, R. (2011) “Urban Competitiveness and Public Procurement for Innovation.” *Urban Studies, 48*(7), 1373-1395. https://doi.org/10.1177/0042098010374512

LOEWEN, B. (2018) “From Decentralization to Re-Centralization: Tendencies of Regional Policy and Inequalities in Central and Eastern Europe.” *Administrative Culture, 18*(2), 103-126. https://doi.org/10.32994/ac.v18i2.162

LUNDVALL, B. Å. (1985) “Product Innovation and User-Producer Interaction.” *Industrial Development Research Series*, *No. 31*. Aalborg: Aalborg Universitetsforlag.

MARCEAU, J. (2008) “Introduction: Innovation in the city and innovative cities.” *Innovation, 10*(2-3), 136-145. https://doi.org/10.5172/impp.453.10.2-3.136

MARQUARDT, J., NASIRITOUSI, N. (2022) “Imaginary lock-ins in climate change politics: the challenge to envision a fossil-free future.” *Environmental Politics, 31*(4), 621-642. https://doi.org/10.1080/09644016.2021.1951479

MARQUES, P., MORGAN, K. (2018) “The Heroic Assumptions of Smart Specialisation: A Sympathetic Critique of Regional Innovation Policy.” *In:* ISAKSEN, A., MARTIN, R. & TRIPPL, M. (*eds*.) *New Avenues for Regional Innovation Systems - Theoretical Advances, Empirical Cases and Policy Lessons.* Cham: Springer International Publishing, 275-293.

MCCANN, P., ORTEGA-ARGILÉS, R. (2013a) “Redesigning and Reforming European Regional Policy: The Reasons, the Logic, and the Outcomes.” *International Regional Science Review, 36*(3), 424-445. https://doi.org/10.1177/0160017612463234

MCCANN, P., ORTEGA-ARGILÉS, R. (2013b) “Transforming European regional policy: a results-driven agenda and smart specialization.” *Oxford Review of Economic Policy, 29*(2), 405-431. https://doi.org/10.1093/oxrep/grt021

MCCANN, P., ORTEGA-ARGILÉS, R. (2015) “Smart Specialization, Regional Growth and Applications to European Union Cohesion Policy.” *Regional Studies*, *49*(8), 1291-1302. https://doi.org/10.1080/00343404.2013.799769

MCCANN, P., ORTEGA-ARGILÉS, R. (2016) “Smart specialisation, entrepreneurship and SMEs: issues and challenges for a results-oriented EU regional policy.” *Small Business Economics, 46***,** 537-552. https://doi.org/10.1007/s11187-016-9707-z

MCCANN, P., SOETE, L. (2020) „Place-based innovation for sustainability.“ Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-20392-6, JRC121271. DOI:10.2760/250023

MCFADGEN, B., HUITEMA, D. (2017) “Are all experiments created equal? A framework for analysis of the learning potential of policy experiments in environmental governance.” *Journal of Environmental Planning and Management, 60*(10), 1765-1784. https://doi.org/10.1080/09640568.2016.1256808

MENDEZ, C. (2013) “The post-2013 reform of EU cohesion policy and the place-based narrative.” *Journal of European Public Policy, 20*(5), 639-659. https://doi.org/10.1080/13501763.2012.736733

MONAR, J. (2010) “Experimentalist Governance in Justice and Home Affairs.” *In*: SABEL, C. F., ZEITLIN, J. (*eds*.) *Experimentalist Governance in the European Union: Towards a New Architecture*. Oxford University Press, 237-260.

MORGAN, K. (2019) “The future of place-based innovation policy (as if ‘lagging regions’ really mattered).” *Regional Studies Policy Impact Books*, *1*(2), 79-89. https://doi.org/10.1080/2578711X.2019.1621103

MORISSON, A., DOUSSINEAU, M. (2019) “Regional innovation governance and place-based policies: design, implementation and implications.” *Regional Studies, Regional Science, 6*(1), 101-116. https://doi.org/10.1080/21681376.2019.1578257

ORNSTON, D. (2012) *When small states make big leaps: Institutional innovation and high-tech competition in Western Europe*. New York: Cornell University Press.

PIKE, A., DAWLEY, S., TOMANEY, J. (2010) “Resilience, adaptation and adaptability.” *Cambridge Journal of Regions, Economy and Society*, *3*(1), 59-70. https://doi.org/10.1093/cjres/rsq001

PUGH, R. (2018) “Questioning the implementation of smart specialisation: Regional innovation policy and semi-autonomous regions.” *Environment and Planning C: Politics and Space, 36*(3)**,** 530-547. https://doi.org/10.1177/2399654417717069

RADOSEVIC, S. (2017) “Chapter 1 - Assessing EU Smart Specialization Policy in a Comparative Perspective.” *In:* RADOSEVIC, S., CURAJ, A., GHEORGHIU, R., ANDREESCU, L., WADE, I. (*eds*.) *Advances in the Theory and Practice of Smart Specialization.* Academic Press, 1-36.

RODRIK, D. (2007) *One Economics, Many Recipes: Globalization, Institutions, and Economic Growth*. Princeton and Oxford – Princeton University Press.

SABEL, C. F., ZEITLIN, J. (2010) "Learning From Difference: The New Architecture of Experimentalist Governance in the EU." *In*: SABEL, C. F., ZEITLIN, J. (*eds.*) *Experimentalist Governance in the European Union: Towards a New Architecture*. Oxford University Press, 1-28.

SCHOT, J., GEELS, F. W. (2008) "Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy." *Technology Analysis & Strategic Management, 20*(5), 537-554. https://doi.org/10.1080/09537320802292651

SCHOT, J., HOOGMA, R., ELZEN, B. (1994) "Strategies for shifting technological systems: The case of the automobile system." *Futures, 26*(10), 1060-1076. https://doi.org/10.1016/0016-3287(94)90073-6

SHOHET, S., PREVEZER, M. (1996) "UK biotechnology: Institutional linkages, technology transfer and the role of intermediaries." *R & D Management, 26*(3), 283-298. https://doi.org/10.1111/j.1467-9310.1996.tb00962.x

SMEDLUND, A. (2006) "The roles of intermediaries in a regional knowledge system." *Journal of Intellectual Capital, 7*(2), 204-220. https://doi.org/10.1108/14691930610661863

SOLLY, A. (2016) "Place-based innovation in Cohesion Policy: meeting and measuring the challenges." *Regional Studies, Regional Science, 3*(1), 193-198. https://doi.org/10.1080/21681376.2016.1150199

SOOTLA, G., KATTAI, K. (2020) "Institutionalization of subnational governance in Estonia: European impacts and domestic adaptations." *Regional & Federal Studies, 30*(2), 283-301. https://doi.org/10.1080/13597566.2018.1511979

SVETIEV, Y. (2010) "Networked Competition Governance in the EU: Delegation, Decentralization, or Experimentalist Architecture?" *In*: SABEL, C. F., ZEITLIN, J. (*eds.*) *Experimentalist Governance in the European Union: Towards a New Architecture*. Oxford University Press, 79-120.

TASSEY, G. (2014) "Innovation in innovation policy management: The Experimental Technology Incentives Program and the policy experiment." *Science and Public Policy, 41*(4), 419-424. https://doi.org/10.1093/scipol/sct060

THOMPSON, M., NOWAK, V., SOUTHERN, A., DAVIES, J., FURMEDGE, P. (2020) "Re-grounding the city with Polanyi: From urban entrepreneurialism to entrepreneurial municipalism." *EPA: Economy and Space*, *52*(6), 1171-1194. https://doi.org/10.1177/0308518X19899698

TÖDTLING, F., TRIPPL, M. (2005) "One size fits all?: Towards a differentiated regional innovation policy approach." *Research Policy, 34*(8)**,** 1203-1219. https://doi.org/10.1016/j.respol.2005.01.018

TRIPPL, M., ZUKAUSKAITE, E., HEALY, A. (2020) "Shaping smart specialization: the role of place-specific factors in advanced, intermediate and less-developed European regions." *Regional Studies, 54*(10), 1328-1340. https://doi.org/10.1080/00343404.2019.1582763

TULMETS, E. (2010) "Experimentalist Governance in EU External Relations: Enlargement and the European Neighbourhood Policy." *In*: SABEL, C. F., ZEITLIN, J. (*eds.*) *Experimentalist Governance in the European Union: Towards a New Architecture*. Oxford University Press, 297-324.

WORLD BANK (2009) “World Development Report 2009: Reshaping Economic Geography.” World Bank. © World Bank. 5991 License: CC BY 3.0 IGO. https://openknowledge.worldbank.org/handle/10986/

YIN, R. K. (2018). *Case Study Research and Applications: Design and Methods (6th ed.).* Thousand Oaks, CA: Sage.

ZELENBABIC, D. (2015) “Fostering innovation through innovation friendly procurement practices: a case study of Danish local government procurement.” *Innovation: The European Journal of Social Science Research, 28*(3), 261-281. https://doi.org/10.1080/13511610.2015.1056724

Acknowledgements

This thesis marks an end of a relatively long journey that started in 2017 with a meeting with my master’s thesis supervisor Adjunct Professor Tarmo Kalvet. I was about to finish my work in the Federation of Estonian Student Unions and my MA thesis defense was in couple of days when he asked whether I would be interested in starting PhD studies under Associate Professor Erkki Karo’s supervision while also working on a couple of projects related to smart specialization and technology pilots. Starting PhD studies was something I always considered as an option, and after a short period of thinking I accepted the offer. I would also like to thank Professor Tarmo Kalvet for his guidance during the MA studies.

The journey has definitely been an interesting one with its own ups and downs. The projects I worked on provided me an opportunity to meet with interesting people all around the Baltic and Nordic area and thanks to the Smart-up BSR project I also had the chance to work in the Tallinn City Government, which I consider a very valuable experience. All of this was useful for my research. I also admit that during the first two years there were moments I felt down. It was the time I worked with two draft papers simultaneously and while my good fellow PhD students managed to publish their first paper, I still had not published anything. Both of the papers are now published and part of this PhD thesis.

The fact that the thesis is based on several different projects posed its own challenges related to how to bring all the results together. My biggest thanks go to my supervisor Professor Erkki Karo. It was his support and guidance throughout the studies that helped me to do that. Although being the director of the department is time-consuming and sometimes really complicated, he always found time for me, and I am really grateful for that. He has also taught me that there are always opportunities if you are agile (!) enough.

I am immensely grateful that I have had the opportunity to study at Ragnar Nurkse Department of Innovation and Governance. The people here are friendly and supportive, and the overall atmosphere of the department has always been positive and constructive. Big thanks to all the members of the Nurkse department for this. I would also like to thank senior faculty members for their guidance, especially Professor Ringa Raudla, Dr. Veiko Lember, Professor Rainer Kattel and Dr. Margit Kirs. I would separately like to thank Dr. Margit Kirs who asked me to be her teaching assistant during my third year of BA studies. That was probably the moment when I first became part of the department. My studies would not have been the same without fellow PhD students Mariliis, Steven, Alex and the members of the infamous PhD room collective Shobhit, Julia, Salah, Ven. Pisith, Luiza, Dika, and Lucas. Thank you all for being such good colleagues.

My gratitude goes to the co-authors of the articles Professor Erkki Karo, Dr. Ralf-Martin Soe, Dr. Kaija Veskioja, Dr. Rhiannon Pugh, Adjunct Professor Mauro Bellone, Associate Professor Raivo Sell, Azat Kuitunen, and Oscar Nissin. Every article had its own challenges, but we managed to overcome them. My gratitude goes also to Jaanus Vahesalu under whom I worked in the Tallinn City Enterprise Department and Kristel Kibus. They both were very helpful when I needed any information about the Tallinn City Administration in relation to my research.

I would like to mention my History and Social Studies teacher Tiiu-Marika Puštšenko. Her classes were always inspiring, and she also encouraged me to participate in History

Olympiads. Interestingly, the topic of the first Olympiad I took part of was the history of technology. Thank you for your guidance because without it I would not be here!

I would not have made this far without my mom Inge. Life has constantly thrown challenges her way. We have seen some really tough times. As a single mom she went through ice and fire to raise me. Thank you and I hope I will one day be able to repay you! I would also like to thank my partner Valeriia who has always been very supportive throughout my studies even if she gets annoyed seeing me exchanging work-related emails or messages at 9 pm.

This thesis has partially been supported by the European Regional Development Fund, Interreg Baltic Sea Region Programme (projects No. #R044 [Smart-up BSR], #R073 [Sohjoa Baltic], #X025 [Sohjoa Last Mile]) and by the European Commission through the H2020 project Finest Twins (grant No. 856602). I would also like to say a couple of good words about the funding of PhD studies in Estonia as not every government is providing student allowances. Interestingly, during my time in the Federation of Estonian Student Unions the question of raising the monthly allowance for PhD students was one of our primary goals (and we succeeded).

Abstract

Place-Based Innovation in Place-Blind Innovation Policy Context

Opportunities for growth and development are something that countries, regions and cities are constantly looking for. Initially, this was pursued by countries through the development and implementation of industrial policy strategies (Rodrik 2007) with emphasis later shifting towards a systemic view of innovation and supportive policy mixes (Lundvall 1985). Research, development and innovation (RDI) policy strategies are by now widely adopted by different levels of government. In the European Union (EU) context, the European Commission is using its experimental governance structures to support regional and national governments in their RDI activities by providing financial support and policy assistance through the structural and cohesion funds with the aim to achieve economic convergence across the EU in a place-based manner (Barca 2009; Beer *et al*. 2020; Karo and Kattel 2018; Sabel and Zeitlin 2010). Prior research has shown how challenging it can be for the EU Member States to follow not just the formalities, but the actual spirit of the EU's regional and RDI policies which promote experimentation, coordination and collaboration between the main stakeholders, and constant policy learning (see for example Karo *et al*. 2017; Karo and Kattel 2018; Kroll 2017).

Estonia is a very good example of an EU Member State that experiences many of these policy challenges that have also been studied at length, but it also offers interesting insight into the question that has gained less attention than it deserves: how place-based RDI activities emerge in the context of largely state-led and place-blind national RDI policy? This thesis focuses on this question and attempts to fill the existing research gap from two perspectives: strategic policy actions and context and local innovation dynamics.

From the strategic perspective, the thesis looks at how RDI policies in Estonia have been developed and implemented, what role the local municipalities as the lowest level administrative entities and actual physical spaces see for themselves in the context of RDI policy, and what is the role of intermediary organizations. The local perspective is used to analyze what are the opportunities and challenges related to experimental RDI activities at the local level.

The thesis shows that while the EU's smart specialization initiative (S3) has failed to spark necessary changes in the strategic governance of innovation policy that would result in a place-based approach, a more practical approach focusing on improving sectors of foundational economy can provide a way for the place-based RDI activities to emerge in the largely place-blind innovation policy context. In addition, the thesis shows how cross-regional collaboration often orchestrated by intermediaries or universities from more advanced regions can spark place-based RDI activities in less developed regions and support policy learning. The thesis also points out that in the context of smart specialization for sustainability (S4+), the RDI policies must be adjusted, and greater emphasis should be put on the adoption of new solutions, which in the S3 context has received less attention.

Lühikokkuvõte

Kohapõhine innovatsioon kohapimeda innovatsioonipoliitika kontekstis

Riigid, regioonid ja linnad on pidevalt otsimas võimalusi kasvuks ja arenguks. Riigid pühendusid sellele esialgu läbi tööstuspoliitika strateegiate arendamise ja rakendamise (Rodrik 2007). Hiljem on fookus nihkunud süsteemsemale arusaamale innovatsioonist ja sellele, milliste poliitikakombinatsioonidega seda toetada (Lundvall 1985). Teadus-, arendus- ja innovatsioonipoliitikale (TAI) keskenduvad strateegiad on nüüd laialt levinud erinevatel valitsemistasanditel. Euroopa Liidu kontekstis kasutab Euroopa Komisjon oma eksperimentaalseid valitsemise struktuure, et toetada regionaalseid ja kesktasandi valitsusi nende TAI tegevustes, pakkudes neile nii finantsilist toetust kui ka poliitikanõu läbi ühtekuuluvus- ja struktuurfondide, seda eesmärgiga saavutada liiduüleselt majanduslik konvergents kohapõhisel viisil (Barca 2009; Beer *et al*. 2020; Karo ja Kattel 2018; Sabel ja Zeitlin 2010). Varasemad uuringud on näidanud kui suureks väljakutseks on Euroopa Liidu liikmesriikidele järgida mitte ainult formaalseid reegleid, vaid ka tegelikke Euroopa Liidu regionaal- ja TAI poliitika põhimõtteid, mis soosivad eksperimenteerimist, koordineerimist ja koostööd peamiste osapoolte vahel ning pidevat poliitikatest õppimist (vaata ka Karo *et al*. 2017; Karo ja Kattel 2018; Kroll 2017).

Eesti on väga hea näide Euroopa Liidu liikmesriigist, kes seisab samuti silmitsi eelpool mainitud väljakutsetega, mida on ka põhjalikult uuritud. Samas pakub Eesti vastuseid ka küsimusele, mis on oluliselt vähem tähelepanu saanud kui peaks: kuidas kohapõhised innovatsiooni toetavad tegevused tekivad suuresti keskvalitsuse poolt juhitud kohapimeda TAI poliitika kontekstis? Käesolev doktoritöö keskendubki sellele küsimusele läbi kahe perspektiivi: strateegiline kontekst koos vastavate poliitikategevustega ja kohalik innovatsioonidünaamika.

Strateegilisest perspektiivist uurib doktoritöö seda, kuidas TAI poliitikaid on Eestis välja töötatud ja rakendatud, millist rolli kohalikud omavalitsused kui madalaima astme administratiivüksused ja ruumilised asukohad näevad omal TAI poliitika kontekstis ning millist rolli mängivad vahendaja rolli täitvad organisatsioonid. Kohaliku perspektiivi roll on analüüsida millised võimalused ja väljakutsed kaasnevad eksperimentaalsete TAI tegevustega kohalikul tasandil.

Antud doktoritöö toob välja, et Euroopa Liidu nutika spetsialiseerumise initsiatiiv (S3) ei ole endaga kaasa toonud strateegilisi muutusi innovatsioonipoliitikas koos kohapõhise lähenemisega. Samas võib täheldada, et praktilisem lähenemine, mille fookuses on arendada alusmajandusega seotud sektoreid, võib luua tee kohapõhiste innovatsioonialgatuste esilekerkimiseks suuresti kohapimeda innovatsioonipoliitika kontekstis. Samuti toob antud doktoritöö välja kuidas regioonideülene koostöö, mis tihtipeale on orkestreeritud enam arenenud regioonis asuvate vahendaja rolli täitvate organisatsioonide või ülikoolide poolt, võib aidata kaasa kohapõhiste innovatsioonialgatuste esilekerkimisele ja poliitikate õppimisele. Lisaks juhib doktoritöö tähelepanu sellele, et jätkusuutlikkusele suunatud nutika spetsialiseerumise (S4+) kontekstis vajavad TAI poliitikad kohandamist ja enam tähelepanu tuleks suunata uute väljatöötatud lahenduste ülevõtmisele, mis on S3 kontekstis vähem tähelepanu saanud.

Appendix

Publication I

1.1 Valdmaa, K., Pugh, R., **Müür, J.** (2021) “Challenges with strategic placed-based innovation policy: implementation of smart specialization in Estonia and Wales.” *European Planning Studies*, *29*(4), 681-698. https://doi.org/10.1080/09654313.2020.1767541

EUROPEAN PLANNING STUDIES
2021, VOL. 29, NO. 4, 681–698
https://doi.org/10.1080/09654313.2020.1767541

Challenges with strategic placed-based innovation policy: implementation of smart specialization in Estonia and Wales

Kaija Valdmaa[a], Rhiannon Pugh[b] and Jaanus Müür[a]

[a]Ragnar Nurkse Department of Innovation and Governance, Tallinn University of Technology, Tallinn, Estonia; [b]School of Humanities, Education and Social Sciences, Örebro University, Örebro, Sweden

ABSTRACT
This paper examines the implementation of smart specialization in Europe and exposes challenges arising from moving towards a more strategic (directional and non-neutral), place-based, and bottom-up mode of regional innovation policy. The analysis focuses on two small European nations – Wales and Estonia – and discusses the challenges that they have experienced with designing and implementing directional and non-neutral policies of smart specialization. Through a decade of research, drawing on interviews and documentary analysis, we find that in both cases, the entrepreneurial discovery process (EDP) was not conducted as it was envisioned. Furthermore, the undertaking of smart specialization has not necessarily delivered on the promise of orienting regional policy towards a more sustainable, place-based, and bottom-up approach. This has led to a situation where local problems as well as opportunities have been overlooked and local smart specialization agendas have instead been shaped by centrally chosen broad values and directions in a top-down manner.

ARTICLE HISTORY
Received 31 December 2019
Revised 5 May 2020
Accepted 6 May 2020

KEYWORDS
Smart specialization; Entrepreneurial discovery process; place-based policy; strategic innovation policy

Introduction

The concept of smart specialization and its implementation in the European Union (EU) policy as Research and Innovation Strategies for Smart Specialization (RIS3) has been much discussed within the academic community interested in regional economic development, European cohesion policy, entrepreneurship and innovation policy (e.g. McCann & Ortega-Argiles, 2015; Ranga, 2018). There is a dynamic body of research exploring case studies across Europe (Radosevic, 2017), from Central and Eastern European (CEE) countries (Healy, 2016; Karo et al., 2017; Reimeris, 2016) to Northern Europe (Dubois et al., 2017). There are also theoretical and conceptual contributions establishing the core theoretical and practical elements (Foray, 2018; Foray et al., 2011). Others have examined the economic principles of the approach (Foray, 2013), the role of universities therein (Goddard et al., 2013), and the intersection of RIS3 and regional innovation system development (Ranga, 2018).

As we approach a decade of RIS3 in Europe, this is an opportune moment to take stock of these various theoretical advancements, longitudinal data, and 'real world' experiences

CONTACT Kaija Valdmaa kaija.valdmaa@gmail.com Ragnar Nurkse Department of Innovation and Governance, Tallinn University of Technology, Akadeemia street 3, 12618 Tallinn, Estonia

to examine how effective the RIS3 approach has been in driving Europe towards more sustainable and inclusive growth in order to tackle grand societal challenges like climate change and sustainability transitions (Fagerberg, 2018; Magro & Wilson, 2019). There is enough experience to analyse the shortcomings of the approach and the challenges arising from its implementation. A critical body of literature is emerging, drawing out the issues with smart specialization when it moves from blueprint to real-life policy (Kroll, 2019; Lundström & Mäenpää, 2017; Marlow & Richardson, 2016). Indeed, a whole special issue of the journal of *European Planning Studies* provides critical reflections, both theoretical and empirical, detailing the implementation of RIS3 in particular places and reflecting on the progress of the approach to date (Capello & Kroll, 2016).

In this paper, we add to this body of work by critically examining the implementation of RIS3 in two countries, Wales and Estonia, and analysing what have been the accompanying problems and challenges. Specifically, we focus on those aspects of smart specialization that hope to deliver more place-based and bottom-up modes of regional innovation policy and reflect on whether this shift has occurred.

Empirically, we draw on research started in 2010 in both countries supplemented with existing literature on these specific cases and other studies from around Europe. Methodologically, our longitudinal case studies draw on interviews with policy actors and regional stakeholders, observations on policy-making processes, and extensive policy document and grey literature analyses. We were inspired to combine these studies into one in order to draw insights from the experiences of two small and (in terms of Europe) peripheral nations attempting to implement RIS3.

This paper is structured as follows. First, the body of work on RIS3 – seen as the largest regional, innovation, and industrial policy experiment ever implemented (Radosevic, 2017) – is reviewed. Secondly, some of the key conceptual challenges of the approach are discussed. Third, the two case studies of Wales and Estonia are introduced, highlighting the key findings from observing the implementation of RIS3 over the past decade. The article concludes by discussing which of the conceptual challenges were confirmed, disproved or complemented by the empirical findings, reflecting on what our study adds to the field of research on smart specialization. Based on the case studies, we provide some insights as to how more place-based and bottom-up perspectives could be embedded into RIS3, thus rendering its implementation more tenable in Europe, especially in weaker and more peripheral regions such as ours.

Overview of the smart specialization approach

Smart specialization was first proposed by Foray and Van Ark (2007) as a policy idea focusing on research and development (R&D) as a duplication of sectors across different regions was taking place based on a limited set of best-practice case studies and fashionable sectors (Hospers, 2006; Martin & Sunley, 2003). Later Foray (2009) added that states are using traditional future forecasting mechanisms that generate similar priority areas for all. Less developed regions were struggling to decrease the knowledge gap with developed regions, and even if a few of them managed to improve their knowledge base, they had difficulties turning it into economic convergence (Foray, 2016). It was proposed that national and regional governments should stop copying successful regions and instead try to find their own original areas of expertise and potential (Foray, 2009).

At its core, smart specialization is based on the idea that regions and countries should implement strategies and investments that support the already existing productive assets of the country (Foray et al., 2009). Secondly, it assumes that the areas of specialization should be chosen through the EDP where the aim is to find out what a country or region does best in terms of science and technology through a bottom-up process demanding collaboration between the public, private, and academic sectors to coordinate and mobilize regional stakeholders around a shared vision based on pre-existing strengths (European Commission, 2011). The EDP is based on a broad sense of entrepreneurial knowledge, which combines knowledge about science, engineering, market growth potential, competitors and inputs and services required to launch new activities (Foray et al., 2011). McCann and Ortega-Argiles (2015) add that the EDP is about exploiting knowledge networks and scale-effects in sectors that are strong in the region and where it is possible to move to related economic activities and technologies. The public sector can play a crucial role by coordinating the activities of local entrepreneurs or providing valuable information, but it is assumed that the entrepreneurs and scientists know best which companies or activities have the most potential to transform the economy (Foray et al., 2011).

Although in the EU smart specialization first emerged as a proposal to make the European R&D system globally more competitive, it is now integrated as a tool for regional policy under RIS3. In short, 'Smart Specialisation is about R&D and innovation' (Foray et al., 2011, p. 5) and the agenda gained currency across Europe following the Innovation Union's publication (European Commission, 2010b), which employs RIS3 to achieve the EU's goals of 'smart, sustainable and inclusive growth'. Eventually, it became obligatory for member states to integrate RIS3 into their local policy-making contexts (Foray & Goenaga, 2013) in order to maximize the impact of the EU structural funding in the next round through 'thematic concentration' (European Commission, 2011). Whilst common guidelines were provided as to how the RIS3 strategies should be formulated (Foray et al., 2011), the approaches adopted in different places were expected to be shaped by the specific regional economic, institutional, and governance contexts within which they were applied (McCann & Ortega-Argilés, 2014).

Foray et al. (2009; 2011) argue that the concept of smart specialization was taken up 'surprisingly' quickly by the EU policymakers, leading to an increasing gap between theory and policy practice. However, there was already a history of regional innovation policy in Europe being influenced by innovation theory since the systems of innovation work were incorporated into the early regional innovation policies in the 1990s (Landabaso, 1997; Mytelka & Smith, 2002). We can also identify discussions that address the shortcomings of regional innovation policy which pre-date RIS3. For instance, Tödtling and Trippl (2005) advocated for a differentiated rather than a 'one-size-fits-all' approach to policy-making. They argue that because of regional differences, especially when considering peripheral and old industrial regions, there is no best-practice model and we should move away from trying to implement everywhere the models developed in exceptional leading core regions. This is similar to Hospers's (2006) argument that the dominant policy modes are leading to a proliferation of 'silicon somewheres' trying to replicate the success of Silicon Valley rather unsuccessfully.

In the EU, RIS3 still follows the place-based approach of the EU's regional policy and contains elements of key sectors thinking based on earlier regional innovation system approaches (Barca et al., 2012; Morgan, 2013). However, conceptual additions, such as general enabling technologies and the EDP, have brought in the non-neutral sectoral approach, which is new in the EU context (European Commission, 2011; Foray, 2016; Foray et al., 2011; McCann & Ortega-Argilés, 2014). The fact that the EDP aims to identify the unique characteristi s and assets of a region, in an attempt to avoid replication of limited 'trendy' sectors where these assets do not exist, distinguishes smart specialization from previous approaches (Coffano & Foray, 2014).

Thus, we view RIS3 as an effort to address perceived problems of previous iterations of regional and innovation policy in Europe: it seeks to alter existing policy mixes, especially the tendency to support similar broad sectors of the economy via supply-side policy measures (European Commission, 2010a). It also integrates a more place-based approach into innovation policy (Barca et al., 2012). Besides the ones discussed, there are some implications inherent in the strategic and place-based approach to policy-making that could be considered as opportunities or challenges depending on how they are addressed, as outlined by Morgan (2013). Local initiatives must adhere, at least to a certain extent, to principles set exogenously by, for example, the European Commission. Place-based policy-making should allow a high degree of public debate and opportunities for those outside of established policy elites to have a voice and should embed a monitoring and evaluation system based on widely agreed indicators (*Ibid.*). The question, for Morgan (2013), revolves around political commitment and whether multi-level actors can create mutual commitments and agreements and also deal effectively with partners who do not keep to these commitments.

Challenges and shortcomings of the smart specialization approach

According to Estensoro and Larrea (2016), research about the difficulties of implementing RIS3 as well as paths for overcoming these emerged around 2014–2015. Camagni and Capello (2013) state that the geography of innovation across Europe requires a more complex model identifying innovation patterns and designing smart innovation policies on this basis, going above and beyond a simplistic core–periphery dichotomy. Additionally, because of the strong theoretical underpinning in systems of innovation thinking, recent works have examined smart specialization in the context of systemic failures of regional innovation systems (Grillitsch, 2016). The following discussion highlights more specific challenges and shortcomings that have received attention in previous literature.

First, the EDP arises as one problematic element of smart specialization. In practice, it has been argued to be 'hard to do' (Coffano & Foray, 2014) and challenging for various regions (Estensoro & Larrea, 2016; Kroll, 2015). The bottom-up approach to policy-making and the integration of private and public stakeholders have emerged as the main difficulties when implementing RIS3 (Estensoro & Larrea, 2016). Iacobucci (2014) highlights the fundamental tension between the idea of a bottom-up policy and having a region-wide strategy. For Boschma (2014), the tension comes from the need to engage with local elites in a collaborative manner, whilst ensuring that they do not assume monopolistic behaviours. Rather than initiating a true and novel EDP, policy-makers have been found to be interpreting RIS3 so that it fits existing policy routines and supports pre-existing approaches in which much investment has been made in previous Structural Funding rounds (Karo et al., 2017; Karo & Kattel, 2015; Pugh, 2014). The inception of smart specialization has not necessarily heralded a wholesale change in predominant innovation policy approaches in weaker regions, and for the approach to be pursued in its true form, a degree of institutional reform of policy practices may be required (Karo & Kattel, 2015).

Second, as directional policies and transformative change require that pre-existing and new policies are productively integrated (Schot & Steinmueller, 2018, p. 1563), challenges arise from path-dependency of policy, which is pertinent in all regions because smart specialization is always building on the previous policies and approaches (Morgan, 2013). This implies that how it is understood and applied will depend on the competencies and familiarities of policy-making that communities built up over time, which can be very context-specific. Therefore, to fully understand contemporary smart specialization and its direction, we must first understand the past (Morgan, 2013). With specific reference to RIS3 in CEE, Karo and Kattel (2015) find that in opposition to core developed regions where self-organizing feedback mechanisms already exist in line with smart specialization and the EDP, in weaker regions policymakers may need to initiate these processes anew.

Third, problems emerge in EU member states where RIS3 strategies are implemented only on the national level. This list mostly includes non-core member states of the EU: smaller members such as the Baltic States but also the Czech Republic and Romania (Healy, 2016; Karo et al., 2017). Quite often, these countries do not have a clear regional governance level to administer and actualize RIS3 strategies. In the other extreme are regions with semi-autonomous or complex status operating in inherently multi-level innovation policy environments (Kroll, 2017; Magro & Wilson, 2013). There can also be a mismatch between the functional and political-administrative regions (Capello & Kroll, 2016). All these studies emphasize the problem regarding the existence and adequacy of suitable governance capacities. This claim is amplified by the historic centralization of industrial and R&D policy routines in CEE countries and the traditional lack of a regional and sectoral focus that could lead to friction between the past logic of long-term national strategies and regional specialization built on current comparative advantages (Charles et al., 2012; Karo & Kattel, 2015; Technopolis, 2006). In addition, Querejeta and Wilson (2013, p. 13) emphasize the importance of analysis that looks beyond regional boundaries and considers specializations and capacities of other regions in Europe, but how this should be done is less clear. This relates to a wider problem with the smart specialization approach, which is the confusing guidance, especially at the inception of the approach, and the contradictory empirical contributions (Estensoro & Larrea, 2016; Kroll, 2015).

Fourth, challenges arise because of the strong innovation logic underpinning RIS3 (Foray et al., 2011) and countries tending to overemphasize its high-tech and R&D elements (Karo & Kattel, 2015). However, it is not clear if the high-tech bias and innovation-driven understanding is the most suitable approach in less developed countries (*Ibid.*). Capello and Kroll (2016) argue that focussing on R&D-based innovation in less developed regions might benefit some standalone companies and industries, but it will not create spill-overs for the rest of the economy. Instead, these regions could adopt a wider concept of territorial development by focussing on their natural and cultural assets or supporting practice-based innovation (*Ibid.*).

Summarizing this conceptual section and structuring the empirical section, after a short introduction of the country, the case studies of Estonia and Wales look at the following research questions:

(1) To what extent did the countries follow the principles of smart specialization brought out in this article's overview of the smart specialization approach?
(2) Did they experience any challenges with implementing the smart specialization approach and RIS3?
(3) What were the potential reasons behind these challenges?
(4) Did the challenges entail any notable effects?

Materials and methods

The following analysis is not an exact comparison between Wales and Estonia, but rather a discussion on the elements of smart specialization drawing on key insights derived from two case studies in different regional settings. By examining different cases, compared to single case studies, we have the potential to develop deeper and more complex understandings of phenomena. We followed a case study methodology (see Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Simons, 2009; Yin, 2003) using a combination of methods including document analysis, policy observations and interviews to build up a picture of innovation policy practice in both countries. Perhaps unsurprisingly, given the dominance of these approaches and the case study methodology in innovation policy studies (Nordling & Pugh, 2019), our separate methods and approaches matched together quite well.

In total, we interviewed 34 experts, policymakers, and officials from local and central government working in the areas of innovation, economic development, and entrepreneurship during the years 2011–2013 and 2019. The interviewees were selected based on the snowball method and most of them had previously been involved in RIS3-related processes. However, as we also wanted to bring in the local government level, we interviewed representatives of local municipalities dealing with economic development and innovation topics (although they were not directly involved in RIS3) to include their perceptions and to have a more balanced sample of key actors of the innovation system. The aim of the interviews was to collect information about how RIS3 was developed and what the interviewees see as the main obstacles to its implementation. In addition, policy review was conducted from the early 1990s to the present day. In building our cases, we relied heavily on government policy documents and other secondary data, such as reports, studies by other scholars, official policy evaluations and more informal sources, like blogs and news coverage. We also undertook making observations about the policy process due to the positionality and access options of the researchers who had the opportunity to see the process 'from the inside'. We used an inductive approach to analyse our cases: reducing and condensing the huge amounts of data and observations before sorting them into categories as also suggested by Eisenhardt (1989).

Two experiences of smart specialization

The case of wales

Wales is a semi-autonomous 'home nation' of the United Kingdom (UK), located west of England. Since devolution in 1999 Wales has its own legislature and executive, which have power and capabilities in areas such as health, education, and economic development whilst certain functions such as defence, tax, and immigration are still controlled at the

UK level. The political situation in the UK is currently somewhat unstable because of the Brexit negotiations. Wales is a post-industrial nation, suffering from the aftermath of the decline of coal mining and heavy industry over the last forty years (Cooke, 2003; Henderson, 2019). At first, this was partly replaced by manufacturing, often through setting up branch plants of large multi-nationals (e.g. Samsung, Bosch, Tata Steel) attracted by government regional aid and infrastructure spending, and more recently by services and the public sector (Cooke, 2003; Johnes, 2012; Pickernell, 2011). Due to persistent problems in the Welsh economy, half of the country (West Wales and the Valleys) qualifies for the highest level of support from Europe.

Research of RIS3 was conducted in Wales as it was being incepted across Europe. Rather than welcoming a new approach to innovation policy and embracing the bottom-up and locally determined EDP, Welsh policymakers 'bolted on' RIS3 to their pre-existing cluster-based approaches that had been implemented already for several years (with little marked success). It was described as 'old wine in new bottles' due to the fact that the same sort of policy was continued but under a new name (Pugh, 2014), as also confirmed by the interviewees with a long-term perspective on the evolution of Welsh innovation policy. Furthermore, the sectors were decided and the policy implemented overwhelmingly at the national level, and little local level engagement and governance was found according to the interviews. Only very recently has a more local (sub-regional) approach to economic development been introduced, and historically, dating back to the work of the Welsh Development Agency, there has been a strong tradition of economic development being governed at an all-Wales level.

