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Opportunities and Challenges Arising from Adapting to External Discourses, Policies, and Instruments Aimed for Sustainability Transitions: Case Studies from Estonia

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

Kaija Valdmaa

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LIST OF PUBLICATIONS

The dissertation is based on the following original publications:

I Tõnurist, P., **K. Valdmaa**, and R. Raudla. 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. (1.1)

II Valdmaa, K. 2014. "Development of the environmental taxes and charges system in Estonia: international convergence mechanisms and local factors." *Policy Studies* 35(4), 339–356. (1.1)

III Raudla, R., E. Karo, **K. Valdmaa**, and R. Kattel. 2015. "Implications of project-based funding of research on budgeting and financial management in public universities." *Higher Education* 70(6), 957–971. (1.1)

Annex:

IV Valdmaa, K., R. Pugh, and J. Müür. 2020. "Challenges with strategic placed-based innovation policy: implementation of smart specialisation in Estonia and Wales." *European Planning Studies*, under review.

AUTHOR'S CONTRIBUTION TO THE PUBLICATIONS

The main arguments of the thesis are developed in four original articles. In one article, the author of the thesis has been the sole author (**II**). In the fourth article, the author of this thesis has been the first author (**IV**), in the first article the second (**I**), and in the third the third author (**III**). In article **I**, the author of the thesis contributed by discussing the research problem and design with the lead author, conducting data collection and analysis, and summarizing the findings. In article **III**, the author was engaged in data collection and analysis and describing the main results. In article **IV**, the author of the thesis contributed by formulating the research problem and structuring the research design together with the second author and conducting data collection and analysis of the Estonian case and summarizing the findings together with the third author.

ABBREVIATIONS

CEE	Central and Eastern Europe
EDP	Entrepreneurial discovery process
ET	Environmental technologies
EU	European Union
GHG	Greenhouse gases
ISL	Industry and science linkages
MLG	Multi-level governance
MLP	Multi-level perspective
MOP	Mission-oriented policies
NPI	New policy instruments
R&D	Research and development
RDI	Research, development and innovation
STI	Science, technology and innovation
TIS	Technology innovation systems

INTRODUCTION

1 FOCUS AND AIM OF THE THESIS

Today's biggest environmental problems, like climate change, loss of biodiversity, and resource depletion, are systemic, highly complex, and comprehensive societal challenges, which are the result of unsustainable consumption and production patterns in electricity, heat, mobility, buildings, and agricultural food systems (Geels 2018a, 2018b). There is a strong scientific consensus that climate change and especially global warming are the result of human activity (Doran and Kendall Zimmerman 2011; Anderegg et al. 2010; Cook et al. 2016): increasing population, transport, and industrialization as well as the accompanying emission of GHG through the burning of fossil fuels. Climate change is also one of the biggest environment-related political discourses on the global level (**I**). The dominant narrative declares that since the cause and effect are scientifically proven, it is possible to reduce the emission of GHG if we change the technologies to greener and cleaner ones. Thus, a simple "technical-fix" should be possible from an objective, value-neutral scientific point of view (Wesselink et al. 2013). Due to this "linear" and "value-neutral" technical approach (Ibid.) and the multi-disciplinary nature of environmentally friendlier or ET (**I**; Frondel et al. 2007) that are seen as the solution to climate change related problems, far more attention has been paid to the rate of innovation (Popp et al. 2010) rather than the overall direction and the transformative nature of innovation in the global climate change discourse (Garcia and Calantone 2002; Johnstone 2005; **I**). In addition, too little attention has been paid to policy implementation and the related networks, actors, and their interactions, policy and technology co-evolution, policy goals, political commitment, and allocated resources (**I**; Kern et al. 2019).

Already in 2009, the EU set a target to reduce carbon emissions by 80–95% below 1990 levels by 2050 (European Commission 2018, 2011). This was a highly ambitious goal because in 2010 fossil fuels made up 80% of global primary energy supplies and renewable energy accounted only for 13% (IEA 2012). These goals illustrate that in the EU the energy and environmental policy are directed by the EU climate policy. Additionally, reductions of GHG of this scale affect not only the energy and environmental sector but also all the other economic, political, and social spheres. This requires comprehensive transformations to new systems called 'sustainability transitions' (Markard et al. 2012).

Sustainability transitions (Loorbach et al. 2017; Markard et al. 2012; Geels 2018b; Silva and Stocker 2018; Parris and Robert 2003) comprise long-term and large-scale disruptive societal changes to more sustainable living system in all-embracing terms. This means that less resources are used, less pollution is produced, and the resources that are used are used in the most efficient and effective way. In essence, sustainability transitions are multi-level phenomena with both bottom-up and top-down features (Loorbach et al. 2017, 605), meaning that, by definition, systemic change is the result of an interplay of a variety of changes at different levels and in different domains that interact and reinforce each other to produce a fundamental qualitative change in a societal system. There are also different approaches to sustainability transitions: socio-technical, socio-institutional, and socio-ecological (Loorbach et al. 2017). As this thesis explores mainly the transitions of technology sectors and interactions and interdependencies of actors, stakeholders, and

institutions in these sectors and transitions, the thesis focuses more on the socio-technical and socio-institutional approaches to sustainability transitions.

In line with the global discourse, over the last decades we can witness an increasing academic interest in sustainability transitions (Markard et al. 2012; Geels and Schot 2010; Parris and Robert 2003; Geels 2018a, 2018b; Köhler et al. 2018; Silva and Stocker 2018; Hölscher et al. 2018a; Hölscher et al. 2018b). There are also many studies of sustainability transitions in the energy sector (e.g. Markard 2018; Skea et al. 2011), in the urban context (e.g. Hodson and Marvin 2010; Haarstad 2016; Ehnert et al. 2018; Dowling et al. 2018; Frantzeskaki et al. 2018; He et al. 2018; Fuenfschilling et al. 2019; von Wirth et al. 2019), and about mitigating climate change through community-led actions (e.g. Henfrey and Penha-Lopes 2018; Shaw et al. 2018; Landholm et al. 2018). There are also recent studies on sustainability transitions in poorer developing countries focusing on the challenges and implications of these contexts (Wieczorek 2018; Ramos-Mejía et al. 2018).

Taking a closer look at the multi-level phenomena of sustainability transitions, there is a clear strand of research that is focused on the MLP of technological and socio-technical sustainability transitions (e.g. Geels 2018a, 2011, 2010; Genus and Coles 2008) and uses the MLP framework for exploring sustainability transitions. There are MLP studies that are especially focused on the role of innovation studies (Smith et al. 2010), policy mixes, and bridging innovation and policy studies (Kern et al. 2019) as well as some that focus on case studies of specific industrial sectors (e.g., Roberts and Geels 2019; Verbong and Geels 2007; Osunmuyiwa et al. 2018). However, the multi-level political-institutional contexts in which sustainability transitions are initiated, shaped, or inhibited, have received much less attention (Ehnert et al. 2018). Among other things, research challenges with using the MLP framework (Smith et al. 2010) emphasize that there is limited research on the geography of transitions (role of space and spatial scales in transitions), governing sustainability transitions, and incorporating the analysis of the policy process as part of the study of innovation in socio-technical systems (role of actors, rules, and policy measures, power and politics). There is additional critique towards the role and interactions between agency, power and politics, the bias regarding bottom-up change models, and the hierarchy of levels versus a flatter model characterized by multiple relations (Geels 2011). All of the previous aspects are linked with governance of multiple levels, their institutions, networks and actors, motives and interpretations, interactions and interlinkages as well as the spread and transfer of new ideas, practices, and policies, experimentation and knowledge sharing on different levels of governance.

The previously discussed challenges with the MLP approach of sustainability transitions lead us to MLG. Although MLG has been widely discussed in political science research, it has remained underexplored in the study of sustainability transitions, as pointed out by Ehnert et al. (2018). There are studies that focus on the politics of sustainability transitions (Roberts et al. 2018; Kern and Rogge 2018; Meadowcroft 2009 and 2011; Smith and Stirling 2010; Scrase and Smith 2009; Shove and Walker 2007), governance and politics of sustainability transitions (Kuzemko et al. 2016; Patterson et al. 2017; Smith et al. 2005; He et al. 2018), and the role of the state in sustainability transitions (Johnstone and Newell 2018). There are also studies on governing sustainability transitions in the urban context, but not from the perspective of MLG (Frantzeskaki et al. 2018; He et al. 2018), and there is research on sustainability governance and the components that are necessary for a multi-level governance framework (Homsy et al. 2018), but no explicit link to sustainability transitions is made.

Thus, there are only few studies from the past years that focus solely on MLG of multi-domain and multi-level sustainability transitions. Among these, some focus on sustainability transitions of TIS in the context of MLG (e.g. Chung 2018) and the majority look at the urban and provincial levels (Ehnert et al. 2018; Borgström 2019; Dowling et al. 2018; Dale et al. 2018; Späth and Rohracher 2012) and do not analyze other governance levels or the interactions between different levels.

This thesis fills a part of this gap by bridging innovation and policy studies and complementing the MLP of sustainability transitions (and especially the transition of socio-technical and socio-institutional systems) with public policy theories of MLG, policy transfer and convergence. The idea of such an analytical focus that links sustainability transitions, STI studies, and public policy is to analyze and understand the opportunities and challenges of European states arising from adapting to imported broad-level discourses, specific policies and instruments while governing sustainability transitions in the EU MLG contexts, at different governance levels and policy fields.

However, governing multi-level and multi-domain sustainability transitions through STI policies and instruments in the MLG context of the EU is facing some crucial and practical policy challenges. Comparing the logics behind the global climate change discourse, sustainability transitions, public policy, and specific STI studies, presents challenges for governance and policymaking at different levels and domains. First, the global climate change discourse is viewed as a scientific, linear, and value-neutral phenomena (Wesselink et al. 2013) with limited attention paid to the direction of innovation and the underlying processes and actors (Johnstone 2005; **I**), while sustainability transitions are seen as a multi-level and multi-domain phenomena of interplay and interaction between these levels, domains, and actors (Loorbach et al. 2017). Secondly, there is an even more fundamental complexity between public policy, sustainability transitions, and specific STI studies and models. Namely, while these STI studies emphasize bottom-up change (social innovation, experimentation, and niche-innovation) for sustainability transitions (Hossain 2016; Schot and Geels 2008; Kemp et al. 1998; Bergek et al. 2008; Verheul and Vergragt 1995) and sustainability transitions stress both top-down and bottom-up features (Loorbach et al. 2017; Geels 2018a, 2018b, 2011, 2010; Genus and Coles 2008), the traditional and mainstream public policy approaches in the EU (climate, energy, and innovation policies; also the top-down model of Europeanization) remain mainly hierarchical and top-down (Egenhofer and Alessi 2013; Dirix et al. 2013; Lenschow 2002; Schmidt 2009; Ladrech 1994; Héritier et al. 2001; Urwin and Jordan 2008). Although there are new modes emerging, e.g. the multi-level participatory implementation of environmental policy in the EU (Newig and Koontz 2014), the traditional approach to global climate policy has mainly been top-down (Falkner et al. 2010; Geden 2016; Hare et al. 2010; Green et al. 2014). These complexities present wider and quite substantial STI policy challenges in Europe, leading to some very specific governance and policy implementation problems and challenges for the member countries.