Welsh policymakers are adept at adapting to shifting policy rationales and directives of the European level and adopting new approaches at least in name if not in substance (Cooke & Clifton, 2005). This began during the 1990s when Wales was a pilot region for the Regional Technology Plans (Morgan, 1997). Welsh policymakers directly responded to Europe's edict regarding the necessity for all regions to put a RIS3 plan in place by publishing *Innovation Wales,* which explicitly aligns with smart specialization approaches and 'methodology' (Welsh Government, 2013, p. 8). However, Pugh (2014) traces this back to the mid-2000s and the *Economic Renewal Programme* (Welsh Assembly Government, 2010), identifying six sectors on which to focus governmental support. These were rationalized into four sector groupings in subsequent policies (Welsh Government, 2012; 2013) to address four 'grand challenge' areas, again reflecting the European discourse: life sciences and health; low carbon, energy, and environment; advanced engineering and materials; and information and communication technology (ICT) and the digital economy. According to some interviewees commenting on the process and Pugh (2014), this was more a deliberate post-hoc rationalization than a serendipitous aligning of agendas at different governance levels. However, a positive outcome of the Welsh RIS3 approach was the setting up of sector panels involving actors from the government, business, universities, and the third sector who were meant to meet regularly and help shape policy for their sector, but these panels have since dissipated. Participants of the panels who were interviewed reported positive experiences and saw the initiative as a good one, albeit a still limited engagement with private and third sectors due to the limited size of the panels and the challenges regarding fitting in this extra work in addition to the participants' regular work duties.

Morgan (2013, 2016) explains how the Welsh government – after the abolition of the Welsh Development Agency (the intermediary previously governing regional economic development issues) – took an increasingly stronger role and more control over economic governance and contrasted this to the Basque country where the state has managed to be less 'invasive' and more enabling. In short, the Welsh Government has increasingly acted in a top-down manner, as also perceived by the interviewees. Unfortunately, the analysis of support schemes under the regional development banner shows that the Welsh Government has changed from being considered to be at the forefront of progress in regional economic development to being known for expensive policy failures, such as the well-reported Technium programme (Morgan, 2012, 2013). This can be summarized as a mismatch between the high-tech and innovation push approach taken in the implemented programmes and the more low-tech and SME dominated nature of the Welsh economy (full analysis of this mismatch can be found in Pugh, 2017, 2018 and Pugh et al., 2018).

The story is not completely grim though and Morgan (2013) and Huggins et al. (2018) profile other more successful policy efforts. Morgan (2013, p. 120) finds the solution to Wales' problematic state-centric governance structures featuring a lack of strategic leadership, a lack of engagement, and poor monitoring and evaluation processes (NAW, 2012) in moving towards a 'transformational' and place-based strategy furthering the steps taken under the smart specialization approach to open up the policy-making process to other stakeholders.

In recent years, the Welsh Government has more or less moved away from the chosen specialization areas of the previous period. Instead, it is concentrating more on a sub-regional approach to economic development – focussing on the different areas of Wales. Morgan (2018) explains that for recent developments the publication of two new and 'long-awaited' economic policy documents – the 'Economic Action Plan' (EAP) and 'Regional Investment in Wales After Brexit' – plays an important role. Accordingly, the previous priority sectors have been replaced with 3 national thematic sectors: tradeable services, high-value manufacturing, and growth enablers like digital (Morgan, 2018). Also, important to our debate around place-based policy-making is the fact that the Welsh Government reinforces the commitment to regional working by appointing Chief Regional Officers to coordinate policy in North Wales, Mid and South West Wales, and South East Wales (*Ibid.*). What is important to note here is that the move away from the centrally driven sector approach has been accompanied by a more local and place-based effort to create economic policy that is more attuned to the sub-regional needs. This is an interesting line of enquiry because it suggests a counterfactual to smart specialization's founding principle that it should indeed be a way of making place-based and bottom-up policy, especially through the EDP mechanism. We already know that this process was never truly implemented in Wales true to the smart specialization diktat (Pugh, 2014). Whilst the focus has shifted to sub-regions and less towards key sectors, the three priority areas for development are still decided by the national government, suggesting they have not completely relinquished their control over setting the thematic agenda. As the new sub-regional policy is implemented, time will tell if the Welsh Government is successful in moving towards a more locally derived mode of innovation policy.

The case of estonia

Estonia is a democratic parliamentary republic that regained its independence in 1991. It has a multi-party system with a historically strong right-centric bias. Estonia has been seen as a rapidly growing country with machinery, mechanical appliances and electric equipment, wood, mineral products and metal products as the main export products, which also host most of the multinationals and Scandinavian foreign investment. Estonia is also well-known for ICT services, but their volume in export figures is not as big. The main challenges have been related to structural changes that are needed to move from subcontract activities to higher value-added activities. Improvements can be seen since the mid-2000s. Today there is a growing number of industrial companies undertaking product development and offering specialized production services, though due to small volumes of niche products fluctuation is inevitable (Karo et al., 2014). During the period of 2014–2020, Estonia has received the highest level of support from the EU as its GDP per capita was below 75% of the EU average.

Since 1991, Estonia's development has been influenced by a market-centric view of economic development and a centralized governance model, being a keen follower of Washington consensus policies with no established industrial policy (Karo & Kattel, 2015). Estonia is a unitary state with a strong central government where the role of the state has mainly been to secure the framework conditions through horizontal policy interventions, with regional and local governments having a limited role in economic and innovation policy (Karo et al., 2017). This has also left a serious mark on how research, development, and innovation (RDI) policies have been developed.

The implementation of RIS3 in Estonia has followed a top-down logic with the national level being responsible for the development and implementation of the policies. The RIS3 growth areas were chosen based on a quantitative study of Estonian economy's specialization and a qualitative collection of expert opinions meant to specify the potential of research and economy – that were not necessarily based on a uniform understanding of the smart specialization logic (Karo et al., 2014). The Estonian RDI Strategy 2014–2020 defines the following RIS3 growth areas (Estonian Ministry of Education and Research, 2014a):

(1) ICT horizontally through other sectors (industry 4.0, automation, robotics, cybersecurity, software development);
(2) health technologies and services (biotechnologies, e-health, use of IT for developing medical services and products);
(3) efficient use of resources (material technologies and industry, new technologies in construction and smart houses, chemistry, efficient and multifunctional use of oil shale).

The exact support measures were developed by the Ministry of Economic Affairs and Communication and the Ministry of Education and Research together with their subordinate agencies, such as Enterprise Estonia and the Estonian Research Council. Other branch ministries have a rather weak role in managing and financing the RDI system (Karo et al., 2014). There is limited integration between the Estonian RDI Strategy 2014–2020 and the Estonian Entrepreneurship Growth Strategy 2014–2020. RDI policy responsibilities have been divided between two ministries and their agencies, which undermines the interdynamics and complementarities of these areas and might also give rise to challenges in implementation due to duplication and mismatching. Recently, the task of making financial payments has been transferred to an agency under the Ministry of Finance, which can further fragmentize the Estonian RDI system. One of the interviewees argued that the implementation agencies (i.e. Enterprise Estonia) should also be involved in the designing of future smart specialization strategies because due to their role they have higher innovation capacities.

The national perspective and lack of regional focus have led to broadly defined RIS3 growth areas that cover the whole economy, contradicting the logic of smart specialization (Foray, 2018; Karo et al., 2017). According to the interviews, this has led to a situation where all sectors have been treated similarly, as also noted in Estonian RDI funding (Karo et al., 2014). However, the private sector has expressed a weak demand for science and applied research (Karo et al., 2014; Karo et al., 2017; Karo & Kattel, 2015). One of the reasons for this is the institutional asymmetry in the Estonian RDI system. Compared to the private sector, the academic community is better organized and more actively participating in the development of the national RDI policy (Karo et al., 2014; Karo et al., 2017; Karo & Kattel, 2015). Throughout the years, the national government has directed large amounts of structural funds into universities without much prioritization, which has created significant stakeholder pressure from the academia to keep the funding through already established means (Karo et al., 2017).

Moreover, the current Estonian RDI Strategy for 2014–2020 and the previous Estonian RDI Strategy for 2007–2013 both emphasize similar, generally trendy priorities, such as ICT, material science, and biotechnology (Estonian Ministry of Education and Research, 2007, 2014a). In addition, the RDI support measures are mostly project-based and competitive (Raudla et al., 2015) and scientific excellence is valued over social relevance (Tõnurist et al., 2019). Such funding logic itself limits the dialogue between social partners, including the private sector (Karo et al., 2014), and thereby undermines the EDP. In Estonia, scientific excellence lies in clinical medicine, molecular biology and genetics, physics, plant and animal science, and ecology, which have only a loose connection to the main export sectors of Estonia (Karo et al., 2017; Lauk & Allik, 2019). In a positive move, the Estonian government has started to fund company-university collaboration in applied research and product development related to RIS3 growth areas (Estonian Ministry of Education and Research, 2014b). However, it has been argued that the funding measure is too limiting as it only supports collaboration with the local universities (Espenberg et al., 2018).

The choice of implementing RIS3 from the national level has been defended on the grounds of efficiency and the smallness of the country (Karo et al., 2017). A place-based policy would mean that policies and support measures consider local and regional needs, which even in small countries can differ county by county. However, the involvement of municipalities in the development of national strategies was superficial as they have historically played a minor role in the economic development policy and may thus be lacking the necessary capabilities for developing and implementing such policies (Karo et al., 2017). In fact, according to the Estonian Local Government Organisation Act, Estonian municipalities are not responsible for economic development policies. This might also partly explain why the concept has been not understood on the subnational levels, as argued by the interviewees. Several interviewees said that it was probably even a conscious choice to exclude individual municipalities from the RIS3 processes as in 2013 Estonia had over 200 municipalities. To ease the process, the Association of Estonian Cities, which acts as a national overarching organization, was consulted.

One interviewee claimed that the regional focus was abandoned because on the world scale the country is too small to manage a regional policy approach as Estonia has only two medium-size universities in Tartu and Tallinn. However, this argument negates the fact that the lack of regional focus has led to a situation where most of the RIS3 funding ends up in the Tallinn and Tartu areas, as indicated by other interviewees and supported by the analysis of smart specialization funding instruments[1] as of spring 2019. This exacerbates the already high levels of inter-regional inequalities within the country. One interviewee mentioned that the further consolidation of local governments could enable them to converge resources and capacities for more successful regional innovation policies.

Interestingly, there were two local level initiatives to develop a RIS3 strategy: from Tallinn City separately and Tartu City together with municipalities and counties in South-Estonia. *Tallinn Enterprise and Innovation Strategy 2014–2018* was based on national growth areas and modified according to the needs of Tallinn City. However, no national funding was linked to it and the focus of the Tallinn Enterprise Department has mostly been on supporting newly established companies by providing consultations and incubation. Tartu City and its partners started their strategy development even before the national one, following the example of Brainport Eindhoven. However, their specialization areas were similar to the national ones, potentially due to the fact that the same researchers from Tartu University supported both strategy development processes. One aspect that differed from Eindhoven, seen as a shortcoming, was that the municipalities did not agree on how to finance the implementation of the strategy: besides Tartu, nobody was willing to pool in financial resources. Various stakeholders, such as Tartu Science Park, local universities, Tartu City, and the county-level development centre, still try to follow the strategy by coordinating their activities (e.g. events, training, seminars, external projects) and different external streams of finance, but such a model limits their possibilities to start new initiatives as the deliverables have to be in line with external financiers (Karo et al., 2014).

The previous indicates a clear contradiction in the RIS3 logic. Namely that the strategy should be designed following a bottom-up logic, but the financial resources are allocated top-down, leading to a situation where the local level needs are overlooked. According to the interviewees, the local level should play a bigger role in both design and implementation (even if the administrative costs increase) because of their better understanding of local circumstances. Giving more responsibility to local actors would enable to develop and support local level initiatives, experimentation and development projects and could be even more efficient in terms of using existing governance structures rather than having to set up new ones at the national level. According to the analysis of smart specialization funding schemes, the municipalities have no role in the implementation of RIS3. Only a couple of measures have a regional/local perspective, such as regional competence centres, county-level development centres, and the public sector innovation procurement scheme, which is also available for local municipalities.

Discussion and conclusions

This article is situated against the emerging body of work on smart specialization with the broad aim of increasing understanding of the practical application of RIS3 and the accompanying challenges by providing empirical observations and experiences from Wales and Estonia.

Both countries have experienced difficulties with the EDP (Coffano & Foray, 2014), confirming the first challenge of smart specialization. In Wales, the EDP was hindered by the strong role of the central government that implemented RIS3 in a top-down manner. This was the result of path-dependency in policy-making (Morgan, 2013) as RIS3 was integrated into the pre-existing cluster-based approach instead of switching to a bottom-up and locally determined EDP. Also, the priority areas have been similar since the mid-2000s. Sectoral panels were established but their size was limited. The Welsh experience emphasizes well the importance of productively integrating pre-existing and new policies (Schot & Steinmueller, 2018), which has been limited, and therefore also confirms the second challenge of smart specialization – that its implementation depends on the competencies and familiarities of existing policy-making communities.

Challenges with the EDP and path-dependency of RDI policy are also prevalent in Estonia. There have been little changes in the priority areas with little connection to the Estonian economic structure and throughout time the central government has exercised close control and strong steering of the RDI policy. The inclusion of private sector stakeholders, as one of the possible challenges pointed out by Estensoro and Larrea (2016), has been a serious issue in Estonia with regard to the low demand for R&D from their side hindering the EDP. In addition to and complementing the main challenge, the inclusion of local municipalities, which would enable to consider local needs, has been extremely limited, as also in previous RDI policies. Meanwhile, the stakeholders from the academia have received significant amounts of funding and actively participated in RIS3-related processes throughout the years, which might imply stakeholder capture (Boschma, 2014). In addition, most of this funding is project- and competition-based and biased towards scientific excellence (Raudla et al., 2015; Tõnurist et al., 2019). This has further challenged the EDP and cooperation with the private sector.

In both countries, RIS3 has been implemented by the central government in a top-down manner, which confirms the third challenge of smart specialization. However, this approach has failed to consider place-specific needs and has further weakened the RDI policy-making capacities of local governments. Estonia is a good example of a small country where tensions between the administrative and functional boundaries collide (Capello & Kroll, 2016). On the one hand, the smallness of the country has been used as an excuse for central level implementation together with a national focus. On the other hand, we can still identify different functional regions inside the country of which the Tallinn and Tartu areas have gained the most as the main universities and companies able to absorb R&D-based knowledge are located in these two cities. Limiting access to Cohesion Funds for these two areas (and especially Tallinn) is complicated as it would negatively impact the whole country because of the concentration and national reach of the organizations (e.g. companies, universities, hospitals) located there. Recently, Wales has shifted its focus to its sub-regional needs which require more attention. However, this is still combined with the strong role of the central government.

Another similarity between the cases is that the chosen specializations are not only broad but are focused on high-tech sectors, which is seen as problematic in countries that outside of capital cores do not have exceptionally high technology or R&D intensive economies. This affirms the fourth shortcoming of the smart specialization approach – the high-tech bias, also identified by other researchers (e.g. Karo & Kattel, 2015). Although the broad description enables to look at the whole economy and adds flexibility, the high-tech undertone might not be the most suitable strategy for less developed regions (Karo & Kattel, 2015). In the case of Estonia, the strong focus on high-tech has mostly benefited the academia and a limited amount of companies but has decreased the spill-over effect to the rest of the economy, as also pointed out by Capello and Kroll (2016) and Tõnurist et al. (2019). In Wales, the high-tech and innovation push approach to innovation policy has been poorly matched to the economy dominated by SME-s and branch-plants (Pugh, 2017, 2018; Pugh et al., 2018).

Analysis of the empirical cases presents well the complementarities and interdependencies between the challenges. Due to path-dependency and lock-in effects of pre-existing RDI policies, related systems and routines, the use of the EDP and the implementation of novel, directional, and non-neutral innovation policies is hampered in countries with limited policy-making but also technology capabilities, not only on the national level but also on different sub-levels of governance. Furthermore, problems with implementing strategic policies might potentially reveal an even wider challenge for small countries, namely that due to the county's smallness and the existence of more personal relations it is more challenging to design and implement selective, directional, and non-neutral policies that might be unfavourable for some previously supported sectors and actors.

To conclude, RIS3 was not originally conceived as a strategy for imposing specialization by means of top-down government planning. Rather, it was seen as being driven by a process of discovery and learning on the part of entrepreneurs, who are the best positioned agents to search for the right types of knowledge (McCann & Ortega-Argilés, 2011, 2014). Several authors have underlined the difficulties in the development of these processes (Estensoro & Larrea, 2016). Accordingly, in neither of the case studies much evidence of the EDP could be noted. RIS3 in Wales and Estonia has not achieved its goal of including essential stakeholders such as state-level ministries and agencies, local governments, academia, the private and third sector together with their capacities and competencies to develop non-neutral and directional policies in a systems approach in order to solve regional and local grand challenges (Foray, 2018).

We posit that a deeper commitment to locally-derived place-based policy could lead to a more successful RIS3 implementation in both cases. The role of the central government should be to create conditions where municipalities together with universities, local companies, and other key stakeholders could design and implement policy interventions that are locally relevant. This would enable to continue supporting the already existing technology sectors located in most developed areas together with developing interventions relevant for mostly peripheral regions where the focus could be more on non-R&D elements (e.g. process management, production, marketing). This would require a deep cultural change and 'stepping back' of national governments who have traditionally had strong control over RDI policy in these small and somewhat peripheral nations. It would also require the development of RDI and innovation policy capacities of local governments. The previous discussion is especially relevant in the context of the Horizon

Europe framework programme, which has set 'Climate-neutral and Smart Cities' as one of its core missions (European Commission, 2019), and the European Urban Initiative, which aims at supporting innovation actions, capacity and knowledge building at the local level (European Commission, 2018). Both of these programmes address local governments and their essential role in bottom-up and place-based sustainable development and transitions towards sustainable systems through using strategic, directional, and non-neutral innovation policy and actions. However, the effectiveness of these initiatives definitely deserves further attention in future research.

Note

1. Information regarding how much Estonian counties have benefited from smart specialisation funding schemes (e.g. the university-company applied research and product development funding schemes and the Enterprise Development Program) is available on the Enterprise Estonia and Archimedes Foundation websites – https://www.eas.ee, http://archimedes.ee/en/archimedes-foundation/.

Acknowledgements

Research for this paper has been partially supported by the European Regional Development Fund, Interreg Baltic Sea Region Programme project no. #R044.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

Research for this paper has been partially supported by the European Regional Development Fund, Interreg Baltic Sea Region Programme [project no. #R044].

References

Barca, F., McCann, P., & Rodríguez-Pose, A. (2012). The case for regional development intervention: Place-based versus place-neutral approaches. *Journal of Regional Science*, *52*(1), 134–152. https://doi.org/10.1111/j.1467-9787.2011.00756.x

Boschma, R. (2014). Constructing regional advantage and smart specialisation: Comparison of two European policy concepts. *Scienze Regionali-Italian Journal of Regional Science*, *13*(1), 51–68. https://EconPapers.repec.org/RePEc:fan:scresc:v:html10.3280/scre2014-001004

Camagni, R., & Capello, R. (2013). Toward smart innovation policies. *Growth and Change*, *44*(2), 355–389. https://doi.org/10.1111/grow.12012

Capello, R., & Kroll, H. (2016). From theory to practice in smart specialization strategy: Emerging limits and possible future trajectories. *European Planning Studies*, *24*(8), 1393–1406. https://doi.org/10.1080/09654313.2016.1156058

Charles, D., Gross, F., & Bachtler, J. (2012). Smart specialisation and cohesion policy – A strategy for all regions? *IQ Net Thematic Paper*, 30(2), European Policies Research Centre, University of Strathclyde, Glasgow.

Coffano, M., & Foray, D. (2014). The centrality of entrepreneurial discovery in building and implementing a smart specialisation strategy. *Scienze Regionali-Italian Journal of Regional Science*, *13* (1), 33–50. https://ideas.repec.org/a/fan/scresc/vhtml10.3280-scre2014-001003.html

Cooke, P. (2003). The regional innovation system in Wales; evolution or eclipse? In P. Cooke, M. Heidenreich, & H.-J. Braczyk (Eds.), *Regional Innovation systems, 2nd Edition* (pp. 214–233). Routledge.

Cooke, P., & Clifton, N. (2005). Visionary, precautionary and constrained 'varieties of devolution' in the economic governance of the devolved UK territories. *Regional Studies*, *39*(4), 437–451. https://doi.org/10.1080/00343400500128457

Dubois, A., Kristensen, I., & Terras, J. (2017). Outsmarting geography: Implementing territorial innovation strategies in sparsely populated regions. *European Planning Studies*, *25*(8), 1316–1333. https://doi.org/10.1080/09654313.2017.1320355

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532–550. https://doi.org/10.5465/amr.1989.4308385

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *The Academy of Management Journal*, *50*(1), 25–32. https://doi.org/10.5465/amj.2007.24160888

Espenberg, S., Nõmmela, K., Karo, E., Juuse, E., Lees, K., Sepp, V., Vahaste-Pruul, S., & Romanainen, J. (2018). Kasvualade edenemise uuring. https://skytte.ut.ee/sites/default/files/skytte/kasvualade_edenemise_uuring_lopparuanne_loplik.pdf

Estensoro, M., & Larrea, M. (2016). Overcoming policy making problems in smart specialization strategies: Engaging subregional governments. *European Planning Studies*, *24*(7), 1319–1335. https://doi.org/10.1080/09654313.2016.1174670

Estonian Ministry of Education and Research. (2007). Knowledge-based Estonia, Estonian research and development and innovation strategy 2007-2013. http://cs.ioc.ee/excs/policy/teadm-pohine-eesti2-en.pdf

Estonian Ministry of Education and Research. (2014a). Estonian research and development and innovation strategy 2014-2020 "knowledge-based Estonia". Available at: https://www.hm.ee/sites/default/files/estonian_rdi_strategy_2014-2020.pdf

Estonian Ministry of Education and Research. (2014b). Rakendusplaan Eesti teadus- ja arendustegevuse ning innovatsiooni strateegia 2014-2020 "Teadmistepõhine Eesti" eesmärkide täitmiseks aastatel 2014-2017. https://www.hm.ee/sites/default/files/tai_rakendusplaan_0.pdf

European Commission. (2010a). *Regional policy contributing to smart growth in Europe 2020*. (COM(2010) 553 final, SEC(2010) 1183).

European Commission. (2010b). *Investing in Europe: Fifth cohesion report on economic, social and territorial Cohesion*.

European Commission. (2011). Report: Regional case study: West Wales and the Valleys. In J. Twomey (Ed.), *Study on the contribution of local development in delivering interventions co-financed by the European regional development Fund (ERDF) in the periods 2000-06 and 2007-13* (pp. 1–45).

European Commission. (2018). *Proposal for a regulation of the European parliament and of the council on the European regional development fund and on the Cohesion fund*.

European Commission. (2019). *Orientations: Towards the first strategic plan for Horizon Europe*.

Fagerberg, J. (2018). Mobilizing innovation for sustainability transitions: A comment on transformative innovation policy. *Research Policy*, *47*(9), 1568–1576. https://doi.org/10.1016/j.respol.2018.08.012

Foray, D. (2009). Understanding smart specialization. In D. Pontikakis, D. Kyriakou, & R. van Bavel (Eds.), *The question of R&D specialisation: Perspectives and policy implications* (pp. 19–27), JRC, IPTS. Seville: European Commission.

Foray, D. (2013). The economic fundamentals of smart specialization. *Ekonomiaz*, *83*(2), 83–102.

Foray, D. (2016). On the policy space of smart specialization strategies. *European Planning Studies*, *24*(8), 1428–1437. https://doi.org/10.1080/09654313.2016.1176126

Foray, D. (2018). Smart specialization strategies as a case of mission-oriented policy – a case study on the emergence of new policy practices. *Industrial and Corporate Change*, *27*(5), 817–832. https://doi.org/10.1093/icc/dty030

Foray, D., David, P. A., & Hall, B. H. (2009). Smart specialisation – The concept. *Knowledge Economists Policy Brief*, 9. Brussels: European Commission.

Foray, D., David, P., & Hall, B. (2011). *Smart specialisation; from academic idea to political instrument. The surprising career of a concept and the difficulties involved in its implementation* (MTI Working Paper), Management of Technology and Entrepreneurship Institute, Ecole Polytechnique Federale de Lausanne.

Foray, D., & Goenaga, X. (2013). The goals of smart specialisation. *S3 Policy Brief Series No. 01/* 2013. Brussels: European Commission.

Foray, D., & Van Ark, B. (2007). Smart specialization in a truly integrated research area is the key to attract more R&D to Europe. *Knowledge Economists Policy Brief*, No. 1. Brussels: European Commission.

Goddard, J., Kempton, L., & Vallance, P. (2013). Universities and smart specialisation: Challenges, tensions and opportunities for the innovation strategies of European regions. *EKONOMIAZ. Revista Vasca de Economía, Gobierno Vasco/Eusko Jaurlaritza/Basque Government*, *83*(2), 83–102. https://ideas.repec.org/a/ekz/ekonoz/2013204.html

Grillitsch, M. (2016). Institutions, smart specialisation dynamics and policy. *Environment and Planning C: Government and Policy*, *34*(1), 22–37. https://doi.org/10.1177/0263774X15614694

Healy, A. (2016). Smart specialization in a centralized state: Strengthening the regional contribution in North East Romania. *European Planning Studies*, *24*(8), 1527–1543. https://doi.org/10.1080/09654313.2016.1184233

Henderson, D. (2019). Policy path dependency in a less developed region: The evolution of regional innovation policy in Wales (UK). *Revista Galega de Economia*, *28*(2), 39–52. https://doi.org/10.15304/rge.28.2.6155

Hospers, G.-J. (2006). Silicon somewhere?: Assessing the usefulness of best practices in regional policy. *Policy Studies*, *27*(1), 1–15. https://doi.org/10.1080/01442870500499934

Huggins, R., Waite, D., & Munday, M. (2018). New directions in regional innovation policy: A network model for generating entrepreneurship and economic development. *Regional Studies*, *52*(9), 1294–1304. https://doi.org/10.1080/00343404.2018.1453131

Iacobucci, D. (2014). Designing and implementing a smart specialisation strategy at regional level: Some open questions. *Scienze Regional – Italian Journal of Regional Science*, *13*(1), 107–126. https://doi.org/10.3280/SCRE2014-001006

Johnes, M. (2012). *Wales Since 1939*. Manchester: Manchester University Press.

Karo, E., & Kattel, R. (2015). Economic development and evolving state capacities in central and Eastern Europe: Can 'smart specialization' make a difference? *Journal of Economic Policy Reform*, *18*(2), 172–187. https://doi.org/10.1080/17487870.2015.1009068

Karo, E., Kattel, R., & Cepilovs, A. (2017). Can Smart Specialization and entrepreneurial discovery be organized by the government? Lessons from central and Eastern Europe. In S. Radosevic, A. Curaj, R. Gheorghiu, & L. Andreescu (Eds.), *I. Wade (Eds.), Advances in the theory of smart specialization* (pp. 269–292). Cambridge, MA: Academic Press.

Karo, E., Kattel, R., Lember, V., Ukrainski, K., Kanep, H., & Varblane, U. (2014). Nutika spetsialiseerumise võimalused ja väljakutsed Eestis teadus-, arendus- ja innovatsioonipoliitika kujundamisel ja juhtimisel 2014-2020. *TIPS poliitikaanalüüs*.

Kroll, H. (2015). Efforts to implement smart specialization in practice – Leading unlike horses to the water. *European Planning Studies*, *23*(10), 2079–2098. https://doi.org/10.1080/09654313.2014.1003036

Kroll, H. (2017). Smart specialisation policy in an economically well-developed, multi-level governance system. In S. Radosevic, A. Curaj, R. Gheorghiu, L. Andreescu, & I. Wade (Eds.), *Advances in the theory of Smart Specialization* (pp. 99–123). Cambridge, MA: Academic Press.

Kroll, H. (2019). Eye to eye with the innovation paradox: Why smart specialization is no simple solution to policy design. *European Planning Studies*, *27*(5), 932–951. https://doi.org/10.1080/09654313.2019.1577363

Landabaso, M. (1997). The promotion of innovation in regional policy: Proposals for a regional innovation strategy 1. *Entrepreneurship and Regional Development*, *9*(1), 1–24. https://doi.org/10.1080/08985629700000001

Lauk, K., & Allik, J. (2019). The state of Estonian research in Mid-2018. In Ü Niinemets, E. Karo, R. Kattel, & R. Villems (Eds.), *Estonian research 2019* (pp. 41–46). Tartu: Estonian Research Council.

Lundström, N., & Mäenpää, A. (2017). Wicked game of smart specialization: A player's handbook. *European Planning Studies*, *25*(8), 1357–1374. https://doi.org/10.1080/09654313.2017.1307328

Magro, E., & Wilson, J. R. (2013). Complex innovation policy systems: Towards an evaluation mix. *Research Policy*, *42*(9), 1647–1656. https://doi.org/10.1016/j.respol.2013.06.005

Magro, E., & Wilson, J. R. (2019). Policy-mix evaluation: Governance challenges from new place-based innovation policies. *Research Policy*, *48*(10), 103612. https://doi.org/10.1016/j.respol.2018.06.010

Marlow, D., & Richardson, K. (2016). How smart is England's approach to smart specialization? *European Planning Studies*, *24*(8), 1478–1493. https://doi.org/10.1080/09654313.2016.1179267

Martin, R., & Sunley, P. (2003). Deconstructing clusters: Chaotic concept or policy panacea? *Journal of Economic Geography*, *3*(1), 5–35. https://doi.org/10.1093/jeg/3.1.5

McCann, P., & Ortega-Argiles, R. (2015). Smart specialization, regional growth and application to European Union Cohesion policy. *Regional Studies*, *49*(8), 1291–1302. https://doi.org/10.1080/00343404.2013.799769

McCann, P., & Ortega-Argilés, R. (2011). *Smart specialisation, regional growth and applications to EU Cohesion policy* (Economic Geography Working Paper) University of Groningen, Groningen.

McCann, P., & Ortega-Argilés, R. (2014). The role of the smart specialisation agenda in a reformed EU cohesion policy." *Scienze Regionali-Italian Journal of Regional Science*, *13*(1), 15–32. http://hdl.handle.net/11370/8c11e028-804c-40d9-945f-a616724f1ec5

Morgan, K. (1997). The learning region: Institutions, innovation, and regional renewal. *Regional Studies*, *31*(5), 491–503. https://doi.org/10.1080/00343409750132289

Morgan, K. (2012). Path dependency and the state: The politics of novelty in old industrial regions. In P. Cooke (Ed.), *Re-framing regional development: Evolution, innovation and transition* (pp. 318–340). Routledge.

Morgan, K. (2013). The regional state in the era of smart specialisation. *Ekonomiaz*, *83*(2), 103–126. https://ideas.repec.org/a/ekz/ekonoz/2013205.html

Morgan, K. (2016). Nurturing novelty: Regional innovation policy in the age of smart specialisation. *Environment and Planning C: Government and Policy*, *35*(4), 569–583. https://doi.org/10.1177/0263774X16645106

Morgan, K. (2018, January 18). Will Wales' economic strategies weather the Post-Brexit Storm?, *GW4 Opinion*. https://gw4.ac.uk/opinion/will-wales-economic-strategies-weather-post-brexit-storm/

Mytelka, L. K., & Smith, K. (2002). Policy learning and innovation theory: An interactive and co-evolving process. *Research Policy*, *31*(8-9), 1467–1479. https://doi.org/10.1016/S0048-7333(02)00076-8

National Assembly for Wales. (2012). *The effectiveness of European structural funds in Wales*. Cardiff: Finance Committee, National Assembly for Wales.

Nordling, N., & Pugh, R. (2019). Beyond the 'usual suspects' – Alternative qualitative methods for innovation policy studies. *African Journal of Science, Technology, Innovation and Development*, *11*(4), 513–522. https://doi.org/10.1080/20421338.2018.1537106

Pickernell, D. (2011). *Economic development policy in Wales since devolution: From despair to where? CASS papers in economic geography*. Centre for Advanced Studies, Cardiff University School of City and Regional Planning.

Pugh, R. (2017). Universities and economic development in lagging regions: 'triple helix' policy in Wales. *Regional Studies*, *51*(7), 982–993. https://doi.org/10.1080/00343404.2016.1171306

Pugh, R. (2018). Questioning the implementation of smart specialisation: Regional innovation policy and semi-autonomous regions. *Environment and Planning C: Politics and Space*, *36*(3), 530–547. https://doi.org/10.1177/2399654417717069

Pugh, R. E. (2014). 'Old wine in new bottles?' Smart specialisation in Wales. *Regional Studies, Regional Science*, *1*(1), 152–157. https://doi.org/10.1080/21681376.2014.944209
Pugh, R., MacKenzie, N. G., & Jones-Evans, D. (2018). From 'techniums' to 'emptiums': The failure of a flagship innovation policy in Wales. *Regional Studies*, *52*(7), 1009–1020. https://doi.org/10.1080/00343404.2018.1444272
Querejeta, M., & Wilson, J. (2013). What can experience with clusters teach us about fostering regional smart specialisation? *Ekonomiaz*, *83*(2), 127–174. https://econpapers.repec.org/RePEc:ekz:ekonoz:2013206
Radosevic, S. (2017). Assessing EU Smart specialization policy in a comparative perspective. In S. Radosevic, A. Curaj, R. Gheorghiu, L. Andreescu, & I. Wade (Eds.), *Advances in the theory of Smart Specialization* (pp. 1–36). Cambridge, MA: Academic Press.
Ranga, M. (2018). Smart specialization as a strategy to develop early-stage regional innovation systems. *European Planning Studies*, *26*(11), 2125–2146. https://doi.org/10.1080/09654313.2018.1530149
Raudla, R., Karo, E., Valdmaa, K., & Kattel, R. (2015). Implications of project-based funding of research on budgeting and financial management in public universities. *Higher Education*, *70*(6), 957–971. https://doi.org/10.1007/s10734-015-9875-9
Reimeris, R. (2016). New rules, same game: The case of Lithuanian smart specialization. *European Planning Studies*, *24*(8), 1561–1583. https://doi.org/10.1080/09654313.2016.1179722
Schot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, *47*(9), 1554–1567. https://doi.org/10.1016/j.respol.2018.08.011
Simons, H. (2009). *Case study research in practice*. London: Sage.
Technopolis. (2006). *Evaluation of the design and implementation of Estonian RTDI policy: Implications for policy planning* (Final Report), Technopolis Consulting Group, Woluwe-Saint-Pierre.
Tõnurist, P., Valdmaa, K., & Raudla, R. (2019). Impact of climate discourse on national scientific networks in energy technologies: The case of Estonian science and industry linkages. *Halduskultuur: The Estonian Journal of Administrative Culture and Digital Governance*, *20*(1), 20–45. https://doi.org/10.32994/hk.v20i1.203
Tödtling, F., & Trippl, M. (2005). One size fits all?: Towards a differentiated regional innovation policy approach. *Research Policy*, *34*(8), 1203–1219. https://doi.org/10.1016/j.respol.2005.01.018
Welsh Assembly Government. (2010). *The economic renewal programme*. Cardiff: Welsh Assembly Government.
Welsh Government. (2012). *Science for Wales*. Cardiff: Welsh Government.
Welsh Government. (2013). *Innovation Wales*. Cardiff: Welsh Government.
Yin, R. (2003). *Case study research design and methods*, (3rd ed.). London: Sage.

Publication II

1.1 **Müür, J.** (2022) “Intermediating Smart Specialisation and Entrepreneurial Discovery: The Cases of Estonia and Helsinki-Uusimaa.” *Journal of the Knowledge Economy, 13*, 541-573. https://doi.org/10.1007/s13132-021-00757-2

Journal of the Knowledge Economy (2022) 13:541–573
https://doi.org/10.1007/s13132-021-00757-2

Intermediating Smart Specialisation and Entrepreneurial Discovery: The Cases of Estonia and Helsinki-Uusimaa

Jaanus Müür[1]

Received: 8 January 2020 / Accepted: 19 January 2021 / Published online: 6 February 2021

Abstract
During the EU Multiannual Financial Framework for 2014–2020, smart specialisation and entrepreneurial discovery as the key tools for drafting the smart specialisation strategies have been at the centre of the European Union's regional and innovation policy. This article analyses the differences in how the smart specialisation and entrepreneurial discovery process have been organised in two regions with different well-being levels and innovation capacities: Estonia and Helsinki-Uusimaa region in Finland. We show that both regions have formally adopted rather generic smart specialisation strategies and specialisations. While the Estonian approach to smart specialisation has remained formalistic and technocratic, Helsinki-Uusimaa has developed a more systemic approach where other national and regional strategies define more clearly the direction for economic development and the role of smart specialisation strategy is to provide complementary leverage via access to EU regional funds. In this paper, we argue that one of the crucial reasons for the differences stems from the organisation of innovation systems and the role of *intermediary organisations*. In Helsinki-Uusimaa, different intermediary organisations play a more active role in RDI policy by bringing together a variety of stakeholders and helping to co-shape a common understanding of the direction of development and launching different cooperation initiatives. While different intermediary organisations also exist in Estonia, they are not focussing on building networks and establishing a common understanding of the direction of economic development. The article emphasises the importance of clear strategic directionality for RIS3 and the role of intermediary organisations that help to maintain a common understanding among different stakeholders about the chosen direction for development through creating the dynamics of interaction between them.

Keywords Economic development · Innovation · Regional economies · Technological change · Industrial relations

✉ Jaanus Müür
jaanus.muur@taltech.ee

[1] Ragnar Nurkse Department of Innovation and Governance; Smart City Center of Excellence, Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia

Introduction

Economic specialisation and industrial policy have lately become important topics in the EU policy debates. One of the key reasons for this has been the enduring productivity gap between the EU and the U.S (Ortega-Argilés, 2012; McCann & Ortega-Argilés, 2015). The existence of this gap has been explained by insufficient investments into R&D in Europe (Uppenberg, 2009) as well as by the more integrated and larger U.S R&D and innovation system, which enables a greater variety of specialisations (Foray, 2009). On the policy level, it has been argued that the EU regions are losing competitiveness because they attempt to copy current policies and strategies of already successful regions and this creates inefficiencies in R&D spending as policies do not tackle the key challenges and take advantage of local possibilities (Foray & Van Ark, 2007; Foray et al., 2009).

The EU has tried to address these issues through the concept of smart specialisation which emphasises the importance of focusing on leveraging the potential of already existing regional strengths and economic diversification into related technologies and sectors (McCann & Ortega-Argilés, 2013; 2015; Foray, 2018). For the 2014–2020 EU Multi Financial Frameworks (MFF), the adoption of a smart specialisation strategy (RIS3) has been the ex-ante conditionality for the member states to get access to the research, development and innovation (RDI)-related European Structural and Investment Funds (ESIF). The concept has been also labelled as the "new industrial policy" of the EU, driven by a strong regional focus and a goal of achieving economies of scale in high-technology and knowledge-intensive sectors through policy prioritisation (McCann & Ortega-Argilés, 2015; Kroll, 2017; Radosevic, 2017).

Through industrial policy, a government can support the search and discovery process by internalising market failures which are related to insufficient information spillovers caused by underprovision of innovation and coordination failures (Hausmann & Rodrik, 2003; Rodrik & Hausmann, 2006). As Rodrik (2007) argues, the most important part of industrial policy is the cooperation between the government and the private sector to discover underlying costs, possible opportunities and engage in strategic coordination to keep the mastery in several areas of specialisation which also have a potential to spawn new specialisations. Such cooperation also enables the establishment of common understanding among different stakeholders about the direction of development. In the smart specialisation framework, this is known as the *entrepreneurial discovery process* (EDP) (Foray et al., 2011).

Several other authors have emphasised the importance of cooperation between different stakeholders in the context of RIS3 and EDP (Carayannis & Rakhmatullin, 2014; De Noni et al., 2017; Kyriakou, 2017). However, the more complex the issues one wants to solve through RDI policy, the more important but also more complex the cooperation will be. One cannot just assume that such cooperation between the government, academia, companies and society will just happen out of thin air. Rather, it should be consciously managed and organised. However, little detailed attention has been paid to how it should be and is done in the context of RIS3 and EDP.

Several papers have already pointed towards the general challenge of organising EDP. For example, Kroll (2015) and Karo and Kattel (2015) argue that in the Central and Eastern Europe, the bottom-up approach has been at odds with the centralist planning system and these states and regions are missing the routines necessary for supporting entrepreneurial discovery and bottom-up public–private coordination. In the context of stakeholder participation in the policy processes, some scholars emphasise the importance of organisational thickness vs thinness as preconditions for sustainable participation and policy-co-creation. Tödtling and Trippl (2005) have argued that some regions can experience organisational thinness in the sense of a low number of innovative companies as well as knowledge suppliers and less specialised educational institutions which inhibits policy co-creation and EDP. Conversely, some regions may benefit from organisational thickness, i.e. the existence existance of intermediary and support organisations that provide a strong basis for stakeholder inclusion and transformation of selected priorities into concrete projects (Trippl et al., 2019). Also, Kitson (2019) has recently argued that connectivity and collaboration between the actors in the local innovation system may require new local structures to align their interests. Yet, this research is often limited to general emphasis on the importance of organisational thickness and system-level analysis and leaves out a more detailed analysis of how this is achieved and organised through different organisations and approaches.

The current paper aims to contribute to the RIS3 research and literature by investigating what role the intermediary organisations play in entrepreneurial discovery processes. While the role of intermediary organisations is central in several adjacent literatures and research streams (knowledge transfer, regional and local government studies, industrial policy), it has been so far largely neglected in RIS3 literature. The narrow definition for intermediaries is that they are organisations located between the users and producers of knowledge that mediate knowledge transfer (Smedlund, 2006) and connect a wider network of stakeholders (Janssen & Frenken, 2019). However, the literature (Howells, 2006; Bakici et al., 2013; Bradford & Wolfe, 2013; Breznitz & Ornston, 2018) identifies additional roles and therefore it is not enough to just look at the number of intermediaries as a proxy for organisational thickness, but it is also relevant to analyse their tasks/missions and how they fulfil them. Analysing the role of intermediaries on this level of detail can provide valuable information on how to design and structure bottom-up collaboration in the context of EDP.

The analysis is based on a comparative case study approach and looks at how smart specialisation, and EDP more specifically, are organised in two regions subject to the EU's regional and cohesion policies through the EU's Nomenclature of Territorial Units for Statistics 2 (NUTS-2) level categorisation: Helsinki-Uusimaa in Finland and Estonia (as a NUTS-2 region). The two countries share many cultural geographical proximities, and in strategic policy documents, both countries also put a strong emphasis on cooperation as the basis for economic, research and development and innovation policies. However, due to historic reasons Estonia and Finland have developed different capitalistic models (liberal vs more coordinated) and are at different levels of wealth and well-being.

In the context of these similarities and differences, we analyse how the smart specialisation and entrepreneurial discovery process have been organised with a specific focus on the roles and missions of intermediary organisations. We show that compared to the relatively formalistic and technocratic approach in Estonia, Helsinki-Uusimaa is characterised by a greater organisational thickness for cross-sectoral collaboration underpinning EDP. While the Estonian intermediaries are mostly intermediaries that distribute EU funds, many intermediaries in Helsinki-Uusimaa have a clear mission of supporting collaboration between stakeholders which is done through building networks and initiating and managing concrete projects to fulfil strategic goals. Such collaboration also helps to develop and maintain a common understanding of strategic directionality in policy and reduces coordination failures.

The paper is structured as follows. The "Literature Review" section provides a literature review on the main challenges of RIS3 and EDP in the EU and how the intermediary organisations could be used to tackle these challenges. The "Methodology" section describes the methodology of the paper. The "The Cases of Helsinki-Uusimaa in Finland and Estonia" section discusses the cases of Helsinki-Uusimaa and Estonia. The "Concluding Discussion" section summarises the main differences between Helsinki-Uusimaa and Estonia and provides theoretical, empirical and policy-level conclusions and proposes future research topics.

Literature Review

Smart Specialisation and EDP in the European Union

Smart specialisation continues the EU's tradition of implementing place-based development policies by targeting EU regions, especially less-developed ones, but at the same time, it has introduced a non-neutral industrial and innovation policy which is a new development in the EU (Barca et al., 2012; Foray, 2016). The aim of smart specialisation strategies (RIS3) is to identify ways to exploit knowledge networks and scale-effects in areas where a region has already shown great potential and where it is possible to diversify into related sectors, activities and technologies (McCann & Ortega-Argilés, 2013; 2015). More specifically, the policy activities must not target existing economic sectors as a whole, but concrete activities and companies that potentially can transform existing sectors and establish new ones (Foray, 2018). Conceptually, smart specialisation is not about picking sectors or consultation on and validation of top-down choices (Kyriakou, 2017). It is rather about ensuring a continuous process where policy focuses are picked and re-evaluated while taking into account the needs of specific places and both incumbent and new companies (*Ibid.*). A more detailed overview of how smart specialisation approach has evolved into a regional policy tool in the EU can be found in Valdmaa et al. (2020).

At the heart of smart specialisation is the EDP which is ideally a process that brings together for the discovery of new entrepreneurial opportunities the contextual knowledge about science, technology, engineering, market growth potential, competitors, and set of inputs and services required for new entrepreneurial activities (Foray et al., 2011). Such knowledge mix is the result of the bottom-up nature of EDP as information and ideas are gathered from all across the quadruple helix to identify economic activities, companies and technologies with growth potential and necessary policy activities that can support them (Kyriakou, 2017). Several other authors have emphasised the importance of cooperation and networks in EDP (Carayannis & Rakhmatullin, 2014; De Noni et al., 2017; Kitson, 2019). Foray (2018) has described EDP as an intermediate process aiming to enhance entrepreneurial coordination within a framework structured by the government. Although the government plays an important role, it is the entrepreneurs and academic community who are best positioned to discover the domains of RDI where the region will most likely excel based on its existing strengths (Foray et al., 2009; 2011). It overlaps with the innovation systems thinking which emphasises the division of tasks between stakeholders such as universities, industry, public agencies and research institutions in innovation-related activities (Lundvall, 1985).

The Challenge of Implementing Smart Specialisation in Practice

The adoption of RIS3 has not been without problems, especially in the Central and Eastern European (CEE) member states and regions characterised by weaker innovation capacities and challenges of intra-EU convergence, integration and catching-up. As Kroll (2015) argues, the regions had had to adopt RIS3 regardless of their economic development levels and specialisations and institutional strengths/thickness. Yet, in policy research, it is normally emphasised that it is important to take into account the structures, power relations and path dependencies of companies, public sector organisations, research and educational institutions, and intermediaries in already existing innovation policies (Aranguren et al., 2019). The main problems of less-developed EU regions have stemmed from their limited experience with industrial policy, regional economic development and innovation policies, and the weak cooperation habits between industry, academia and public sector resulting in broadly defined economic development priorities and specialisations and lacking routines for EDP and bottom-up public–private coordination (Karo & Kattel, 2015; Karo et al., 2017; Kroll, 2015). At the same time, many Central and Northern European regions have had little difficulties with the RIS3 development process as they have long experience and strong capacity in strategy building and stakeholder coordination (Kroll, 2015).

Intermediary Organisations as Necessary Structures for Collaboration

Hence, EDP in the context of RIS3 should not be conceptualised just as “more” cooperation between the public sector, companies and academia. A variety of organisations and networks can exist that provide mutual support in this process. As Edquist (1997, 14) argues, one needs to consider “all important economic, social, political, organisational, institutional and other factors that influence the development, diffusion, and use of innovations”. Kitson (2019) adds that new local structures may be required for connectivity and collaboration between the actors of the local innovation system, such as businesses, universities and governments, which would help to align their interests and coordinate their activities. Such organisations can be called intermediaries.

The narrow definition of intermediaries which focuses on technology transfer sees companies as knowledge users and universities as knowledge producers with intermediaries located in between them to mediate the knowledge transfer (Smedlund, 2006). The analysis of Shohet and Prevezer on the UK's biotechnology industry is a good example of such approach (1996). However, the definition of knowledge users and producers can be wider, and it can include all organisations that could need particular knowledge for their everyday activities produced by another organisation. Intermediaries can represent the interests of certain economic sectors, business elite or labour (David et al., 2009; Clark, 2014; Eichenberger & Ginalski, 2017), or connect a wider network of stakeholders that are organised around a certain technology or societal theme to encourage cross-industry collaboration (Janssen & Frenken, 2019). Intermediaries can operate at the national, regional and/or local level and be part of and crucial for building different production, development and innovation networks (Howells, 2006; Smedlund, 2006; Janssen & Frenken, 2019; Kitson, 2019). Their tasks/missions could be to attract project ideas from these networks, execute projects and increase awareness, collaboration, and thinking about public issues (Bakici et al., 2013). Other possible functions are foresight, gatekeeping, brokering, funding-related activities (finding, organising and providing), evaluation of outcomes and knowledge processing (Howells, 2006). They can also function as development agencies (Bradford & Wolfe, 2013; Breznitz & Ornston, 2018). Smedlund (2006) adds that often it is not that easy to define the clear role/function of specific intermediaries, but overall they help to create the dynamics of interaction between different actors and utilise the existing assets such as infrastructure or legislation, and capabilities such as knowledge, skills and competencies.

Overall, the existence of intermediaries illustrates the organisational thickness of a region and it has been argued that for organisationally thin regions, it may be challenging to mobilise a critical number of capable actors into the RIS3 processes while institutionally too thick regions might not know whom to include and exclude to be able to legitimately pursue innovation activities characterized by uncertainty, risks, and creative destruction (Tödtling & Trippl, 2005; Trippl et al., 2019).

Methodology

This paper follows the holistic comparative case-study approach. As Yin (2003) explains, the holistic approach is used to evaluate the global nature of a programme or and organisation. In this sense, smart specialisation can be considered as a programme and the focus of the current paper is to look at and compare how it is implemented in two NUTS-2 level EU regions with a specific focus on the roles of intermediary organisations. The descriptions of two cases should be taken as narrative stories that do not necessarily follow the same structure (given the contextual differences of the two cases) but they both give a sense of how RIS3 has been developed and implemented, how EDP is organised and what is the role of intermediary organisations.

For empirical analysis, we relied on several secondary sources of data, such as strategic documents, action plans, public information on the websites of organisations, and prior research. In addition, 13 semi-structured expert interviews (see Appendix) were conducted between February and September 2019. One of the key challenges and limitation of our approach was to compare regional-level RIS3 practices (Helsinki-Uusimaa) with predominantly state-level RIS3 practices (in Estonia). Although they both are NUTS-2 level regions, we have to take into account the differences in responsibilities and institutional structures. For example, the central government in Estonia is responsible for RIS3 but has to also have a broader view on policy issues than the regional council of Helsinki-Uusimaa. Still, one has to recognise that even if RIS3 in Estonia is organised on the level of the nation-state, the impacts of the RIS3 would be still place-based, especially as most of the GDP and innovation performance in Estonia concentrates in two larger regions (Tallinn and Tartu). We have tried to overcome this limitation by combining comparable state and regional level input from secondary literature and purposive sampling of our interviews.

The first two interviews in Helsinki-Uusimaa were done with the representatives from Helsinki-Uusimaa Regional Council and Forum Virium Helsinki. While the Helsinki-Uusimaa Regional Council is responsible for RIS3, the second organisation is one of the most well-known intermediaries in the region. The rest of the interviews were selected based on recommendations from prior interviews or based on the information found in the strategic documents. The interviews focused on the following topics: the role of RIS3 in the region and organisation interviewed; the development of economic and smart specialisation strategies and the division of RDI and economic development related tasks in the region, including the role of intermediaries; how does the design and functioning of collaboration between companies, public sector and research institutions look like.

In Estonia, prior research by Karo and Kattel (2015) and Karo et al. (2017) has provided very valuable insight on how the state government in Estonia has handled the development and implementation of RIS3 and reports interviews with most key stakeholders of RIS3. Hence, additional interviews were carried out with the representative from the former Estonian Development Fund who was directly involved in drafting the RIS3 in Estonia as well as with representatives of the two key regions (Tallinn and Tartu) to gain insights on the actual impact of RIS3 on regional/municipal strategies and policies. The interviews focused on the following topics: the role of RIS3 in the region and organisation interviewed; the development of economic and smart specialisation strategies and the division of RDI and economic development related tasks, including the role of intermediaries; the design and functioning of collaboration between companies, public sector and research institutions.

The Cases of Helsinki-Uusimaa in Finland and Estonia

In this section, we will look at the RIS3 development process and implementation, including the design of EDP and role of intermediary organisations, in two NUTS-2 regions—Estonia and Helsinki-Uusimaa—with different contexts and levels of economic development. Several reasons make this comparison interesting for analysis. The population size of Helsinki-Uusimaa and Estonia is comparable with 1.6 million and 1.3 million, respectively. Comparable population size is important for local market size, available human capital and economic activity. Helsinki-Uusimaa produces over 1/3 of Finnish GDP and in 2017 its GDP per capita PPS was 141% of the EU average (43 200€). In 2017, more than half of Finnish R&D spending was done in Helsinki-Uusimaa.[1] In 2017, the GDP per capita PPS of Estonia was 79% of the EU average (23 600€).[2] Tallinn together with the surrounding Harju county contributed 65.1% of total GDP and the GDP per capita in Harju county was 146% of the national average. The City of Tartu together with the surrounding Tartu county contributed 10.3% of total GDP and GDP per capita in Tartu county was 90.5% of the national average. Helsinki-Uusimaa region and Finland as a whole are both considered as leading innovators in Europe while Estonia is considered a strong innovator (European Commission, 2019; 2020a). According to the EU Social Progress Index which measures societal development and quality of life, the Helsinki-Uusimaa region is ranked 1st and Estonia 89th of 240 regions in the EU (European Commission, 2020b). As these two NUTS-2 regions differ in terms of GDP per capita and innovation capacities, it is interesting to analyse whether there are also differences in innovation policy capacities and specifically in the context of this paper what roles do intermediary organisations play in RIS3 and EDP. Although Estonia is considered to be one of the success stories among the transition countries, it has also been among the major receivers of ESIF (KPMG, 2016; Sootla & Kattai, 2018) and hence strongly influenced by general EU policy narratives and best practices. Both countries are also culturally, linguistically and economically closely tied and the strategic economic policy documents of both countries emphasise the importance of collaboration between the stakeholders. Hence, we could expect mutual learning and the interlacing of culture and experience.

After the collapse of the Soviet Union, Estonia followed a “no policy” industrial and innovation policy and started emphasising innovation and innovation policy only in the early 2000s with the arrival of EU accession preconditions and ESIF (Karo & Kattel, 2015). By now, Estonia has tried to introduce its own industrial strategy (Industrial Policy Green Paper was adopted in 2018), RDI strategies (Knowledge-Based Estonia 2004–2006, 2007–2013, 2014–2020) and public sector driven innovation pilots (e-Residency, nationwide electric mobility network, nation as a test-bed for self-driving mobility solutions, gene data, etc.) with different degrees of success and links to its RIS3 and other economic restructuring strategies.

Finland has managed to transform itself from one of the lowest-technology economies in the OECD during the 1980s into one of the strongest high-technology

[1] According to Statistics Finland

[2] Statistics about the population and GDP per capita PPS of Helsinki-Uusimaa region and Estonia was extracted from Eurostat.

exporters in the 2000s (Breznitz & Ornston, 2013). In comparison to other Scandinavian economies, Ornston (2012) claims that Finland has achieved this by emphasising most explicitly and intensively the role of technology and innovation in its industrial development and innovation strategies. Helsinki-Uusimaa region itself has covered the headlines with innovative projects such as autonomous vehicles or smart district development. As a first impression, many of these initiatives fit with the growth areas of the regional RIS3 strategy.

Smart specialisation and EDP in Helsinki-Uusimaa

The economic development of Finland has strongly been influenced by the presence of corporatist arrangements. Before the 1990 economic crisis, the Finnish economy relied on traditional corporatism with close relations between the government, powerful banking blocs, price-fixing cartels, trade unions, capital-intensive industries and state-owned enterprises which were mostly related to mature industries (Schienstock, 2007; Ornston, 2012; Breznitz & Ornston, 2013; Tokumaru, 2018). According to Schienstock (2007), during the presidency of Urho Kekkonen, the government had a very strong role in steering the economy through national programmes which caused immense business investments in mature capital-intensive industries and low R&D intensity.

During the 1980s Finland started to move towards greater liberalisation to stimulate innovation and restructuring but balanced it with increased social benefits for workers (Ornston, 2012). Previous experience with traditional corporatism was not abandoned (Jahn, 2016). Industrial companies were willing to collaborate with each other, the government and research organisations like the Technical Research Centre of Finland VTT and universities through official intermediaries such as Tekes or Science Policy Council and unofficial roundtables (Ornston, 2012). As Ylä-Anttila and Palmberg (2007) explain, a very important feature of Finnish industrial policy has been the systemic view and acknowledging the importance of the interdependencies between research organisations, universities, companies and industries. Tokumaru (2018) adds that in the 1990s Finland based its policymaking on "national systems of innovation" approach. It can be said that this view still exists and is also important at the regional and local level.

The overall directionality of economic development is set by the national level. The Research and Innovation Council of Finland (2017) has adopted a vision and roadmap that by 2030 Finland is the most attractive and competent environment for experimentation and innovation. Thematic strategic documents such as *Energy and Climate Roadmap 2050*, *Government report on the National Energy and Climate Strategy for 2030*, *Strategy 2030*, and *Agenda for sustainable growth* set more clear objectives. Climate change, energy efficiency, carbon neutrality, protection of nature, circular economy and sustainable urban development are the main issues addressed by these documents. The overall ambitious goal for Finland is to become a carbon–neutral society by 2035 (Finnish Government, 2019). Technology- and sector-specific strategies have also been adopted such as the *Finnish Bio-economy Strategy*, *Health Sector Growth Strategy for Research and Innovation Activities, The Six City Strategy – Open and Smart Services*, *Finland's space strategy for years 2013 to 2020*, and *Nuclear Energy Research Strategy*.

In the context of smart specialisation, Finland has followed the general logic of the concept. Out of the 19 counties which serve as functional regions, 18 have their own RIS3 strategy with Åland being the only exception. Interestingly, all 19 counties are NUTS-3 level regions with only Helsinki-Uusimaa and Åland functioning also as higher-level regions: Helsinki-Uusimaa as NUTS-2, Åland as NUTS-2 and NUTS-1.[3] The fact that RIS3 has been adopted by lower regional levels shows how much RIS3 and EDP-type cooperation is valued and used in Finnish strategic and policy planning. Finland has also long experience with regional development as the regional councils must develop long-term regional development plans together with four-year regional programmes and annual implementation plans.

Helsinki-Uusimaa is the largest county and according to their RIS3 strategy for 2018–2020, the growth areas are:

1. Urban Cleantech—energy and resource efficiency, circular economy, bioeconomy, cleantech;
2. Health & Wellness—healthcare solutions, processes, technologies, services and taking care of yourself;
3. Digitalising Industry—logistics, robotics, the Internet of Things;
4. Citizen City—the well-being of all citizens, open urban development, citizen participation, usability of services, co-creation (Helsinki-Uusimaa Regional Council, 2017).

These are also emphasised in the *Helsinki-Uusimaa Regional Programme 2.0* for 2018–2021 which is a broader document than the RIS3 strategy. The two documents make up a single whole with the RIS3 strategy setting more concrete priorities in RDI. The RIS3 strategy is also the basis for Helsinki Smart Region network which connects local municipalities, higher education and research institutions, and different intermediaries.

Culminatum which was the regional development company of Helsinki-Uusimaa organised workshops to collect feedback from stakeholders for selecting the regional spearheads. This happened in parallel with the preparation of the regional programme for 2014–2017 by the Helsinki-Uusimaa Regional Council. Workshop results were integrated into the regional programme which became the first draft of RIS3 strategy with the final version developed by the regional council and Aalto University (Interview 1). Although different stakeholders were involved with the development of local RIS3 strategy, it was largely shaped by the three largest municipalities of the region—Helsinki, Espoo and Vantaa (Interview 1). These cities have emphasised sustainability, well-being and ICT in their respective development strategies which are in line with the national priorities. Therefore, it is not surprising that regional RIS3 growth areas are emphasising urban issues.

The role of regional councils in economic development varies and their main responsibility is land-planning (Interview 4; 5). One interviewee expressed an opinion that the regional councils in rural areas of Finland have a bigger role through their regional development agencies than in the capital region (Interview 5). In economic development, the role of the Helsinki-Uusimaa Regional Council is mostly limited to organising networking events for companies and other stakeholders related to RIS3

3 Regulation (EC) No 1059/2003

spearheads for possible cooperation (Interview 1). Several interviewees emphasised that the regional council cannot dictate what the municipalities should do and the cities of Espoo, Vantaa and especially Helsinki are separately doing a lot for economic development (Interview 1; 2; 7; 8).

It was pointed out that the regional RIS3 strategy has no importance for Helsinki City and it does not much influence their activities as the city has its priorities set with *Helsinki City Strategy 2017–2021* and *The Carbon–neutral Helsinki 2035 Action Plan* (Interview 5; 7). Both strategic documents steer also other key organisations such as Forum Virium Helsinki (FVH) and Helsinki Business Hub (HBH) (Interview 2; 3). There is also no significant funding related to RIS3 strategy, and it was questioned if specialisation is a smart strategy for a city in the first place (Interview 5). However, the same interviewee explained that they aim to support the cooperation between different sectors, especially between the local IT sector and other sectors such as maritime or health which is exactly one of the aims of smart specialisation concept. Other interviewees thought that RIS3 strategy is a general guiding document which helps to justify already existing activities and functions as a tool which can help with applying for EU funding (Interview 1; 2; 3; 7; 8).

Economic development is a very important priority for Helsinki City as it generates jobs and helps to make the city attractive (Interview 5; 7; 8). It is worth noting that the Economic Development Department in Helsinki City is part of the Executive Office and has a staff of ca 200 people. The city is facing challenges such as lack of talent and how to promote new entrepreneurship and the creation of companies from R&D activities which the city tries to address by developing different support services and activities (Interview 5).

The city-as-a-platform approach was heavily emphasised which is mostly related to smart city developments and is one way how Helsinki City tries to support companies and at the same time improve the urban environment and public services to achieve its strategic goals (Interview 2; 3; 4; 5; 6; 7; 8). Helsinki City provides opportunities for companies to test their solutions in a real-life setting which enables quick improvements and gives the companies a valuable reference (Interview 2; 3; 5; 6). This is often done through innovation procurements or different, mostly EU-funded projects. Several areas function as district-level platforms, e.g. Jätkäsaari or Kalasatama with topics varying from mobility solutions to education. A similar approach is applied for medical services and solutions through the Health Capital Helsinki (HCH) initiative. The goal is not only to support local companies but also to attract companies from abroad or other Finnish regions to test their solutions in Helsinki which might motivate the company to make an investment and establish a local presence (Interview 3; 8).

Several other activities were brought up during the interviews. Probably the most important one is the use of innovation procurements which is also related to city-as-a-platform approach (Interview 5; 6; 7; 8). Helsinki is procuring small-scale rapid prototypes from different companies to test new solutions in public services. The city has its own innovation fund which accepts applications for projects (Interview 5). It also provides incubation for new companies which is especially important for companies that the city cannot support otherwise such as the local gaming industry (Interview 3; 5). The cooperation with local universities and universities of applied sciences in different research projects, platforms or in providing incubation for start-ups was also emphasised (Interview 2; 3; 4; 5; 6; 7; 8). It was noted that the universities of applied sciences have been especially active in RIS3-related activities (Interview 1).

We can identify several elements of how EDP, as part of RIS3 and broader regional development strategies, is designed and implemented. First, different policy instruments for experimentation are widely used to improve public services and urban environment and to provide opportunities for local companies. These include innovation procurements, rapid testing and city-as-a-platform approach. Second, the activities are closely related to reaching broader mission-goals set with the *Helsinki City Strategy 2017–2021* and *The Carbon–neutral Helsinki 2035 Action Plan* which provide a clear direction for development. The role of the RIS3 strategy is to support their implementation. All three documents are supporting the national goal of carbon-neutrality. Third, the way how these activities are carried out is based on the Finnish corporatist tradition where mutually beneficial cooperation between stakeholders is facilitated by intermediaries established for this purpose. Several key organisations in Helsinki-Uusimaa are constantly in active partnership with each other and often fulfil multiple roles simultaneously such as building and maintaining cooperation networks or managing innovation and development projects.

Based on interviews and secondary sources, Table 1 describes some of the main intermediaries in the region related to RIS3 and other local strategies together with their tasks. It includes organisations with the purpose to build and develop cooperation networks and organisations which fulfil other intermediary tasks such as foresight and allocation of funding. Figure 1 categorises different key organisations in the region as *knowledge creators*, *knowledge users* and *intermediaries*, based on the narrow definition of intermediaries (Smedlund, 2006). We bring out *policy agents* that influence the strategic directionality as a separate category. However, they can also act as organisations under the previous categories. Table 1 and Fig. 1 are not all-inclusive but give a snap-shot overview of the organisational thickness in the area.

National policy agents include the Finnish Research and Innovation Council, the Ministry of Economic Affairs and Employment and the Ministry of Environment that have been responsible for national strategies. Helsinki-Uusimaa Regional Council is a platform for local municipalities responsible for regional planning and in the context of RIS3 is helping local companies to find partners for cooperation. Helsinki City is the key stakeholder in the region. The city has a clear strategic vision towards which it moves through different policies and it also fulfils the functions of intermediary, knowledge-user, and indirectly through its companies the role of knowledge-producer. Helsinki City is also behind the establishment of several intermediaries.

The cooperation between these organisations from Fig. 1 is not only project-based or informal collaboration and networking. It is often cemented through formal institutional partnerships, memberships and ownership. Helsinki City has established several organisations and owns them solely (FVH, energy company Helen, construction company Stara), or partly. HBH is established and owned by Helsinki, Espoo, Vantaa and Kauniainen while Metropolia University of Applied Sciences is owned by aforementioned municipalities and Kirkkonummi. There are several good examples of formal memberships. The member organisations of FVH vary from Helsinki City itself to organisations such as VTT, Helen, Metropolia University of Applied Sciences, Elisa, Demos Helsinki and Helsinki University

Table 1 Main intermediaries in the Helsinki-Uusimaa region that are related to RIS3 and other local strategies together with their tasks. Based on the author

Organisation	Tasks	Members/network
Sitra	Finnish innovation fund, whose tasks include training, foresight analysis, conducting experimental pilot projects, investing into companies and venture capital funds	National agency, accountable to the Finnish Parliament
Business Finland	Finnish government agency for innovation funding and promotion of trade, travel and investment	National agency under the Ministry of Economic Affairs and Employment
Health Capital Helsinki	Business and innovations services in the fields of life sciences and health tech, e.g. support for start-ups, living labs and test environments, business development services, research services, workspace	Helsinki City, Aalto University, Helsinki University, Helsinki University Hospital, Espoo City, Metropolia University of Applied Sciences, Haaga-Helia University of Applied Sciences, Laurea University of Applied Sciences, Helsinki Business Hub
6Aika	A network of six cities with an aim to support urban development through innovation projects where new solutions are tested in an urban environment. Activities are funded by the cities, the state and by using EU funding	Helsinki, Espoo, Vantaa, Tampere, Turku, BusinessOulu, Forum Virium Helsinki, Helsinki-Uusimaa Regional Council, Ministry of Economic Affairs and Employment, Häme Centre for Economic Development, Business Tampere, Ministry of Transport and Communications
Smart & Clean Foundation	Focuses on RIS3 growth area *Urban cleantech* through testbed development, launching innovation projects and supporting the execution of projects conducted by the members	The cities of Helsinki, Espoo, Vantaa, Kauniainen, and Lahti, Helsinki-Uusimaa Regional Council, Caverion, Fortum, Gaia, Gasum, Helen, KONE, Lassila & Tikanoja, Neste, Pöyry, Ramirent, Siemens, St1, Vaisala, YIT, Aalto University, the University of Helsinki, the Lappeenranta University of Technology, VTT, Sitra, Business Finland, the Ministry of Transport and Communications, the Ministry of Economic Affairs and Employment, the Ministry of the Environment
Helsinki Business Hub	Trade and foreign investment promotion. Connects foreign companies with local companies, research institutions and the public sector	The cities of Helsinki, Espoo, Vantaa, and Kauniainen, Helsinki-Uusimaa Regional Council

Table 1 (continued)

Organisation	Tasks	Members/network
Forum Virium Helsinki	Innovation company of Helsinki City active in smart city development through innovation projects and living labs (e.g. Jätkäsaari, Kalasatama)	Business Finland, IBM, CGI, Ministry of Transport and Communications, Demos Helsinki, Metropolia, DIMECC, Sitra, EIT Digital, Technology Industries of Finland, Elisa, Telia, Helen, Tieto, Helsinki City, VTT, Helsinki University Hospital, Yle
Development companies: Keuke, Novago, Posintra, TechVilla	Business consulting, support for R&D and design departments in companies, location services for companies	Owner municipalities such as Järvenpää, Karkkila, Kerava, Nurmijärvi, Pornainen, Sipoo and Tuusula, Askola, Lapinjärvi, Loviisa, Myrskylä, Porvoo, Hanko, Inkoo, Lohja, Raseborg, Siuntio, Hyvinkää; Helsinki-Uusimaa Regional Council, Borealis Polymers, EM Group, Ensto, Fimet, Neste, Suomen Selluvilla-Eriste, Viessmann, Aktia Bank, Aktia Insurance, OP East-Uusimaa Cooperative Bank, Fennia Insurance, LocalTapiola Uusimaa Insurance, Nordea Bank, Sampo Bank, East-Uusimaa Vocational Training Centre, Yrittäjät, Old Porvoo Merchants Association, Rahling Gallery, Osuuskauppa Varuboden-Osla Handelslag, Porvoo Realization Market, Porvoo Yrityslaskenta, Vuoristo-yhtiöt, client companies
Demos Helsinki	Think- and do-tank focusing on issues related to sustainable and fair society through foresight, strategy work, co-creation and experimentation	Helsinki City, Sitra, Ylva, Åbo Akademi University

Table 1 (continued)

Organisation	Tasks	Members/network
Helsinki Smart Region	A network built around the Helsinki-Uusimaa RIS3 strategy to promote collaboration	26 municipalities located in the region, Forum Virium Helsinki, Keuke, Novago, Posintra, TechVilla, Health Capital Helsinki, Helsinki University Hospital, Health Village, Upgraded Life Festival, Smart & Clean Foundation, Naava, Aalto Uni., Helsinki Uni., Hanken School of Economics, VTT, University of the Arts Helsinki, Social Insurance Institution of Finland, Finnish Environment Institute, National Institute for Health and Welfare, Finnish Institute of Occupational Health, universities of applied sciences (Haaga-Helia, Diaconia, Novia, Arcada, HUMAK, Metropolia, Laurea)
Industry associations and cluster organisations	Export promotion, marketing, training activities, advocacy, R&D related cooperation between the companies and universities	Member companies
R&D and higher education institutions: Helsinki University, Aalto University, VTT, Metropolia, Laurea and Haaga-Helia universities of applied sciences	R&D activities, providing higher education	Bring together different stakeholders through RDI projects

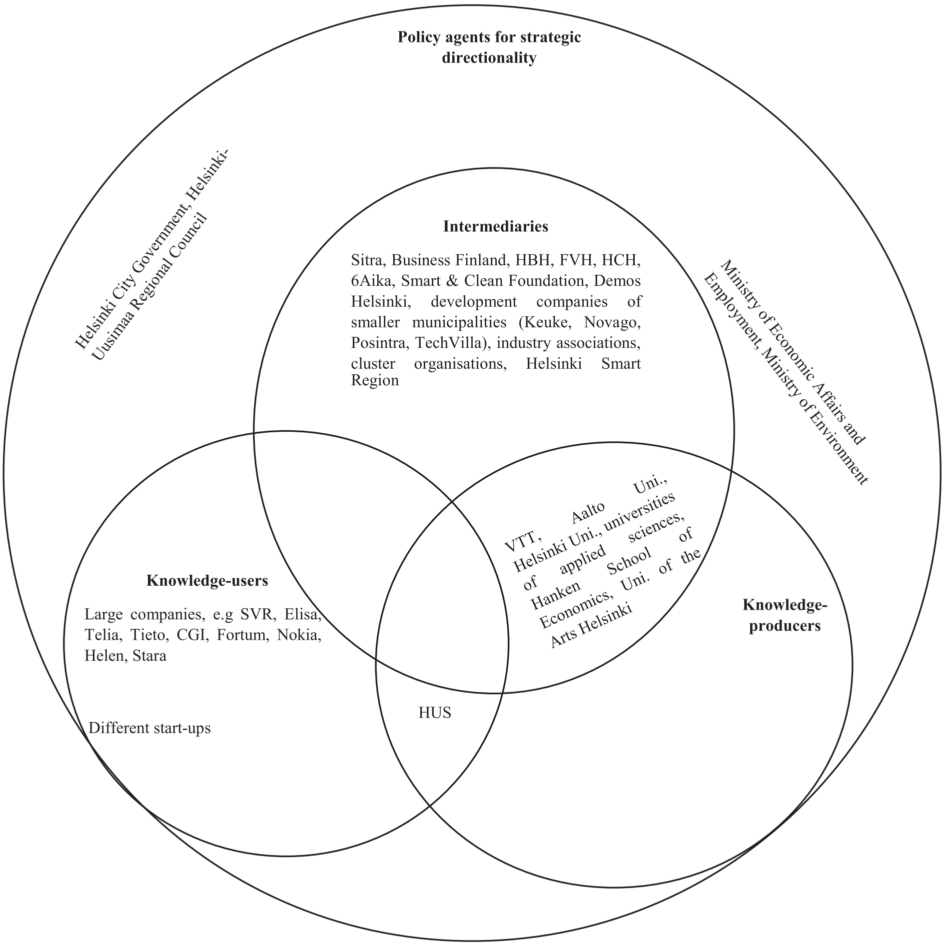

Fig. 1 Categorisation of key organisations in the Helsinki-Uusimaa region. Based on Smedlund (2006) and the author

Hospital (HUS). Together with Helsinki City, local universities and universities of applied sciences, HUS is also one of the members of HCH platform. Other important partnerships include 6Aika and Smart & Clean Foundation.