This thesis analyzes a selection of these problems and challenges but also some opportunities that countries face when adopting generic policy discourses and specific policies and instruments developed at the global and the EU levels for mitigating climate change and governing sustainability transitions. More specifically, the thesis focuses on sustainability through green and clean technologies and more concrete STI policies and instruments (e.g. economic steering policies, taxation models, science and innovation financing models) as they are seen as central mechanisms for tackling the challenges and

enabling transitions. For smaller EU member states, these discourses, policies, and instruments are quite often narratives and tools of imported policies that have been externally developed – designed at the EU level or in other more powerful member states. This thesis analyzes how such imported discourses and related STI policies and instruments are integrated and implemented and how they function in the STI, environmental, and energy sectors of one of the smallest EU member states – Estonia. Due to the multi-disciplinary and comprehensive nature of climate change and sustainability transitions, the focus of this thesis is on the very complex interplay and dynamics between the climate, energy, and environmental sectors and policy areas and STI as an enabler or challenger of sustainability transitions. In the STI sphere, specific aspects of STI policy are considered. First, the ISL in energy technologies (**I**) because their strength determines how well research results can be commercialized and used for solving grand challenges like climate change. Secondly, taxation models that influence the energy sector are analyzed (**II**) because in many countries taxes are the most common tools for dealing with climate change related problems (e.g. road taxes, consumption taxes, energy taxes). Third, funding of science is examined (**III**) because the dynamics of research systems play an essential role in enabling innovation (for fighting against climate change and speeding up sustainability transitions) that is collaboratively produced by science and industry networks. Fourth, economic steering policies (i.e. smart specialization policies) are considered (**IV**) as, in their essence, they are believed to be the ideal solutions for societal grand challenges.

Additionally, and looking from a broader perspective, this thesis also provides insights into how ideas designed at the global level evolve while moving down the governance levels and facing new or different contexts. Based on different examples, the thesis looks at whether the EU level policy discourses and imported instruments have been developed and used as originally designed or have they shifted away from the initial ideas and setup and been adapted to local contexts, and what have been the challenges and problems for small countries in these processes. On the one hand, policy diffusion, transfer, and learning in the EU might lead to higher convergence in those policy domains (fields) of member states where the EU is more in control. On the other hand, divergence might emerge as national differences might give rise to differences in local implementation, practices, and perceptions.

The topic of this thesis is particularly pertinent in light of the recently published European Green Deal (European Commission 2019) that describes climate policy as Europe's new growth strategy and given that the EU is in the process of updating its energy policy framework – the legislative package[1] called the Clean Energy for All Europeans (Clean Energy package in short). The latter was ratified in the spring of 2019 with the main aim to facilitate the clean energy transition of the 21st century, make a significant step towards the creation of the Energy Union and deliver on the EU's Paris Agreement commitments. Thus, this thesis also provides insights about historical experiences in the context of STI policy (with links to environmental and energy policy), sustainability transitions, and MLG, regarding problems and challenges that smaller states with limited governance, technology, and policy capabilities and capacities face

[1] The package includes 8 different legislative acts: Energy Performance in Buildings Directive, Renewable Energy Directive, Energy Efficiency Directive, Governance Regulation, Electricity Directive, Electricity Regulation, Risk-Preparedness Regulation, Regulation for the Agency for the Cooperation of Energy Regulators (ACER).

while implementing externally developed public policy discourses, policies, and instruments.

On the macro (external landscape) level, the thesis looks at the global and the EU policymaking levels as the highest levels where climate policies for sustainability transitions are designed. More specifically, the thesis focuses on the complementarities and interplay between the EU climate, energy, environmental, and STI policies and how they can foster sustainability transitions. On the meso and micro (regime and niche) levels, the articles analyze how the global and the EU level policies and instruments are implemented at the member state and local levels and what are the opportunities and challenges for governance to support sustainability transitions. The articles zoom in on specific STI policy aspects and focus on processes and challenges at the national level (ISL in energy technologies – **I**; development of environmental taxation of the energy sector – **II**; budgeting and financial management in public universities – **III**). In the smart specialization article (**IV**) and to some extent in the environmental taxes article (**II**), the local government level is also analyzed.

Based on the above-mentioned aspects, the thesis addresses the following research questions covering the selected aspects of STI policy that are related to energy and environmental policy on the macro, meso, and micro levels of policy, governance, and STI:

- How have the imported discourses, policies, and instruments of climate change and sustainability transitions designed at the EU and global levels been developed and adapted in member countries? Have they converged or diverged from the central EU policy and their initial ideas?
- More specifically, how have the imported STI policy discourses, policies, and instruments influenced the implementation of national policies and related networks? How have they been integrated and implemented on local levels? How have they affected the national context in striving towards sustainability transitions, and how has the local context influenced the central policies?
- The individual articles, in turn, zoom in on the following research questions:
    a. How does the global climate change discourse influence the implementation of national STI policy and ISL in the field of energy technologies (**I**)?
    b. What kind of international and local factors influence the adoption and development of NPI for sustainability transitions based on the example of the Estonian environmental taxes and charges system (**II**)?
    c. How do R&D funding models influence the sustainability of research strategies, ISL, university management, and research systems more broadly (**I**; **III**)?
    d. How can economic steering policies enable sustainability transitions? Would more focus on local governments' bottom-up EDP, mission-oriented and "place-based" strategies lead to more sustainable smart specialization (**IV**)?

Besides specific aspects of STI policy, the case studies also look at different time periods when different discourses, policies, and instruments were developed at the EU and global levels and implemented and integrated at the member state and local levels. In the 1990s, the EU industrial and environmental policies influenced policy change in European countries mainly through diffusion and learning (the example of the development of the Estonian environmental taxes and charges system – **II**). During the 2000s, central management and harmonization of R&D funding through the EU

Framework Programmes for Research and Technological Development (FP 5, FP 6, and FP 7 in particular) gained attention due to the remarkable growth in allocated funds and number of areas funded (the example of project-based funding of research – **III** and impact of climate change discourse on the energy technology ISL – **I**). In the 2010s, the focus of the EU STI policy was on harmonizing policies of economic specialization with the focus on smart specialization (the example of the smart specialization implementation and the role of local governments – **IV**).

Combined together, the articles analyze through different case studies, periods and analytical lenses how wider policy discourses and specific public policy measures developed at the EU and global levels have influenced STI, energy, and environmental policy design and implementation as well as STI networks and actors in the field of energy technologies in Estonia (i.e. ISL – **I**; taxing systems – **II**; budgeting and financial management in public universities – **III**; involvement of local government in developing smart specialization strategies – **IV**), and what have been the accompanying opportunities and challenges for governance and MLG. Most of the research conducted for this thesis focuses on green or environmental technologies (greentech), clean technologies (cleantech), and energy technologies. These are especially interesting to study because due to the dependence on fossil fuels, energy and transport sectors are now facing the biggest challenges in the transition to more sustainable systems. The thesis emphasizes the uniqueness of these technologies and the importance of understanding the differences of different technologies and related socio-institutional settings. An important part of this thesis focuses on the dynamics of industry and science networks and how the changes are perceived and interpreted by the broad range of actors engaged in these networks (research institutes, universities, enterprises, policy-makers, public support structures for innovation and entrepreneurship, etc.) who are involved in and responsible for the actual innovative activities (Taylor 2008). Furthermore, the thesis stresses the need to develop relevant technological capacities of governance for designing and implementing effective and sustainable public STI policies for climate change mitigation and sustainability transitions in practice.

Estonia serves as an interesting country for analysis due to several specific contextual and case-related reasons explained in the articles and summarized in the next section. It also has many of the small state characteristics – the combination of size, material resources, economic structure and developmental level, geographic location (core and periphery relations), and military might – that determine the extent to which a smaller state might perform as a vulnerable rather than a resistant and a passive rather than an active member of the international community (Vital 2006 [1967]; Bishop 2012; Tõnurist 2010). Randma-Liiv and Sarapuu (2019, 175) argue that global mega-trends such as climate change pose new tests for small states that are distinctive but under-researched and potentially present new challenges to their viability and capacity due to their limited resources and smaller power in the international arena. There is a growing body of research focused on sustainability transitions in small and micro states that emphasizes their vulnerability and dependence on international actors (Malatesta and Massa 2018) and other more powerful countries for managing their environmental policy, energy access and security strategies, and sustainability transitions in general (Wolf et al. 2016). However, there are also exceptional cases where small states, including Estonia, have influenced EU level policy-making through niche developments and right timing (Kraiko 2019) and other successful examples where small member states have developed competitive niches through strategic flexibility and flexible specialization (Baldacchino

2019). These small state aspects make Estonia even more appealing in terms of analyzing the MLP and MLG of sustainability transitions and accompanying opportunities and challenges arising from adapting to externally developed policy discourses, policies, and instruments.[2]

Theoretically, the thesis contributes to the innovation and policy studies research by creating an analytical framework that complements the MLP of sustainability transitions with public policy theories of MLG (together with related concepts of Europeanization, convergence, and divergence) and policy transfer (with the focus on factors that influence the transfer of policy instruments). This framework is further enriched with the debates from previous literature on implications (opportunities and challenges) for governance and MLG of selected externally developed aspects and imported mechanisms of STI policy meant to enable transitions in the complex, interlinked, and co-evolving area of sustainability transitions (with links to STI, energy, and environmental spheres).

The empirical part of this thesis contributes to the academic debate on the MLP and MLG of sustainability transitions by providing insights about the local reactions and countermeasure trends of smaller countries in adapting to external policies, policy discourse, and instruments meant to govern sustainability transitions in the MLG context. In the public policy context, the thesis contributes with giving an overview of different opportunities and challenges that countries face with top-down policies that are aimed to regulate areas with a bottom-up logic, such as specific STI models in the sustainability transitions discourse (Hossain 2016; Schot and Geels 2008; Kemp et al. 1998; Bergek et al. 2008; Verheul and Vergragt 1995). In addition, it contributes to the MLG and governance literature in general with examples and discussions of implications for governance at different levels from specific case studies of STI policy with the wider aim of tackling climate change and supporting sustainability transitions. Thus, the synthesized discussion of the opportunities and challenges for governance and MLG from the latest literature is enriched with the context of a small country with less resources, potentially weaker institutions and capacities. All this also contributes to the climate change and sustainability transitions policy debate in Estonia. In addition, in the empirical part of the study, the case studies uncover whether convergence towards the EU level policies can be observed and in what form the opportunities and challenges outlined in the theoretical discussion have emerged and whether any additional problems have arisen.

In the first paper, co-authored by Dr. Piret Tõnurist and Prof. Ringa Raudla, on the global climate change discourse and energy technology ISL, we find that the global climate discourse has indeed led to the diversification of research agendas and networks but the shifts in research strategies (so far) tend to be rhetorical and opportunistic. The ambiguity of the global climate change discourse has also facilitated incremental innovation towards energy efficiency and the potentially sub-optimal lock-in of technologies. The Estonian case illustrates how the introduction of policy narratives from the global climate change discourse to the national level can shape the actual policy

[2] Besides Estonia, the secondary case of Wales is presented in the study of smart specialization (**IV**) where the development and implementation of smart specialization is analyzed through a comparative case study of Wales and Estonia. The Welsh case adds some comparative value to the thesis and contributes to the external validity of the conclusions.

practices and also networks of actors in a complex and non-linear fashion, with unintended effects.

In the second, single-authored article, the case study about the initial development of the environmental taxes and charges system that influences the energy sector in Estonia highlights the significance of policy learning, harmonization, and coercive imposition but most apparently, and contrary to common belief, that different domestic factors have played a more essential role in shaping the development of the environmental taxes and charges system in Estonia. This case study illustrates some small state opportunities, such as close collaboration and active engagement of key players (i.e. industry and companies), as essential success factors in transition processes.

The third article, co-authored with Prof. Ringa Raudla, Dr. Erkki Karo, and Prof. Rainer Kattel, about the implications of project-based research funding for budgeting and financial management at public universities brings out the many challenges of project-based funding of research (e.g. fluctuating revenues, coordination problems, high complexity in managing the finances) and indicates that extreme reliance on project-based funding of research can lead to a paradoxical situation in specific cases where the success of research groups in obtaining project-based funding from diverse sources strains the budget of the university as a whole. In the context of this thesis, such dependence on project-based funding may potentially limit the ability of top national academic institutions to autonomously re-focus on sustainability transitions and other pertinent issues.

The fourth article, co-authored with Dr. Rhiannon Pugh and Jaanus Müür, about the implementation of smart specialization in Estonia and Wales finds that in both cases the EDP (Kirzner 1997; Foray et al. 2009; Foray 2015; Foray 2018) was not conducted in the bottom-up and organic mode in which it was envisioned, and instead, sectors were chosen at the national level in quite a top-down manner with limited directionality and selectivity. We claim that this can partly explain why the smart specialization approach with the potential to solve global and local societal challenges has not delivered on its promise in these two regions. In Estonia, it has not enabled one of the most relevant transitions in terms of sustainability – the transition of the oil shale based energy sector is still in its infancy. Instead, we argue for more bottom-up and place-sensitive modes of innovation policy in the future, but this might be challenged by limited RDI policy-making capacities of local governments.

The rest of the introduction of this thesis continues as follows. First, the research methodology used in the articles is explained. Second, the analytical framework is outlined. Third, the empirical findings and their implications for governance and MLG are introduced. Fourth, the contribution of this thesis is explained and fifth, further avenues of research are suggested.

2 METHODOLOGY

Due to the complexity of the research objects (ISL, taxing systems, budgeting and financial management in universities, strategic planning in central and local governments), actors, and stakeholders involved in these different processes, their perceptions and understandings, issues of interdependencies, dynamics, and path dependency, a single case study (Stephenson 1974; Stake 2005; **I**; **II**) and comparative case study (Bartlett and Vavrus 2017; Fox-Wolfgramm 1997; Gerring 2009; **III**; **IV**) approaches are taken. Mainly qualitative research methods have been used (**I**; **II**; **III**; **IV**). The network analysis of the energy technology ISL also included quantitative methods (**I**).

The case study methodology is widely regarded as a useful research approach (Eisenhardt 1989, Yin 2003, Gummesson 2000, De Massis and Kotlar 2014) and is particularly beneficial when looking for insights and in-depth understanding about a particular phenomenon (Penrose 1960, Pettigrew 1973). Furthermore, a case-based approach is thought to be one of the better methods for capturing the multi-disciplinary nature of green technologies and also accounting for country context (see del Río González 2009, Yin 2003). In addition, through an in-depth case study, a variety of data sources also help to explain economic and social relationships between firms and R&D units and the change in the direction of technologies that is the central interest of this research (**I**; **II**). Multiple data sources are recognized as being critical for triangulating and validating the findings of a study (Eisenhardt 1991, Denzin and Lincoln 1994). The case study approach allows phenomena to be studied in context by drawing on multiple sources of evidence and therefore enabling in-depth understanding (Eisenhardt 1989, Stake 1995, De Massis and Kotlar 2014).

The empirical analysis carried out for this dissertation draws on the following data sources and research methods for collecting and processing data.

First, in order to analyze the effects of the global climate change discourse on the implementation of science policy in the field of energy technologies in Estonia (specifically on research topics, collaboration and networks, and ISL), an in-depth single case study approach was deployed (**I**). A variety of data sources were used, including existing studies, secondary data, media articles, transcripts of Parliament sessions and reports of research projects, structured in-depth interviews, and network analysis. Out of all the structured in-depth interviews, 11 interviews with energy technology research group representatives and 4 interviews with representatives of R&D departments of the three main technology universities[3] in Estonia were carried out in 2013. 20 interviews with Estonian green and energy technology companies were conducted in 2011 under the Global Vision[4] project. The network analysis was carried out based on the CV-s of researchers and reports of research projects of the largest technology-oriented universities in Estonia from 1998 to 2012 available in the electronic database, Estonian Science Information System (ESIS). Since the strength of ties and

[3] Our study covered the largest technology-oriented universities in Estonia: Tallinn University of Technology (TalTech), Tartu University (TU), Estonian University of Life Sciences (EULS), and an autonomous research institute – National Institute of Chemical Physics and Biophysics. TalTech is the main contributor of energy technologies in Estonia, while in the other universities, singular renewable energy centered research units emerged during the 1990s.

[4] Central Baltic INTERREG IV A project "Enabling a Global Vision for the Baltic Clean-tech industry" (Global Vision) was run from 2011 to 2013, see more in Global Vision cleantech report by Valdmaa and Kalvet (2011).

informal communication are difficult to analyze through project data alone, we used the interview data to triangulate the information gathered from documents. In addition, document analysis was carried out to compose a profile for each research group. The documents included government funded research proposals and project reports from 1998 to 2012, co-publication analysis, and career data from ESIS. These profiles were created to have a more in-depth view of the strategic activities of research groups and also to account for shifts over time, which is difficult to outline solely through network analysis.

Second, to examine the development of the environmental taxes and charges system in Estonia and analyze which international and local factors (including all the factors under the national level) influenced the processes, an in-depth single case study approach was taken as well (**II**). In 2010, semi-structured interviews with open-ended questions were conducted among local environmental policy experts using the snowball method. In addition, an analysis of documents (laws, regulations, their explanatory notes, and other documents) was used to supplement the findings of the interviews. For comparison reasons, descriptive international experience was also used (based on literature analysis).

Third, in order to uncover the implications of increasing reliance on project-based funding of research for the financial management and budgeting at universities, a comparative case study of the two largest public universities in Estonia was undertaken (**III**). The data sources of the case studies included official documents, budgets of the universities, and semi-structured interviews conducted in 2013 with 7 officials of the universities' central administrations (employees of the finance and R&D departments) and 32 researchers (leaders of research groups from the fields of biotechnology, IT, environmental technologies, and energy technologies). These four fields were chosen because they partly overlap with national science and innovation policy priorities (and are therefore eligible for the widest range of funding sources).

Fourth, to analyze whether municipal governments are better equipped to design and implement smart specialization policy through a bottom-up EDP not through a top-down approach (like it has been done in CEE), we used a cross-case policy comparison approach (**IV**). A combination of methods was used, including document analysis and policy review (analysis of policy and official documents pertaining to innovation and economic development, observations of policy meetings) and semi-structured interviews with policymakers and key actors in the innovation system conducted in 2011–2013 and 2019 to build up a picture of innovation policy practice and local governments' perception of how smart specialization was and could have been implemented at municipal levels in both countries. These case studies were then combined into a comparison, with key themes drawn out inductively as contrasts and similarities emerged. As a result, a set of key insights about the translation of the smart specialization concept from the European to the local level and the role of local governments and place-based policies in the success of the implementation of smart specialization in the small-peripheral-young country context has been produced.

From the perspective of how imported public policy discourses, policies, and instruments influence national and local level policymaking and how they are adopted and integrated into local context, Estonia is interesting to study in many ways, as noted in all of the articles. The 'smallness' of a country (small population and territory) may give

rise to opportunities[5], but usually it poses additional challenges[6] (or amplifies the ones already in place) related to the limitations of resources (i.e. natural and financial resources, human capital, governance, knowledge, etc.). As explained below through the specific case studies, the case of Estonia enables us to highlight the opportunities and problems related to the policy discourses, policies, and policy instruments developed at the EU and global levels and how they develop while moving down the governance levels and encountering new contexts.

First, in terms of global policy discourse, the Estonian case study presents an opportunity to explore the effects of the changes in the global climate policy discourse in a particularly pure form – in a small country context that, first, had no significant environmental policy prior to the 1990s, and second, had a mono-technological energy sector with a very high GHG-impact until the beginning of the 2000s (**I**). Therefore, this case (**I**) illustrates very well the MLP of sustainability transitions and the interlinkages and interdynamics of landscape (global and EU policy discourse on climate change), regime (mono-technology oil shale based energy sector, weak environmental policy), and niche (industry and science collaborations in innovative energy technologies) levels of sustainability transitions. From the MLG and policy transfer angle, the case study shows that the implementation of the global climate change policy discourse into national STI policy might not be as clear cut as initially hoped and can lead to various unintended effects for ISL.

Second, regarding imported policy instruments, the Estonian case and the development of the environmental taxation model is interesting for research because the local context makes it possible to test the general belief that international actors and factors have had an important role in the development of policies in CEE countries (**II**). That is because most of the CEE countries[7] were closed to the West until the beginning of the 1990s and had to build up new independent systems on their own, taking more after the West and North because of their dismissal of the Soviet system.

Third, in the case of imported science and innovation financing models, until recently (2014–2015) the Estonian case was an 'extreme case' among the European countries given that more than 80% of research funding in Estonia was project-based (**III**). In other European countries, on average, project-based funding makes up around 20% of total university revenues (Lepori et al. 2007, 2013), and national project-based research

[5] E.g., flexibility (Katzenstein 2003) that makes it easier to cope with changes and might even lead to conclusions that small states are actually particularly well-prepared for a world of deregulated financial and increased trade flows (Tõnurist 2010, 11). Furthermore, they have higher economic growth potential due to their greater degree of social homogeneity, cohesion, and identity that encourage the formation of social capital and thus lower many transaction costs (Armstrong and Read 2003; Bräutigam and Woolcock 2001; Hey 2002). Therefore, decisions can be reached more quickly. Besides, it is easier for them to cope with far-reaching structural changes and adjust to new technologies (e.g. Lemola and Ylä-Anttila 2003; Lundvall et al. 2002). Moreover, export-oriented states with small markets are more "conscious" than large states of the demands of multinational corporations (MNCs), as they are typically hosts to only a small number of MNCs (Culpepper 2007).

[6] E.g., small power and impact on the international system (e.g. Keohane 1969; Rothstein 1968), in terms of finance and trade, less control in global politics (Payne 2004), export-dependence and dependence on foreign capital, and limited power over fluctuations of the international market (see, e.g., Andersen and Lundvall 1988; Baker 1992).

[7] With the exception of Hungary and Yugoslavia.

funding of the higher education sector rarely reaches beyond 50% in Europe (Steen 2012). This makes the Estonian case an especially interesting research object and due to the increasing reliance on project-based funding of academic research in Europe and beyond, the Estonian case can provide useful insights for learning for other countries and universities.

The second and third case contribute to the MLG (how policy measures transfer and develop in EU member countries – **II**; **III**) and also to the MLP research of sustainability transitions in terms of how certain parts of socio-technical regimes (taxation models – **II** and science funding systems – **III**) develop and how they influence everyday practices of important parts of the regime (impact of research funding on budgeting and financial management in universities – **III**).