Smart Specialisation and EDP in Estonia

During the Soviet occupation, the Estonian economy was mostly based on industry and agriculture. The local industry was dependent on natural resources imported from other Soviet republics and almost 1/3 of industrial output came from companies directly controlled by the ministries in Moscow while agriculture was dominated by large collective farms (Tang & Nilgo, 1995; Tomson, 1999).

After regaining independence, Estonia went through rapid market liberalisation and privatisation. As the industrial manufacturing was concentrated with 20% of companies giving 2/3 of industrial output, the Estonian government privatised these large companies by selling them to the highest bidders which often were foreign investors (Brown, 1993; Gillies et al., 2002). Since 1991, the economic development has very much been based on foreign direct investments together with “no policy” industrial as well as innovation policy and reluctance for industrial prioritisation and “picking winners” (Thorhallsson & Kattel, 2013; Karo & Kattel, 2015; Karo et al., 2017). Such policies and actions were considered as market interventions and lacked legitimacy because of past experiences with planned economy. The country was one of the keenest followers of Washington Consensus principles in CEE and horizontal and non-targeted innovation policy entered Estonian policy discourse in the early 2000s mostly because of the external pressure of the EU and its financial support (Karo & Kattel, 2010a; 2010b, 2015).

Thorhallsson and Kattel (2013) and Karo et al. (2017) have argued that Estonia is a simple polity with a strong central government and weak coordination culture where corporatist structures, trade unions and other civil society organisations such as industry associations have had a minor role to play. Among the 42 highly industrialised countries, Estonia is one of the least corporatist countries (Jahn, 2016). In regional governance, Estonia first followed the Finnish model of single-tier self-governing subnational authorities with elected county councils, but since 1993, Estonia has moved towards centralised governance model with no regional level and limited coordination between the central and local government (Sootla & Kattai, 2018).

In the EU context, RIS3 is a regional policy tool meant to affect RDI and economic policy at the regional level. However, in Estonia RIS3-related strategies and policies were developed and are implemented by the central government together with a national focus. Its reasons are related to the regional policy of the EU and how regional policy and governance have developed in Estonia. First, because of its small population of 1.3 million people, Estonia as a whole is considered as a single NUTS-2 level region. Second, the regional and local levels have historically played a minor role in economic and innovation policy and have a weak policy and administrative capacities for such interventions (Karo & Kattel, 2015; Karo et al., 2017). In fact, according to the Estonian Local Government Organisation Act,[4] economic policy is not the responsibility of local municipalities.

The Ministry of Economic Affairs and Communications (MEAC), the Ministry of Education and Research (MER) and their subordinate agencies such as Archimedes Foundation, Enterprise Estonia and Estonian Research Council have been mainly responsible for the development and implementation of RIS3 policy instruments. These agencies are also responsible for allocating ESIF and their use is directly linked with *Knowledge-based Estonia 2014–2020* and *Estonian Entrepreneurship Growth Strategy 2014–2020*. In fact, most of innovation and entrepreneurship support funding is related to ESIF which makes innovation and entrepreneurship policy subordinate to RIS3. Other important strategies related to the previous two are *Estonia 2020*, *Sustainable Estonia 21*, *National Development Plan of the Energy Sector Until 2030* and *Regional Development Strategy for 2014–2020*. With the development of *Estonia 2035* strategy and thematic strategies with the same time period (e.g. a single *RDI and Entrepreneurship Strategy* for

[4] Local Government Organisation Act (RT I 1993, 37, 558) §6

2021–2035), a shift has recently occurred towards long-term planning. *Estonia 2035* also sets the goal to become climate neutral by 2050. However, compared to Finland who is one of the leaders on this topic and is actively promoting it, Estonia has adopted this goal largely due to developments in the EU.

The two ministries asked the Estonian Development Fund, a Sitra-like intermediary under the Estonian Parliament that was closed in 2016, to analyse the economic activities in Estonia for choosing the RIS3 growth areas. First, a quantitative analysis was carried out focussing on economic activities that were characterised by the highest added value, high export-intensity and high rate of employment (Estonian Development Fund, 2013). It was followed by a qualitative analysis to identify the areas where local researchers and the private sector have the greatest potential to collaborate which was based on interviews with entrepreneurs, researchers, officials, and professional associations and one conference with participants from academia and the private sector (*Ibid.*). Interestingly, no regional or local municipality representatives can be found among the interviewees. Based on these analyses, the final growth areas which ended up in the *Knowledge-based Estonia: Estonian Research and Development and Innovation Strategy 2014–2020* were:

1. Information and communication technology (ICT) horizontally through other sectors—use of ICT in the industry (including automation and robotics), cybersecurity, software development;
2. Health technologies and services—biotechnology, e-health (use of ICT for the development of medical services and products);
3. More effective use of resources—materials science and industry, innovative construction ("smart house"), health-supporting food, chemical industry (more effective use of oil shale) (Estonian Ministry of Education and Research, 2014).

Similar broad categories were also highlighted in the previous *Knowledge-based Estonia 2007–2013* which emphasised biotechnology, material sciences and ICT.

It has been argued that *Knowledge-based Estonia 2014–2020* is implemented the same way as the previous RDI strategies, and it still supports the same broadly defined priorities through similar administrative structure and process that are based on competitive open calls and international scientific excellence benefitting research areas with little connection to the local economy (Karo et al., 2014, 2017) and little conscious networks and cluster building. The interviewee from Tartu City Government added that the Estonian RIS3 should have been more technology-oriented which would have enabled more narrowly focused support measures and would have been more future-oriented (Interview 12). However, an interviewee who was involved with the analysis of growth areas argued that although there was an understanding among different stakeholders that prioritising resources and selecting specific topics is important, there was a lack of readiness because of the fear of losing funding and the overall dominant liberal economic thinking in Estonia (Interview 13). The same interviewee added that the result was a compromise.

Several policy actions under *Knowledge-based Estonia 2014–2020* and *Estonian Entrepreneurship Growth Strategy 2014–2020* are specifically targeting RIS3 growth areas, some dating back to the previous funding periods. These include project-based funding schemes for technology centres, cluster organisations, regional competence centres and county-level development centres. Although the ideas about consolidating technology centres by preferring those related to RIS3 growth areas and changing their ownership structure to make them more attractive for companies were under discussion, they did not go through because of the resistance from universities and technology centres who were afraid of losing their funding (Interview 13). Support to cluster organisations has gone through some change. Compared to the previous funding period, the priority is now to fund fewer organisations with more money, slightly preferring clusters related to RIS3 growth areas. However, as these cluster organisations are often organised around the project-based national funding, their sustainability is questionable. For example, the Estonian Smart City Cluster which in 2015 received funding for three years failed to get funding in 2019. The project-based funding means that the relationships between different actors tend to be contractual, formalistic and time-bound, which limits the thickness of the institutional landscape.

Newer policy actions include scholarships for university students who study in programmes related to RIS3 growth areas; Enterprise Development Programme which provides consulting and funding for product development and more efficient manufacturing equipment to companies active in manufacturing and RIS3 growth areas; co-funding for ICT-related Horizon 2020 Teaming applications; funding for university researchers to fund experimental development based on previous research with a market potential; funding for public sector organisations and NGO-s that covers up to 50% of innovation procurement costs which can support RIS3 growth areas; product development funding for industrial companies; and funding for company-university collaboration in applied research and product development conducted in RIS3 growth areas.

However, we can also identify some issues with new policy actions. Although the funding scheme for company-university collaboration in applied research is one of the first examples of how the government tries to prioritise at least some R&D funding as all funding applications are related to the RIS3 growth areas, the companies and funded projects vary a lot even inside a single growth area. Most notably, companies and projects related to *more efficient use of resources* vary from energy and mining to oil shale chemistry, material science and food production. Based on funded companies and their projects, it can be said that funding is tilted towards high-tech sectors. The innovation procurement funding scheme had an initial budget of 20€ million but as of September 2019, only 1.9€ million was spent with the total budget reduced to 5.5€ million. The scheme could have great potential to promote experimentation in the public sector. However, it has been pointed out that the scheme is too bureaucratic, officials have limited awareness about innovation procurements and the co-funding rate is too high (Interview 9; 10).

These issues are the outcome of mostly state-led entrepreneurial discovery (Karo & Kattel, 2015). The main argument of the policymakers why RIS3 has been executed on the national level is that for a small country, it is more efficient and therefore a wide variety of economic and research activities should also be supported without targeting specific domains (Karo et al., 2017). Such a lack of prioritisation has been an issue since the structural funds first became available for Estonia (Kattel, 2004). Compared to the private sector, the academia has benefitted more as it has traditionally been more active and organised and during the development of national strategies managed to push the ministries so that the already established research entities and funding schemes could continue to get funded (Karo et al., 2017). However, these funding schemes have rather benefited exploratory and basic research and compared to more developed countries, Estonia spends less on applied research (Karo, 2019). Meanwhile, the private sector has expressed a weak demand for science and applied research which has led to RDI policy that is mostly state-led where private demand is not clearly expressed, organised, and linked to the policymaking (Karo & Kattel, 2015). Only a few companies and sectors were interested of RIS3 strategy discussions while the majority was worried about the social tax level and labour supply as their focus was largely on subcontracting and/or improving the efficiency of production processes (Interview 13). Funding schemes for companies exist, but funding is divided between single projects that are either focusing on a single company (rather than industries, R&D consortia, etc.) or a single company collaborating with a research group from universities or with public sector organisations. These projects emerge in bottom-up logic (companies draft their proposals within broad guidelines) and have little connection with each other as there is a lack of directionality related to broadly defined growth areas. Broadly defined growth areas also fail to give directionality to quantitative performance indicators such as R&D spending or the number of exporting companies.

Crucially, there is a lack of national-level specialised intermediaries which could build a common understanding among different stakeholders about the direction for development and/or facilitate the cooperation between them. The main intermediary organisations at the national level are government agencies such as Enterprise Estonia and Estonian Research Council. However, their function is not to build partnerships and networks for developing a common understanding of the direction of economic development or coordinate RDI projects with different stakeholders. Different cluster organisations and industry associations are present, but they are mostly focussing on marketing and training activities, export promotion, advocacy and some of them are also active in developing R&D related cooperation between the companies and universities (Mihkelson et al., 2013; Ojamäe & Visnapuu, 2015). Most of their members are companies, research and educational institutions or related NGO-s. In some, the members also include state-owned companies or public bodies such as hospitals. Only the Estonian Smart City Cluster has public organisations as members of the cluster, in this case, the cities of Tallinn, Tartu and Pärnu. This limits their ability to act as intermediary organisations and facilitate triple-helix and quadruple-helix cooperation as they represent narrow sector-specific interests.

The central government level organisation and implementation of RIS3 and EDP have resulted in the lack of local-level focus. Tallinn and Tartu are the only municipalities that have developed their own RIS3 strategies. Tallinn created its *Enterprise and Innovation Strategy 2014–2018* based on national RIS3 growth areas, but it was not linked with national funding. There are no reports available about the implementation of that strategy. One interviewee from the Tallinn Enterprise Department explained that their focus is mostly to help newly established businesses and provide incubation services (Interview 9). There was an attempt to have a regional RIS3 strategy for Tartu and South-Estonia. The process was led by Tartu Science Park together with local municipalities and the University of Tartu. Although the strategy was finished, the local municipalities did not agree on how to finance its implementation and it was not linked with the national RIS3 funding (Interview 11; 12). Tartu City and Tartu Science Park claim that they still follow the strategy in their activities. At the same time, there are significant differences between counties in Estonia in terms of economic performance and population—a result of the post-Soviet deindustrialisation in the periphery. Although deindustrialisation in other regions would require a regional policy response, most of the funding for enterprises, tourism, technology and innovation has been transferred to Tallinn and Tartu (Bachtler & Downes, 1999; Raagmaa et al., 2014).

Lack of cooperation was also expressed by the interviewees from Tallinn City Government as an overall problem (Interview 9; 10). According to the interviewees, the cities could have helped the national level with designing different policy actions such as the innovation procurement funding scheme. Several interviewees also expressed an opinion that larger cities in Estonia could play an important role in RDI policy by being test platforms for innovation projects (Interview 9; 10; 13). All interviewees from Tallinn City Government agreed that if funding schemes from which municipalities could easily apply funding for innovation projects would exist, the spending pace could be better as large municipalities could easily find possible projects (Interview 9; 10). As an official from Tallinn Enterprise Department pointed out, the city can more easily establish collaboration with stakeholders such as companies and universities (Interview 9). Interviewees from the Tartu region added that if some of the resources would be directed to counties or cities, it would give more opportunities to finance bottom-up initiatives (Interview 11; 12). However, such a role would also require a more proactive role from the cities to act as local level intermediaries that bring together different stakeholders.

This role is mostly fulfilled by universities located in Tallinn and Tartu or science parks who have a wide network of public and private partners. The universities are also operating most of the regional competence centres. However, their focus is usually narrow, e.g. based on a single research project, educational cooperation, or bringing together different companies. Larger municipalities such as Tallinn and Tartu are participating in different EU-funded innovation projects but mostly as project partners and not as lead partners, limiting their ability to act as intermediaries. Each county has a development centre, but their tasks are mostly limited to providing business counselling and helping companies and local municipalities to find funding for development projects, e.g. public infrastructure. Interestingly, the interviewees from Tallinn City Government expressed an opinion that it is not necessary to establish intermediary organisations with a purpose of building networks and facilitating cooperation as the key issues, for now, are rather about the availability of competent people and the empowerment of already established structures, such as industry associations, or larger municipalities (Interview 9; 10). For example, the interviewees from Tallinn Enterprise Department were sceptical about the sustainability of cluster organisations which are artificially created around the project funding from Enterprise Estonia while already existing industry associations have been established as bottom-up initiatives by private companies and relevant stakeholders and could fulfil the same function. Table 2 gives an overview of the key intermediaries in the Estonian RDI system that are involved with RIS3 and their tasks. Figure 2 allocates different key organisations under the categories of *knowledge creator*, *knowledge user*, *intermediary* and *policy agents*. Table 2 and Fig. 2 are not all-inclusive but give a snapshot overview of the organisational thickness in the area.

Table 2 Key intermediaries in the Estonia RDI system that are related to RIS3 together with their tasks. Based on the author

Organisation	Tasks	Members/network
Estonian Development Fund (closed in 2016)	Foresight analysis, monitoring, investing in companies	National agency, was accountable to the Estonian Parliament
Enterprise Estonia	Implementing agency of structural funds; provides financial assistance, counselling, cooperation opportunities and training for entrepreneurs, research institutions, the public and non-profit sectors	National agency under the Ministry of Economic Affairs and Communications
Estonian Research Council	Supports researchers, awards research grants and facilitates applied research in the fields of smart specialisation	National agency under the Ministry of Education and Research
Science and industrial parks: Tallinn Science Park Tehnopol, Tartu Science Park, Tartu Biotechnology Park, Pakri Science and Industrial Park	Incubation services, business services, innovation services, office and production space	Tartu Uni., TalTech, Tallinn Uni., Estonian Uni. Of Life Sciences, universities of applied sciences, Tallinn City, Tartu City, Ministry of Economic Affairs and Communications, companies located in parks, Tartu University Hospital
6 technology competence centres: Competence Centre for Food and Fermentation Technologies; Bio-competence Centre of Healthy Dairy Products; STACC (machine learning and data science competence centre); Competence Centre of Health Technologies; ELIKO (IoT); Innovative Manufacturing Systems Competence Centre IMEC	Applied research and product development in collaboration with private companies	Tartu Uni., TalTech, Tallinn Uni., Estonian Uni. of Life Sciences, Estonian Genome Centre, Karolinska Institute, KU Leuven, Kaunas University of Technology, University of Lorraine, Helsinki University, University of Reading, University of Valencia, University of Padua, Institute for Food Nutrition & Health, Enterprise Estonia, Estonian Chamber of Commerce and Industry, Estonian Electronics Industries Association, Animal Breeders Association of Estonia, Connected Health Cluster, Ministry of Economic Affairs and Communications, Tartu Biotechnology Park, Tartu University Hospital, Cybernetica AS, Reach-U AS, Nortal, CGI Estonia, Quretec, Decawave, UWB Alliance, Valio, Lactosan, Nova Vita, Clinic Elite, Fertilitas, Igenomix, client companies

Table 2 (continued)

Organisation	Tasks	Members/network
Fifteen county-level development centres	Businesses and entrepreneurs: counselling on establishing a company, grants, writing of business plan, training; Investors: support for investing activities; intermediation and obtainment of investment inquiries; preparation and dissemination of information materials for investors; Local governments: counselling on development ideas; finding resources for development activities; preparation of grant applications	Local client companies, municipalities and NGO-s

Table 2 (continued)

Organisation	Tasks	Members/network
Five regional competence centres: Small Craft Competence Centre; Competence Centre for Knowledge-Based Health Goods and Natural Products; Oil Shale Competence Centre; The Centre of Excellence in Health Promotion and Rehabilitation; Centre of Competence for Wood Processing and Furniture Manufacturing	Applied research, product development in cooperation with private companies, R&D related to their respective field	Client companies (mostly local), Eesti Energia, Viru Keemia Grupp, Kiviõli Keemiatööstuse, Kunda Nordic Tsement, Steiger Engineering Bureau, Metrosert, TBD-Biodiscovery, A. Le Coq, Desintegraator Tootmise, Elujõud, Märja Monte, Orto, Tervix, Mayeri Industries, Ami Treipuit, Barrus, Gomab, IITEE, Lasva Liimpuidu AS, Puidukoda, Sanwood, Sense Building, Sirje, Tarmeko, Wermo, Competence Centre of Food and Fermentation Technology, Estonian Spa Association, Põltsamaa Felix, Saarek, Enterprise Estonia, Haapsalu Neurological Rehabilitation Centre, Tartu, University Hospital, AS Heal, Haapsalu Kuurort, Ida-Viru Enterprise Centre, Saaremaa Development Centre, Development Centre of Võru County, Development Centre of Põlva County, Tartu Business Advisory Services, Ida-Viru County Industrial Areas Development Foundation, Tartu Biotechnology Park, Tartu Science Park, Estonian Employers' Confederation, Estonian Chamber of Commerce and Industry, Estonian Forest and Wood Industries Association, Estonian Furniture Industry Association, Furniture Cluster of South-East Estonia, Association of Estonian Marine Industries, TalTech, Tallinn Uni., Estonian Uni. Of Life Sciences, Tartu Uni., National Institute of Chemical Physics and Biophysics, Võru County Vocational Training Centre, Ida-Virumaa Vocational Education Centre, Rakvere Vocational School, Kuressaare Regional Training Centre, local municipalities

Table 2 (continued)

Organisation	Tasks	Members/network
R&D and higher education institutions: TalTech, Tallinn University, University of Tartu, Estonian University of Life Sciences, universities of applied sciences	R&D activities, providing higher education	Bring together different stakeholders through RDI projects
Industry associations and cluster organisations	Export promotion, marketing, training activities, advocacy, R&D related cooperation between the companies and universities	Member companies, TalTech, Tartu Uni., Tallinn Uni., Estonian Uni. Of Life Sciences, Estonian Art Academy, Tehnopol, Tartu Biotechnology Park, Tartu Science Park, Pakri, vocational education centres, universities of applied sciences, local municipalities (Tallinn, Tartu, Pärnu)

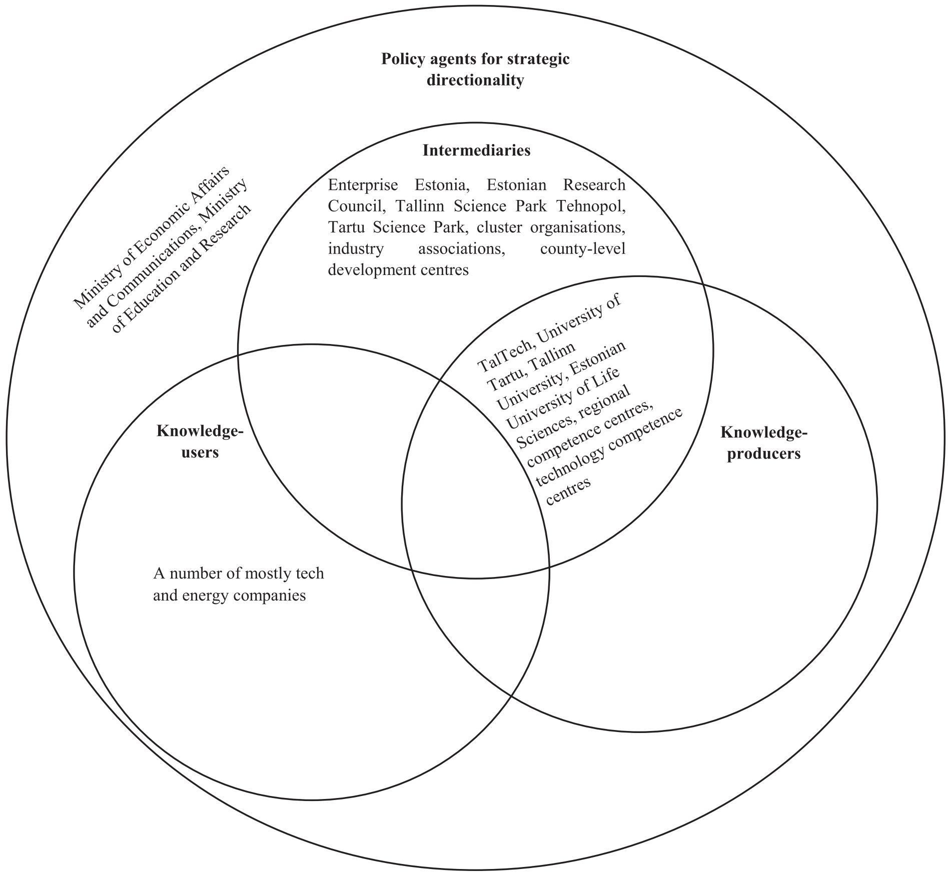

Fig. 2 Categorisation of key organisations in Estonia. Based on Smedlund (2006) and the author

Concluding Discussion

Helsinki-Uusimaa as a corporatist Northern European region seems to have faced little difficulties with adopting RIS3 because of already existing collaboration networks and strategic planning routines. The RIS3 strategy of Helsinki-Uusimaa region is part of a larger nation-wide planning logic and empowers the already chosen direction of moving towards carbon-neutrality set by the national strategies. The role of the regional council that is responsible for developing and implementing the RIS3 strategy is limited compared to its formal mandate. It is rather the City of Helsinki who is playing the most active role in setting directions and rhythm for economic and innovation policies through its clearly defined goals in the *Helsinki City Strategy 2017–2021* and *The Carbon–neutral Helsinki 2035 Action Plan*. It is possible to draw parallels with mission-oriented policy-making gaining ground in the last 5 years (Mazzucato, 2014; 2018).

In the region, numerous intermediaries exist that operate at the regional or national level (Helsinki-Uusimaa as the capital region). However, it is not only the number of intermediaries that is important, but also their activities. Several intermediaries in Helsinki help to maintain a common understanding and the directionality such as FVH, HBH, Smart & Clean Foundation, HCH, development companies and 6Aika. They bring together private companies, state- and city-owned companies, research institutions and public sector organisations such as cities, ministries and national agencies. Such networks and collaborations are maintained in several ways. One of the ways is through formal memberships and partnerships. The other is through different projects, including RDI projects. RIS3 strategy provides additional support in applying EU funding for these projects and helps to justify the already existing activities. At the same time, projects together with innovation procurements that are in line with existing strategies provide opportunities for local businesses.

It is important to emphasise the existence of a very active policy agent that creates space for the aforementioned collaboration between the stakeholders which in this case is Helsinki City. The city has been behind the establishment of previously mentioned intermediaries, belongs among the owners of several key organisations and provides opportunities for companies through the city-as-a-platform approach.

In Estonia, RIS3 has become the main mechanism for national prioritisation. However, directionality is missing because the broadly defined RIS3 growth areas are not supported by strategies with clear directionality nor collaboration structures to establish a common understanding among the stakeholders. Different intermediaries exist but none of them is focussing on building networks and establishing a common understanding about the direction of development, like in Finland. National agencies are focusing on distributing funding, providing consulting and monitoring their specific areas of responsibility. County-level development centres are also mostly focussing on consulting services. Universities and science parks are active, but it is very much based on individual projects. However, these projects can sometimes bring together a wide variety of different stakeholders. Technology and regional competence centres have even narrower focus as they participate mostly in applied research and product development projects together with client companies. The cluster organisations and industry associations bring together companies, research and education institutions but public sector institutions are usually not part of these networks. Cities could play a larger role but so far, they have mostly been just project partners and not active project initiators or developers of active collaboration networks. This can also be related to top-down logic where RIS3-related funding is distributed by national agencies and the national strategies have given no significant role to municipalities. However, there is a growing understanding that the cities can play a bigger role in RDI policy by acting as pilot platforms for different innovation projects, especially in the context of developing smart and sustainable cities.

The differences between Helsinki-Uusimaa and Estonia can be linked to differences in previous policy traditions and capacities. As the public sector has long played an important role in the Finnish economy and has been rather successful, it has the legitimacy to interfere through different policies. This has been supported by corporatist structures of the Finnish society. Estonian public sector is missing such legitimacy for directionality because of its Soviet past when the economic decisions were made top-down, and wider coordination was missing. This created inefficiencies which delegitimised government intervention after Estonia regained its independence. Helsinki-Uusimaa region has also capacities to draft context-specific policies. It is common in Finland and in Helsinki-Uusimaa to establish networks and partnerships between different stakeholder to build consensus or to compromise while Estonia can be characterised by a paradoxical mix of state-centrism and limited willingness to use the power (for priority setting, directing development) as well as little coordination between different key stakeholders. Because of the state-centrism and the importance of national agencies, the administrative capacities in Estonia are related to managing and distributing EU funding while the administrative capacities in Helsinki-Uusimaa are very much related with developing favourable conditions for companies to develop and improve their technological solutions. These favourable conditions are very much based on networking capacities which the intermediaries help to create by supporting cross-sectoral collaboration.

The literature on smart specialisation has for a long while emphasised the importance of multi-stakeholder cooperation and coordination in the context of the entrepreneurial discovery process. The success or challenges related to the development and implementation of RIS3 strategies have often been linked with the existing capacities and routines related to strategic planning and multi-stakeholder collaboration (Karo & Kattel, 2015; Kroll, 2015) while less attention has been put on how such coordination is organised or should look like. Here the concept of intermediaries can provide valuable insight on how coordination between the stakeholders could be organised. Our comparison shows that the main difference between Helsinki-Uusimaa and Estonia is that the former has developed a denser network of such intermediaries that create the dynamics of interaction which spurs wider collaboration between the public sector, companies, academia and civil society. Hence, our study emphasises that as the list of tasks that intermediaries can fulfil is broad (Howells, 2006), it is not enough to just focus on the organisational thickness and existence of intermediaries, but it is also necessary to look at which intermediaries deal with creating the dynamics of interaction between different actors and how.

As the MFF for 2014–2020 has now ended, the focus of further research should be directed towards evaluating the actual impact that RIS3 has had on economic development of different regions. However, such analysis should not be limited to analyses which evaluate the impact of RIS3 on RDI funding or productivity. We also need to follow Rodrik's (2007) thought that the most important aspect of industrial policy is to make the government, companies but also academia to cooperate with each other. Therefore, it should be analysed how RIS3 has impacted such cooperation in the EU member states. Such analysis would benefit much from acknowledging the importance of intermediaries as they can create the dynamics of interaction between the stakeholders who represent different interests and possess knowledge, skills and resources that complement each other, which is the basis for EDP. For example, a more thorough analysis on intermediary organisations in countries and regions recognised as leading innovators could provide valuable lessons for weaker regions on how to nurture cooperation between the key stakeholders of their own innovation system.

Appendix. List of interviews

Interview 1—Official, Helsinki-Uusimaa Regional Council

Interview 2—Senior manager, Forum Virium Helsinki

Interview 3—Senior manager, Helsinki Business Hub

Interview 4—Senior consultant, Demos Helsinki think-tank

Interview 5—Senior official, Helsinki Economic Development Department

Interview 6—Official, traffic engineer, Helsinki Urban Environment Division; Project Manager working with mobility solutions, FVH

Interview 7—Official working with smart and clean solutions, Helsinki Economic Development Department

Interview 8—Official working with digitalisation issues, Helsinki Economic Development Department

Interview 9—Senior official, Tallinn Enterprise Department; Official working with smart city initiatives, Tallinn Enterprise Department

Interview 10—Official, Tallinn Strategic Planning Division

Interview 11—Specialist and one of the authors of Tartu and South Estonia RIS3 Strategy, Tartu Business Advisory Service

Interview 12—Official and one of the authors of Tartu and South Estonia RIS3 Strategy, Tartu City Department of Business Development

Interview 13—Entrepreneur and business consultant, previously a senior manager in the Estonian Development Fund who was involved with the analysis of RIS3 growth areas in Estonia

Acknowledgements The author would like to thank Dr. Erkki Karo and Dr. Chris Giotitsas for their valuable comments.

Funding The research for this study was partially supported by the European Regional Development Fund, Interreg Baltic Sea Region Programme [project no. #R044] and by the European Commission through the H2020 project Finest Twins (grant No. 856602).

References

Aranguren, M., & J., Magro, E., Navarro, M., Wilson, J., W. . (2019). Governance of the territorial entrepreneurial discovery process: Looking under the bonnet of RIS3. *Regional Studies, 53*(4), 451–461.

Bakici, T., Almirall, E., & Wareham, J. (2013). The role of public open innovation intermediaries in local government and the public sector. *Technology Analysis & Strategic Management, 25*(3), 311–327.

Barca, F., McCann, P., & Rodriguez-Pose, A. (2012). The case for regional development intervention: Place-based versus place-neutral approaches. *Journal of Regional Science, 52*(1), 134–152.

Bachtler, J., & Downes, R. (1999). Regional policy in the transition countries: A comparative assessment. *European Planning Studies, 7*(6), 793–808.

Bradford, N., & Wolfe, D. A. (2013). Governing regional economic development: Innovation challenges and policy learning in Canada. *Cambridge Journal of Regions, Economy and Society, 6*(2), 331–347.

Breznitz, D., & Ornston, D. (2018). The politics of partial success: Fostering innovation in innovation policy in an era of heightened public scrutiny. *Socio-Economic Review, 16*(4), 721–741.

Breznitz, D., & Ornston, D. (2013). The revolutionary power of peripheral agencies: Explaining radical policy innovation in Finland and Israel. *Comparative Political Studies, 46*(10), 1219–1245.

Brown, W., & S. . (1993). Economic transition in Estonia. *Journal of Economic Issues, 27*(2), 493–503.

Carayannis, E., & G., Rakhmatullin, R. (2014). The quadruple/quintuple innovation helixes and smart specialisation strategies for sustainable and inclusive growth in Europe and beyond. *Journal of the Knowledge Economy, 5*(2), 212–239.

Clark, J. (2014). Manufacturing by design: The rise of regional intermediaries and the re-emergence of collective action. *Cambridge Journal of Regions, Economy and Society, 7*(3), 433–448.

David, T., Ginalski, S., Mach, A., Rebmann, F. (2009) "Networks of coordination: Swiss business associations as an intermediary between business, politics and administration during the 20th century." *Business and Politics*, **11:4**, Art. 4

De Noni, I., Ganzaroli, A., & Orsi, L. (2017). The impact of intra- and interregional knowledge collaboration and technological variety on the knowledge productivity of European regions. *Technological Forecasting & Social Change, 117,* 108–118.

Edquist, C. (1997). Systems of innovation approaches – Their emergence and characteristics. In C. Edquist (Ed.), *Systems of innovation – Technologies, institutions and organizations* (pp. 1–35). London: Pinter Publishers/Cassell Academic.

Eichenberger, P., & Ginalski, S. (2017). 'Si vis pacem, para bellum' – The construction of business cooperation in the Swiss machinery industry. *Socio-Economic Review, 15*(3), 615–635.

Estonian Development Fund (2013) "Smart Specialisation – Qualitative Analysis." Accessed at http://www.arengufond.ee/wp-content/uploads/2013/04/Estonia_Smart_Specialisation_Qualitative_Analysis.pdf on November 1, 2019

Estonian Ministry of Education and Research (2014) "Knowledge-based Estonia: Estonian Research and Development and Innovation Strategy 2014–2020." Accessed at https://www.hm.ee/sites/default/files/estonian_rdi_strategy_2014-2020.pdf on November 1, 2019

European Commission (2020a) "European Innovation scoreboard 2020." Luxembourg: Publications Office of the European Union. Accessed at https://ec.europa.eu/docsroom/documents/42981 on December 17, 2020

European Commission (2020b) European Social Index Scorecards. Accessed at https://ec.europa.eu/regional_policy/en/information/maps/social_progress2020/#2 on December 29, 2020

European Commission (2019) "Regional Innovation Scoreboard 2019." Luxembourg: Publications Office of the European Union. Accessed at https://ec.europa.eu/growth/industry/policy/innovation/regional_en on December 17, 2020

Finnish Government (2019) Programme of Prime Minister Sanna Marin's Government 2019. Accessed at https://valtioneuvosto.fi/en/marin/government-programme on January 7, 2021

Foray, D. (2018). Smart specialization strategies as a case of mission-oriented policy – a case study on the emergence of new policy practices. *Industrial and Corporate Change, 27*(5), 817–832.

Foray, D. (2016). On the policy space of smart specialization strategies. *European Planning Studies, 24*(8), 1428–1437.

Foray, D. (2009) „Understanding 'smart specialisation',“ in Pontikakis, D., Kyriakou, D., van Bavel, R. (*eds.*) *The Question of R&D Specialisation: Perspectives and Policy Implications*.

Foray, D., David, P.A., Hall, B.H. (2011) "Smart specialization: From academic idea to political instrument, the surprising career of a concept and the difficulties involved in its implementation." *MTEI Working Paper*, 2011–001.

Foray, D., David, P. A., & Hall, B. (2009). *Smart specialisation – The concept* (p. 9). No: Knowledge Economists Policy Brief.

Foray, D., & Van Ark, B. (2007). *Smart specialization in a truly integrated research area is the key to attract more R&D to Europe* (p. 1). No: Knowledge Economists Policy Brief.

Gillies, J., Leimann, J., & Peterson, R. (2002). Making a successful transition from a command to a market economy: The lessons from Estonia. *Corporate Governance: An International Review, 10*(3), 175–186.

Hausmann, R., & Rodrik, D. (2003). Economic development as self-discovery. *Journal of Development Economics, 72,* 603–633.

Helsinki-Uusimaa Regional Council (2017) "Helsinki Smart Region – Strategy update 2018–2020." Accessed at https://www.uudenmaanliitto.fi/files/21305/Helsinki_Smart_Esite_englanti.pdf on November 1, 2019

Howells, J. (2006). Intermediation and the role of intermediaries in innovation. *Research Policy, 35,* 715–728.

Jahn, D. (2016). Changing of the guard: Trends in corporatist arrangements in 42 highly industrialized societies from 1960 to 2010. *Socio-Economic Review, 14*(1), 47–71.

Janssen, M., & J., Frenken, K. . (2019). Cross-specialisation policy: Rationale and options for linking unrelated industries. *Cambridge Journal of Regions, Economy and Society, 12*(2), 195–212.