Fourth, regarding imported economic steering policies, the case studies of Estonia and Wales are analyzed together because of the similarities noted in their experiences with the latest innovation policy experiment – smart specialization – and their status as weaker, peripheral, and "young" countries in administrative terms, allowing us to examine smart specialization in this specific context (**IV**). Whilst the two countries have very different histories, cultures, and other characteristics, there are a number of similarities in their experiences of implementing smart specialization that provide interesting insights about the concept itself and the diverse regional contexts within which it is currently employed across Europe. In spite of the confusing and diverging practices of the UK exiting the EU (Brexit), historically, both countries have been tied to Europe and thus have usually conformed quite closely to innovation policy edicts. This case is mainly focused on the transfer and implementation of policies and instruments developed at the EU level and the MLG of these policies and instruments (**IV**). However, the case illustrates well that the municipal level of governance has not been utilized. By discussing the implementation challenges of smart specialization strategies, the case also links to the MLP of sustainability transitions, especially through niche developments, and how the different levels (niche, regime, landscape) complement and influence each other.

There are also limitations to the chosen methodology. The author of this thesis recognizes that single case studies and comparative case studies of a small number of cases do not allow for broader generalizations. Therefore, on the one hand, the conclusions of this research apply to certain country contexts and help to understand the processes and phenomena more deeply. On the other hand, interesting conclusions of single country analysis can be developed further if other similar cases are analyzed in a comparative manner and the results confirm the same findings as the single case study.

3 ANALYTICAL FRAMEWORK

It is impossible to ignore the growing influence and importance of the international arena – discourses, actors, processes, and institutions – on the formation, development, and change of local (both national and sub-national) politics, policies, and related systems and networks (**I**; **II**; **III**; **IV**) that are part of local sustainability transitions. This is due to the effects of globalization and internationalization, the cross-border and cross-sector nature of climate change related problems and the sustainability transitions needed, as well as the need for harmonized regulation to ensure equal competition and investment security. At the same time, externally developed policies and their discourses, policy transfer and convergence are also highly influenced by local context and factors: institutional, social, and historical perspectives (e.g. culture and traditions of public management, motives of policymakers, path dependency) (Pedersen 2007), not to forget the specificities of the policy instruments themselves (Tews et al. 2003) (**I**; **II**; **III**; **IV**). These factors might foster or hinder local adaptation of externally developed policies for sustainability transitions and therefore deserve special attention.

To systematically analyze different STI policy aspects of sustainability transitions interlinked with the energy and environmental sectors on different governance and institutional levels and the interaction between the different levels and sectors, this thesis uses an analytical strategy that first, links the MLP of sustainability transitions with public policy theories of MLG, Europeanization, convergence, and policy transfer (focused on factors that influence policy transfer and learning). Secondly, the framework is further enriched with key governance implications, opportunities and challenges of imported STI policies and instruments for sustainability transitions as outlined in the main debates of related literature (Figure 1).

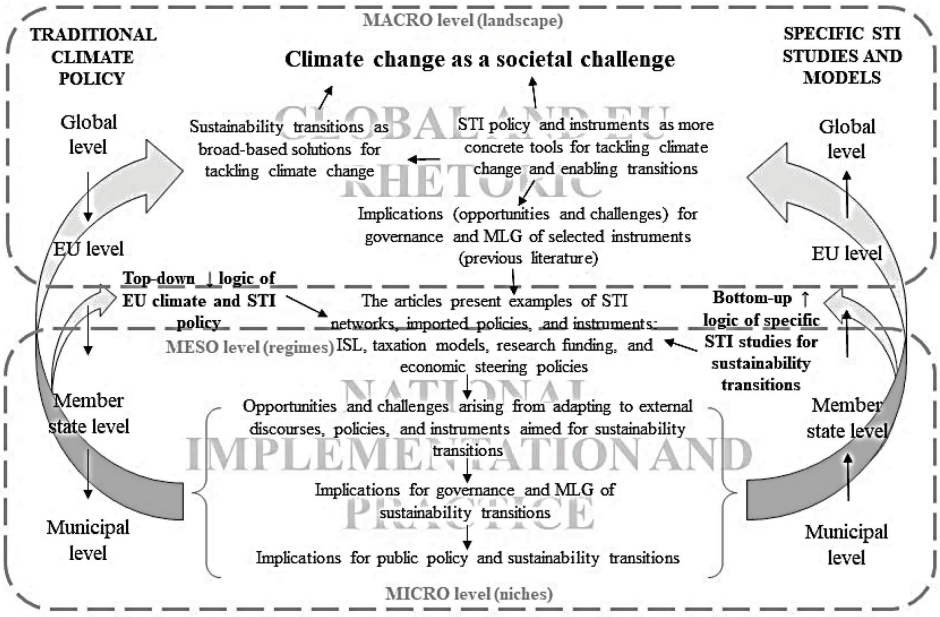

Figure 1: Analytical framework: MLG and MLP of sustainability transitions, implications for governance of selected STI aspects.

Source: Author.

Looking at the multi-level and multi-domain sustainability transitions through the MLP framework complemented with the public policy context (MLG, policy convergence and transfer) – and through this linking of sustainability transitions, STI studies, and STI policy – we can analyze the complexities and contradictions between sustainability transitions (with bottom-up and top-down features; Loorbach et al. 2017; Geels 2018a, 2018b, 2011, 2010; Genus and Coles 2008), public policy theories (with the hierarchical top-down logic; Egenhofer and Alessi 2013; Dirix et al. 2013; Lenschow 2002; Schmidt 2009; Ladrech 1994; Héritier et al. 2001; Urwin and Jordan 2008), and specific STI studies (that emphasize bottom-up change, hidden experimentation and innovation for sustainability transitions; Hossain 2016; Schot and Geels 2008; Kemp et al. 1998; Bergek et al. 2008; Verheul and Vergragt 1995) that are the core of this thesis.

Accordingly, the aim of the analytical strategy is to further explain and understand the opportunities and problems of policy design and implementation in countries using imported STI policies and instruments to enable sustainability transitions. An overview of the main implications drawn from the public policy, STI studies, and sustainability transitions literatures are summarized in Table 1.

3.1 MLP of sustainability transitions linked with MLG and Europeanization

Loorbach et al. (2017) characterize sustainability transitions through the concepts of nonlinearity (e.g., disruptive change and innovation), multi-level dynamics (tied to technological, institutional, and spatial dynamics, e.g., upscaling of technology, multi-level governance, spatial diffusion), co-evolution (e.g., multi-domain and complementarity instead of linear causalities), emergence (e.g., of a new dynamically stable order out of a process of chaotic and coevolutionary change), variation and selection (e.g. experimentation and learning-by-doing leading to disruptive innovation).

The MLP of sustainability transitions (Loorbach et al. 2017; Geels 2018a, 2018b, 2011, 2010; Genus and Coles 2008; Smith et al. 2010) takes these characteristics into account. It illustrates and enables to analyze the co-evolution of the socio-technical landscape (as the exogenous context), socio-technical regimes (the prevalent socio-institutional set-up, routines, culture, dominant technologies, lock-in phenomena), and socio-technical niche developments (experimentation, innovation, and search networks for new technologies) (Kemp 1994; Kemp et al. 1998; Kivimaa and Kern 2016; Schot and Geels 2008; Kemp et al. 2001). Smith et al. (2010, 441) argue that regime shifts occur through interactions and interlinkages between multiple developments on these three levels. Throughout these developments, it is crucial to recognize that the transition processes involve essential actors who decide on normative questions and operate through structured and complex relations (Rip and Kemp 1998; Smith et al. 2005, 2010; Geels and Schot 2007). Therefore, the role of the actors and their networks, their motives and interactions, power and politics on multiple governance levels deserves more attention in order to understand regime transitions and the geography of transitions.

MLG offers an additional lens for the analysis of different policy fields and policymaking levels examined in this thesis. Sustainability transitions, EU STI policy linked with energy and environmental policy under the wider umbrella of the EU climate policy (as policy domains or fields), smart specialization and research funding more specifically (as specific policies and instruments) are designed, developed, and implemented under MLG. Besides the variety of policy fields, MLG also focuses on different levels of

governance. The MLG concept contains both vertical and horizontal dimensions: "multi-level" refers to the increased interdependence of governments operating at various territorial levels, while "governance" refers to the growing interdependence between governments and nongovernmental actors at different territorial levels (Bache and Flinders 2004, 3).

Homsy et al. (2018) bring out that many scholars embrace MLG as an analytical framework for complex problems, such as climate change (also titled as super wicked problems by Levin et al. (2012) and Tõnurist 2015), but the elements needed to comprehensively operationalize multi-level governance remain undefined in the literature. They describe the five necessary ingredients of a multi-level framework – sanctioning and coordinating authority, provision of capacity, knowledge co-production, framing of co-benefits, and engagement of civil society – with the wider aim to balance local and central actors to promote a more effective governance regime. While it is clear that in the European context sanctioning and coordinating authorities are the EU and national level institutions that implement legislative, executive, and judicial power, it is much more complex and less obvious how provision of capacity, knowledge co-production, framing of co-benefits, and engagement of civil society are designed and implemented in the EU MLG framework.

MLG emerged in the mid-90s next to the two main contrasting theoretical descriptions of European integration – intergovernmentalism (Hoffmann 1966, 1982; Moravcsik 1993, 1994; Pollack 1995) and supranationalism (Haas 1958; Lindberg 1963; Sandholtz and Zysman 1989). MLG is seen as a mixture of both – "a system of continuous negotiation among nested governments at several territorial tiers − supranational, national, regional and local − as a result of the broad process of institutional creation and decisional reallocation that has pulled some previously centralized functions of the state up to the supranational level and some down to the local/regional level" (Marks 1993, 392). The main assumption of MLG emphasized in the thorough work of Tatar (2016) and empirically studied by many others (Bache 2008; Bache and Andreou 2010; Goldsmith and Klausen 1997; Hooghe 1996; Kelleher et al. 1999; Reynaert et al. 2011) claims that because of the EU cohesion-policy implementation in particular, some movement towards MLG should be seen in the member states, even though there would be some variation in different national settings.

This leads us to Europeanization as one of the largest strands in the MLG studies that explains the processes through which EU policies and institutions influence national policies and institutions within the EU member states (Bache 2008; Börzel and Risse 2003; Risse et al. 2001; Vink and Graziano 2006). As a theoretical concept, Europeanization combines a variety of approaches from European integration theory, comparative politics, and public policy analysis (Tatar 2016, 30). As an empirical approach, it is mainly used to refer to the effects of the EU on domestic politics (Bache 2010) or, in other words, studying the impact of EU membership on domestic policymaking (Tatar 2016, 30). However, the concept of Europeanization has also been criticized for being too vague and encompassing explanations for a wide variety of institutional and policy changes (Olsen 2002).

Europeanization is closely related with the concepts of convergence and divergence (Holzinger and Knill 2005, 775). Convergence is the tendency of societies to become similar, develop similarities in structures, processes, and performances (Kerr 1983, 3). Knill (2005, 768) defines policy convergence as growing similarities between one or more characteristics of a particular policy (e.g. policy goals, instruments, frameworks) within a

given group of political jurisdictions (supranational institutions, states, regions, local authorities) within a specified timeframe. Therefore, convergence can be seen as a result and also as a process. Pollitt (2002, 477–478) argues that convergence should be understood in a more dynamic way, consisting of four stages: discursive, decisional, practice, and results convergence. Based on experience with public management reforms, Pollitt (2002, 483, 489–490) hypothesizes that moving through the four stages, the level of convergence decreases. In the context of this thesis and while looking at the geography of transitions and the role of power and politics in the transitions, climate change and the need for sustainability transitions might be recognized by many national governments in the EU at the discourse level. In addition, policies and instruments for the energy and environmental sectors might be in place (decisions on national but also subnational levels); however, how the system is implemented in practice and what the results are, can vary greatly, e.g. from country to country, from sector to sector, and from municipality to municipality.

3.2 Factors that influence the transfer and adoption of new policy instruments

To explain and understand the geography of sustainability transitions, it is essential to understand how ideas and policies transfer and spread between countries. In general, the existing literature brings out three broad factors that are considered to play a role in the development, spread, and convergence of new environmental policy instruments, like environmental and energy taxes, and the formation of complex systems or packages of these policy instruments (**II**):

(1) international factors[8] (Busch and Jörgens 2005a, 2005b; Jordan et al. 2003; Kern et at. 2001; Tews et al. 2003; Tews 2005);
(2) national factors and the domestic context (e.g. Kern et al. 2001; Rose 1991; Bennett 1991; Pedersen 2007; Bemelmans-Videc et al. 2010; Freeman 1985; Linder and Peters 1989; Hood 1983);
(3) special characteristics of the policy instruments (e.g. Tews et al. 2003; Bemelmans-Videc et al. 2010; Linder and Peters 1989; Hood 1983).

Regarding international factors, many scholars (Busch and Jörgens 2005a, 2005b; Bennett 1991; Dolowitz and Marsh 2000; Tews 2005; Liefferink and Jordan 2005; Knill and Lenschow 2005) have agreed on the main typology of international convergence mechanisms (**II**): (1) co-operative harmonization[9]; (2) coercive imposition[10]; and

[8] It is important to note that the international factors are also different means of policy diffusion in the broader sense. In addition, they are also the specific convergence mechanisms conceptualized by Busch and Jörgens (2005a, 2005b), whose approach is taken as the basis in the development of the Estonian environmental taxation system analysis (**II**). According to Knill (2005, 766), the same concepts form the wide approach of policy diffusion that links the spread of policy ideas between countries with three specific causal factors that drive these developments. These mechanisms consider the impact of different actors (e.g. EU and other interstate and supranational organizations), but they also take into consideration the activities, power, and consequent instruments of these actors in the general diffusion and convergence processes.

[9] Co-operative harmonization of local practices by means of international legal agreements and supranational law.

[10] Coercive imposition of political practices through economic, political, and even military threat, intervention, or conditionality.

(3) interdependent but uncoordinated diffusion[11] of local political practices. A distinction between these three types is made based on their mode of operation, primary motivation of policymakers to adopt policies, and the freedom of action and independence they grant national policymakers to influence the policy content and decide on the adoption of policies (Busch and Jörgens 2005a, 862).

In terms of linking the factors that influence policy transfer with sustainability transitions, there are recent studies that emphasize the role of international examples and experiments in fostering sustainability transitions through learning. Rosenbloom et al. (2018) describe transition experiments as deliberate interventions that test novel configurations of social and technical elements that can lead to substantial low-carbon change. They suggest that transition experiments can provide four primary benefits that might be leveraged to open low-carbon pathways: learning, capacity building, de-risking, and public education and engagement. Smith et al. (2010) argue that successful niche experiments feed actor networks with shared expectations, inform the identities of the supportive coalitions, and help orient interests and social norms. Matschoss and Repo (2018) claim that as governance experiments integrate policy with innovation and as experimentation is positioned more within socio-technical regimes than in strategic niches, they may indeed provide new transition opportunities towards low-carbon societies. However, experiments of this kind assume high-level of governance capacities and besides policy and administrative capacities also technological capacities discussed further below.

Still, despite the fact that the positive role of examples and demonstrations as policy instruments has been known and used for a long time (Macey and Brown 1990), Nagorny-Koring (2019) questions the wide usability of best practices as they feature sticky and place-bound characteristics that limit their diffusion and usability in the transition to a low-carbon society more broadly. She illustrates that this mismatch (why the expectations about best practices and their actual effects differ significantly) can be understood not as a simple failure of a governing technique, but rather, as a result of the inherently conflict-laden interplay of rationalities and technologies of government. Moreover, the literature brings out many challenges related with how to widen the positive effects of local examples and best practices from local levels to regional and national levels (Späth and Rohracher 2012). There are studies that focus on the governance challenges of sustainability transitions (Turnheim et al. 2015; Ehnert et al. 2018; Sarrica et al. 2018; Nagorny-Koring 2019) and the local capacities and competences needed for sustainability transitions (Hölscher et al. 2018a; Holtz et al. 2018; Schoon and Cox 2018). The previous studies emphasize the essential role of local context (Kern et al. 2001; Rose 1991; Bennett 1991; Pedersen 2007; Bemelmans-Videc et al. 2010; Freeman 1985; Linder and Peters 1989; Hood 1983) and also the institutional, administrative, policy, and technology capacities (Painter and Pierre 2005, Wu et al. 2015, Randma-Liiv 2002, Karo and Kattel 2015, Wu et al. 2018, Karo and Kattel 2018; Lember et al. 2018, Mergel et al. 2018, Tõnurist et al. 2017) in the success or failure of adopting externally developed discourses, policies, and instruments.

Relatedly, Kern et al. (2001, 2) point out that although the global diffusion of policy innovations or NPI is influenced by global transfer institutions (like OECD, IMF, EU, UN), the change and success of national public policy is mainly affected by national factors.

[11] Interdependent but uncoordinated diffusion of practices by means of cross-national imitation, emulation, and learning.

Based on the general assumption 'that institutionally grown structures and routines prevent easy adaptation to exogenous pressure' (Knill and Lenschow 1998, 2), it is argued that national institutional arrangements serve as filters for the adoption of NPI (Tews et al. 2003, 576; Kern, Jörgens and Jänicke 2001). Therefore, in exploring how policy instruments work and the impact they have, it is important to understand the context in which they are used and with which they interact (Linder and Peters 1989; Hood 1983, 2). The development of policy instruments is influenced by the culture, history, and institutions of the country they are transferred from as well as the same factors of the destination country (Rose 1991, 21; Bennett 1991). More specifically, Bemelmans-Videc et al. (2010, 13) argue that policy context is a complicated concept and might refer to the characteristics of a nation's or sector's general nature (systemic context), characteristics of government-arrangements (structure), and the dimensions of culture. Freeman's (1985, 485) policy-sector approach argues that the style of policymaking and the nature of political conflict in one country will vary significantly from sector to sector. He claims that the policy-sector approach implies that there should be cross-national similarities in the ways issues are treated in one sector, irrespective of the policy styles nations adopt.

In addition, under local context and institutions, policy capabilities and capacity of governments also play a significant role in the transfer processes as explained before. Cepilovs (2017, 11) claims that successful policy transfer and policy learning is only possible where local policy capacity and capabilities are already strong, while policy transfer to immature policy environments can fundamentally undermine the legitimacy of such policy interventions, thus potentially further weakening the state-policy capacity. Moreover, he adds to the policy context approach by Bemelmans-Videc et al. (2010) and the policy-sector approach by Freeman (1985) with the example of fiscal and innovation policy and emphasizes (Ibid., 12) that the nature of the policy domain has a significant impact on the nature of policy transfer and policy learning, as well as the resulting policy outcomes.

Furthermore, even in the same policy domains, the same (type of) policy instrument may still be implemented differently as no two governments use the same policy tool in exactly the same manner (Hood 1983, 106). Knill (2005, 764) explains that the critique against convergence emphasizes the essential differences in state institutions and the opportunities of domestic actors and that the related literature showcases more diverging than converging policy developments between countries. Due to contextual differences, the same instrument is likely to work differently in different contexts (**I**; **III**; **IV**).

3.3 Implications for governance and MLG of selected imported STI policies and instruments aimed for sustainability transitions

The following sub-sections highlight the main debates from the literature on key perspectives of sustainability transitions focused on the opportunities and challenges for governance and MLG in terms of the selected STI policy aspects and related energy and environmental sectors. First, sustainability transitions through multi-disciplinary green and clean technologies, their innovation systems and the related implications for ISL and MLG are discussed. Second, the complexity of the energy sector as a socio-technical system that calls for higher state capacities in areas of governance, administration, policy, and also technology is explained. Third, sustainability transitions through directionality and specialization in innovation and STI policies through the example of smart specialization as well as the accompanying opportunities and challenges are

outlined. Fourth, public funding of research as an example of an STI policy instrument for allocating R&D funding for scientifically excellent and socio-economically relevant research in the context of climate and sustainability challenges, and the related implications and problems for governance are explained.

3.3.1 Sustainability transitions through clean technologies

Cleaner, greener, and environmentally friendlier technologies are already on the market and competing with the fossil fuel alternatives, but the question here is how to make a systematic or radical change not just incremental changes towards energy efficiency and pollution treatment. The notion of socio-technical regimes helps to explain path dependency and lock-in of existing socio-technical systems around specific old and traditional technologies, such as coal-based energy generation (Loorbach et al. 2017), and thus, also difficulties with transitions to new systems of clean technologies. Structural change is challenged by many existing but unsustainable systems that are stabilized through various lock-in mechanisms (e.g. scale economies, sunk investments in machines, infrastructures, and competencies, also institutional commitments, shared beliefs and discourses, power relations, political lobbying by incumbents, and consumer lifestyles and preferences) that create path dependence and make it difficult to dislodge existing systems (Geels 2011, 27; Unruh 2000). Smith et al. (2010, 438) argue that the innovation studies literature suggests that environmentally-oriented innovation policy has to take a broader innovation systems perspective (Lundvall 1992; Breschi and Malerba 1997; Truffer 2008), meaning it has to recognize that the capabilities of individual organizations to innovate as well as their broader selection environments are formed by more complex processes, opening the analysis to related practitioner routines, skills and training, governing institutions, facilitating infrastructures, and effective and prospective market demand.

However, based on the last decade's literature and case studies, Wise et al. (2014) argue that efforts to adapt to climate change have not led to a remarkable rise in the rates of implementation of adaptation actions, despite substantial investments in adaptation science. Moreover, they argue that implemented actions have mostly been incremental and focused on proximate causes and that there are far fewer reports of systemic or transformative actions. Directional and radical transitions require investments and regulative security that these investments will pay off in the future. The continuous increase of renewable energy and electrification (e.g. in the transport sector and beyond), in parallel with climate and energy targets, does and will require considerable investments in energy security, both in terms of security of supply and technical security (ENTSO-E 2019). For these investments, harmonized regulative security is needed.

This adds pressure to the implementation of the new Clean Energy package – the legislative package ratified in the European Parliament in the spring of 2019 that updates the EU energy policy framework. In the center of the new policy framework are renewable energy, energy efficiency, and empowerment of EU consumers[12] to become

[12] The new legislation aims to put the consumers at the heart of the transition – in terms of giving consumers more choice, strengthening their rights, and enabling everyone to participate in the transition by producing their own renewable energy and feeding it into the grid. By allowing electricity to move freely to where it is most needed and when it is most needed via undistorted price signals, consumers will also benefit from cross-border competition. On the one hand, this is

fully active players in the energy transition, with two new related targets for EU 2030: a binding renewable energy target of at least 32% and an energy efficiency target[13] of at least 32.5% (with a possible upward revision in 2023) (Renewable Energy Directive, Energy Efficiency Directive).[14] These ambitious targets are believed to stimulate Europe's industrial competitiveness, boost growth and jobs, reduce energy bills, help tackle energy poverty, and improve air quality. In addition, the new package introduces national energy and climate plans for 2021 to 2030 in order to outline how respective targets will be achieved, to support regulatory certainty, and encourage essential investments into the energy sector (Governance Regulation).