Karo, E. (2019) "The Future and Societal Importance of Estonian Research and Development." In Niinemets, Ü., Karo, E., Kattel, R., Villems, R. (*eds.*) *Estonian Research 2019*. Estonian Research Council: Tartu, Tallinn, Brussels, 49–62.

Karo, E., & Kattel, R. (2015). Economic development and evolving state capacities in Central and Eastern Europe: can 'smart specialization' make a difference? *Journal of Economic Policy Reform, 18*(2), 172–187.

Karo, E., & Kattel, R. (2010a). Coordination of innovation policies in the catching-up context: A historical perspective on Estonia and Brazil. *International Journal of Technological Learning, Innovation and Development, 3*(4), 293–329.

Karo, E., & Kattel, R. (2010b). The copying paradox: Why converging policies but diverging capacities in Eastern European innovation systems? *International Journal of Institutions and Economies, 2*(2), 167–206.

Karo, E., Kattel, R., & Cepilovs, A. (2017). "Can smart specialization and entrepreneurial discovery be organized by the government? In S. In Radosevic, A. Curaj, R. Gheorghiu, L. Andreescu, & I. Wade (Eds.), *Lessons from Central and Eastern Europe"* (pp. 269–292). Advances in the Theory of Smart: Specialization. Academic Press.

Karo, E., Kattel, R., Lember, V., Ukrainski, K., Kanep, H., Varblane, U. (2014) "Nutika spetsialiseerumise võimalused ja väljakutsed Eestis teadus-, arendus- ja innovatsioonipoliitika kujundamisel ja juhtimisel 2014–2020." Accessed at http://tips.ut.ee/index.php?module=32&op=1&id=3658 on November 1, 2019

Kattel, R. (2004) "Governance of innovation policy: the case of Estonia." *Trames: Journal of the Humanities and Social Sciences*, **8:4**, 397−418

Kitson, M. (2019). Innovation policy and place: a critical assessment. *Cambridge Journal of Regions, Economy and Society, 12*(2), 293–315.

KPMG (2016) "EU Funds in Central and Eastern Europe: Progress Report 2007–2015." Accessed at https://assets.kpmg/content/dam/kpmg/pdf/2016/06/EU-Funds-in-Central-and-Eastern-Europe.pdf on November 5, 2019

Kroll, H. (2017) "The challenge of smart specialisation in less favoured regions." *Arbeitspapiere Unternehmen und Region*, No. R1/2017, Fraunhofer ISI, Karlsruhe

Kroll, H. (2015). Efforts to implement smart specialization in practice – Leading unlike horses to the water. *European Planning Studies, 23*(10), 2079–2098.

Kyriakou, D. (2017). Smart specialisation concepts and significance of early positive signals. *European Structural and Investment Funds Journal, 5*(1), 4–11.

Lundvall, B. Å. (1985) "Product Innovation and User-Producer Interaction." *Industrial Development Research Series*, No. 31. Aalborg: Aalborg Universitetsforlag.

Mazzucato, M. (2018). *Mission-oriented research & innovation in the european union: A problem-solving approach to fuel innovation-led growth*. Luxembourg, Luxembourg: Publications Office of the European Union.
Mazzucato, M. (2014) "A mission-oriented approach to building the entrepreneurial state." A "think piece" for the Innovative UK
McCann, P., & Ortega-Argilés, R. (2015). Smart specialization, regional growth and application to European Union cohesion policy. *Regional Studies, 49*(8), 1291–1302.
McCann, P., & Ortega-Argilés, R. (2013). Transforming European regional policy: A results-driven agenda and smart specialization. *Oxford Review of Economic Policy, 29*(2), 405–431.
Mihkelson, P., Rebane, T., Peters, E., Lember, K. (2013) "Klastriprogrammi vahehindamine." Accessed at https://www.eas.ee/images/doc/sihtasutusest/uuringud/ettevotlus/klastriprogrammi-vahehindamine-2013.pdf on November 1, 2019
Ojamäe, K., Visnapuu, L. (2015) "Klastriprogrammi vahehindamise kvalitatiivne analüüs." Accessed at https://www.mkm.ee/sites/default/files/klastriprogrammi_vahehindamise_kvalitatiivne_analuus.pdf on November 1, 2019
Ornston, D. (2012). *When small states make big leaps: Institutional innovation and high-tech competition in Western Europe*. New York: Cornell University Press.
Ortega-Argilés, R. (2012). The transatlantic productivity gap: A survey of the main causes. *Journal of Economic Surveys, 26*(3), 395–419.
Raagmaa, G., Kalvet, T., & Kasesalu, R. (2014). Europeanization and de-Europeanization of Estonian regional policy. *European Planning Studies, 22*(4), 775–795.
Radosevic, S. (2017) "Assessing EU smart specialization policy in a comparative perspective." In Radosevic, S., Curaj, A., Gheorghiu, R., Andreescu, L., Wade, I. (*eds.*) *Advances in the theory of smart specialization*. Academic Press, 1–36
Research and Innovation Council of Finland (2017) "Vision and road map of the Research and Innovation Council Finland." Accessed at https://valtioneuvosto.fi/documents/10184/4102579/Vision_and_roadmap_RIC.pdf/195ec1c2-6ff8-4027-9d16-d561dba33450/Vision_and_roadmap_RIC.pdf on November 5, 2019
Rodrik, D. (2007). *One economics, many recipes: Globalization, institutions, and economic growth*. Princeton, New Jersey: Princeton University Press.
Rodrik, D., Hausmann, R. (2006) "Doomed to choose: Industrial policy as predicament." Accessed at http://j.mp/2oWZa7W on November 5, 2019
Schienstock, G. (2007). From path dependency to path creation: Finland on its way to the knowledge-based economy. *Current Sociology, 55*(1), 92–109.
Shohet, S., & Prevezer, M. (1996). UK biotechnology: Institutional linkages, technology transfer and the role of intermediaries. *R&D Management, 26*(3), 283–298.
Smedlund, A. (2006). The role of intermediaries in a regional knowledge system. *Journal of Intellectual Capital, 7*(2), 204–220.
Sootla, G., & Kattai, K. (2018). Institutionalization of subnational governance in Estonia: European impacts and domestic adaptations. *Regional & Federal Studies*. https://doi.org/10.1080/13597566.2018.1511979.
Tang, P., & Nilgo, H. (1995). Chapter 5: Budget Reform. In O. Lugus & G. A. Hachey (Eds.), *Transforming the Estonian Economy* (pp. 92–125). Estonian Academy of Sciences: Tallinn.
Thorhallsson, B., & Kattel, R. (2013). Neo-liberal small states and economic crisis: Lessons for democratic corporatism. *Journal of Baltic Studies, 44*(1), 83–103.
Tokumaru, N. (2018) "Transforming the role of public policies for innovation: The role of institutional foundations in Finland as a Nordic state." In Boyer R., Uemura H., Yamada T., Song L. (*eds.*) *Evolving Diversity and Interdependence of Capitalisms: Transformations of Regional Integration in EU and Asia*. Evolutionary Economics and Social Complexity Science, Vol 11. Springer: Tokyo, 235–258
Tomson, E. (1999) *Eesti Majandusajalugu 20. sajandil*. Tartu: Tartu Ülikooli Kirjastus
Tödtling, F., & Trippl, M. (2005). One size fits all? Towards a differentiated regional innovation policy approach. *Research Policy, 34*(8), 1203–1219.
Trippl, M., Zukauskaite, E., & Healy, E. (2019). Shaping smart specialization: the role of space-specific factors in advanced, intermediate and less-developed European regions. *Regional Studies*. https://doi.org/10.1080/00343404.2019.1582763.
Uppenberg, K. (2009). Innovation and economic growth. *EIB Papers, 14*(1), 10–35.

Valdmaa, K., Pugh, R., & Müür, J. (2020). Challenges with strategic place-based innovation policy: Implementation of smart specialization in Estonia and Wales. *European Planning Studies*. https://doi.org/10.1080/09654313.2020.1767541.

Yin, R. K. (2003). *Case study research: design and methods*. Thousand Oaks: California, Sage Publications.

Ylä-Anttila, P., & Palmberg, C. (2007). Economic and industrial policy transformations in Finland. *Journal of Industry, Competition and Trade, 7*(3–4), 169–187.

Publication III

1.1 Soe, R.-M., **Müür, J.** (2020) "Mobility Acceptance Factors of an Automated Shuttle Bus Last-Mile Service." *Sustainability, 12*(13), 5469. https://doi.org/10.3390/su12135469

sustainability

MDPI

Article

Mobility Acceptance Factors of an Automated Shuttle Bus Last-Mile Service

Ralf-Martin Soe [1,*] and Jaanus Müür [2]

[1] FinEst Twins Smart City Center of Excellence, Tallinn University of Technology, 19086 Tallinn, Estonia
[2] Ragnar Nurkse Department of Innovation and Governance, Tallinn University of Technology, 12618 Tallinn, Estonia; jaanus.muur@taltech.ee
* Correspondence: ralf-martin.soe@taltech.ee

Received: 21 May 2020; Accepted: 3 July 2020; Published: 7 July 2020

check for updates

Abstract: The main interest of this paper is to analyze the mobility acceptance factors of an automated shuttle bus last-mile service. There is limited research on the passengers' perception of security and safety of automated mobility, whereas prior research is mostly based on surveys interested in attitudes towards self-driving vehicles, without being linked to the experience. We, on the other hand, are interested in passengers' feeling of security and safety, after taking a ride with an automated shuttle in an open urban environment. For studying this, we conducted an automated shuttle bus last-mile pilot during a four-month period in the city of Tallinn in late 2019. The method is a case study focusing on one city with several tools for data collection applied (surveys, interviews, document analysis). The pilot, open and free for everybody, attracted approximately 4000 passengers, out of which 4% responded to the online feedback survey. For studying the operational capacity, we had a panel interview with operators of the shuttle service, in addition to analyzing daily operational log files. The results indicate that passengers' perceived feeling of security and safety onboard was remarkably high, after taking a ride (and lower without a ride, in a different control group). The bus was operated only if operational capacity was secured, thus having significant downtime in service due to environment, technology and traffic-related factors.

Keywords: automated mobility; sustainable transportation; urban mobility; last-mile; passenger's safety; passenger's security; operational capacity

1. Introduction

In the context of urbanization, cities face challenges related to the growing number of cars on the streets, which, in turn, causes traffic congestions and increases the overall emissions. Thus, cities are showing increasing interest towards shared, automated and electric mobility. However, the adoption of automated vehicles (AVs) can be challenging because of reasons related to passenger safety, passenger security and operational capacity. Passenger safety is understood here as the passengers' subjective feeling of traffic safety onboard an automated bus. Passenger security is understood as the passengers' subjective feeling of security onboard an automated bus. Operational capacity refers to the quality of service of an automated bus influenced by the factors of environment, traffic and technology. Although there are several studies measuring the attitudes towards transference from manual to automated driving based on non-experimental surveys [1–5], there are very limited perception studies that are based on the actual experiment of automated trials. Therefore, one of our key interests is to investigate passengers' perceived risk aversion regarding security and safety of automated urban mobility. The second key interest of this study is to map out the main factors which can affect the operations of an automated shuttle bus and how they were addressed. The occurrence of different issues and how they were addressed can also influence the passenger experience, including their perceived safety and security. Thus, the overall contribution of this paper is to address the differences between perceived safety and security concerns versus technological challenges of integrating such a last-mile service with urban mobility.

This paper is based on a last-mile shared automated mobility pilot that was conducted on the open urban roads in Tallinn, the capital of Estonia, in the second part of 2019. The pilot was open and free for all interested passengers. The passengers were also offered the possibility to fill in an online survey which was available in Estonian and English. The case study results were triangulated with panel interviews of the Tallinn pilot shuttle bus operators in early 2020, daily operational log files and with a control group of 55 students that answered the survey without actual automated driving experience. Section 2 provides an overview of literature which focuses on AVs and introduces the research gap. Section 3 describes the used methodology and introduces the automated shuttle bus pilot in Tallinn. Section 4 brings out the main results. Section 5 summarizes the paper.

2. Literature Review and the Research Gap

This section starts with an overview of the possible impact of the technology of AVs. The reason for such an overview is to picture the magnitude of change that could happen when AVs become widely adopted. It also helps to better understand the importance of investigating user acceptance and how the passengers perceive safety and security in relation to AVs. It is followed by the overview of research which focuses on investigating user acceptability and the research gap that this paper investigates.

2.1. The Impact of AVs

During the last seven years (2013–2020), several academic publications and reports have been published that focus on the impact of autonomous vehicles. An early study by Fagnant and Kockelman [6] estimated that shared autonomous vehicles (SAVs) could diminish the vehicle fleet size by ten times. In the later study of Fagnant and Kockelman [7] which was based on a simulation of Austin, Texas, they estimated that one SAV could replace 10.77–11.53 cars, depending on how many trips are shared between passengers. Similarly, an OECD [8] study found that the combination of TaxiBots together with high-capacity public transportation would remove 9 out of 10 cars in mid-sized cities in the case of the city of Lisbon. These studies have also analyzed the impact on emissions and total travel kilometers. In the EU, approximately one-fifth of greenhouse gas emissions is produced by road transport (https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases/transport-emissions-of-greenhouse-gases-12). Reduction of emissions due to automation has been estimated by several studies [6,9] but it will also depend on what kind of technology will be used [8]. Studies have also estimated different impacts on the total amount of travel kilometers. As Martinez and Viegas [9] argue, the actual impact depends on how the technology will be deployed. In reality, it will depend on which transport modes are used and how fast they will be automated, as well as what the combination of different transport modes will be and how many rides are shared [9].

Several publications have analyzed the impact of AVs and SAVs on other aspects of mobility. It has been argued that autonomous vehicles will provide greater access to mobility for population groups who currently are disadvantaged such as the elderly, youth and people without a driver's license, as well as change people's mobility patterns [7,10,11].

Land use will heavily be impacted by autonomous transportation. It has been argued that the introduction of autonomous vehicles could bring a second wave of suburbanization [12,13]. As Heinrich [13] argues, autonomous driving can compensate for longer travel distances as the passenger(s) can be engaged with productive activities while commuting. This could be a tempting choice by many as the land prices in suburban areas are much cheaper compared to the urban centers [12]. In the cities, the districts could be organized around transport hubs in which public transportation is provided by autonomous vehicles, which, in turn, will reduce the need for parking spaces [13]. A study conducted by Zhang and Guhathakurta [14] estimates that with only 5% of the trips served with SAVs, the parking land use in Atlanta could be reduced by 4.5%. A similar reduction was found with the case of Lisbon, where a 100% shared self-driving taxibot fleet could reduce parking spaces by more than 90% [8].

Clements and Kockelman [15] have estimated that when connected AVs will capture the majority of the automotive market, their impact on the whole US economy would be 1.2 trillion dollars annually, as such a development would affect numerous industries such as insurance, electronics, freight movement, the car industry and others by destroying the current business models and creating new ones. The car industry will especially be under heavy pressure if SAVs will dominate over private AVs, as the sale of cars to private individuals, which is the current main business for car manufacturers, will drop significantly. On the other hand, the increased mileage and active service hours per SAV will shorten the life cycle of the vehicles, which, in turn, creates additional demand [8,9]. The deployment of AVs and SAVs also require large investments in infrastructure which has an impact on the economy. This includes investments in charging stations and the electric grid [16]. Further investments are required in sensor technology, software, batteries, and electric motors [16]. AVs could also potentially provide efficiency gains. Ongel et al. [17] predict that adapting autonomous electric vehicles in Singapore's public transport system would reduce total cost of ownership per passenger kilometer around 60% compared to the regular buses. We could also expect a decrease in real estate development costs and more affordable urban housing as SAVs would eliminate the need to invest in building garages for private cars [16]. Changes in land use and new service opportunities provided by autonomous driving will also impact tourism. Cohen and Hopkins [18] bring out several possible changes and challenges that AVs might bring in tourism such as pre-planned sightseeing routes, targeted advertising in AVs and SAVs, loss of employment (couch and taxi drivers), decreased encounters between locals and tourists, etc. Pre-planned routes can also decrease market competition when AVs and SAVs will take people only to businesses that pay the fleet operators [18].

2.2. User Acceptance and Perception of Security and Safety

As the wide adoption of private AVs, SAVs and autonomous public transport would certainly have an impact on the economy and society at large, user acceptance and passengers' safety and security perception become important topics to investigate. Several studies have been conducted to evaluate user acceptability and willingness to purchase this technology. A cross-national study with 5000 respondents from 109 countries conducted by Kyriakidis et al. [4] found out that while most of the people find manual driving most enjoyable, a large proportion favored fully autonomous driving. Prior experience seems to be the key reason. They found that frequent drivers are more willing to pay for autonomous features [4]. In addition, people with prior experience with adaptive cruise control are more willing to pay for AVs, more comfortable with driving without a steering wheel and more comfortable with data transmission [4]. Similar results were given by the study of Zmud et al. which analyzed the answers of a survey with 556 respondents [5]. They concluded that people whose current vehicle has highly automated features showed higher intent to use self-driving vehicles. The study conducted by Pakusch and Bossauer [19] focuses on fully automated public transport systems. The results of their study are in line with previously mentioned studies—people who have prior experience with automated transportation such as automated trams, trains, and metro are more willing to use autonomous transport than people without such experience. In addition, the participants of their study preferred autonomous rail-bound transportation over autonomous private cars, buses, taxis and carsharing.

The fact that a person has had prior experience with an SAV and has shown willingness to use it in the future does not mean that the same person is also willing to use a privately-owned AV or vice versa. However, the aforementioned studies do show that prior experience with the technology can increase the willingness to use the technology in the future.

Safety is one of the key aspects in the adoption of any kind of autonomous vehicle. It has been argued that the technology has the potential to significantly reduce the number of traffic accidents that are caused by driver error [20]. Although the potential is there, concerns over the safety of the technology must be acknowledged. The study by Kyriakidis et al. [4] found safety as one of the biggest concerns related to automated driving. According to the survey conducted by Zmud et al. [5], the main reasons why the respondents were unlikely to ride with AVs were lack of trust in the technology (40%) and safety (24%), while cost was only the third most relevant factor (20%). A technology which is not perceived safe will not gain users. Safety itself can be looked at from several different angles. For example, Hulse et al. [21] point out that people's perception towards AVs depends on their road user perspective: AVs were perceived more dangerous as passengers and less dangerous as pedestrians. They add that this difference is possibly related to concerns about whose safety AVs will prioritize. A study by Dong et al. [2], focusing on autonomous public transportation concluded that the willingness of public transportation users to ride with an autonomous public transportation bus very much depends on the presence and tasks of the bus operator onboard. They point out that an onboard operator is especially crucial during the early stage of technology adoption, and there are also concerns that without the operator, certain groups such as disabled people will not receive assistance during the use of the service. It can be argued that such a concern points towards a general concern of safety onboard the bus.

One of the main worries with the previously mentioned studies is that the survey respondents have not been introduced with a real, physically existing technology. Although the study of Pakusch and Bossauer [19] was not introducing the autonomous technology to the participants, it was the only study focusing on the previous experience with fully autonomous transportation. As is argued by Xu et al. [22], participants in online surveys may not be able to visualize the operation and functionality of AVs. During the literature review, we found only seven studies that included actual vehicles with autonomous functionality. Six of these studies used automated shuttle buses without a steering wheel and pedals which offered first and last-mile public transportation service [23–30]. The study of Xu et al. used a rebuilt passenger car with steering wheel and pedals [22]. In most of these studies, the focus has been to determine user acceptability before and after having a direct experience with the technology. The study of Salonen and Haavisto [27] was based on the interviews conducted with people who just had used an AV. The study of Madigan et al. was based on the questionnaire which was filled by people who had at least once come across an operational AV, and the data was collected in the vicinity of two AV pilots (Lausanne and La Rochelle) [23]. Researchers from ETH Zürich have conducted multiple surveys as part of the Route 12 pilot in the Canton of Schaffhausen to investigate the public opinion towards the pilot [28–30]. One pre-pilot survey was followed by two follow-up surveys. The study of Harb et al. [11] is also worth mentioning. Although autonomous vehicles were not used, the researchers of that study provided chauffeurs to the participating households to simulate a privately-owned AV.

The study of Distler et al. [26] distinguishes acceptability and acceptance, of which the former refers to a prospective judgement before using the technology and the latter describes a person's judgement after using it. The study gives a clear example of how the judgement towards the technology can change after having a real experience with it. Participants of the Distler et al. [26] study significantly decreased their performance expectancy and perceived usefulness after having a chance to use an automated shuttle bus. The drop in perceived usefulness happened because the participants of the study had the first-hand experience with how limited the autonomy of these shuttles actually are. In the study by Xu et al. [22], trust, perceived usefulness and perceived ease of use increased among participants after they had first-hand experience with the technology. Nordhoff et al. [25] found that the participants of their study believed driverless shuttles to be useful and easy to use but not compared to their current travel modes. Perceived usefulness was also found as an important factor by Moták et al. [24]. Salonen and Haavisto [27] found that interviewees were acceptable towards AVs if they operate on a useful route. Similarly, the results of Madigan et al.'s study shows that the intention to use auto transportation is influenced by how well they believe it will perform in comparison with the existing public transportation options [23]. The surveys related to the Route 12 pilot in Switzerland show that the population's support towards automated shuttle bus pilots slightly increased after the start of the pilot, but it was statistically insignificant [28–30]. In the second survey, Wicki and Bernauer [30] also compared ride experience ratings between those participants of the general population survey who had taken a ride with the bus on Route 12 and the passengers who filled the survey right after the ride. The ride experience was slightly lower among the respondents of the general survey of whom 62.9% rated the experience with a grade “4” or “5” on a 5-point scale (69.8% among the passengers). Compared to the general survey participants, the passengers were also more eager to rate the experience with a grade “5” (41.7% vs. 25.3%).

The studies of Distler et al. [26], Xu et al. [22], Salonen and Haavisto [27], and Wicki and Bernauer [28–30] have also investigated safety. The results of Xu et al.’s [22] study show that the participants whose perception of safety was high were more likely to use AVs in the future. In the study of Salonen and Haavisto [27], the participants expressed that the feeling of safety onboard the bus was better than they expected but people still had concerns regarding the overall safety of AVs in traffic. In the study of Distler et al. [26], the participants expressed that the actual experience with an automated shuttle bus had a reassuring effect on security and, in general, they felt safe in the bus. Their study also showed that both before and after riding with an AV, safety was one of the most important needs for the passengers. The results of the three Swiss surveys show that among the general population, the biggest concerns were related to software misuse [28–30]. Among the respondents of the second general survey who had taken a ride with the automated shuttle bus, over two-thirds of respondents rated safety as “good” or “very good” [30].

2.3. Research Gap

Our research adds to the previous discussions which have focused on automated shuttle buses in the context of first and last-mile public transportation service. The study identifies the differences in perception of safety and security between the passengers who recently experienced the technology and those who have not. Although the report of Wicki and Bernauer [29] compares the biggest concerns related to AVs throughout all three waves of surveys, they do not compare the perception of safety between people who have and have not taken a ride with an automated shuttle bus. The study of Salonen and Haavisto [27] does show that for many of the users, the experience with an automated shuttle bus enhances the feeling of safety. However, the study does not look at the exact difference before and after using the shuttle bus. The study of Distler et al. [26] shows that the importance of security as a basic human need did increase after the experience, although the participants expressed that the experience had a reassuring effect. Furthermore, it was also expressed that there were even too many security measures.

One can argue that the more safety precautions are implemented, the safer the passengers feel. In addition to comparing the perception of safety and security between the recent passengers and the control group that had not taken a ride with an AV bus, the current article also looks at the safety precautions as we link the perception of security and safety with how the pilot was set up. For that, we map out the main factors that can influence the everyday operations of automated shuttle buses and investigate how the issues were dealt with. This has not been done in the previous studies. However, we believe that the AV experience of the passengers can be influenced by factors such as the environment where the bus is driving or technical factors. For example, if the operation of the automated shuttle bus is interrupted by rain or some technical issue then it can negatively impact the experience compared to a situation where the bus is driving in perfect conditions.

3. Case Study

3.1. Methods

The main research method used in this paper is the case study method as we are focusing on one specific city with several tools for data collection applied (surveys, interviews, document analysis). Compared to other methods, the case study allows us to do in-depth analysis of one pilot site—the City of Tallinn. According to Yin [31], a case study investigates a contemporary phenomenon within its real-life context especially when the boundaries between phenomenon and context are not clearly evident. The case selection for this project is, on one hand, dependent on a potential to set up an open-street automated shuttle bus last-mile service pilot, and on the other hand, is dependent on a potential to gather primary data to study the link between user experience and automated mobility and various operational capacity factors influencing this. The collected data is both quantitative (especially survey questions on numeric scales) and qualitative (non-numeric responses in surveys, exclusively within a panel interview and log document analysis). Considering the theoretical framework and availability and access to primary data, the mixed methods approach is proposed that combines the following data:

- Passenger survey feedback analysis
- No-pilot control group survey feedback
- Daily communication log with shuttle operators
- Panel interview data of automated bus operators

3.2. Passenger Safety and Security

In the Sohjoa Baltic project, safety and security are reasoned in the following context [32]:

- "With autonomous driving still in its infancy, road safety is a topic followed closely by public, politics and researchers. When automated vehicles operate among others, and in normal traffic conditions, i.e., with other vehicles either autonomous or not, the probability of collisions and the impact of accidents is increased compared to operation in a closed environment. Due to differences in operating environments in between the pilot cities, variations in user experience is expected. The behavior of an automated vehicle can differ from a human driver, generating confusion and creating an uncomfortable or unsafe feeling about the ride, even if the accident rate does not increase or is even reduced. Passenger safety is understood here as the passengers' subjective feeling of traffic safety onboard an automated bus. The automated shuttle buses used in this study are designed in such a way that any traffic risk, triggered by sensor input, automatically results in sudden braking. Thus, the passengers' perception about safety can be altered by such hard braking, while also increasing the risk of falling for passengers standing in the bus or bumping into the interior parts of the bus. Road safety experience was surveyed by asking each passenger to respond with a grade from 1 to 7 about the safety onboard.
- Personal security on an autonomous vehicle is still largely an unknown factor. In our study, it is defined as the passengers' subjective feeling of security traveling with other passengers without the presence of a human driver, since the enclosed shared environment of an autonomous vehicle without a dedicated driver or supervisor might provide challenges to the personal security of the passengers. Experienced threats or perceived risks of safety both have a negative impact on the overall user experience and acceptance. Possible risks for personal security are, for instance, other passengers, people outside the vehicle, or cyber threats. The factors affecting the security were not surveyed. All the pilot projects were organized with a safety operator onboard, which may affect the perceived personal security. The topic was included in the survey nevertheless to provide a baseline for further pilots without a safety operator onboard, and to identify other possible issues related to security. The personal security was evaluated by respondents on a scale from 1 to 7."

3.3. Pilot Design

The first long-term open traffic pilot in Tallinn, Estonia, with the SAE 3 level automated shuttle started its operations on 28 August 2019 around Kadriorg Park. The preparation process for this started already in October 2017 with the route selection. Three possible routes were found which could demonstrate a last-mile use case and had a low traffic intensity. Taking into consideration the possible changes in traffic arrangements that needed to be done, road conditions and the impact of the service, Kadriorg Park was selected as the best option. Later preparation activities included preparing changes in traffic arrangement on the selected route, public procurement process to rent an automated electric bus, and recruitment and training of shuttle-service operators. The rented bus is manufactured by the French company Navya and was delivered by the Danish company Holo who is the contract partner to the Tallinn Transport Department. According to the SAE International, this pilot was on SAE level "3—Conditional Driving Automation" where the driving task was fully automated with human fallback—operators had to respond promptly. The operators were students from Tallinn University of Technology who passed the two-week training organized by Holo. The operators were responsible for the safety of the bus and passengers as they took over control whenever it was necessary. The operators also explained to the passengers how the technology works. Other minor responsibilities included cleaning the bus, upgrading the software and sending data reports to the manufacturer. Before the start of operations, the bus had to pass an exam which was organized by the Estonian Road Administration to ensure the safety of the bus and its capability to drive in open traffic. In general, the bus was scheduled to run regularly from Tuesday to Sunday between 10.00–16.00 (till 18.00 on Thursday, Saturday and Sunday), and carried passengers free of charge. The bus seated up to eight passengers at a time with seatbelts fastened.

The bus served as a last-mile extension of the Kadriorg tram line connecting it with the Estonian Art Museum which is located 700m away from the tram stop. The bus drove in a circle around the Kadriorg Park and had four stops: Katharinenthal cafeteria located close to the Kadriorg tram stop, Kadriorg Art Museum, Estonian Art Museum, and Miiamilla Children's Museum (Figure 1). In addition to several museums, the park is also a location for a small luna park and a tennis club. Several residential houses and a kindergarten are located at the Mäekalda street (south-west from the Estonian Art Museum). Most of the car traffic in the area is related to the Estonian Art Museum, residents who live at Mäekalda street, tennis club guests and people working in the Office of the President. Due to the pilot, traffic flow was changed on the Mäekalda and Koidula streets from two-way traffic to one-way traffic. The real-time position of the bus was available via the Letsholo app (available via Google Play or Apple App Store). Approximately 100 people were using the service during the operational days with 3877 users in total, although there were several issues that influenced the stability of operation resulting in a significant downtime in order to mitigate the risks. The operations were paused on 21.12.2019 due to seasonal conditions. Although the Tallinn pilot is planned to be reopened from 1.06 to 31.08.20 (Navya bus and some operators are ready for this during the time of writing this paper; provided COVID-19 restrictions will be over by June), key results can be drawn from the first operational period with a potential to update the survey results later.

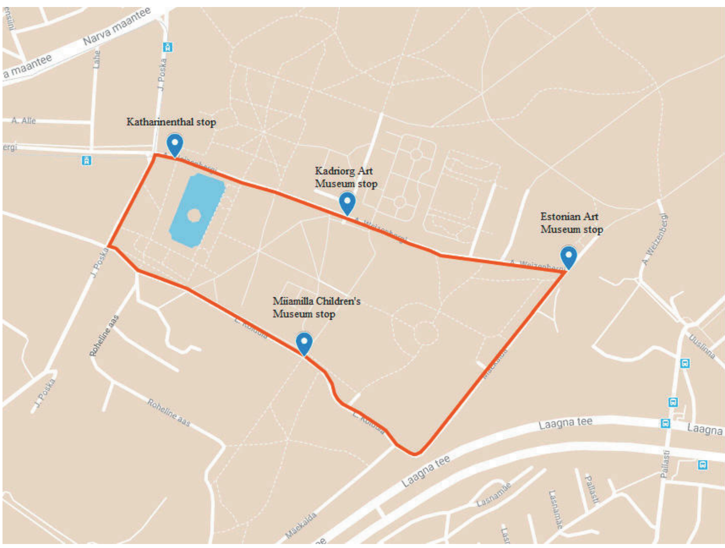

Figure 1. Route of the Tallinn automated shuttle pilot.

Key Characteristics:

- Path length (km): 1.7 km
- Average speed (km/h): 7 km/h
- Travel time (min): 15
- Number of stops: 4
- Total number of users: 3877

3.4. Perception Survey

During the Tallinn pilot, passenger feedback was gathered via an anonymous online survey that was co-developed within the Sohjoa Baltic (www.sohjoabaltic.eu) project and used also in other pilot sites (in the European cities of Kongsberg, Helsinki and Gdansk). The aim was to provide a quick and easy to fill survey in order to increase the response rate. This is why only a number of questions were asked with limited depth. The survey form was designed in two parts: thematic questions regarding the general acceptance of the automated buses and demographic data about the passengers. The survey was run in two languages (Estonian and English).

This survey was available in Google Forms and distributed to participants via business card-size paper flyers (Figure 2) with an online link (taltech.ee/robotbus) and also a QR-code that directed the passengers to the survey in two languages. The survey invitations with general QR-codes were distributed exclusively to passengers after taking the ride. Technically, we cannot rule out the risk that some participants filled in the survey twice or distributed this invitation to non-participants. However, when comparing with other forms of collecting the same survey data (the city of Gdansk collected the same surveys on paper and the city of Helsinki asked participants to fill in the survey during the ride on a tablet), these results are similar—thus, there seems to be no systematic data entry error (see also www.sohjoabaltic.eu for comparative results which will be added by late Summer of 2020).

Figure 2. Feedback paper flyers distributed to passengers.

The main analysis method of the survey was descriptive statistics, although a few correlation tests were also to be performed in order to analyze whether there are any statistically significant socio-demographic differences in the overall feedback to the experience. This survey does not represent the entire population as the sampling was not representing the passengers that voluntarily took the automated shuttle bus ride—this came from the pilot design with the goal to offer free and open service for everybody. There were no incentives for taking part in this survey.

The survey was designed within the Sohjoa Baltic project consortium, led by Metropolia University of Applied Sciences with the involvement of Chalmers University of Technology, Tallinn University of Technology (involving authors of this paper), mobility analytics company Flou and four Baltic Sea Region cities—Kongsberg (Norway), Gdansk (Poland), Tallinn (Estonia) and Helsinki (Finland). The goal was to design a simple fill-in survey that can be used across different pilot sites. The simplicity was an important factor to increase the take-up rates. The consortium first developed a board list of questions that were later ranked jointly against importance. During this period, guided by research and mobility experts, only the most important questions remained. In total, there were three rounds of joint workshops where the sequence, wording and scaling of questions were also discussed. For example, it was agreed to use the Likert scale with odd numbers for numeric questions (on the scale of 1–5 and 1–7 where 3 or 5 is neutral), as the consortium considered the safety and security more sensitive—these were on the scale 1–7, whereas the overall experience was on the scale 1–5. Most questions allowed respondents to choose only one answer; only "When would you use this service?" allowed more than one answer. The main topics and questions were:

Traffic Safety: to study passengers' subjective feeling of safety (e.g., risk of accidents) in a real-life urban environment, after taking a ride with an automated bus. In general, compared to the previous 2017 pilot in Tallinn in a closed environment, the theoretical risk of collision is higher when this pilot is conducted in the open street environment (compared to no-traffic pilot). The survey question studying this link was: "*How do you feel about general traffic safety onboard? Please mark on a scale of 1 (very unsafe) to 7 (very safe)*."

Personal security: to study passengers' perceived feeling of security when the pilot is conducted in a real-life environment, after taking a ride with an automated bus. There was also a security risk related to the design of the robotbus as it is very sensitive to outside risks, received via sensors. Each potential outside risk triggers a sudden brake which can cause indoor accidents—this is the main reason why speed is capped. The survey question studying this link was: "*How do you feel about your personal security onboard? Please mark on a scale of 1 (very unsafe) to 7 (very safe)*."

Operator onboard: to study the willingness to participate in a pilot without operator onboard. In order to mitigate the risks, the bus always had an operator onboard who introduced the pilot's goals to the passengers and replied to various questions. In addition, the operator took over the control manually if it was needed. The survey question representing this interest was: "*Would you also use the service with no operator onboard? Options: Yes, definitely; Yes, but not now; Maybe; No, never.*"

Automated last-mile use cases: to study the demand for automated last-mile shuttle service with predefined use cases. A multiple-choice survey question was: "*When would you use this service? Options: In bad weather; When carrying heavy items; Daily commute; As a link to transport hubs/other Public Transport options; In closed large areas (e.g., campuses, industrial parks, airports, hospitals); Never; Other.*"

Safety for children: to study the perceived feeling of safety and security when the service is offered to vulnerable groups, e.g., school children. This question was designed as a potential control question to the perceived feeling of security and safety—all combined indicating trust towards automated mobility. The survey question was: "*Would it be feasible for children to use this vehicle to travel to/from school? Options: Yes; Yes, but only if attended; No; Don't know.*"

Overall experience: to study the combined personal experience of the pilot. From the quantitative analysis perspective, this question was chosen to run various correlation tests between various socio-demographic groups as it represents the combined subjective experience. The survey question was: "*How would you describe your experience? Please mark on a scale of 1 (very bad) to 5 (very good)*."

Frequency of use: to study the frequency demand for automated last-mile shuttle service. When the use case question above was mainly interested in the variety of demand for the last-mile service, this question was posed to study more narrow demand for the frequency of use. The survey question was: *"If this service had been available as part of your daily commute, how often would you use it? Options: Daily; Weekly; Less often; Never."*

General suggestion: to provide an option for passengers to give general feedback to the pilot, along with open questions regarding the future development expectations, both for planning next stage pilots and also for obtaining an indication in terms of perceived risks. The survey question was: *"What wishes do you have about the future development on autonomous minibuses? Other feedback is also welcome!"*

This was followed by socio-economic questions (sex, age, education, occupation, public transport usage).