The Clean Energy package can be seen as the formal, EU level regulative framework for sustainability transitions and mitigating climate change; and therefore, it has an essential role in the wider climate change policy discourse. While the EU regulations become immediately enforceable as law in all member states simultaneously, directives need to be transposed into national law. The latter offer national policymakers more freedom in local policy design and implementation but might also lead to bigger national variations. From the international convergence mechanisms perspective, EU directives are instruments of co-operative harmonization of local practice by means of international legal agreements and supranational law, and regulations can be seen as mechanisms of coercive imposition of political practices through economic and political conditionality, as put by Busch and Jörgens (2005a).

Sarrica et al. (2018) argue that the transition towards low-carbon societies requires multi-scalar and coordinated actions that implies top-down and bottom-up processes of translation connecting supra-national regulations and targets with policies and discourses enacted at the national and local levels. They argue that there is a dearth of research analyzing the coordination of different scales and explore how alternative views associated with energy sustainability are translated, supported, or resisted across different levels of governance (national, regional, and local levels in Italy). Their findings indicate elements of coherence as well as tensions and inconsistencies between discourses on energy sustainability taking place at different levels, corresponding to diverse models of governance and policy scenarios (Ibid., 451). Chung (2018) adds to this from a socio-technical system and TIS perspective and argues that international institutions could play a role in guiding the search, while national governments should ensure that policies are consistent and help to ensure the appropriateness of domestic TIS' functions. He claims that if the domestic TIS' functions are appropriately guided by

believed to drive the investments necessary for providing security of supply, whilst decarbonising the European energy system. On the other hand, recognizing the role of the consumer, a human being, in the heart of the transition can be interpreted as a huge change in the climate change discourse that has been very technology and science biased.

[13] This means that all EU countries are required to use energy more efficiently at all stages of the energy chain (i.e. energy generation, transmission, distribution, and end-use consumption) (Energy Efficiency Directive).

[14] In addition, the new package introduces national energy and climate plans for 2021 to 2030 in order to outline how respective targets will be achieved, to support regulatory certainty, and encourage essential investments into the energy sector (Governance Regulation). The package also outlines specific measures for the building sector for increasing energy performance (Energy Performance in Buildings Directive) and for the EU electricity market – to establish a modern design that is more flexible, more market-oriented, innovation driven, and better placed to integrate a greater share of renewables (Electricity Directive and Electricity Regulation).

the institutions on the above levels, novel technologies that sustainably transit the systems would then emerge on a micro level (Ibid., 140).

3.3.2 Socio-technical systems and state capacities

Sustainability transitions of socio-technical systems, e.g., the energy system, in essence incorporate a variety of dimensions like technology, society, economy, culture, institutions, governance, policy, etc. that interact with each other and co-evolve (e.g. Geels and Schot 2007 and 2010; Kemp 1994; Markard et al. 2012; Markard et al. 2015; Smith et al. 2005). The energy sector in general is a conservative and path dependent sector with a lot of inertia built into the system (**I**). Due to several and often contradicting interests, political, social, and economic goals might clash. For example, decarbonization, more renewables, distributed production, more sub-connections, more data management and reliance on ICT might interfere with the goals of energy security and the security of energy supply, not to mention economic growth that in many countries is heavily tied to oil production and consumption.

Global challenges arising from this level of complexity require not only coordinated policies and transnational agreements but also necessitate that discourses from supra-national institutions are translated and connected with national, regional, and local level discourses, policies, and institutions (Späth and Rohracher 2010; Sarrica et al. 2018). This strongly implies the need for effective MLG. Turnheim et al. (2015, 240–242) summarize the reasons why sustainability transitions present many challenges to policy-makers and thus also for governance in general: (1) they cross multiple scales, geographies, and temporalities; (2) there is a high level of uncertainty connected to radical innovations, which makes predictions inaccurate; (3) there can be a high level of inertia connected to existing socio-technical systems; (4) there are many competing public goods and social objectives that innovation needs to fit in with (e.g., decarbonization, energy security, economic growth); and lastly, (5) the governance processes of socio-technical change are complex and frequently contested.

Considering the centrality of certain actors in the reproduction of the socio-technical configurations of regimes and niches with their likely responses to governance interventions, according to Smith et al. (2010, 445), we can develop informed expectations about the contribution of various policies to sustainability transitions. Smith et al. (2010) claim that governance schemes that account for socio-technical complexities while retaining a sense of significant niche-regime-landscape reproduction processes and targeting their policy attention towards the key players in the transitions, are more likely to generate effective transition policies. Furthermore, they argue that according to the MLP, portfolios of policy measures have to work across the destabilization of incumbent regimes (to increase opportunities for structural change), the promotion of radical green niches (to broaden the portfolio of promising solutions), and processes for translating ideas and practices from niches into mainstream settings.

The previous discussions also refer to the role of state capacities – governance, policy, and administrative capacities (Painter and Pierre 2005, Wu et al. 2015, Randma-Liiv 2002, Karo and Kattel 2015, Wu et al. 2018, Karo and Kattel 2018). Additionally, technology or technological capacities (Lember et al. 2018, Mergel et al. 2018, Tõnurist et al. 2017) of public sector organizations have recently gained much attention. These studies (Ibid.) analyze the impact of technological change on administrative capacities and emphasize the important role of technological capacities in effective governance and policymaking. Technological capacities and the capability to design and implement successful RDI

policies are substantially important in the contexts of sustainability transitions and socio-technical systems because the latter cross political, technological, economic, social, and cultural spheres (e.g. Geels and Schot 2007 and 2010; Kemp 1994; Markard et al. 2012; Markard et al. 2015; Smith et al. 2005).

Policy capacity of small states, i.e. the competences and capabilities necessary for effective policymaking (Wu et al. 2015), is claimed to be weak (Randma-Liiv 2002, Karo and Kattel 2015). In the context of the Baltic states, Cepilovs (2017, 9) summarizes the three main reasons of weak policy capacity: first, strong policy capacity requires strong administrative capacity, which has often been quite weak in small states (Randma-Liiv 2002); second, as the Baltic states have just recently completed the transition period of joining the EU, they have had limited time to develop strong political and administrative capabilities; third, the capabilities of other stakeholders involved in the policy process, as well as the coordination instruments, remain largely underdeveloped in the Baltic states, therefore further weakening the governments' policy capacity (Karo and Kattel 2015).

Therefore, on the one hand, in the context of sustainability transitions, well-coordinated MLG – the interdependence, interaction, and co-evolution of governments vertically and horizontally across country borders and their governance capacity – becomes even more essential in speeding up the transition processes. On the other hand, this kind of extremely complex and all-embracing global problems challenge MLG and the strength and quality of collaboration between and at different governance levels.

3.3.3 Sustainability transitions through directionality and specialization in innovation

In a recent study, Fagerberg (2018) analyzes the role of innovation policy (e.g., mission-oriented innovation policy, strategic niche management, transition management, national innovation systems, and transformative innovation policy) in sustainability transitions and claims that lessons from innovation policy should be considered for the development and implementation of transformative innovation policy for speeding up sustainability transitions. Kern et al. (2019) link innovation and policy studies and focus on policy mixes that could support innovation with their direction towards fostering sustainability transitions. They bring out that policy mixes that support the right directionality are key for managing structural and transformative system failures, i.e. institutional failures or failures of the direction of a transformation process (Weber and Rohracher 2012), which has also been recognized by OECD (OECD 2015) in the context of the climate crisis. Besides directional policy mixes, transformative change towards sustainability requires that pre-existing and new policies are productively integrated (Schot and Steinmueller 2018, 1563). However, using policy mixes for sustainability transitions is also challenging (Kern et al. 2019, 2) because they go beyond single policy domains (e.g. they require coordination between innovation policy and other policy fields, such as market regulations or tax rules) and incorporate uncertain future developments (e.g. technical, political, cultural). Further challenges are introduced by the fact that transitions go beyond technologies (e.g. also require changes in infrastructures, social practices, and market arrangements) and therefore involve the significant complexity of the change process and the desired direction of change (Kern et al. 2019). There are also some recent analyses of policy, policy mix, and sustainable transition pathways (Byskov et al. 2019) with more emphasis on policy mix feedback (Edmondson et al. 2019) and comprehensiveness of policy mixes (Rogge and Reichardt 2015). Kern et al. (2019) and Edmondson et al. (2019) bring out that policy

(mixes) and socio-technical systems co-evolve over time – policy can shape developments of the socio-technical system through resource, institutional, and interpretive effects while developments within the socio-technical system in turn influence policy developments through socio-political, administrative, and fiscal feedback.

Furthermore, previous research also provides opportunities to learn from other countries' experience, as there are many examples in the literature about case studies of countries and sectors regarding energy policy change and transition policy (Markard et al. 2015; Kern and Smith 2008), policy mixes for sustainability transition (Scordato et al. 2018), case studies of sustainability transition pathways (Fastenrath and Braun 2016), and analysis of large-scale post-carbon economy transition strategies (Wiseman et al. 2013). All of these in one way or another touch upon innovation and innovation policy and the role of supply- and demand-side policy instruments in tacking climate change and enabling sustainability transitions. More specifically, considering previous research, Creutzig et al. (2018) claim that research on climate change mitigation tends to focus too much on supply-side technology solutions; thus, the potential of demand-side solutions for mitigating climate change should be promoted.

Magro and Wilson (2019) argue that new place-based innovation policies are being strongly shaped by regional smart specialization strategies that seek to generate structural transformation in the economy, which in many regions include the task of fostering sustainable transitions and therefore require joined-up interventions from different policy domains. Smart specialization (Foray et al. 2009; Foray 2015) is seen as a large-scale innovation policy experiment that took place within the framework of the European regional cohesion programs between 2011 and the present, as claimed by one of the godfathers of the smart specialization concept, Dominique Foray and many others (Radosevic et al. 2017). The smart specialization approach attempts to provide an answer to the eternal question in regional policy discussions – how to allocate RDI investments − by encouraging investments in programs that will complement the country's other productive assets to create future domestic capability and interregional competitive advantage (Foray 2018, 818).[15] Consequently, smart specialization is expected to create more diversity among regions, contrary to a situation where each region tries to create something that is more or less the same in an imitative manner which would almost certainly result in excess duplication of R&D and educational investment programs, which in turn would diminish the potential for complementarities within the European knowledge base (Foray et al. 2009).

Furthermore, smart specialization falls into the category of MOP (Foray 2018) – policies that are non-neutral and have a clear direction – it means preferential intervention in accordance with certain objectives in technological, social, ecological, and/or industrial domains. Therefore, it is argued to be suitable for solving complex and global societal challenges, such as climate change and sustainability transitions (e.g. Fagerberg 2018;

[15] Via the European Regional Development Fund (ERDF) more than EUR 40 billion (and more than EUR 65 billion with national co-financing) will be allocated to regions from 2014–2020 to fund the priorities (European Commission 2017). The scale of activities and investments that are being mobilized under the label of smart specialization during the 2014–2020 period is estimated to total around EUR 120 billion or even EUR 250 billion if a very broad definition of smart specialization is used that also includes the funding for the low-carbon economy (only some of which is innovation) and if EU funding, national co-financing, and private sector leverage are included (Radosevic et al. 2017). Thus, to receive financial support from the ERDF, the smart specialization strategies need to be in place beforehand.

Magro and Wilson 2019; Foray 2018). Foray (2018, 823) argues that strategies of smart specialization, as a policy aimed at generating new so-called transformative activities[16] within a region, form an inalienable part of the MOP sphere, as they are essentially determined by these principles of non-neutrality (preferential intervention), direction (predetermination of domain), and the adoption of a systems approach.

In turn, smart specialization as a place-based policy has become an important part of EU innovation and economic development policy, and member countries and regions are obliged to integrate the concept into their local policy-making contexts (European Commission 2013). Similarly to the climate change and energy sector regulations, though common guidelines are provided as to how the RIS3 should be formulated (Foray et al. 2011), the approaches adopted in different places are likely to be shaped by the institutional and governance contexts and the specific regional economic contexts in which they are applied (McCann and Ortega-Argilés 2014) (**IV**). These practices oppose the traditional top-down logic of the global climate change policy and introduce bottom-up processes to the climate discourse and related policymaking.

Thus, integrating and implementing the concept of smart specialization into STI policy on the member state and local levels might bring along many challenges. Foray (2018) claims that the same principles of non-neutrality and direction, as well as the systemic vision that must be adopted, clearly impose substantial constraints and challenges in terms of policy design and policy governance, particularly to minimize the risks inherent to these principles. Magro and Wilson (2019) study the governance challenges of smart specialization policy mix evaluations and argue that evaluating place-based strategies for research and innovation oriented towards complex challenges (such as sustainable industrial transitions) implies not only evaluating the specific impacts of policy mixes, but also assessing how those impacts are contributing to the direction and process of the structural transformation desired by the strategy. In addition, they claim that evaluating policy mixes within a dynamic territorial strategy emphasizes the importance of governance because policy design and implementation become integrally related to broader decisions on the direction of the territorial strategy (e.g. which R&D activities to prioritize) at a local or regional level. In sum, the study by Magro and Wilson (2019) shows that strategic learning and intelligence gained through appropriately governed evaluation processes can be used to boost regional capacity building to develop successful smart specialization policy mixes.

Foray (2018) argues that smart specialization strategies will not succeed if policymaking capabilities at a regional level do not reach a high level of competence and commitment. Morgan (2013, 2016) explains that smart specialization can be seen as part of the so-called new industrial policy family that aims at designing and deploying a rather sophisticated approach to increase compatibility between vertical choices for resource allocation and decentralized market dynamics. Therefore, poor quality of government poses an essential barrier to the formulation and application of smart specialization

[16] Foray (2018, 819) accentuates the importance of transformative activities that can lead to structural changes – "a transformative activity concentrates the necessary actions – R&D projects, partnerships, and supply of new specific public goods – to explore the new area of opportunity and facilitate the implementation of collective actions between the different innovation actors concerned". Thus, designing smart specialization strategies means identifying a small number of transformative activities, which will be developed and supported and are managed at a regional level and possibly modified as new opportunities for structural change (Ibid.).

strategies (Rodriguez-Pose et al. 2014). Studies from CEE regions highlight comprehensively all the institutional and capacity deficits that challenge the implementation of smart specialization (e.g. Karo et al. 2017).

Foray (2018, 829–830) brings out three generic challenges for implementing smart specialization (related with government quality, institutional and governance capacities) coupled with design principles for successful implementation:

(1) establishing priorities that are non-neutral and directional in resource allocation in accordance with the analysis of the desired structural changes, the comparison between existing capacities and opportunities, and the identification of the correct level of granularity where public-private interactions and their transparency are also taken into account;
(2) developing transformative activities using a system approach corresponding to the selected priorities, which involves the deployment of various instruments to respond to the different obstacles and difficulties, human capital with related demand for R&D sequence, and integrated vision of innovation and diffusion;
(3) recognizing and implementing the implications of an experimental policy with entrepreneurial discovery, flexibility, monitoring, and maximization of spillovers as principles for design that determine the success of implementation.

Foray (2018, 830) claims that these challenges must motivate and encourage public agencies to invent new structures and change their political practices and culture and notes that a new policy mindset is slowly being instilled into policymakers. This mindset (Ibid.) comprises of – (1) prioritization and vertical choice instead of neutral and horizontal programs; (2) decentralization, self-discovery, and flexibility rather than central planning; and (3) transformative activities rather than sectoral priorities. The previously mentioned aspects can also be seen as a transition or transformation of traditional governance and policymaking that used to work in more isolated contexts but is no longer viable or sustainable in the globalization and internationalization context that involves complex societal challenges.

3.3.4 Impact of research funding models on research systems and the socio-economic relevance of science

Funding of research as a policy instrument influences the direction and dynamics of RDI systems, budgeting and financial management in public universities (**III**), specific fields of research (such as energy and environment), and the related industry and science networks (**I**) that have a high stake in providing viable solutions for sustainability transitions. The discussion below supplements the study of competitive and project-based funding of research (**III**) and the energy technology ISL (**I**) by explaining the wider dynamics in research systems, and the related problems and challenges for governance of research funding and STI in general that might support or hinder the creation of relevant RDI solutions for sustainability transitions. The following sub-section elaborates the effects of research funding on the direction of research and university management in general, and more precisely, on the dynamics of technologies and their ISL that are considered under the socio-economically relevant science (e.g. climate related technologies, environmental and energy technologies).

As funding instruments are quite often focused on only one of the aims, it is important to explain the distinction between socio-economic 'relevance' and scientific 'excellence' related goals of scientific research. Relevance is becoming the central concept in describing scientific research in the new socio-economically aware understanding of

science – e.g. in post-normal-science (Funtowicz and Ravetz 1993), Mode 2 research (Hessels and Van Lente 2008), the Triple Helix approach (Etzkowitz and Leydesdorff 2000), and strategic research (Rip 2004). Therefore, research for tackling societal challenges like climate change and enabling sustainability transitions can also be subsumed under socio-economically relevant science. For some approaches, relevance is intrinsically connected to scientific excellence, as the idea is to build up the scientific base to propose solutions for 'grand challenges' discussed in the science policy discourse (Rip 2011), e.g. in the context of this thesis, climate change and sustainability transitions. This suggests that without excellence there cannot be relevance, the excellence and relevance division is somewhat overlapping: excellence-based knowledge does not exclude socio-economic adaptability, but it is supposed to deliver broad-based solutions for the future (Irvine and Martin 1984). This can be connected to the 'centres of excellence and relevance' promoted by Rip (2004), thus engaging universities in both regional development and academic excellence. Nevertheless, many authors, including Merkx et al. (2007) make the distinction between the 'scientific' and the 'societal' quality criteria more explicit. The first is connected to peer review and bibliometric quality evaluation[17] and the second to context, the significance of research for national and regional strategies and also for end-users.[18]

At the same time, directing the discourse towards societal impact creates pressures for universities to find alternative sources of funding, which includes consulting, commercialization, and marketing activities (Strehl et al. 2007). With external sources of funding increasing, the substitution and complementary effects are becoming more and more discussed (Thursby and Thursby 2011; Muscio et al. 2013). Thus, some critics could also presume that if the funding mechanisms are too focused on the socio-economic impact, it could affect the choices of scientists so that research could shift closer to the market and further away from creating new knowledge (**I**), and the latter has been seen as the primary task of universities for a long time. This relates to the wider discussion about the role of universities and university research.

There are also debates surrounding the influence of different research grants on research outcomes (Manjarrés-Henríquez et al. 2008; Hottenrott and Thorwarth 2011; Jacob and Lefgren 2011; Banal-Estanol et al. 2013; Lawson 2012). Funding agencies and their instruments have become more multi-faceted and autonomous (Lepori et al. 2007). With high-level competition for research funds (**I**), lottery effects are introduced into the system where usually only the very low-level project proposals are easily disregarded (Van den Besselaar and Leydesdorff 2009). To legitimize the choices in these circumstances, objective criteria become handy. Furthermore, selection becomes increasingly dependent on prior performance, thus contributing to funding concentration and creating almost monopoly barriers to new entrants to the funding system (**I**; **III**). Braun (1998) argues that policymaking in funding agencies is the focus of

[17] As it is difficult to assess socio-economic impact, funding schemes tend to become highly skewed towards excellence as more standardized measures are taking prominence in science policy and governance (Hicks 2012).

[18] Being a broad and 'fuzzy' area, societal impact is usually postulated rather than empirically measured (Niederkrotenthaler et al. 2011). Usually there are also challenges with time horizon, diffusion, attribution (causality) and multi-policy and multi-level problems (Martin 2007; Lemola and Lievonen 2008; Martin 2012; Bornmann 2013; Weber and Polt 2014) that complicate the evaluation of socio-economic relevance.

diverse interests because funding resources contribute significantly to the chances of doing research and therefore to the maintenance of existing power relations in the scientific field. Furthermore, scientists are able to adapt to different funding modes and increased competition through selecting the viable funding sources, shaping research content, or even 'creatively' balancing resources between research activities (Laudel 2006; **I**; **III**). There is also evidence that scientists change their activities in accordance with the indicators used for evaluation (Abbott et al. 2010; Bornmann 2010; Erno-Kjolhede and Hansson 2011; **I**).

As a result, research groups themselves act in a strategic manner and establish linkages with different funding agencies to further enhance a feedback loop to the system (developing capabilities based on the ideas of future funding and competition for available schemes) determining funding allocation (Lepori 2011). Due to the complexity and cross-financing practices in university budgeting and financial management (**III**), it is also impossible to eliminate the influence of other funding mechanisms and general motives of the actors within a university with regard to acquiring research funding. Thus, academic research systems are described by "winner takes it all" reward systems that give a strong 'cumulative advantage' to high-level researchers (see discussion in Viner et al. 2004; Defazio et al. 2009; Grimpe 2012).[19] Therefore, in Continental Europe, the excellence-driven research milieus have come to the forefront and these excellence and output based funding systems inevitably lead to resource concentration – in terms of fewer fields and fewer recipients being funded (Wang and Hicks 2013). As award criteria of public funding have started to evolve around peer review reports (collegial procedures), it promotes academic excellence (Viner et al. 2004, Sorensen and Fleming 2004; Hicks 2012). At the same time, noting the effects discussed above, the direction of research and innovation has largely been left without attention and unexamined (**I**). Accordingly, it is claimed that national commissions and advisory boards in general do not have effective mechanisms for regulating research practices and target resources in terms of long-term social considerations (e.g. Fleischman et al. 2011; Schanker and Ulvestad 2011).

Despite the growing acknowledgment of the importance of socio-economic effects of science (see e.g. Salter and Martin 2001; Martin and Tang 2007; Wolfe and Salter 1997), excellence-based science evaluation schemes seem to prevail in performance-based public funding systems. Obviously, sustainability transitions imply the importance of socio-economically relevant science to cope with the global and complex energy, climate, and environmental challenges. Moreover, it requires both basic and applied science: basic research can create radical changes and applied science can apply these to the industry, transport, energy, and environmental sectors in practice, supporting the strand of research described above, where relevance is intrinsically connected to scientific excellence in order to deliver broad-based solutions for global challenges (Rip 2011; Irvine and Martin 1984). The question here is about the collaboration and integration of socio-economic 'relevance' and scientific 'excellence' focused research and the commercialization (and innovation) possibilities of this research. In the context of small countries, establishing and managing a sustainable balance between funding

[19] There are also some works that discuss the connected signalling and reputation effects of research grants (Blume-Kohout et al. 2009), third-party funding, and overall funding schemes (Cherchye and Abeele 2005; Banal-Estanol and Macho Stadler 2010; Hottenrott and Lawson 2012; van Leeuwen and Moed 2012).

instruments dedicated to societal relevance and scientific excellence might become a challenge due to limited resources and limited state capacities (e.g. administrative, policy, technology capacities). Considering the broader economic structure and industrial capacity to commercialize research for the wider goal of tackling climate change and managing sustainability transitions adds another layer of complexity and challenges for governance.