Control group data was gathered during one smart city course among Tallinn University of Technology public administration bachelor-level students in late 2019 with a focus to study attitudes of Estonian students towards automated driving without actual driving experience. The service was introduced to the control group in the format of a lecture including introduction to the project goals and specific design of the route and pilot. Therefore, the questions were rephrased in order to investigate the perceived attitude towards automated driving in the control group. Students responded to this theoretical survey in December 2019 as part of their coursework. The results can be biased and do not represent the entire population as the survey was not voluntary nor fully anonymous. The following questions were asked:

- *How would you feel about general traffic safety onboard?*
- *How would you feel about your personal security onboard?*
- *Would you also use the service with no operator onboard?*
- *When would you use this service?*
- *Would it be feasible for children to use this vehicle to travel to/from school?*
- *How would you (theoretically) describe your experience?*
- *If this service had been available as part of your daily commute, how often would you use it ?*
- *What wishes do you have about the future development on autonomous minibuses? Other feedback is also welcome!*

3.5. Operators Issue Reporting and Panel Interview Data

In order to analyze the risk mitigation via operational capacity of the pilot, operators' daily communication channel that covers the operational progress was analyzed. This channel was operational from late August to late December in the format of a Skype chat. In general, most operational challenges, issues and decisions went through this log, e.g., where and how to store the bus, how to provide maintenance and electricity, weekly update on the daily working shifts of the operators and various ad hoc issues ranging from leaves interrupting the automated mode to traffic accident descriptions and its technical consequences. This log file, when imported to a Word document, is approximately 215 pages and 47,000 words.

In order to perform document analysis, a qualitative research software based on text-coding and analysis was applied using the ATLAS.ti software in order to map the operational capacity factors of automated vehicles in three dimensions. The purpose of ATLAS.ti qualitative data analysis software is to systematically analyze 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.

We came up with code words to find out main issues related to technology, traffic and environment and their frequency. The code words were based on the area where the bus was driving (park), technical aspects of the bus and the discussions in the Skype chat. Table 1 illustrates the used code words under each topic and their frequency. The frequency of the code words gives only a partial overview of the main issues. For example, the words "Signal" and "GPS/GNSS" have a low frequency, the fact that there were issues with GNSS signal paused the operations for several weeks (see Section 4.3).

Table 1. The coding strategy of the log file.

Topic	Used Code Words (Frequency)
Technical	Technical, Signal (3), GPS/GNSS (3), Mechanical (1), Battery (45), Computer (4), Software (5), Door/s (79), Tire/s (8), Wheel/s (2)
Traffic	Car (48), Parking (30), Congestion (2), Pedestrian, People/Person (96), Sign (8), Bicycle (1)
Environment	Rain (16), Temperature (3), Leaves (42), Trees (2), Branches (5), Snow (5), Squirrel (1)

In addition to the document analysis, we invited all four operators to a face-to-face panel interview that took place in the beginning of February 2020. The panel interview with joint discussions and responses from operators took approximately 1.5 h and it was recorded. The aim of the panel interview was to gather additional feedback from operators that participated in all rides, regarding the technology, traffic and environmental operational capacity factors. The openly structured questions were the following, translated from Estonian:

- *Please describe your operational experience on the Navya shuttle bus and its technology (sensors, software etc.)*
- *How long did you operate issue-free?*
- *What were the most common issues during the operation?*
- *What caused these issues (environment, technology, traffic)?*
- *What were the main weather conditions that influenced the operation? (Specific questions on the impact of precipitation, wind, temperature, extreme weather condition etc.)*
- *How many issues directly or indirectly influenced the weather? (on the scale from 1–10)?*
- *Could you describe the split between routine and dynamic factors?*

4. Results

In total, 152 passengers answered the survey out of the 3877 people that took the ride between late August to late December with a response rate of 4%. 55.3% of the respondents were women and 44.7% were men. 35.5% of the respondents were between the ages of 31–45, making it the most dominant age group. The least represented group was >61 as only 10.5% of the respondents were part of this age group. A large majority, 62.5% of respondents, reported that they were employed. 14.5% of respondents were students, 12.5% self-employed or other, and 9.9% were retired or unemployed. The survey was dominated by people with higher education as 64.5% reported that they had a university degree. 20.4% of respondents had a secondary education or vocational degree (see Figure 3).

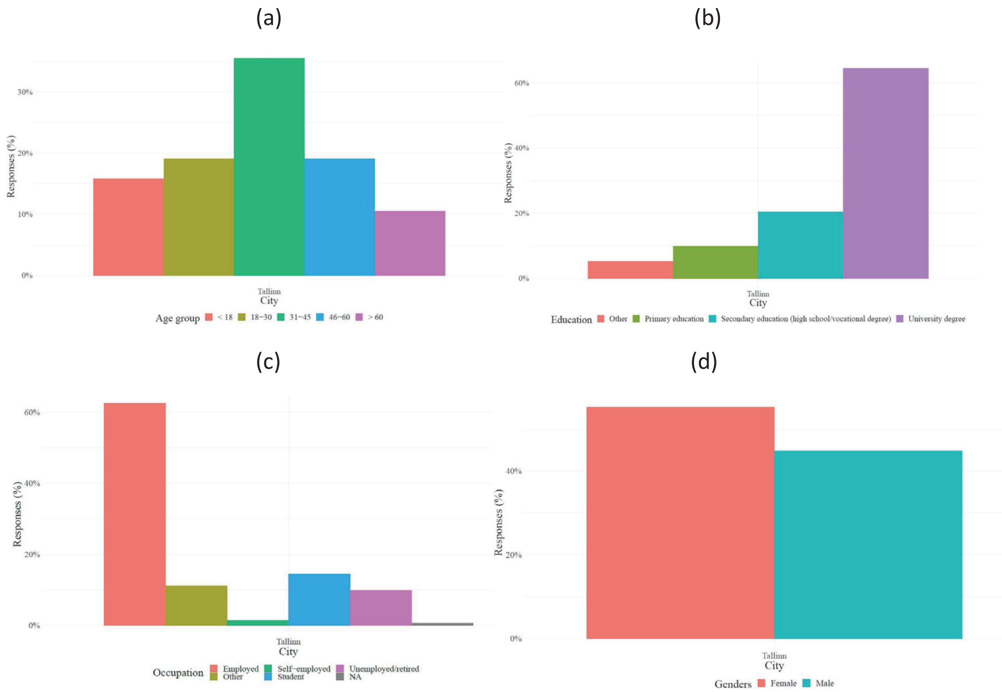

Figure 3. Socio-economic data of respondents: age (**a**); education (**b**); occupation (**c**) and gender (**d**).

4.1. *Automated Driving Experience and Implemented Safety and Security Precautions*

When operated, the risks were reduced by always having an operator onboard and also by careful design of a pilot including low-intensity traffic and mandatory seatbelts. Specifically, the mobility risks were mitigated by relatively low average speed (7 km/h) with maximum speed capped at around 15 km/h for a 1700 m route with four stops (average time was 15 min for a full ride). The pilot ran in low-intensity traffic with no traffic lights, with relatively simple junctions, and avoided service during the weekly peak times (the service was not operated during the weekdays between 8:00–10:00 and 16:00–18:00). Most importantly, an operator was always ready to take over the manual control.

The importance of safety precautions also came out in the panel interview with operators that indicated a rather high amount of downtime. For example, during three weeks in October, approximately 50% of the time, the service was not operational in order to prioritize the safety and security of passengers (see also Figure 4).

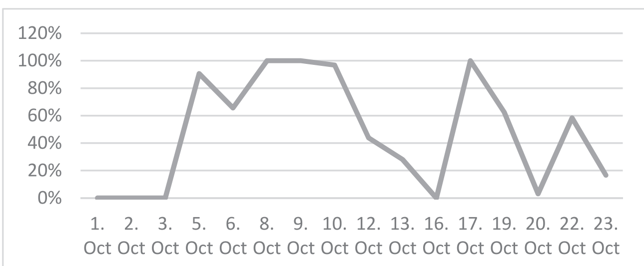

Figure 4. Actual versus planned hours in operation.

In this mitigated risk situation, the general feedback from 152 passengers taking the ride was remarkably positive with no extremely negative scores, see Table 2. In order to analyze potential socio-economic factors influencing the overall feedback, we also performed a regression analysis based on generalized linear regression coefficients, see Table 3. As a result, none of the variables have statistically significant effect on the overall experience score, making correlation analysis not central to this study.

Table 2. Mean scores on safety, security and overall experience.

	Mean	**Median**	**Scale**
Traffic safety	6.06	6	1 (very unsafe) to 7 (very safe)
Personal security	6.33	7	1 (very unsafe) to 7 (very safe)
Overall experience	4.79	5	1 (very bad) to 5 (very good)

Table 3. Regression analysis.

Factor		**Estimate**	**Std. Error**	***t* Value**	**Pr(>|t|)**
	Intercept	**4.84**	**0.27**	**17.72**	**0**
Education	Primary education	−0.13	0.24	−0.53	0.6
	Secondary education	0.19	0.25	0.76	0.45
	University degree	−0.04	0.25	−0.15	0.88
Age	>60	−0.12	0.33	−0.35	0.72
	18–30	−0.01	0.26	−0.03	0.98
	31–45	−0.16	0.28	−0.6	0.55
	46–60	−0.05	0.28	−0.19	0.85
Gender	Male	0	0.09	−0.01	0.99
Occupation	Other	0.04	0.21	0.19	0.85
	Self-employed	0.07	0.41	0.17	0.86
	Student	0.13	0.17	0.74	0.46
	Unemployed/retired	0.14	0.2	0.73	0.47
How often public transit used	Less often	0.06	0.11	0.56	0.58
	Never	0.18	0.34	0.53	0.59
	Weekly	−0.11	0.11	−1.04	0.3

Carefully managed risks also indicated that people are more willing to use the minibus without an operator onboard, either already now or in the future (most people responded "yes, definitely" or "yes, but not now" to the question "Would you use it without an operator onboard?"). This also is represented in the question regarding feasibility for the use of kids—the vast majority of respondents would allow children to use the service to travel to/from school, either alone or attended (Figure 5).

There were no clear differences regarding the preferred use cases of the automated shuttle service—demand for last-mile, bad weather, heavy items and closed areas was relatively equally represented, with no-use case option ("never") not selected. On the other hand, respondents would prefer to use this service for the daily or weekly commute—indicating actual need for the last-mile service between the tram stop and the National Art Museum (most responses, see Figure 6).

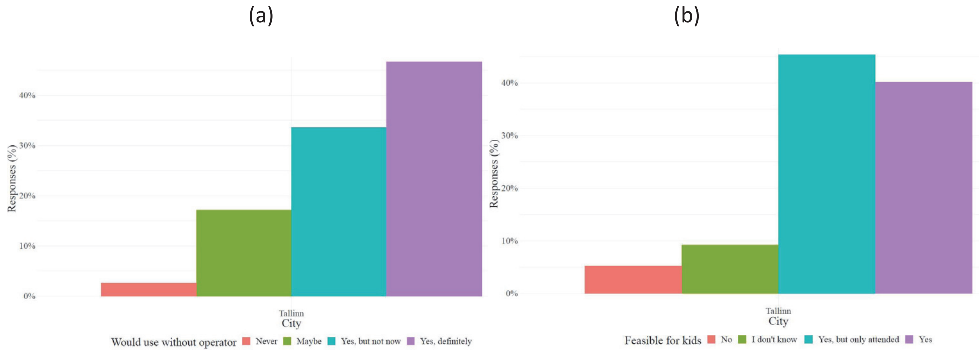

Figure 5. Use without operator (**a**) and feasibility for children (**b**).

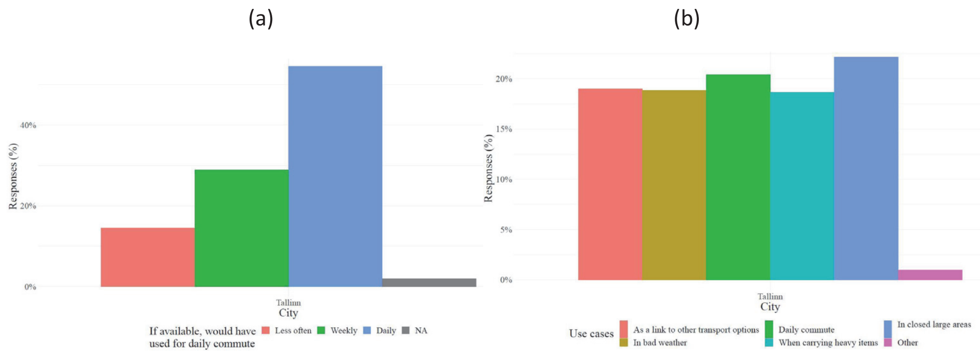

Figure 6. Demand for the automated bus service: commuting frequency (**a**) and preferred use cases (**b**).

4.2. Automated Driving User Experience in Terms of Safety and Security

Passengers taking the ride gave strong positive feedback to the general safety and security onboard questions, see also Table 2. On the other hand, when asked the same questions from the control group (55 respondents) in a more theoretical way, without being linked to the actual driving experience ("How would you feel about general traffic safety onboard?" and "How would you feel about your personal security onboard?"), this gave significantly lower average scores (4.8 and 5.0, respectively). Thus, we can conclude that the group that took the ride perceived safety and security significantly differently compared to the group with no driving experience (see Table 4). However, these differences cannot be claimed to be statistically significantly different as they represent different populations. In the group taking the ride, most people were employed, had university education and were most often in the age group of 31–45—see also Figure 3 above. This survey was done in two languages—Estonian (87 responses) and English (65 responses) and was both fully voluntary and anonymous. However, the "no pilot" group consisted of Estonian students of whom over 90% were females in the age group of 18–30. The survey was also not fully anonymous nor voluntary.

Table 4. Mean scores on safety and security (pilot/control group).

	Pilot Group	Control Group	Scale
Traffic safety	6.06	4.82	1 (very unsafe) to 7 (very safe)
Personal security	6.33	5.07	1 (very unsafe) to 7 (very safe)
Number of respondents	152	55	

4.3. Key Factors Influencing the Daily Operations of an Automated Shuttle Bus

Based on the panel interview and the daily communication channel analysis, we can say that the most common issues that hindered the bus operation were related to traffic and environment or were technical in nature. Due to that, the automated shuttle bus had significantly more issues with downtime than expected, as explained earlier.

Firstly, several technical issues were experienced during the pilot. The biggest technical issue was related to GPS connection, which, for some time, made it impossible to operate the bus autonomously. There was also a mechanical issue with doors which prevented them to open and close properly. Although the error was not related to sensors, cameras or the GPS which help to make the vehicle autonomous—according to the operators, this decreased passengers' trust towards the technology as it was a visible error. There were also problems with charging the battery as the museum's electric panel often switched off due to overload. Additionally, the air conditioning did not work properly which made it more complicated to work in low temperatures in November and December. The main reason for several technology-related errors was that the technical support was provided from a distance (from Denmark and/or France). For example, there was an issue with doors not working properly and it took one operator four days to understand how to open and close these doors. In addition, the distant problem-detection decision tree assumed that most challenges are related to issues with software, although the problem with doors was actually a mechanical one.

Secondly, traffic also influenced the operational capacity. Despite low-intensity traffic, several traffic-related issues were brought up by bus operators. For example, the bus did not understand that it is in a traffic jam and started to "beep" as it thought there was an obstacle in front. In addition, everyday operations were influenced by cars parked on the road (often not legally) and cars driving against the rules in the opposite direction on a one-way street. As the bus was operational around one popular park, there were also issues with pedestrians who either crossed the road in the wrong place or, on purpose, tested whether the bus would stop or not, if suddenly interacted with. The operation was ceased for weeks due to one traffic accident with a heavy goods vehicle which ignored the automated bus and hit it at a slow speed.

Lastly, several environmental factors affected the operations. According to operators, weather had a significant impact on the operation. During the operations from the end of August till December 21st, the main issues linked to weather conditions were related to rain, leaves, and temperature. All these issues also occurred due to seasonal changes. Rain, falling and already fallen leaves were the main weather-related issues in September and October. While falling and already fallen leaves caused the bus to have an emergency stop 10–15 times per circle, the combination of leaves with heavy rain made it impossible for the bus to drive smoothly. During such times, the operation was paused and continued when the rain stopped. In December, temperature started to become an issue because of two reasons. When the bus was not operating, it was stored in the outside tent located at the parking lot of the Estonian Art Museum as there was no warm garage in the vicinity that could be used. After each day of operation, the bus was left in the tent with its battery charging for the next morning. As battery charging needed at least more than 5 degrees Celsius temperature, the tent was equipped with additional radiators to keep the temperature above that threshold. Extreme temperatures made it also necessary to turn on the heating or air conditioning which decreased the daily operating hours because of the increased power consumption. In addition to the weather, other environmental factors played a role. For example, the bus stopped due to birds that flew in front of the sensors as the bus recognized them as obstacles. The bus also stopped due to outgrown tree branches, especially during the heavy wind. The biggest environmental issue was the seasonal change. After the leaves completely fell from the trees, the bus did not recognize the environment as it did not match with the pre-mapped route and the pilot had to be paused till the Navya technicians solved the problem.

4.4. Open Feedback and Suggestions for Future Pilots

In the case of the open feedback questions of the pilot survey, positive comments dominated. In total, 61 people gave additional comments (frequency of 40%). Most of the suggestions and comments dealt with the size of the bus, smoothness of the ride, capability of the bus to overcome obstacles, the wish for more pilots, and feedback about bus operators. Several people pointed out that the bus is too small. This refers to the fact that the bus was operational in one of the main parks in Tallinn which is also a popular tourist destination. In crowded areas like Kadriorg Park, it would be reasonable to provide the last-mile service with at least two buses. Survey respondents also wished for more such pilots in areas where last-mile service would be needed and for popularization reasons. Survey respondents also wished that the bus could better detect and pass obstacles, evaluate the surrounding environment, drive more smoothly and without bumpy breaks which can happen due to unexpected obstacles, and read traffic signs. These issues are mostly related to the technological limitations. It might also refer to the fact that people have high expectations towards the technology and expect close to zero errors. People also pointed towards the issues with connectivity which happened during the pilot as the bus used GNSS as one of the tools for navigation. Several positive comments were left about the bus operators. Respondents were happy to get additional bus-related information from the operators. One respondent pointed out that an operator was very useful while the bus had technical issues. It shows that during the early piloting and adoption of the technology, bus operators are important. Another respondent wished for this bus to have similar speed to manually driven buses.

5. Discussion and Conclusions

The current paper is an addition to the research which investigates mobility acceptance towards AVs. The key contribution of this paper is to point out that it is not so much perceived safety and security concerns but rather technological challenges of integrating such a last-mile service with urban mobility. Compared to most other studies that are based on online surveys and give no possibility for respondents to actually experience the technology, the current study investigates user acceptance after they had taken a ride with an automated shuttle bus. A total of 152 people out of 3877 passengers answered the survey. Passengers taking the ride with an automated minibus provided positive feedback on security and safety and overall experience. In the regression analysis of the overall feedback and socio-demographic factors, we did not find any statistically significant differences—this could be due to the biased data towards good experience grades. To ensure traffic and passenger safety, the bus did not offer service for passengers if major issues or risks were identified. This resulted in significant downtime of the service. Thus, we can say that the service was offered only during close to perfect conditions.

The results were compared with a control group that consisted of 55 students who did not take a ride with the shuttle. Passengers taking the ride gave more positive feedback to the general safety and security onboard questions compared to the control group. These results are also in line with several other studies that have shown that the ride with an automated shuttle bus had a reassuring effect on safety [26] or that the experience enhances the feeling of safety [27]. Based on these results, we can argue that the feedback from passengers to an automated driving experience is also related to the risk management during the pilots as the bus was operational only when the conditions were close to perfect and allowed a smooth drive.

We can say that the most common issues that hindered the bus operation were related to traffic and environment or were technical in nature, thus making this dimension important for future mobility risk management. Importantly, the technical issues were considered as the biggest ones. The issues were related to the technology that makes the shuttle autonomous but were also more trivial such as issues with doors. Although it is understandable that the development of sensors, radars and other technologies, which makes a vehicle autonomous, is the priority for these companies, cutting corners from mechanical reliability can have negative implications from the user acceptability side.

The study has several limitations related to how the pilot was conducted and how the survey was designed. This survey does not represent the entire population as the sampling was not representing the passengers that voluntarily took the automated shuttle bus ride—this came from the pilot design with a goal to offer free and open service for everybody. For future research, an interesting contribution would be to invite participants based on sampling tools—only the ones invited from the general population could participate in the survey. In addition, the control group could be also sampled from the same pool. To our knowledge, this kind of randomized approach is lacking in the literature. The survey could benefit from a higher response rate, e.g., by having a paper-based alternative. Paper-based responses could increase the response rate among elderly people who, in the current survey, were an underrepresented group. Although the bus was driving in open traffic, the pilot was carried out in the area which has a much lower traffic intensity compared to most other parts of the city. The speed was also limited to 15 km/h. It is also important to point out that for safety precautions, the operation was paused if during severe rain, the bus started to make emergency brakes. These factors could have improved the feeling of safety among the passengers. One of the main limitations of the survey was the fact that the respondents were not chosen based on a random sample. All respondents were passengers who chose to respond to the survey themselves. This limits the generalization of the results to a wider population. For example, the majority of respondents were people with higher education. We can assume that these people are also keener towards using and testing new technologies compared to the rest of the population. Although, according to the operators, the bus mostly served elderly people, they were underrepresented in the survey. The reason for this was probably the fact that the survey took place online. The survey also did not provide much in-depth information about respondents' mobility patterns or socio-economic or health status.

For further research, focus should be directed towards socio-economic groups that so far have been underrepresented in different studies. These include people with different disabilities, elderly people or children. Such research would provide valuable insight about the needs that every such group has in using autonomous technology. For example, people with different disabilities might feel more uncomfortable if there is no driver/operator in the vehicle, as they might need help in using transportation. Therefore, the question for AV manufacturers, public transport authorities and operators is which obstacles can be solved and how they can be solved.

Author Contributions: The first author (R.-M.S.) as has been responsible for the research design and publication strategy throughout the process. The second author (J.M.) has significantly contributed to the overall scientific quality of the paper. In addition, a few S.B. team members have contributed to this paper with smaller roles (e.g., regression analysis and illustrations were partially performed by T.K. and S.M. from Flou; Section 3.2 process was led by M.B. from Chalmers University). All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the EU-Interreg through the Sohjoa Baltic project, grant number R073. The FinEst Smart City Center of Excellence part was additionally supported by the H2020 project "Finest Twins," grant number 856602.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Bansal, P.; Kockelman, K.M. Are we ready to embrace connected and self-driving vehicles? A case study of Texans. *Transportation* **2018**, *45*, 641–675. [CrossRef]
2. Dong, X.; DiScenna, M.; Guerra, E. Transit user perceptions of driverless buses. *Transportation* **2019**, *46*, 35–50. [CrossRef]
3. Haboucha, C.J.; Ishaq, R.; Shiftan, Y. User preferences regarding autonomous vehicles. *Transp. Res. Part C* **2017**, *78*, 37–49. [CrossRef]
4. Kyriakidis, M.; Happee, R.; de Winter, J.C.F. Public opinion on automated driving: Results of an international questionnaire among 5000 respondents. *Transp. Res. Part F Psychol. Behav.* **2015**, *32*, 127–140. [CrossRef]
5. Zmud, J.; Sener, I.N.; Wagner, J. Self-Driving Vehicles: Determinants of Adoption and Conditions of Usage. *Transp. Res. Rec. J. Transp. Res. Board* **2016**, *2565*, 57–64. [CrossRef]

6. Fagnant, D.J.; Kockelman, K.M. The travel and environmental implications of shared autonomous vehicles, using agent-based model scenarios. *Transp. Res. Part C Emerg. Technol.* **2014**, *40*, 1–13. [CrossRef]
7. Fagnant, D.J.; Kockelman, K.M. Dynamic ride-sharing and fleet sizing for a system of shared autonomous vehicles in Austin, Texas. *Transportation* **2018**, *45*, 143–158. [CrossRef]
8. OECD. Urban Mobility System Upgrade: How shared self-driving cars could change city traffic. *Corp. Partnersh. Board Rep.* **2015**, *96*, 776–778. [CrossRef]
9. Martinez, L.M.; Viegas, J.M. Assessing the impacts of deploying a shared self-driving urban mobility system: An agent-based model applied to the city of Lisbon, Portugal. *Int. J. Transp. Sci. Technol.* **2017**, *6*, 13–27. [CrossRef]
10. Meyer, J.; Becker, H.; Bösch, P.M.; Axhausen, K.W. Autonomous vehicles: The next jump in accessibilities? *Res. Transp. Econ.* **2017**, *62*, 80–91. [CrossRef]
11. Harb, M.; Xiao, Y.; Circella, G.; Mokhtarian, P.L. Projecting travelers into a world of self-driving vehicles: Estimating travel behavior implications via a naturalistic experiment. *Transportation* **2018**, *45*, 1671–1685. [CrossRef]
12. Kim, K.; Yook, D.; Ko, Y.; Kim, D. An Analysis of Expected Effects of the Autonomous Vehicles on Transport and Land Use in Korea. *Work. Pap.* **2015**, 1–29. Available online: http://marroninstitute.nyu.edu/uploads/content/Kim,YookDevelopment_of_Autonomous_Driving_SystemMarron.pdf (accessed on 6 July 2020).
13. Fassbender, D.; Heinrich, B.C.; Wuensche, H.J. Motion planning for autonomous vehicles in highly constrained urban environments. In Proceedings of the 2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Daejeon, Korea, 9–14 October 2016; pp. 4708–4713. [CrossRef]
14. Zhang, W.; Guhathakurta, S. Parking spaces in the age of shared autonomous vehicles: How much parking will we need and where? *Transp. Res. Rec.* **2017**, *2651*, 80–91. [CrossRef]
15. Clements, L.M.; Kockelman, K.M. Economic Effects of Automated Vehicles. *Transp. Res. Rec. J. Transp. Res. Board* **2017**, *2606*, 106–114. [CrossRef]
16. Ainsalu, J.; Arffman, V.; Bellone, M.; Ellner, M.; Haapamäki, T.; Haavisto, N.; Josefson, E.; Ismailogullari, A.; Lee, B.; Madland, O.; et al. State of the art of automated buses. *Sustainability* **2018**, *10*, 3118. [CrossRef]
17. Ongel, A.; Loewer, E.; Roemer, F.; Sethuraman, G.; Chang, F.; Lienkamp, M. Economic assessment of autonomous electric microtransit vehicles. *Sustainability* **2019**, *11*, 648. [CrossRef]
18. Cohen, S.A.; Hopkins, D. Autonomous vehicles and the future of urban tourism. *Ann. Tour. Res.* **2019**, *74*, 33–42. [CrossRef]
19. Pakusch, C.; Bossauer, P. User Acceptance of Fully Autonomous Public Transport. In Proceedings of the 14th International Joint Conference on e-Business and Telecommunications (ICETE 2017), Madrid, Spain, 24–26 July 2017; Volume 2, pp. 52–60. [CrossRef]
20. Fagnant, D.J.; Kockelman, K. Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. *Transp. Res. Part A* **2015**, *77*, 167–181. [CrossRef]
21. Hulse, L.M.; Xie, H.; Galea, E.R. Perceptions of autonomous vehicles: Relationships with road users, risk, gender and age. *Saf. Sci.* **2018**, *102*, 1–13. [CrossRef]
22. Xu, Z.; Zhang, K.; Min, H.; Wang, Z.; Zhao, X.; Liu, P. What drives people to accept automated vehicles? Findings from a field experiment. *Transp. Res. Part C Emerg. Technol.* **2018**, *95*, 320–334. [CrossRef]
23. Madigan, R.; Louw, T.; Dziennus, M.; Graindorge, T.; Ortega, E.; Graindorge, M.; Merat, N. Acceptance of Automated Road Transport Systems (ARTS): An Adaptation of the UTAUT Model. *Transp. Res. Procedia* **2016**, *14*, 2217–2226. [CrossRef]
24. Moták, L.; Neuville, E.; Chambres, P.; Marmoiton, F.; Monéger, F.; Coutarel, F.; Izaute, M. Les variables prédictives des intentions d'utilisation d'une navette autonome: Aller au-delà du MAT et de la TCP ? *Rev. Eur. Psychol. Appl.* **2017**, *67*, 269–278. [CrossRef]
25. Nordhoff, S.; van Arem, B.; Merat, N.; Madigan, R.; Ruhrort, L.; Knie, A.; Happee, R. User Acceptance of Driverless Shuttles Running in an Open and Mixed Traffic Environment. In Proceedings of the 12th ITS European Congress, Strasbourg, France, 19–22 June 2017; pp. 1–14. [CrossRef]
26. Distler, V.; Lallemand, C.; Bellet, T. Acceptability and acceptance of autonomous mobility on demand: The impact of an immersive experience. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, Montreal, QC, Canada, 21–26 April 2018; pp. 1–10. [CrossRef]
27. Salonen, A.O.; Haavisto, N. Towards autonomous transportation. Passengers' experiences, perceptions and feelings in a driverless shuttle bus in Finland. *Sustainability* **2019**, *11*, 588. [CrossRef]

28. Wicki, M.; Bernauer, T. *Public Opinion on Route 12*, Interim report on the first survey on the pilot experiment of an automated bus service in Neuhausen am Rheinfall, ISTP Paper Series, 3, Institute of Science, Technology and Policy (ISTP), ETH Zürich, Zürich. 2018.
29. Wicki, M.; Bernauer, T. *Public Opinion on Route 12*, Interim report on the second survey on the pilot experiment of an automated bus service in Neuhausen am Rheinfall, *ISTP Paper Series*, **4**, Institute of Science, Technology and Policy (ISTP), ETH Zürich, Zürich. 2019.
30. Wicki, M.; Bernauer, T. *Public Opinion on Route 12*, *ISTP Paper Series*, **5**, Institute of Science, Technology and Policy (ISTP), ETH Zürich, Zürich. 2020. [CrossRef]
31. Yin, R. The Case Study Crisis: Some Answers. *Adm. Sci. Q.* **1981**, *26*, 58. Available online: http://www.jstor.org/stable/10.2307/2392599 (accessed on 25 May 2013). [CrossRef]
32. Bellone, M.; Ismailogullari, A.; Kantala, T.; Mäinen, S.; Soe, R.-M.; Åman Kyyröe, M. A Cross-Country Comparison of User Experience of Public Autonomous Transport. Submitted to the European Transport Research Review [Under Review].

Publication IV

3.1 Bellone, M., Ismailogullari, A., **Müür, J.**, Nissin, O., Sell, R., Soe, R.-M. (2021) "Autonomous Driving in the Real-World: The Weather Challenge in the Sohjoa Baltic Project." *In*: Hamid, U.Z.A., Al-Turjman, F. (*eds*.) *Towards Connected and Autonomous Vehicle Highways*. EAI/Springer Innovations in Communication and Computing. Springer, Cham. https://doi.org/10.1007/978-3-030-66042-0_9

Autonomous Driving in the Real-World: The Weather Challenge in the Sohjoa Baltic Project

Mauro Bellone, Azat Ismailogullari, Jaanus Müür, Oscar Nissin, Raivo Sell, and Ralf-Martin Soe

1 Introduction

According to [1] in the United States, there are 6,301,000 vehicle crashes every year, 24% of which are related to road weather conditions. The major cause, for weather-related crashes, is the wet road surface, followed by ice and snow, revealing an important safety aspect to be considered in the future development of autonomous driving. In Europe, 29% of fatalities happen in nondry conditions (including rain, fog, snow, etc.), according to [2] showing data from 2016. The same data correlating weather conditions and autonomous driving are yet not available as most of the driverless vehicles are driving for test purposes. Furthermore, the number of crashes is not statistically significant to show, and, in fact, there are millions of vehicles driving billions of kilometers every day without crashing, while only a few of them are autonomous (e.g., the Google's fleet is currently composed of 55 vehicles driving one million of kilometers per year). This means that many more testing

M. Bellone (✉)
Chalmers University of Technology, Gothenburg, Sweden
e-mail: mauro.bellone@chalmers.se

A. Ismailogullari · O. Nissin
Metropolia University of Applied Sciences, Vantaa, Finland

J. Müür
Ragnar Nurkse Department of Innovation and Governance, Tallinn University of Technology, Tallinn, Estonia

R. Sell
Department of Mechanical and Industrial Engineering, Tallinn University of Technology, Tallinn, Estonia

R.-M. Soe
Smart City Center of Excellence, Tallinn University of Technology, Tallinn, Estonia

U. Z. A. Hamid, F. Al-Turjman (eds.), *Towards Connected and Autonomous Vehicle Highways*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-66042-0_9

vehicles would be required to effectively demonstrate safety in autonomous driving [3]. Supporting the correlation between weather and crashes, in [4] the authors investigate the impact of meteorological conditions on the frequency of road-crashes in urban environments, concluding that daily precipitation and mean temperature below 10 Celsius present a positive correlation with the number of daily crashes. There are two possible reasons: human error and machine error. Manufacturers and developers are working constantly to reduce the machine error to the minimum, and to build driving assistance systems to help to limit the human error. The effects of weather on autonomous driving and the effect of weather conditions on sensors such as GPSs, cameras, lidar, and radar are also discussed in other research studies [5, 6]. From a different perspective, standardization organizations are also contributing to create advanced standards for road vehicles functional safety (ISO26262) and sensors for autonomous driving in adverse weather (ISO/WD 24650 – under development).

Developing an autonomous vehicle (AV) involves the design of a control system able to behave according to predefined rules. This can be done in two ways, classical control theory or data-driven controllers. The classical method to address the control problem is to build a precise analytical model of the vehicle (including driving environment) and to design a controller in such a way that the process (vehicle) follows the desired behavior. Even though successful autonomous driving tests were conducted in restricted areas and test tracks in the last decades, the classical control theory approach was found as not effective to solve the autonomous driving problem in the real world. The main barrier resides in finding an analytical model that describes the real world in its entire complexity, including moving obstacles, urban traffic, and weather conditions. While those three items are all major issues deserving thorough individual studies, this chapter will mainly focus on the weather conditions.

In contrast to classical control theory, data-driven approaches seem to be effective in many real-world scenarios. Data-driven approaches are based on model identification methods that strongly depend on the big quantities of data acquisition and selection of scenarios for training and testing. However, it is often forgotten that the majority of safety-critical situations are very rare and thus hard to demonstrate in reality by including them into the testing scenarios. The main strength of data-driven methods is that they work very well with artificial intelligence (AI) and neural network-based methods.

Driving under adverse weather conditions is challenging even for experienced drivers for two main reasons (among others), namely, friction loss and sensing loss. By friction loss, one can refer to the change in adherence between the tyre and the asphalt, due to special conditions that make the road surface more slippery (for instance, snow, rain, dust, etc.). In cases of low friction, the velocity of the vehicle must be reduced to ensure safety and comfort for passengers. Sensing loss is more related to the loss of visibility (for example, in case of fog, heavy rain, and snow) or better to lack in incoming information about the external environment, resulting in a challenging issue for autonomous driving. This is a major problem as algorithms strongly rely on sensors to grab information about the environment and to derive the best action (driving decision) accordingly. The main sensors used for this purpose are image cameras and range sensors, and the process of grabbing and interpreting sensory information is typically referred to as *perception*. The reliability of sensory information is, indeed, fundamental for each control system to work properly as it affects the reliability of the controller. In the classical approach, the measure of the robustness is carried out by the designer by simulating several noise levels in different parts of the system (for instance input, control output or feedback loop), and then measuring the sensibility and sensitivity index of output signals to the noise. This method has the advantage of providing precise information about the operational range in which the system will work reliably. In AI-based autonomous driving, the system is already trained with noisy data to obtain more general-purpose controllers able to perform well also in such noisy conditions. However, these methods have a strong drawback of lacking information about the real operational range, the system has a nonzero probability to fail in any condition even without any mechanical or electronic failure.

A new trend of research is looking toward interpretable models for autonomous driving [7], meaning that driving models generated using AI should provide easy-interpretable rationales for their behavior in such a way that passengers, insurance companies, developers, etc. can understand the input–output relation for specific behaviors. This is in response to a specific change in the legislation, which is included in the GDPR directive, namely, the *right of explanation* [8]. This can be considered analogous to the *Algorithmic Accountability Act* [9] recently introduced in the legislation of the United States. The rationality of this concept is that many algorithms present abstract decision-making capabilities, and, according to the recent regulation, a user can ask for an explanation about an algorithmic decision. This is in direct conflict with pure AI-based algorithms that are able to take decisions without any rational explanation.

This chapter will further describe sensors and related issues in detail, starting from a description of our use-study case project (Sohjoa Baltic) in Sect. 2, then the most recent technologies for sensors and intelligent driving are reviewed in Sect. 3, with specific reference to weather-related issues, including a description of typical testing environments that are used in the research phase to measure the performance of sensors and algorithms. As most of the technologies available today are based on data coming from sensors, the problem of intelligent perception and how to interpret such a big quantity of data is described in Sect. 4, leading the reader to the most valuable asset in today's technology: data sets. Many research and industrial players are acquiring and providing publicly available data sets to be used by anyone who is willing to contribute to the field. A list of data sets available today is given in Sect. 5, with a specific distinction between real road data and simulated data. Finally, Sect. 6 provides a qualitative description of the pilot studies in Sohjoa Baltic project and how the weather affected the performance during the pilot studies. Relevant conclusions and ideas for further studies are given in Sect. 7.

2 Piloting Autonomous Electric Minibuses: Sohjoa Baltic

Sohjoa Baltic (EU's Interreg BSR funding) researches, promotes, and pilots automated, driverless electric minibuses as part of the public transport chain, especially for the first/last-mile connectivity. The project studies the environmentally friendly and smart automated public transport solutions, also providing guidelines on legal, regulatory, and organizational setup needed for running such a service in an efficient way in the Baltic Sea Region. Driving in the Baltic Sea Region is challenging for different reasons, the legislative aspect was investigated in several project studies resulting in nonharmonized legislation and standardization among different states in the European Union [10]. Finland and Norway have been reliable testbeds as it was possible to acquire special permits from local transportation authorities for autonomous driving on public roads.

In order to have sufficient diversity, during the project (2017–2020), six partner cities planned to take on the autonomous public transportation trials, open to the public and running in mixed traffic on a regular timetable with different schedules, routes, and their own bus stops. The cities of Kongsberg (NO), Helsinki (FI), Gdansk (PL), and Tallinn (EE) launched their pilots in 2018–2019. Tallinn pilot was paused for the winter and will continue in spring 2020. Unexpected Danish regulatory issues lead to the cancellation of the pilot in Vejle (DK).

The schedule of the pilots was chosen also in consideration of the climate conditions in the specific locations and the technical requirements of the buses. The underlying principle for the scheduling of the pilots in different locations is related to the investigation of the impact of weather conditions in different seasons, providing diversity of information for the study. According to the Finnish Meteorological Institute (see Fig. 1), wintertime provides less precipitation probability while having some problems with possible snow on the road, whereas summertime is characterized by higher precipitation and higher temperature. A conclusion from this analysis is that hardware itself, including sensors and electronic components, must be robust enough to work in a wide temperature range (from -20 to $+50$).

Rain and snow are critical problems for autonomous vehicles, precipitations occur all year long while the temperature may vary in a wide range. Furthermore, in conditions with extreme air temperature (below -20 °C and over $+50$ °C), many technical issues may arise with AVs. Automated vehicles are often fully electric, which may be subject to overheating in warm environments, especially if the operated route has large elevation gradients. In addition to the stress caused to the electric drivetrain, warmer temperatures dictate the need to increase the use of air conditioning, which negatively affects the operational range of the batteries.

In cold environments, unheated vehicle battery packs may show reduced performance, and the need for heating inside also negatively affects the range that can be operated between charging the vehicle. Cold weather, and changes in ambient temperature, may cause ice formation on surfaces and equipment, and removing liquid water (plumbing and seal design) is a very important design parameter in vehicles that will be operated in cold environments. Formation of ice or packed snow

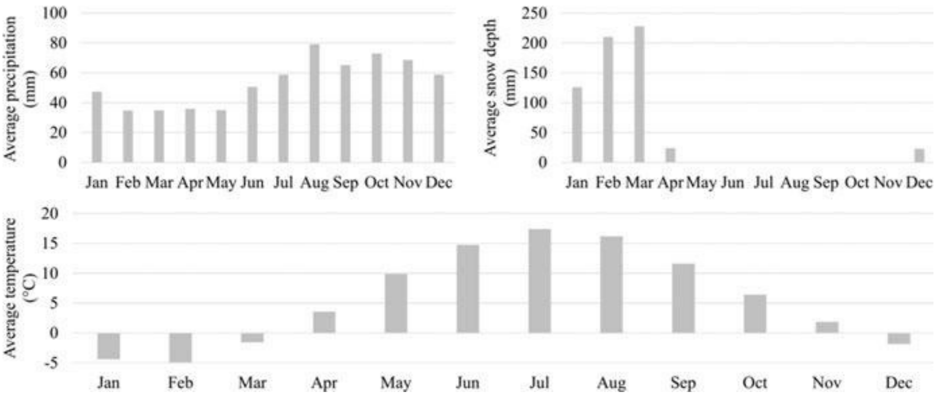

Fig. 1 Average precipitation, snow depth, and monthly temperature in Helsinki between 1961 and 2019. Data source: Ilmatieteenlaitos.fi

to the spatial awareness sensors needs to be considered in the vehicle (or operation process) design, as it might prevent the operation of the vehicle completely. Even door operation, floor heating, etc. need to be carefully studied in locations where packed snow or ice can be an issue.

Below-freezing temperatures on the road surface may cause the formation of an ice layer on top of the tarmac, yielding to lowered tyre-road friction. This is a normal phenomenon in areas, where temperatures regularly drop to freezing conditions. With regular cars and human drivers, the effects of this phenomenon are mitigated in various ways: driver training and experience, decreasing operational velocity (both by the driver voluntarily and via lowered top speed regulations), using specialized winter tyres (studded and/or high-friction rubber mixtures). These methods can be partly applied to robotic vehicles as they can use winter tyres, and they can be connected to a centralized meteorological station that can impose automatic speed limitations according to local weather conditions. The operation during low-friction conditions should take into account the vehicle speed, lowering the operational velocities. Low friction yields to increased stopping distances, as shown in (1), which generalizes the calculation for stopping distance as a factor of vehicle initial speed and friction coefficient between the tyre and the road.

$$d = \frac{v_o^2}{2\mu g} \tag{1}$$

where d (m) is the stopping distance, v_0 (m/s) is the initial speed, μ is the friction coefficient, and finally g (m/s^2) the gravitational acceleration constant. In consideration of this relevant issue, in [11] the authors study a machine learning model for road surface and friction estimation using cameras. Their results show that a neural network-based model leads to 94–99% classification accuracy for dry, wet/water, slush, and snow/ice conditions. During the design of automated vehicles that will operate under nonoptimal weather conditions, designers need to take the road friction issue into account, by lowering the operational speeds and/or increasing the safety margins of reaction when an obstacle is detected, increase safety distance between vehicles, and decrease maximum deceleration (to avoid hard braking).

In areas, where snowfall is significant, the road characteristics (i.e., lane measurements and roadside profile) will change due to packed snow. If robotic vehicles operate on a road from which the accumulated snow is removed by plowing, the snowbanks on the roadside could be interpreted as a modified environment or obstacle by the vehicles, causing the operation to slow down or stop, or causing the vehicle to lose localization accuracy due to changed environmental landmarks. Furthermore, the measurements of the road lane might change because of the snow, and this may cause all traffic to travel closer to the centerline of the road, limiting the lateral distance for the robot vehicle to operate.

3 Weather-Related Effects on Sensors

The main prerequirement to achieve weather-independent autonomous driving is a proper sensor input and dependable algorithm designed to target the operational domain. All system elements, hardware and software must be reliable, properly interfaced, and designed in a way that safety is always considered as the highest priority. However, both hardware and software have limitations particularly in case of adverse weather conditions and system design requirements put additional pressure to optimize certain criteria, quite often, for example, the cost. Finding an optimal solution in these conditions without compromising safety is a challenging task. Sensor weather-limitations can be roughly divided as follows:

Functional and Parametric Limitations All sensors have functional technical parameters that are limited in their nature, alike human sensing. For example, range sensors have a minimum and a maximum distance they are able to measure or maximum sampling frequency. All these parameters may be affected by weather conditions in a different way.

Operational Limitations Every piece of hardware is always affected by the environment they are operating. For example, sensors have minimum and maximum operational temperature, humidity, etc., which cannot be violated.

Reliability and Robustness Limitations Even the highest quality hardware is not 100% guaranteed in harsh weather conditions. Sensors' signals can interrupt during the operation, or in the worst case provide a high level of noise in the data signal. Furthermore, robustness is often affected by the design requirements, such as cost optimization, thus cost-effective sensors may be preferred resulting in reduction robustness and reliability.

Interface and Communication Limitations Interfaces between sensors and computers have limitation in terms of communication bandwidth and reliability that can also be triggered by weather conditions (e.g., too hot or humid climate can influence the performance of onboard computers; heavy wind can influence the mobile network connection between the vehicle and the operation center). If the communication channel is overloaded, sensor reading may not reach the control algorithm in a proper time resulting in a full system failure.

Software Limitations Software limitations are more weather-independent, that is, affected by the system logic and may be hidden. Eliminating or at least taking into account these limitations is harder than it looks as they can appear only in worst-case scenarios. Proper simulation models and big data training sets may help find out edge cases and algorithm limitations.

Due to hardware and software limitations, it is very hard to design and implement fault-tolerant systems and ensure that autonomous driving works in every weather condition and situation. At the current state, the most advanced autonomous driving archived is SAE level 4 [12], which means full autonomy in a limited operational domain. The operational domain defines the terms and conditions when the vehicle is considered reasonably safe and can operate in autonomous mode. Beside the operational domain for the vehicles also the infrastructure may require some change to allow autonomous driving on public road, the levels are better defined as infrastructure support of automated driving, aka ISAD [13]. Operational domains can be defined according to weather conditions, traffic conditions, geographical area, etc. As an example, a level 4 AV shuttle—operational domain definition is presented in Table 1. In principle, this applies to all popular shuttles available in the market, Navya, and Easymile, just to name a few, but also to more recent ones like ISEAUTO and Gacha. Easymile EZ10 and Navya shuttles are the most common autonomous shuttles, they are both manufactured in France, and they are used in a wide range of applications (including the pilots in Sohjoa Baltic). They are both equipped with standard sensors for perception and localization, and utilize ROS (Robot Operating System) as middleware and bus interface. ISEAUTO is a last-mile AV shuttle designed and manufactured in Tallinn, Estonia, in cooperation by TalTech and the university and AuVe Tech [14, 15]. ISEAUTO is equipped with a standard set of sensors for a low-speed AV—cameras, lidars, and radar supported by GNSS, IMU, and ultrasonic sensors. The autonomy is archived by open-source software stack Autoware.AI utilizing ROS. Figure 2 shows the sensors' placement and the visual shape of the vehicle.

Sensor and algorithm limitations must be properly taken into account to implement safe autonomous vehicles. It is important to define the operational domain and if operational domain limitations are violated, for example, in extreme weather conditions, autonomous functionality must be limited, in case of SAE level 4+ [12]. The vehicle may re-adapt the level of automation to SAE level 3 or 2, and, in extreme cases, it should stop the operation and switch to manual driving or taken over by remote control.

Autonomous vehicles are constantly localized in real time through a combination of satellites, for example, Global Navigation Satellite System (GNSS) [16, 17], and odometer sensors that provide data on wheels' velocity, also referred to as

Table 1 Example of an operational domain definition for a Level 4 AV shuttle

Operational domain	Limitations	Risks
Geographic location	Predefined route with pre-recorded and clean lidar maps are required	Due the weather and season changes the maps lose accuracy
Roadway type	Paved roads only without unknown objects and potholes	Unexpected changes of the road structure due harsh weather events or reconstruction works
Speed	Cruising speed up to 30 km/h	Due the higher speed limits, vehicle may lower traffic flow
Day/night	Direct sunlight towards cameras is not allowed Driving in nighttime only allowed in urban environment with public illumination	Direct sunlight toward camera can generate loss in object detection accuracy
Weather conditions	Up to moderate rain, fog, and snow	Rapid changes of weather conditions
Traffic conditions	Light traffic only	Interference with other vehicles and road users
Network conditions	Constant online connection is required	Overload of mobile network, malfunction of network service

Fig. 2 Example of a last-mile shuttle with sensor setup, ISEAUTO

encoders; that is, mechanical motion sensors that generate digital signals in response to the motion. As satellite-localization requires a direct connection between a spot-on Earth and satellites, in the case of disrupted connection (e.g., being indoors or between tall urban buildings or extreme weather conditions), odometers help to estimate the position of the vehicle via a process commonly known as dead-reckoning [18]. Automated vehicles also need to report constantly on their exact pose and for this, GNSSs are integrated with Inertial Measurement Units (IMUs) that help to measure the vehicle's orientation using specific sensors (accelerometer, gyroscope, and magnetometer). The IMUs are typically located inside the vehicle and mounted on the chassis. They are typically not affected[1] by weather conditions. This combination helps to localize the vehicle also in tunnels and areas where satellite vision is not enough. In the case of low-speed self-driving vehicles, the localization is mostly calculated based on prerecorded point cloud map real-time distance measurements. These methods can also be combined to ensure more precise results and redundancy in case of loss of one sensor input.

The main sensors used to acquire information from the environment in autonomous driving are cameras, lidars, and radars. All these sensors have different working principles and work in different ranges in terms of illumination condition, temperature, and visibility, and they are, by far, the most affected by weather-related issues. Front and back cameras could be used to improve vehicles' global positioning, via map localization based on visual data, also referred to as visual simultaneous localization and mapping or visual-SLAM in short [19]. However, such techniques are under development in a very active research community. The real-time analysis of the surrounding environment is performed via cameras and 3D sensors with the main goal of detecting objects on the road rather than localization. The cameras are sensitive to weather conditions, for example, rain, snow, fog, and so on, and this effect has been already studied in several works. In [20], a method to benchmark image sensors' behavior in adverse weather, focusing explicitly on fog, is shown. The study provides measures for cameras tested into a fog chamber, highlighting performance at different visibility distance. Following the same line of evidence, in [21] two methods to detect fog in image cameras in night scenarios are presented. However, these methods are simply aimed at giving, to the vehicle or the driver, the information about the presence of fog, which can be used to regulate velocity or (in principle) improve perception. Working on the perception line of research, in [22] the authors propose a neural network-based algorithm to enhance visibility from cameras in poor weather with the final aim to detect and track vehicles on road, and they use simulation to show the performance under snowstorm conditions. However, monocular cameras are still tied to 2D images thus providing no information about distance.

With the final objective of having more reliable measures of the distance between the vehicle and any surrounding object in the environment, light detection and

[1]Very rare events such as magnetic storms, affecting the magnetometers inside IMUs, are not considered here.

ranging sensors, commonly known as LIDARs, are commonly used for autonomous vehicles. The working principle of this type of sensors is the measure of the time of flight of a light wave emitted and received back, providing an indirect measure of distance. LIDARs improve issues related to weather and illumination change, though subtle distortion may occur due to fog and rain, and particularly snow. Indeed, as other spatial awareness sensors, lidars are susceptible to weather effects producing opaque barriers for light to travel, resulting in a loss of intensity.

These barriers include, but are not limited to, liquid and solid water particles, in the form of ice crystals, fog and rain droplets, solid particles, such as dust, and other debris, e.g. fallen tree leaves. In these cases, the main spatial awareness sensors, the LIDARs will receive reflections from these barriers and most often vehicle systems will interpret these reflections as obstacles and initiate obstacle avoidance protocol, namely velocity reduction. Most of the current robotic bus manufacturers define operating conditions so that, during limited visibility, the autonomous operation is not permitted. Only little study has been done in research in this field, for example in [23] the authors show the effect of fog and rain on the energy attenuation of LIDARs emitted and received light, but only in simulation using synthetic data. Similar results are shown in [24], where the authors used synthetic data to predict the performance of LIDARs in the rain, underling its effect on driving assistance systems, showing a systematic reduction of object detection distance as a function of the rain rate. The same effect is not shown under snowy conditions, in this case, a snowflake hit by the laser provides an echo to the sensor resulting in false object detections [25]. This effect has been widely experienced during the pilot studies in the Sohjoa Baltic project.

A robust sensor widely used in many vehicles, for tasks such as adaptive cruise control, is the RADAR. It uses the measure of the time of flight of radio-frequency waves to build an indirect measure of distance [26]. Though based on the same principle, LIDARs and RADARs provide different accuracy as the higher frequency of light also has the advantage of having a smaller beamwidth of the wave (i.e., the opening angle from which most of the wave is emitted). The higher beamwidth of RADAR constitutes a strength in case of bad weather, making the wave able to pass through small objects [27].

By now, it should be evident that each sensor and technology has strengths and drawbacks, hence using a variety of different sensors, operating on different wavelengths in the electromagnetic spectrum, and using data combining algorithms, technique called sensor fusion would be a reasonable choice to increase the overall robustness of the vehicles [28]. Supporting this hypothesis, in [29] the authors show the performance of an algorithm that integrates information coming from LIDAR, RADAR, and camera to achieve all-weather object tracking and classification with over 80% accuracy on their benchmark. Furthermore, in [30] the authors deal safety-critical situations in automated vehicles resulting in a robust RADAR–LIDAR sensor fusion method.

3.1 Typical Testing Environments

Reliability in autonomous driving is considered a serious challenge to overcome, especially for public transportation that requires to work in any condition, including adverse weather. Weather-related issues are tested in the literature using the following methods: virtual simulation, indoor simulation, test tracks, and real environment.

In virtual simulation, it is possible to test the performance of algorithms on synthetic data. In this category, it is possible to count simulation on virtual data sets or simulated environment conditions on real data sets. For example, in [31] the authors use the data set cityscapes [32] to test the robustness of recognition algorithms by simulating fog on the real image data set. On the same line of research, in [5] the authors simulate fog on the images coming from the Kitti data set [33]. Rain is also commonly used in simulated environments to predict its effects on sensors, for instance, LIDARs [24] or cameras [34]. However, it must be noted that these techniques are not fully reliable, for example in [34], rain is simulated by simply adding vertical lines on camera images, while it is clear that the effects of rain on cameras are much more complicated than that, causing refraction and blurring on camera lenses that cannot be simply described as vertical lines.

An alternative way is to simulate weather conditions and analyze their influence on sensors by using climate chambers [35]. This means that specific laboratories must be built featuring special equipment to simulate temperature variations, rain, snow, fog, or dust. This is a reasonable compromise to have cost-effective realistic data, though not able to grab the motion effects of the vehicle. Supporting the same topic, [36] introduces a benchmark data set recorded in well-defined weather conditions in a climate chamber. In [27], the authors simulate dust (for example, during strong wind in the desert of Australia) to evaluate the performance of a radar. Whereas in [37], the authors simulate rain in a climate chamber to analyze the effect on a LIDAR and a camera positioned at the front of a vehicle. With a specific focus on LIDARs' performance or more in general on point cloud sensors, also including in the set the depth-sensing cameras, in [38] a testing methodology involving a climate chamber to validate fog and turbulent snow performance was shown, where the results clearly indicate a consistent drop of performance.

Only a little work has been done in real environments such as test tracks and public roads due to the intrinsic difficulties and costs of data acquisition. Furthermore, vehicles are typically manually driven to acquire data and test algorithms offline. One example is shown in [39], where the authors show the performance of a deep learning-based algorithm on a data set composed of 10,000 km driving in the northern countries in any weather condition. The data set used in [39] is not yet publicly available at the time of writing this chapter.

4 Intelligent Control

Human eyes have evolved in structure through the eons to improve the overall sensing capability, but this is not yet enough to justify our extraordinary ability to distinguish objects, interpret daily scenarios, and take reasonable decisions in any circumstance. Along with our eyes, neural connections and brain plasticity have also developed, resulting in a highly complex system capable of performing high-level perception. On the same line, autonomous vehicles are following two paths of evolution: the former is the hardware, sensors are becoming increasingly more accurate, whereas the latter is the software, performing an incredible amount of calculations, nearly real-time, enabling perception capabilities.

Back in the 90s, industry and academia realized that driving a vehicle was not only a matter of accelerating, braking, and steering (these operations can easily be done with high accuracy using classical control theory and feedback loops with simple controllers). The most challenging part concerns the decisional process. Given the desired vehicle speed and steering angle, a well-designed closed-loop control system is capable of following the desired behavior, but the real question is: which is the desired behavior?

The answer to this question involves the study of perception, cognition, and decisional processes. An example is given in Fig. 3, here it is possible to see different elements: what is indicated as “system” is, in fact, the vehicle that responds to the input u (the driver pushing the pedals or the steering wheel) with different velocity v and steering angle θ. Assuming that the vehicle is autonomous, there is a controller computing the control input to the vehicle according to the desired velocity v_{des} and steering angle θ_{des}. The controller simply reacts to the measure of the error between the desired velocity and the actual velocity (given from the measurements of the current output). Up to this point, the classical approach of control theory could provide a reasonable control law to drive the vehicle at a desired speed and steering angle.

Everything changes when one considers that the desired control input cannot be derived regardless of the driving scenario; the picture in the bottom part of Fig. 3, for example, shows a child following a ball. What will this child do in a few seconds? Will he stop? How should the vehicle react in such a situation? What is the quantity that should be measured? What is the relation between the speed of the vehicle and the approaching child?

Note that the figure is intentionally built to remind an external control loop acting on a subsystem. The external loop is dedicated to the high-level interpretation of images (perception), providing such information to a decisional process that calculates the desired control input for the subsystem. These two blocks, perception, and decisional process constitute the fundamental keys to build intelligent vehicles. Remaining on the analogy to the classical control systems, perception can be seen as the measurement process, whereas the decisional process can be seen as the controller.

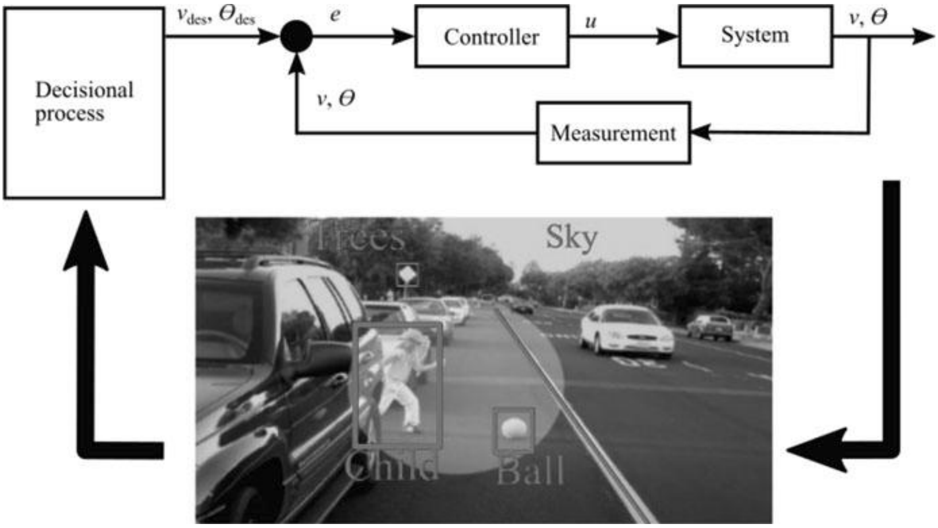

Fig. 3 Example of perception system in a feedback loop. Velocity and steering angle can be measured in an inner loop, while perception and environmental information must be processed at a higher level of the feedback loop where the decisional process takes place

Table 2 indicates the capabilities of different sensors in comparison with human eyes in specific tasks such as object detection, classification, and so on. Clearly, each sensor has strengths and drawbacks, including human eyes. The mainstream in research supports the idea that sensor fusion could be the best solution to combine information coming from different sources and reach high performances in any condition, despite weather, daylight, and other limitations [40, 41]. It is also assumed that, with proper selection of sensors and fusion algorithms, the potential perception capabilities may surpass any given single sensor performance. This aspect is very important to ensure that perception in self-driving vehicles can perform better than humans and, in turn, be much safer in any weather conditions, eventually leading to vision zero in terms of fatalities in traffic.

Assuming that the perception process provides reliable results, the decisional process could calculate the desired velocity and steering angle values for the vehicle. However, in the case of disturbances and uncertainties, like weather conditions or sensor failures, etc., the information content for the decisional process decreases leading to a high probability of global failures.

In the research community, there are two mainstream views to solve this problem: the modular approach and the end-to-end approach [42]. The former attempts to solve small problems in many separate modules that can be based on different intelligent control techniques, whereas the latter, a.k.a. *end2end*, considers the vehicle in its entirety as a black box providing a full driving model. Supporters of end2end learning propose to build a full backpropagation-based model having all sensor data as input and velocity/steering wheel angle as output. Whereas modular approaches aim at building a pipeline of individual blocks connected in a predefined

Table 2 Summary of performance for sensors in specific tasks

Performance aspect	Human	Automated Vehicle			
	Eyes	Radar	Lidar	Camera	Sensor fusion
Object detection	Good	Good	Good	Fair	Good
Object classification	Good	Poor	Fair	Good	Good
Distance estimation	Fair	Good	Good	Fair	Good
Edge detection	Good	Poor	Good	Good	Good
Lane tracking	Good	Poor	Poor	Good	Good
Visibility range	Good	Good	Fair	Fair	Good
Weather	Fair	Good	Fair	Poor	Good
Low illumination	Poor	Good	Good	Fair	Good

manner. It is clear that end2end learning can work in many circumstances providing a very high capacity of generalization and abstraction. The biggest concern with end2end is that they tend to oversimplify the problem and an error in the control system is unpredictable and very hard to detect in a testing stage, leading to untestable AI [43]. This is the main argument to support modularity in systems that can be better interpreted and debugged.

Please note that it is not in the objective of this chapter to provide theoretical knowledge about AI and data-driven tools for control and perception, for which the reader can refer to [44], containing a thorough explanation of many data-driven techniques for control, and [45] for a theoretical background about deep learning.

5 Data Hunger

Along with the chapter, the shift from the classical approach for vehicle control to the machine learning-based approach was mentioned; the main reason is that ML is expected to solve the problem of perception in autonomous driving using data as the main driving force. As past applications of ML shown, the more the data the better the solution that any AI-based system can provide. The result is that research and industry require massive quantities of data to work with, generating a race toward big data acquisition that has seen a continuous increment of both open and privately owned data sets.

Nowadays, data are considered a valuable asset, generating massive investments though not yet enough to feed the data hunger. Indeed, the real question is: how much data should autonomous vehicles collect to generate a reasonable driving model? Currently, Google (with its subsidiary Waymo) has a fleet composed of roughly 55 vehicles tested for over one million kilometers per year, corresponding roughly to 30,000 h of driving, which is more or less what one taxi driver does in his/her entire work life. Such data cover most of the common scenarios, different illumination conditions, and weather, but still not enough to be considered safe [3]. The reason why autonomous driving is not considered safe yet is to be found by analyzing the driving statistics, which, for most of the situations, involves previously seen and predictable scenarios. However, unpredictable events, though part of the real driving scenarios, hence probable, cannot be considered as outliers, as they can generate catastrophic events. This concept is known in economics as “the black swan,”, but often neglected in AI systems, though fundamental to reach a high level of safety. The black swan is an example of an event that can occur with low probability, thus part of the distribution, and with major effects on the system. Swans are white, should a black one still be considered as a swan? For an intelligent system to recognize unpredictable events effectively, it is necessary to acquire as much information as possible regarding the occurrence of such events that for autonomous driving correspond to safety loss. To answer the initial question, we do need more data describing unpredictable events and variability, but many hours of driving are required to find a black swan.

Table 3 provides a review of the most common data sets publicly available today with relative literature references. The items in the list have been categorized by year of acquisition (or publication), sensors available, illumination, and weather scenarios. In [46], a table listing data set for autonomous driving from 2001 to 2007 is available as a sign of the activities of the last 20 years in the field; those data sets have been omitted in Table 3.

The first important evidence from Table 3 is that the sensor configuration is not consistent, only some of the data set provides visual information, depth information, and geo-localization. This means that this data can hardly be integrated into each other to abstract more knowledge for the learning procedures of the algorithms. Not all of them contain scenes in daylight and nightlight, resulting in a lack of generalization of illumination during the driving data. As expected, most of the data sets contain sunny scenes (typically including also cloudy scenarios), but not many include rain, fog, or snow, and only a few of them contain all those scenarios. Exploring the data sets in detail, it is also possible to note inconsistencies in scenes labeling, which results in poor algorithmic performance.

However, it is important to emphasize that all these data sets have been acquired with a big effort from providers. This must be acknowledged as a relevant result without which the most recent results in perception would not have been achieved. Besides the technical issues to overcome, also legal restrictions are preventing big data sets to be recorded and used. For this reason, a recent trend of research is investigating the use of virtual data sets (see Table 4), which are cost-effective and prevent any legal issue related to driving autonomous vehicles in the urban environment. This trend started in the last 5–10 years with the objective to improve consistency and generality in the data, and the trend keeps growing. In virtual data sets, one can find all scenarios, including rain, fog, and snow, generated by simulating cars driving in realistic game-like environments. It has been proven that ML algorithms are able to generalize fairly well on this data, but they are less performant real scenarios.

Table 3 List of open data sets available

Data set			Sensors			Weather			
	Year	Day/night	Camera	Lidar	Geo location	Sunny	Rain	Fog	Snow
VidCam [46]	2008	D	y	n	n	y	n	n	n
Ford Campus Vision and Lidar [47]	2009	D	y	y	y	y	n	n	n
Kitti [33]	2012	D	y	y	y	y	n	n	n
Malaga urban data set [48]	2013	D	y	y	y	y	n	n	n
EISATS [49]	2014	D/N	y	n	y	y	y	y	y
KAIST multispectral [50]	2015	D/N	y	n	y	y	n	n	n
Cityscape [32]	2015	D	y	n	y	y	n	n	n
Udacity	2016	D	y	y	y	y	n	n	n
Vistas [51]	2017	D/N	y	n	y	y	y	n	n
Oxford robotcar [52]	2017	D/N	y	y	y	y	y	n	y
BDD100k [53]	2018	D/N	y	n	y	y	y	n	n
Apolloscape [54]	2018	D	y	y	y	y	y	y	n
NuScenes [55]	2018	D/N	y	y	y	y	y	n	n
A*-3D [56]	2019	D/N	y	y	y	y	y	n	n
D2city [57]	2019	D	y	n	y	y	y	n	n
A2D2 [58]	2019	D	y	y	y	y	n	n	n
KAIST Urban [59]	2019	D	y	y	y	y	n	n	n
Waymo	2019	D/N	y	y	y	y	y	n	n
Unsupervised Llamas [60]	2019	D	y	y	y	y	n	n	n

6 Experience from the Pilot Studies

The pilots in Sohjoa Baltic have provided first-hand experiences for thousands of passengers, most of them being introduced to automated vehicle transportation for the first time. To ensure safety onboard, an operator was always on board to be able to take control of the vehicle in case of an emergency. The passengers have taken part in an anonymous feedback survey, and these results indicate that traveling on a small, self-driving electric shuttle is a positive experience. It is interesting to note that roughly 80% of passengers answering the question "would you use the service with no operator on board?" were willing to consider the idea. Precisely, 35% answered "yes, definitely" and 44% answered "yes, but not now," demonstrating that all these pilot projects help to improve technology and to build the right environment for communities to accept innovation. However, during these

Table 4 List of open virtually generated data sets available

Data set	Year	Day/night	Sensors				Weather		
			Camera	Lidar	Geo location	Sunny	Rain	Fog	Snow
Synthia [61]	2016	D/N	y	y	y	y	y	y	y
P.F.B [62]	2017	D/N	y	y	y	y	y	y	y
Virtual Kitti [63]	2017	D/N	y	y	y	y	y	y	n
Virtual Kitti 2 [64]	2020	D/N	y	y	y	y	y	y	n
Marulan [65]	2010	D/N	y	y	y	y	y	y	y
PixelAccurate DepthBenchmark [66]	2019	D/N	y	y	y	y	y	y	n
CARLA [67]	2017	D/N	y	y	y	y	y	y	y

pilots, a responsible and qualified operator has been always onboard explaining the technology answering passengers' questions regarding the functions of the vehicle. This may have some impact on the passengers' feedback.

Three big pilots have been implemented along with the Sohjoa Baltic project and here the experience will be shared with specific focus to the city of Helsinki in Finland, Tallinn in Estonia, and Kongsberg in Norway, the route for each pilot is shown in Fig. 4. Although these pilots are not enough to fully demonstrate safety in autonomous driving in the urban environment for public transportation purposes, the pilots surely contribute to the development of the technology, build trust in future users of the public transportation and helps to identify possible causes of failures that can be debugged by manufacturers.

Three small pilots are also planned into the project, but only one of them already took place. The small pilot in Gdansk (Poland) was active for a month, from September 6th to October 4th, 2019, on the bus line 322 going to the city zoo. The automated bus was active 7 days a week and 5 h per day free of charge for passengers and transported over 3300 travelers during the operation. As indicated in Table 5, the length of the path was 1.8 km for a round trip, going back and forth between the two different points shown in the map in Fig. 4d. In this case, differently from the others, the bus was going back and forth on the same route, while in Helsinki and Tallinn the route was designed as a closed loop. The maximum speed for all the pilots was limited to 15 km/h, the average speed during the pilot in Gdánsk was 8.22 km/h, and the bus had three stops during the path.

6.1 *Observation from Helsinki Trials*

The Sohjoa Baltic pilot in Finland took place in Helsinki, more specifically at the Aurinkolahti residential area. The pilot route went from Vuosaari metro station

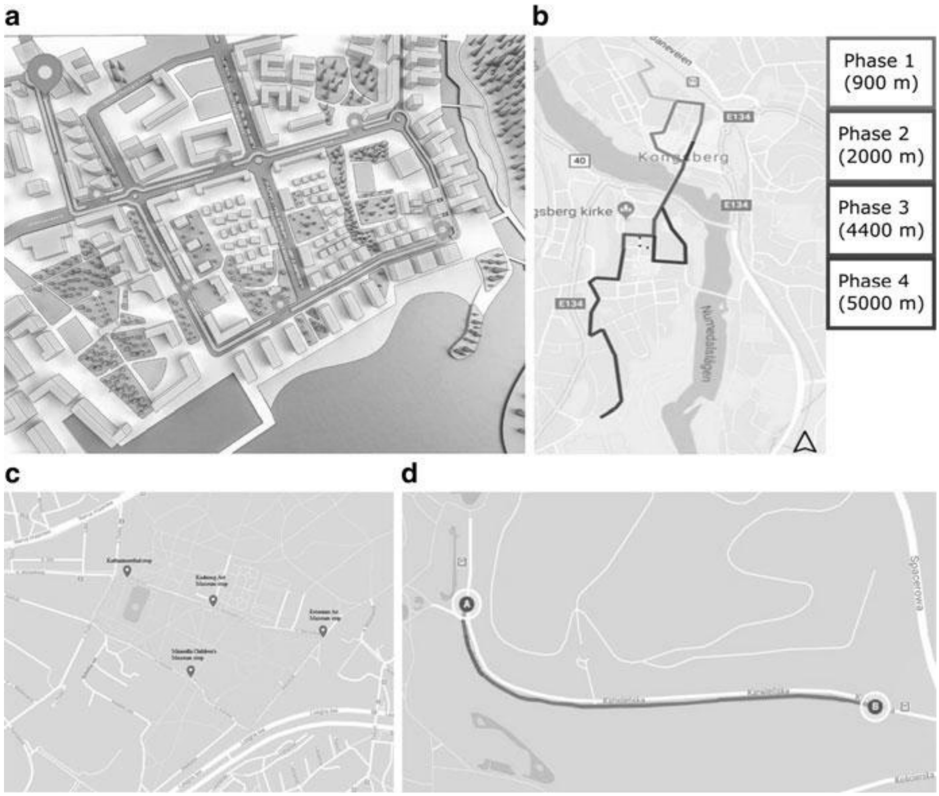

Fig. 4 Depiction of the routes of the buses during the pilots in Helsinki (**a**), Kongsberg (**b**), Tallinn (**c**), and Gdansk (**d**). Path lengths and other parameters are summarized in Table 5

Table 5 Summary of pilots' characteristics in terms of path length, average speed, travel time, and number of stops. For Kongsberg 5000 m refers to phase 4 (see Fig. 4)

Pilot	Path length [m]	Average speed [km/h]	Travel time [min]	Number of stops
Helsinki	2500	7.5	20	7
Tallinn	1700	7	15	4
Kongsberg (p4)	5000	8	37	8
Gdánsk	1800	8.22	14.5	3–5

(eastern terminus) to the Aurinkolahti beach and back. The scheduled duration of the operation was 4 months, from June 2019 to September 2019 (included). During the pilot, the robotic bus drove 2596 km (automatic + manual) with a total of 3932 passengers. In Fig. 5, the driving distance and the number of passengers per day is shown, the chart also shows the rainy days denoted by using blue areas. The pilot was stopped earlier than expected because the shuttle faced a battery-related issue. The vehicle used on the site is manufactured by the French company Navya and was both leased from and operated by the Danish company Holo with a partnership to Metropolia University of Applied Sciences.

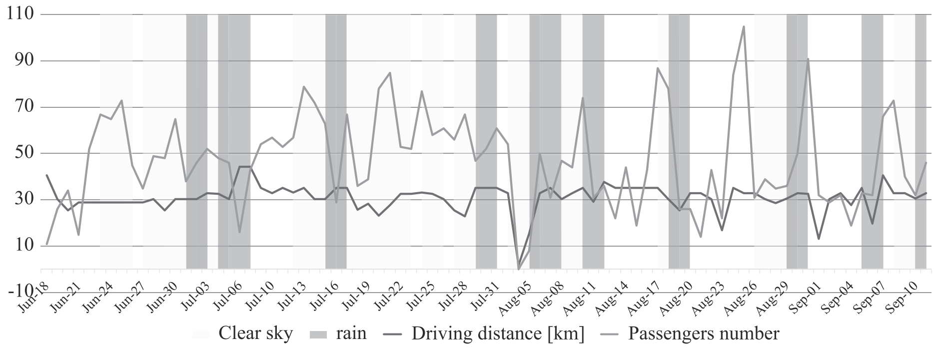

Fig. 5 The chart shows the distance driven by the vehicle per day (blue line) and the number of passengers (orange line). Blue areas denote the rainy days during the pilot, whereas the light-orange areas are the full sunny days

Sometimes the operator was obligated to switch to from automatic mode to manual mode for different reasons, for example, leaves falling from trees have been wrongly detected as obstacles causing many hard brakes that can endanger passengers. The reduction of false object detections (also known as false positive) is an important direction for research as the robustness of the algorithms is not yet sufficient for an effective drive. Frequent false detections oblige the operator to switch to manual mode, but on the other hand, a missing detection would generate a crash, and for this reason, the manufacturer still preserves conservative policies to ensure safety for passengers. Heavy rain and strong wind also affected the operation causing interruptions or switch to manual mode.

During the pilots, a base station to improve GPS localization was used. The base station was installed on the roof of the highest building on the route. The station had to be rebooted manually a few times during the pilot months, this was not always easy or even impossible as a thunderstorm prevented operators to restart the base station.

One of the main issues that unfortunately cannot be truly quantified is related to localization and mapping. In literature, there are no effective and fully working methods to update the map and perform localization in real-time during the bus operation. The result is that the map is firstly recorded before the pilot, the autonomous bus then drives always on the same map. Growing vegetation, snowbanks, and building renovation generates slight changes in the original map, making the localization capability of the vehicle to decrease drastically.

6.2 *Experience from Kongsberg*

The pilot in Kongsberg took place from October 2018 to June 2019, transporting 2.064 passengers. The vehicle used during the pilot was provided by Easymile, EZ10 Generation 2, and organized in cooperation with the local private company AppliedAutonomy and the Municipality of Kongsberg. Defining the pilot route was one of the first tasks done and part of a phase 1 preproject in the form of a workshop. Several alternatives were considered and evaluated with regards to safety, usefulness, visibility, feasibility, scalability, and cost. The chosen route was extended in several steps, both to ensure security and fulfill the legislative requirement for gradual implementation and to assess the public's response at the same time. A new risk assessment had to be submitted to the national traffic authority for each stage of the route scaling. See Fig. 4b for the phases of the route scaling.

In October 2018, the phase one started, and a bus was put into operation on a short route (900 m) to be considered as an initial test. At the end of October 2018, the route was extended into phase two, now the path length was 2 km (including the route of phase 1). In April 2019, the route was extended further in phase three, now reaching from one end of town to the other (4.4 km, including the routes of phases one and two). The pilot was in operation until June 2019.

A challenge in the route planning arose when road works had to be executed on part of the pilot route. As a result, the route was adapted (as increased in length from 4.4 km to 5 km) and a new risk analysis had to be conducted.

The vehicle operators were employees of Vy (the national Norwegian railway company). Each operator must have a valid driving license and be trained by the vehicle provider and on the pilot track. A total of six vehicle operators and employees of Vy were trained and certified by Applied Autonomy. The operators had extensive experience with public transport, which proved to be useful as it helped with the evaluation of traffic patterns, quick learning the vehicle behaviors, and good interaction with passengers. The operators also reported any anomalies of the vehicle and the route and made proposals for improvements.

6.3 Tallinn Pilot Study

The first long-term open traffic robotic bus pilot in Estonia started its operations on August 28, 2019, in Kadriorg Park, which is located right next to the Presidential Palace and Kadriorg Palace. The operations were paused December 21, 2019, due to winter conditions (overnight charging too complicated when outside weather below 5 degrees Celsius). The bus is manufactured by the French company Navya and was delivered by the Danish company Holo who is the contract partner to Tallinn Transport Department. The operators are students from Tallinn University of Technology who passed the 2-week training organized by Holo. Before the start of operations, the bus had to pass an exam organized by the Estonian Road Administration to ensure the safety of the bus and its capability to drive in open traffic.

The bus drives in a circle around the park and takes the passengers to the Estonian Art Museum. The bus runs regularly from Tuesday to Sunday between 10.00 and

6.00 (till 18.00 on Thursday, Saturday, and Sunday) and carries passengers free of charge. The bus seats eight passengers at a time. The bus drives around the Kadriorg Park and has four stops: Katharinenthal cafeteria located close to the Kadriorg tram stop, Kadriorg Art Museum, Estonian Art Museum, and Miiamilla Children's Museum (Fig. 4c). All passengers can download the Letsholo app from Google Play or Apple App Store to see the real-time location of the bus. Approximately 100 people were using the service during the operational days, although there have been several issues that have influenced the stability of operation.

6.3.1 Weather Conditions and Issues of the Pilot

This section will give an overview of how weather conditions affected the pilot in Tallinn. The section is largely based on the chat log with operators. The chat was used for everyday communications between the operators and responsible personnel from Tallinn Transport Department and Tallinn University of Technology. Atlas.ti software was used to filter out issues related to weather issues. Code words such as "leaves," "rain" ("vihm"), "temperature" ("temperatuur"), "snow" ("lumi"), "battery" ("aku"), "tree branches" ("puuoksad"), "wind" ("tuul"), "snow" ("lumi"), and "slush" ("lörts") were used to find relevant discussions. Relevant parts were later marked as quotes, and the code words were attached to them.

First, operators were surprised that the autonomous bus had so many issues, and other sites of Holo operations in Norway (Oslo) and Finland (Helsinki) had similar issues with constant downtime. The most common issues were related to technology, traffic, and weather.

Technology The main reason for several technology-related errors was that the technical support was managed from the distance (from Denmark and/or France). For example, there was an issue with doors not working properly, and it took one operator 4 days to understand how to open and close these doors. In addition, the distant problem-detection decision tree made an assumption that most challenges are related to issues with the software, although the problem with doors was actually a mechanical one.

Traffic The operation was ceased for weeks due to one traffic accident with a heavy-good-vehicle that ignored the automated bus and hit it at a slow speed. In addition, every-day operations were influenced by cars parked on the road (often illegally), cars driving in the opposite direction (illegally). In addition, the bus does not understand the concept of congestion, it just starts beeping once there are cars waiting at the traffic junction.

Weather All operators agreed that the weather had an impact on the operation. During the operations from the end of August till December 21, the main issues linked to weather conditions were related to precipitation, temperature, and seasonal changes.

All the weather conditions were also related to seasonal changes. Rain, falling, and already fallen leaves were the main weather-related issues in September and October. While falling and already fallen leaves made the bus to have the emergency stop 10–15 times per circle, the combination of leaves with heavy rain made it impossible for a bus to drive smoothly. It must be pointed out that precipitation in autumn 2019 was above the norm of previous years: September 115% of the norm, October 144% of the norm, November 85% of the norm (no operations in November because of technical issues). Such changes in weather need to be taken into consideration in the development of sensor technology.

In December, temperature started to become an issue because of two reasons. When the bus was not operating, it was stored in the outside tent located at the parking lot of the Estonian Art Museum as there was no warm garage in the vicinity that could be used. After each day of operation, the bus was left to the tent with its battery charging for the next morning. Battery charging issues started when the outside temperature fell below +5 degrees Celsius as it did not charge properly. The cold temperature made it also necessary to turn on the air conditioning. This decreased the daily operating hours because of the increased power consumption.

7 Conclusions

This chapter covered several aspects related to autonomous driving in a real-urban environment with a specific focus on weather-related issues. Clearly, going out from the testing scenarios introduces a high number of challenges to overcome and unpredictable effects. Due to the hardware and software limitations, it is very hard to design and implement fault-tolerant systems and to ensure that autonomous driving works in every weather condition and situation. At the current state, the most advanced autonomous driving archived is SAE level 4, which means full autonomy in a limited operational domain. The operational domain defines the terms and conditions when the vehicle is considered reasonably safe and can operate in autonomous mode. An operational domain can be defined according to weather conditions, traffic conditions, geographical area, etc. However, it must be said that the automated shuttles used in this studied have shown autonomous driving capabilities of SAE level 3, too many times the operator had to take over the vehicle in case of emergency.

The experience gathered from real-world piloting of automated buses for public transportation is a valuable achievement, highlighting how many practical issues may occur during a pilot. The main challenge faced during the pilots of Sohjoa Baltic is the technical immaturity of the robotic buses. Their reliability is not yet on the level that operators would like it to be. The pilots have been done with a relatively small budget, which in many cases does not allow operators to have spare vehicles in case of failures. Therefore, the operation has had many cancellations because of technical issues with the only bus available on the site.

Fig. 6 Roadmap of predicted future evolution of the usage of autonomous driving in public areas

From the authors' perspective, all these challenges will be overcome in the next future, but further testing and pilots are still required to identify possible causes of danger and make the vehicles safer. The authors' vision is summarized in the roadmap presented in Fig. 6, foreseeing further pilot projects at low speed for the next 5 years. It will probably be possible to see an autonomous bus in continuous operation, though with many limitations only in 5–10 years from now. This may seem a pessimistic vision, though a realistic one. The full automation in mixed traffic for rural and urban areas will be seen in roughly 15 years from now, this will be the real integration in the mobility as a service (MaaS) solution. Only when the service will be fully integrated with the public service, the real strengths of autonomous public transportation will be fully exploited.

A fundamental aspect to be further investigated in research and product development is the localization and mapping for autonomous vehicles, as there is no well-established method to update the map during the operation. The current methodology is to record one single map at the very beginning of the pilot, and never change it to allow the robot to localize in it. However, the environment is in a continuous change, trees grow, leaves fall in the autumn, snowbanks may be formed, road pavement changes, buildings get older or renovated, resulting in a lack of localization capability. Employing highly skilled engineers to constantly record and update maps is not a cost-effective solution to the problem.

One of the major challenges in the Helsinki pilot was related to incorrectly parked vehicles and drivers parking on bus stops. This reveals two additional major issues a technical issue and a social issue. The technical issue is that the robotic bus cannot adapt to humans' behavior, making the interaction in a shared environment very complex. The social issue is related to the awareness of road users that they share the environment with autonomous machines, even though simple solutions like leaflets informing about the pilot, studies shared on the windscreens of incorrectly parked vehicles reduced the problem. This is assumed to be a change in the behavior of people frequently visiting the area with their vehicles. This raises the most interesting question: Are we, as humans, ready to see robotic vehicles in our cities?

Acknowledgments The financial support of EU-Interreg through the Sohjoa Baltic project, Grant Number R073, is gratefully acknowledged.

References

1. Federal Highway Administration, *Road Weather Connected Vehicle Applications – Interim Report* – January 11, 2013 FHWA-JPO-14-124
2. European Road Safety Observatory "Annual Accident Report 2018"
3. N. Kalra, S.M. Paddock, Driving to safety: How many miles of driving would it take to demonstrate autonomous vehicle reliability? Transp. Res. A Policy Pract. **94**, 182–193 (2016)
4. A. Lobo, S. Ferreira, I. Iglesias, A. Couto, Urban road crashes and weather conditions: Untangling the effects. Sustainability **11**(11), 3176 (2019)
5. Z. Liu, Y. He, C. Wang, R. Song, Analysis of the influence of foggy weather environment on the detection effect of machine vision obstacles. Sensors **20**(2), 349 (2020)
6. S. Zang, M. Ding, D. Smith, P. Tyler, T. Rakotoarivelo, M.A. Kaafar, The impact of adverse weather conditions on autonomous vehicles: How rain, snow, fog, and hail affect the performance of a self-driving car. IEEE Veh. Technol. Mag. **14**(2), 103–111 (2019)
7. J. Kim, J. Canny, Interpretable Learning for Self-Driving Cars by Visualizing Causal Attention, in *2017 IEEE International Conference on Computer Vision (ICCV), Venice*, (2017), pp. 2961–2969. https://doi.org/10.1109/ICCV.2017.320
8. S.1108–116th Congress (2019–2020), Algorithmic Accountability Act of 2019, https://www.congress.gov/bill/116thcongress/senate-bill/1108
9. B. Goodman, S. Flaxman, European union regulations on algorithmic decision-making and a "right to explanation". AI Mag. **38**, 50. arXiv:1606.08813 (2016)
10. J. Ainsalu, V. Arffman, M. Bellone, M. Ellner, Haapamäki, et al., State of the art of automated buses. Sustainability **10**(9), 3118 (2018)
11. S. Roychowdhury, M. Zhao, A. Wallin, N. Ohlsson, M. Jonasson, Machine learning models for road surface and friction estimation using front-camera images, in *2018 International Joint Conference on Neural Networks (IJCNN)*, (IEEE, Piscataway, 2018, July), pp. 1–8
12. SAE Automotive, *Taxonomy and Definitions for Terms Related to Driving Automation Systems for on-Road Motor Vehicles*, Report J3016_201609 (SAE Automotive, Warrendale, 2016)
13. A. Carreras, X. Daura, J. Erhart, S. Ruehrup, Road Infrastructure Support Levels for Automated Driving. In proceedings of the 25th ITS world Congress, Copenhagen, Denmark, International Transport Forum, (2018, September), pp. 17–21
14. A. Rassõlkin, R. Sell, M. Leier, Development case study of the first Estonian self-driving car, ISEAUTO. Electr. Control. Commun. Eng. **14**(1), 81–88 (2018)
15. R. Sell, M. Leier, A. Rassõlkin, J.P. Ernits, Self-driving car ISEAUTO for research and education, in *2018 19th International Conference on Research and Education in Mechatronics (REM)*, (IEEE, Piscataway, 2018, June), pp. 111–116
16. B. Hofmann-Wellenhof, H. Lichtenegger, J. Collins, *Global Positioning System: Theory and Practice* (Springer, Berlin, 1997)
17. B.L. Decker, *World Geodetic System 1984*, Technical Report, DTIC Document (Defense Mapping Agency Aerospace Center, St Louis, 1986)
18. K. Park, H. Chung, J. Lee, Dead Reckoning Navigation for Autonomous Mobile Robots, In proceedings of intelligent autonomous vehicle, Madrid, Spain, March 1998, Elsevier, (1998), pp. 775–781
19. C. Chen, H. Zhu, M. Li, S. You, A review of visual-inertial simultaneous localization and mapping from filtering-based and optimization-based perspectives. Robotics **7**(3), 45 (2018)
20. M. Bijelic, T. Gruber, W. Ritter, Benchmarking image sensors under adverse weather conditions for autonomous driving. IEEE Intelligent Vehicles Symposium (IV), Changshu, China, (2018, June.). pp. 1773–1779. IEEE
21. R. Gallen, A. Cord, N. Hautière, D. Aubert, Towards Night Fog Detection through Use of in-Vehicle Multipurpose Cameras. IEEE intelligent vehicles symposium (IV), Baden-Baden, Germany, (2011, June). pp. 399–404. IEEE

22. M.S. Alluhaidan, I. Abdel-Qader, Visibility enhancement in poor weather-tracking of vehicles, in *Proceedings of the International Conference on Scientific Computing (CSC),* pp. 183–188. The Steering Committee of The World Congress in Computer Science, Computer Engineering and Applied Computing (WorldComp) (2018)
23. M. Hadj-Bachir, De Souza P., LIDAR sensor simulation in adverse weather condition for driving assistance development. HAL Id : hal-01998668. (2019)
24. C. Goodin, D. Carruth, M. Doude, C. Hudson, Predicting the influence of rain on LIDAR in ADAS. Electronics **8**(1), 89 (2019)
25. S. Michaud, J. Lalonde, P. Giguère, in IEEE International Conference on Intelligent Robots and Systems, in *Towards Characterizing the Behavior of LiDARs in Snowy Conditions*, (Hamburg, Germany, 2015)
26. I. Bilik, O. Longman, S. Villeval, J. Tabrikian, The rise of radar for autonomous vehicles: Signal processing solutions and future research directions. IEEE Signal Process. Mag. **36**(5), 20–31 (2019)
27. T. Peynot, J. Underwood, S. Scheding, Towards reliable perception for unmanned ground vehicles in challenging conditions, in *2009 IEEE/RSJ International Conference on Intelligent Robots and Systems*, (2009, October), pp. 1170–1176
28. B. Schoettle, Sensor fusion: A comparison of sensing capabilities of human drivers and highly automated vehicles. Sustain. Worldw. Transp. **12**, 1–42 (2017)
29. P. Radecki, M. Campbell, K. Matzen, All weather perception: Joint data association, tracking, and classification for autonomous ground vehicles. arXiv preprint arXiv:1605.02196 (2016)
30. N. Druml, O. Veledar, G. Macher, G. Stettinger, S. Selim, J. Reckenzaun, S.E. Diaz, M. Marcano, J. Villagra, R. Beekelaar, J. Jany-Luig, PRYSTINE-technical progress after year 1, in *2019 22nd Euromicro Conference on Digital System Design (DSD)*, (IEEE, Piscataway, 2019, August), pp. 389–398
31. C. Sakaridis, D. Dai, L. Van Gool, Semantic foggy scene understanding with synthetic data. Int. J. Comput. Vis. **126**(9), 973–992 (2018)
32. M. Cordts, M. Omran, S. Ramos, T. Rehfeld, M. Enzweiler, R. Benenson, U. Franke, S. Roth, B. Schiele, in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), in *The Cityscapes Dataset for Semantic Urban Scene Understanding*, (Las Vegas, Nevada, United States, 2016)
33. A. Geiger, P. Lenz, C. Stiller, R. Urtasun, Vision meets robotics: The KITTI dataset. Int. J. Robot. Res. **32**(11), 1231–1237 (2013)
34. M. Zhang, Y. Zhang, L. Zhang, C. Liu, S. Khurshid, DeepRoad: GAN-based metamorphic testing and input validation framework for autonomous driving systems, in *proceedings of the 33rd ACM/IEEE international conference on automated software engineering*, (Montpellier, France, 2018, September), pp. 132–142
35. R. Heinzler, P. Schindler, J. Seekircher, W. Ritter, W. Stork, Weather influence and classification with automotive lidar sensors. arXiv preprint arXiv:1906.07675 (2019)
36. M. Bijelic, P. Kysela, T. Gruber, W. Ritter, K. Dietmayer, Recovering the unseen: Benchmarking the generalization of enhancement methods to real world data in heavy fog, in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition Workshops*, (2019), pp. 11–21
37. S. Hasirlioglu, A. Riener, Challenges in object detection under rainy weather conditions, in *First International Conference on Intelligent Transport Systems*, (Springer, Cham, 2018, November), pp. 53–65
38. M. Jokela, M. Kutila, P. Pyykönen, Testing and validation of automotive point-cloud sensors in adverse weather conditions. Appl. Sci. **9**(11), 2341 (2019)
39. M. Bijelic, F. Mannan, T. Gruber, W. Ritter, K. Dietmayer, F. Heide, Seeing through fog without seeing fog: Deep sensor fusion in the absence of labeled training data. arXiv preprint arXiv:1902.08913 (2019)
40. M. Bellone, G. Reina, L. Caltagirone, M. Wahde, Learning traversability from point clouds in challenging scenarios. IEEE Trans. Intell. Transp. Syst. **19**(1), 296–305 (2017)

41. L. Caltagirone, M. Bellone, L. Svensson, M. Wahde, LIDAR–camera fusion for road detection using fully convolutional neural networks. Robot. Auton. Syst. **111**, 125–131 (2019)
42. S. Grigorescu, B. Trasnea, T. Cocias, G. Macesanu, A survey of deep learning techniques for autonomous driving. J. Field Rob. **37**, 362 (2019)
43. S. Segura, D. Towey, Z.Q. Zhou, T.Y. Chen, Metamorphic testing: Testing the untestable. IEEE Softw. **37**, 1 (2018)
44. S.L. Brunton, J.N. Kutz, *Data-Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control* (Cambridge University Press, Cambridge, 2019)
45. I. Goodfellow, Y. Bengio, A. Courville, *Deep Learning* (MIT press, Cambridge, MA, 2016)
46. G.J. Brostow, J. Fauqueur, R. Cipolla, Semantic object classes in video: A high-definition ground truth database. Pattern Recogn. Lett. **30**(2), 88–97 (2009)
47. G. Pandey, J.R. McBride, R.M. Eustice, Ford campus vision and lidar data set. Int. J. Robot. Res. **30**(13), 1543–1552 (2011)
48. J.L. Blanco-Claraco, F.Á. Moreno-Dueñas, J. González-Jiménez, The Málaga urban dataset: High-rate stereo and LiDAR in a realistic urban scenario. Int. J. Robot. Res. **33**(2), 207–214 (2014)
49. M. Rezaei, M. Terauchi, Vehicle Detection Based on Multi-Feature Clues and Dempster-Shafer Fusion Theory, in *Pacific-Rim Symposium on Image and Video Technology*, (Springer, Berlin/Heidelberg, 2013, October), pp. 60–72
50. S. Hwang, J. Park, N. Kim, Y. Choi, I. So Kweon, Multispectral Pedestrian Detection: Benchmark Dataset and Baseline, in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, (Boston, MA, USA, 2015), pp. 1037–1045
51. G. Neuhold, T. Ollmann, S.R. Bulo, P. Kontschieder, The Mapillary Vistas Dataset for Semantic Understanding of Street Scenes, in *International Conference on Computer Vision (ICCV)*, (Venice, Italy, 2017), pp. 5000–5009
52. W. Maddern, G. Pascoe, C. Linegar, P. Newman, 1 year, 1000 km: The Oxford RobotCar dataset. Int. J. Robot. Res. **36**(1), 3–15 (2017)
53. F. Yu, W. Xian, Y. Chen, F. Liu, M. Liao, V. Madhavan, T. Darrell, BDD100K: A diverse driving video database with scalable annotation tooling. arXiv:1805.04687 (2018)
54. P. Wang, X. Huang, X. Cheng, D. Zhou, Q. Geng, R. Yang, The apolloscape open dataset for autonomous driving and its application. IEEE Trans. Pattern Anal. Mach. Intell. **42**, 2702 (2019)
55. H. Caesar, V. Bankiti, A.H. Lang, S. Vora, V.E. Liong, Q. Xu, A. Krishnan, Y. Pan, G. Baldan, O. Beijbom, nuScenes: A multimodal dataset for autonomous driving. arXiv preprint arXiv:1903.11027 (2019)
56. Q.-H. Pham, P. Sevestre, R.S. Pahwa, H. Zhan, C.H. Pang, Y. Chen, A. Mustafa, V. Chandrasekhar, J. Lin, A*3D dataset: Towards autonomous driving in challenging environments. arXiv:1909.07541 (2019)
57. Z. Che, G. Li, T. Li, B. Jiang, X. Shi, X. Zhang, Y. Lu, G. Wu, Y. Liu, J. Ye, D2-City: A large-scale dashcam video dataset of diverse traffic scenarios. arXiv:1904.01975 (2019)
58. J. Geyer, Y. Kassahun, M. Mahmudi, X. Ricou, R. Durgesh, A.S. Chung, L. Hauswald, V.H. Pham, M. Mhlegg, S. Dorn, T. Fernandez, A2d2: Audi autonomous driving dataset. arXiv preprint arXiv:2004.06320 (2020)
59. J. Jeong, Y. Cho, Y.S. Shin, H. Roh, A. Kim, Complex urban dataset with multi-level sensors from highly diverse urban environments. Int. J. Robot. Res. **38**(6), 642–657 (2019)
60. K. Behrendt, R. Soussan, Unsupervised Labeled Lane Markers Using Maps, in *Proceedings of the IEEE International Conference on Computer Vision Workshops*, (Seoul, Korea, 2019)
61. G. Ros, L. Sellart, J. Materzynska, D. Vazquez, A.M. Lopez, The SYNTHIA Dataset: A Large Collection of Synthetic Images for Semantic Segmentation of Urban Scenes, in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, (Las Vegas, Nevada, United States, 2016), pp. 3234–3243
62. S.R. Richter, Z. Hayder, V. Koltun, Playing for Benchmarks, in *IEEE International Conference on Computer Vision (ICCV)*, (Seoul, Korea, 2017), p. 3

63. A. Gaidon, Q. Wang, Y. Cabon, E. Vig, Virtual Worlds as Proxy for Multi-Object Tracking Analysis, in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, (Las Vegas, Nevada, United States, 2016), pp. 4340–4349
64. Y. Cabon, N. Murray, M. Humenberger, Virtual KITTI 2. arXiv preprint arXiv:2001.10773 (2020)
65. T. Peynot, S. Scheding, S. Terho, The Marulan data sets: Multi-sensor perception in a natural environment with challenging conditions. Int. J. Robot. Res. **29**(13), 1602–1607 (2010)
66. T. Gruber, M. Bijelic, F. Heide, W. Ritter, K. Dietmayer, Pixel-accurate depth evaluation in realistic driving scenarios. arXiv preprint arXiv:1906.08953 (2019)
67. A. Dosovitskiy, G. Ros, F. Codevilla, A. Lopez, V. Koltun, CARLA: An open urban driving simulator. arXiv preprint arXiv:1711.03938 (2017)

Publication V

1.1 **Müür, J.**, Karo, E. (2023) "Learning from public sector innovation pilots: the case of autonomous bus pilots." *Innovation: The European Journal of Social Science Research*. 1-24. https://doi.org/10.1080/13511610.2023.2286438

Curriculum vitae

Personal data

Name:	Jaanus Müür
Date of birth:	15.11.1990
Place of birth:	Iisaku, Estonia
Citizenship:	Estonian

Contact data

E-mail:	Jaanus.muur@taltech.ee

Education

2017–2022	Tallinn University of Technology – PhD in Public Administration (specialization in Technology Governance)
2013–2017	Tallinn University of Technology – MA in Technology Governance (*cum laude*)
2010–2013	Tallinn University of Technology – BA in Public Administration (*cum laude*)
1998–2010	Iisaku Gymnasium (silver medal)

Language competence

Estonian	Native
English	Fluent
German	Basic
Russian	Basic

Professional employment

2017–…	Tallinn University of Technology, School of Business and Governance, Ragnar Nurkse Department of Innovation and Governance, Project assistant
2017–2020	Tallinn City Enterprise Department, Project manager
2015–2017	Federation of Estonian Student Unions, Chairperson
2014–2015	Mandatory military service
2012–2014	Student Union of Tallinn University of Technology, Member of the Board

Defended dissertations

Jaanus Müür, Master's Degree, 2017, (sup) Tarmo Kalvet, The Role of State-Owned Enterprises in the Internationalisation of Local Companies: The Case of Eesti Energia's Shale Oil Production, Tallinn University of Technology, School of Business and Governance, Ragnar Nurkse Department of Innovation and Governance.

Honours and awards

2022, Jaanus Müür, Dean's letter of appreciation for a published paper ("Intermediating Smart Specialisation and Entrepreneurial Discovery: The Cases of Estonia and Helsinki-Uusimaa." *Journal of the Knowledge Economy*) – Tallinn University of Technology, School of Business and Governance

2014, Jaanus Müür, Silver Merit Badge – Federation of Estonian Student Unions

2014, Jaanus Müür, Silver Merit Badge "FIDELIS STUDIOSUS" – Student Union of Tallinn University of Technology

2014, Jaanus Müür, Jaan Poska scholarship – Tallinn University of Technology, Tallinn City Government

2012, Jaanus Müür, Professor, Dr. Anne Jennings Smith, and Gerhard Treuberg scholarship – Rotalia Foundation

Publications

1.1 Müür, J. (2022) "Intermediating Smart Specialisation and Entrepreneurial Discovery: The Cases of Estonia and Helsinki-Uusimaa." *Journal of the Knowledge Economy, 13*, 541-573. https://doi.org/10.1007/s13132-021-00757-2

1.1 Valdmaa, K., Pugh, R., **Müür, J.** (2021) "Challenges with strategic placed-based innovation policy: implementation of smart specialization in Estonia and Wales." *European Planning Studies*, *29*(4), 681-698. https://doi.org/10.1080/09654313.2020.1767541

3.1 Bellone, M., Ismailogullari, A., **Müür, J.**, Nissin, O., Sell, R., Soe, R.-M. (2021) "Autonomous Driving in the Real-World: The Weather Challenge in the Sohjoa Baltic Project." *In*: Hamid, U.Z.A., Al-Turjman, F. (*eds*.) *Towards Connected and Autonomous Vehicle Highways*. EAI/Springer Innovations in Communication and Computing. Springer, Cham. https://doi.org/10.1007/978-3-030-66042-0_9

1.1 Soe, R.-M., **Müür, J.** (2020) "Mobility Acceptance Factors of an Automated Shuttle Bus Last-Mile Service." *Sustainability, 12*(13), 5469. https://doi.org/10.3390/su12135469

2.5. Müür, J.; Rutanen, E.; Ronke, R. (2020) "Starting Your Own Pilot – Sohjoa Baltic. The Roadmap to Automated Electric Shuttles in Public Transport." *Helsinki: Publications of Metropolia UAS, OIVA-series 25*. Available: https://urn.fi/URN:ISBN:978-952-328-246-9

1.1. Ainsalu, J.; Arffman, V.; Bellone, M.; Ellner, M.; Haapamäki, T.; Haavisto, N.; Josefson, E.; Ismailogullari, A.; Lee, B.; Madland, O.; Madžulis, R.; Müür, J.; Mäkinen, S.; Nousiainen, V.; Pilli-Sihvola, E.; Rutanen, E.; Sahala, S.; Schønfeldt, B.; Smolnicki, P. Marek; Soe, R.-M. ... Vaskinn, I.: Åman, M. (2018) "State of the Art of Automated Buses." *Sustainability*, *10*(9), 3118. https://doi.org/10.3390/su10093118

2.5. Karo, E., Müür, J., Kirs, M., Juuse, E., Ukrainski, K., Shin, Y., Kokashvili, N., Tänav, T., Masso, J., Terk, E. (2018) "Eesti ettevõtete osalemine rahvusvahelistes väärtusahelates ja poliitikameetmed kõrgemat lisandväärtust andvate tootmisprotsesside toetamiseks." https://www.etag.ee/wp-content/uploads/2018/06/Eesti-ettev%c3%b5tete-osalemine-rahvusvahelistes-v%c3%a4%c3%a4rtusahelates.pdf

Elulookirjeldus

Isikuandmed

Nimi:	Jaanus Müür
Sünniaeg:	15.11.1990
Sünnikoht:	Iisaku, Eesti
Kodakondsus:	Eesti

Kontaktandmed

E-post:	jaanus.muur@taltech.ee

Hariduskäik

2017–2022	Tallinna Tehnikaülikool – PhD avalik haldus (spetsialiseerumine tehnoloogia valitsemisele)
2013–2017	Tallinna Tehnikaülikool – MA tehnoloogia valitsemine (*cum laude*)
2010–2013	Tallinna Tehnikaülikool – BA avalik haldus (*cum laude*)
1998–2010	Iisaku Gümnaasium – Keskharidus (hõbemedal)

Keelteoskus

Eesti keel	Emakeel
Inglise keel	Kõrgtase
Saksa keel	Algtase
Vene keel	Algtase

Teenistuskäik

2017–...	Tallinna Tehnikaülikool, Majandusteaduskond, Ragnar Nurkse innovatsiooni ja valitsemise instituut, projekti assistent
2017–2020	Tallinna Ettevõtlusamet, projektijuht
2015–2017	Eesti Üliõpilaskondade Liit, juhatuse esimees
2014–2015	Kohustuslik ajateenistus
2012–2014	Tallinna Tehnikaülikooli Üliõpilasesindus, juhatuse liige sotsiaal- ja spordivaldkonnas

Kaitstud väitekirjad

Jaanus Müür, magistrikraad, 2017, (juh) Tarmo Kalvet, The Role of State-Owned Enterprises in the Internationalisation of Local Companies: The Case of Eesti Energia's Shale Oil Production (Riigiettevõtete roll kohalike ettevõtete rahvusvahelistumisel Eesti Energia põlevkiviõli tootmise näitel), Tallinna Tehnikaülikool, Majandusteaduskond, Ragnar Nurkse innovatsiooni ja valitsemise instituut.

Teaduspreemiad ja tunnustused

2022, Jaanus Müür, dekaani tänukiri avaldatud artikli eest ("Intermediating Smart Specialisation and Entrepreneurial Discovery: The Cases of Estonia and Helsinki-Uusimaa." *Journal of the Knowledge Economy*) – Tallinna Tehnikaülikool, Majandusteaduskond

2014, Jaanus Müür, Hõbemärk – Eesti Üliõpilaskondade Liit

2014, Jaanus Müür, Hõbedane teenetemärk „FIDELIS STUDIOSUS" – Tallinna Tehnikaülikooli Üliõpilasesindus

2014, Jaanus Müür, Jaan Poska stipendium – Tallinna Tehnikaülikool, Tallinna Linnavalitsus

2012, Jaanus Müür, Professor, Dr. Anne Jennings Smith'i ja Gerhard Treubergi nimeline mälestusstipendium – Rotalia Foundation

Publikatsioonid

1.1 Müür, J. (2022) "Intermediating Smart Specialisation and Entrepreneurial Discovery: The Cases of Estonia and Helsinki-Uusimaa." *Journal of the Knowledge Economy, 13*, 541-573. https://doi.org/10.1007/s13132-021-00757-2

1.1 Valdmaa, K., Pugh, R., **Müür, J.** (2021) "Challenges with strategic placed-based innovation policy: implementation of smart specialization in Estonia and Wales." *European Planning Studies*, *29*(4), 681-698. https://doi.org/10.1080/09654313.2020.1767541

3.1 Bellone, M., Ismailogullari, A., **Müür, J.**, Nissin, O., Sell, R., Soe, R.-M. (2021) "Autonomous Driving in the Real-World: The Weather Challenge in the Sohjoa Baltic Project." *In*: Hamid, U.Z.A., Al-Turjman, F. (*eds*.) *Towards Connected and Autonomous Vehicle Highways*. EAI/Springer Innovations in Communication and Computing. Springer, Cham. https://doi.org/10.1007/978-3-030-66042-0_9

1.1 Soe, R.-M., **Müür, J.** (2020) "Mobility Acceptance Factors of an Automated Shuttle Bus Last-Mile Service." *Sustainability, 12*(13), 5469. https://doi.org/10.3390/su12135469

2.5. Müür, J.; Rutanen, E.; Ronke, R. (2020) "Starting Your Own Pilot – Sohjoa Baltic. The Roadmap to Automated Electric Shuttles in Public Transport." *Helsinki: Publications of Metropolia UAS, OIVA-series 25*. Available: https://urn.fi/URN:ISBN:978-952-328-246-9

1.1. Ainsalu, J.; Arffman, V.; Bellone, M.; Ellner, M.; Haapamäki, T.; Haavisto, N.; Josefson, E.; Ismailogullari, A.; Lee, B.; Madland, O.; Madžulis, R.; Müür, J.; Mäkinen, S.; Nousiainen, V.; Pilli-Sihvola, E.; Rutanen, E.; Sahala, S.; Schønfeldt, B.; Smolnicki, P. Marek; Soe, R.-M. ... Vaskinn, I.: Åman, M. (2018) "State of the Art of Automated Buses." *Sustainability*, *10*(9), 3118. https://doi.org/10.3390/su10093118

2.5. Karo, E., Müür, J., Kirs, M., Juuse, E., Ukrainski, K., Shin, Y., Kokashvili, N., Tänav, T., Masso, J., Terk, E. (2018) "Eesti ettevõtete osalemine rahvusvahelistes väärtusahelates ja poliitikameetmed kõrgemat lisandväärtust andvate tootmisprotsesside toetamiseks." https://www.etag.ee/wp-content/uploads/2018/06/Eesti-ettev%c3%b5tete-osalemine-rahvusvahelistes-v%c3%a4%c3%a4rtusahelates.pdf

ISSN 2585-6901 (PDF)
ISBN 978-9949-83-928-5 (PDF)