Table 1. Summarized implications from previous research for governance and MLG of selected STI instruments

Opportunities and challenges	Public policy	STI studies	Sustainability transitions
"Linear" and "value-neutral" global climate change discourse where a simple "technical-fix" is possible.	Wesselink et al. 2013; I		
Multi-disciplinary nature of environmental technologies and the accompanying ambiguity problem.		Frondel et al. 2007; I	
Complex, co-evolving, nonlinear sustainability transitions (competing public goods and objectives, multiple domains and levels, uncertainty, and inertia in existing socio-technical systems).		Loorbach et al. 2017; Smith et al. 2010; Geels 2018ab; Turnheim et al. 2015; Tõnurist 2016; I	
	Kern et al. 2019		
Transitions involve actor networks in normative questions, their motives and interactions, power and politics on multiple levels that influence regime transitions and the geography of transitions.		Rip and Kemp 1998; Smith et al. 2005, 2010; Geels and Schot 2007	
Capabilities of individual organizations to innovate and their broader selection environments are formed by complex processes of innovation systems (practitioner routines, skills, and training, governing institutions, facilitating infrastructures, market demand).		Lundvall 1992; Breschi and Malerba 1997	Truffer 2008
	Smith et al. 2010		
Framing, motivations, and interpretations of innovative activities and the directionality of technological trajectories are embedded in broader societal contexts in which specific innovation systems operate.		Bell 2007; Nelson 2008; Von Tunzelmann et al. 2008	
Path dependence and lock-in of existing socio-technical systems around unsustainable technologies.		Loorbach et al. 2017; Geels 2011; Unruh 2000	
Balance between supply- and demand-side technology solutions in mitigating climate change.	Creutzig et al. 2018		
Co-evolvement of policy and socio-technical systems (policy shapes socio-technical systems and vice versa).	Kern et al. 2019; Edmondson et al. 2019		
Policy mixes for sustainability transitions go beyond single policy domains and require coordination.	Kern et al. 2019; Magro and Wilson 2019		
Policy mixes and productive integration of pre-existing and new policies are key for managing structural and transformative system failures.	Weber and Rohracher 2012; OECD 2015; Schot and Steinmueller 2018		
Effective transition policies require that governance schemes consider socio-technical complexities and significant niche-regime-landscape reproduction processes and target key players of transitions.	Smith et al. 2010		

Transition experiments integrate policy with innovation and test novel configurations of socio-technical elements, providing learning, capacity building, de-risking, public education, and engagement.	Rosenbloom et al. 2018; Smith et al. 2010; Matschoss and Repo 2018		
Systemic vision of directional and non-neutral MOPs and place-based policies with transformative activities, entrepreneurial discovery, flexibility, monitoring, and maximization of spill-overs.	Foray 2018; IV		
Systematic and radical changes require transformative and directional innovation.		Johnstone 2005; Wise et al. 2014; Garcia and Calantone 2002; I	
Identification of 'sustainable' technologies and their prioritization.	Smith et al. 2010		
Evaluation of place-based R&I strategies can be used for regional capacity building to develop successful policy mixes that contribute to the direction and process of structural transformation.	Magro and Wilson 2019		
Allocation of RDI investments by encouraging investments in programs that complement the country's other productive assets to create future domestic capability and interregional competitive advantage.	Foray 2018; IV		
Appropriate balance in funding instruments between the socio-economically relevant and scientifically excellent science and between project-based and long-term funding.		Martin 2012; Gulbrandsen and Slipersaeter 2007; Gibbons et al. 1994	
Selection mechanisms of funding instruments have to enable sustainability of research fields but also the emergence of new entrants with radical technologies.	Braun 1998; Wang and Hicks 2013; Viner et al. 2004; Defazio et al. 2009; Grimpe 2012; I; III		
High quality of policy, institutional, administrative, and technology capacities is essential for effective governance and policymaking.	Karo and Kattel 2015, 2018; Tõnurist et al. 2017; Lember et al. 2018; Mergel et al. 2018		
	Painter and Pierre 2005; Wu et al. 2015, 2018; Randma-Liiv 2002		
Local context (culture, history, institutions, governance, policy) and the specific regional economic contexts (broader economic structure, industrial capacities of a country to commercialize research results) initiate, shape, or inhibit the adoption of imported discourses, policies, and instruments.	Kern et al. 2001; Rose 1991; Bennett 1991; Pedersen 2007; Bemelmans-Videc et al. 2010; Freeman 1985; Linder and Peters 1989; Hood 1983; Ehnert et al. 2018; II	McCann and Ortega-Argilés 2014; IV	Ehnert et al. 2018
Consistency, coordination, and translation of policies (top-down and bottom-up) – external discourses have to be translated and connected with national and sub-national level discourses, policies, and institutions.	Späth and Rohracher 2010; Sarrica et al. 2018; Chung 2018	Chung 2018	Späth and Rohracher 2010; Sarrica et al. 2018

Source: Author.

4 EMPIRICAL FINDINGS AND IMPLICATIONS FOR GOVERNANCE AND MLG

In the following sub-sections the previously established analytical framework together with the debates on key implications of selected STI aspects (as tools and factors to enable or challenge the governance of sustainability transitions) are used to understand and explain the opportunities and challenges of smaller states, and especially Estonia. To summarize the research focus of this thesis, has adaptation and convergence towards climate change and sustainability transitions' discourses, selected policies and instruments developed at the global and EU levels emerged in practice, and what have been the governance problems and challenges while designing and implementing these specific imported STI policies and instruments? Convergence and divergence are discussed in terms of whether the imported policy discourses, policies and instruments have developed and performed in member states as originally designed at the global and EU level, or have they shifted away from their initial ideas and setup and been adapted to local context, and what have been the challenges and problems for governance and MLG of these processes? As explained below, the empirical findings present both, converging and diverging trajectories.

4.1 Adaptation and convergence towards EU policy: the role of local context, external examples, learning, and state capacities

The research done for this thesis shows that in the case of environmental taxation, adaptation and convergence towards EU policy, at least to some extent and with certain exceptions, has happened (**II**). This supports the Europeanization (Bache 2008; Börzel and Risse 2003; Risse et al. 2001; Vink and Graziano 2006) and the EU convergence theories (Holzinger and Knill 2005; Knill 2005; Kerr 1983) and argues for the influence of EU politics and policymaking on domestic politics (Bache 2010; Tatar 2016). The case study of environmental taxation (**II**) can be viewed as a positive case of convergence in terms of the EU level climate change discourse. More specifically, it is also a positive case in terms of the transition of the taxation system towards a more sustainable mode that implements the 'polluter pays' principle (Jorgensen 2003, 17–18; Adolino and Blake 2001, 320), enables the abatement of already existing pollution (through reallocating targeted environmental charges into environmental projects), and supports the uniform regulation of the Common Market (through energy taxes). The practice of developing a taxation model that presents a mix of previously used environmental charges and imported energy taxes (**II**) also confirms that policy mixes that integrate pre-existing instruments and account for context specificities are key for managing transformation processes (Weber and Rohracher 2012; Schot and Steinmueller 2018).

In general, the case study highlights more opportunities than challenges and problems arising from adapting to externally developed policies and instruments. Moreover, from the MLG angle it illustrates a positive case in terms of both bottom-up (environmental charges) and top-down (energy taxes, fuel and electricity excise duties) policymaking in the EU (**II**), and from the MLP angle it emphasizes the role of landscape (e.g. international convergence mechanisms) and niches (e.g. environmental taxes as novel policy instruments) in the changes of regimes or parts of regimes (e.g. the Estonian environmental taxation model, the national energy system). The results also indicate that the convergence of environmental taxes in general was not influenced solely by

international convergence mechanisms (Busch and Jörgens (2005a) as usually believed but that local context, factors, actors and institutions, and the right timing played a significant role in the development of the taxation model (**II**; Kern et al. 2001; Rose 1991; Bennett 1991; Pedersen 2007; Bemelmans-Videc et al. 2010; Freeman 1985; Linder and Peters 1989; Hood 1983). The local favorable context of the existing socio-technical regime (energy and environmental sectors) with support to environmental protection initiatives and readiness for adopting stricter and new measures, also past experience with similar policy instruments (e.g. environmental charges as niche instruments), and joining the EU facilitated a smoother adaption to imported instruments. These conditions can also be considered responsible for better convergence with EU environmental and energy taxation policies in general – the case of Estonian environmental taxes and charges system (**II**) is the only policy convergence case among the analyzed case studies. Convergence with EU energy taxation policies can clearly be witnessed with regard to some country specificities (like the essential role of environmental charges in Estonia for financing environmental protection projects that were not used at this scale in other countries). In the case of energy taxes (fuel and electricity excise duties) that are needed for the uniform regulation of the Common Market, the EU has used co-operative harmonization and coercive imposition (Busch and Jörgens 2005a; **II**) to harmonize and converge consumption taxes (also including fuel and electricity duties) with the aim of enabling equal competition in the Common Market.

Moreover, the Estonian case of environmental taxation (**II**) can be seen as a "success case" of external policy adaptation. The case study clearly emphasizes the role of local context and 'administrative fit' or the 'logic of appropriateness' (March and Olsen 1989) in explaining the adoption, rejection, and frequent national variations of NPI that have been widely discussed by many scholars (Tews et al. 2003; Rose 1991; Knill and Lenschow 1998; Hoberg 2001; Jordan 2001; Kern et al. 2001). The main local factors that sped up the convergence of the Estonian environmental taxation system (**II**) with other European countries were high public awareness and willingness to deal with environmental problems, also the government's need for resources and for (co-)financing environmental protection projects. In addition, no less relevant was the local experts' knowledge of the NPI and how they work in other countries, past experience with similar instruments, right timing that enabled a significant increase in charge rates and last but not least, joining the EU. The case study (**II**) also refers to the advantages of small states like flexibility and lower transaction costs, faster and easier discussions and agreements, designing and implementing new ideas and solutions just to name a few (Katzenstein 2003; Tõnurist 2010; Armstrong and Read 2003; Bräutigam and Woolcock 2001; Hey 2002; Lemola and Ylä-Anttila 2003; Lundvall et al. 2002).

Regarding international best practices and examples from which countries can learn from, there are well presented studies, especially among the recent sustainability transitions literature, about the role and positive impact of local initiatives and demonstrations (Dowling et al. 2018; Jenkins and Hopkins 2019; Späth and Rohracher 2012) and urban experiments and living-labs (Fuenfschilling et al. 2019; von Wirth et al. 2019; He et al. 2018). There are also examples in the form of transition experiments with long-term transformation vision across sectors (Rosenbloom et al. 2018) and more specific governance experiments (Matschoss and Repo 2018). All of these studies point out that successful national and international examples of designing and implementing NPI for enabling sustainability transitions are essential, but local context also plays a significant role in successful policy transfer, as also shown by the Estonian case that took

after the German and Scandinavian models of environmental taxation (**II**). These findings support the previous studies on the positive role of transition experiments (Rosenbloom et al. 2018) and governance experiments (Matschoss and Repo 2018) because they integrate policy with innovation where experimentation is positioned more within socio-technical regimes than in strategic niches. Therefore, as seen in the case study of the environmental taxation in Estonia (**II**), the experience and examples of other countries with NPI (like environmental taxes) provided Estonia with opportunities to learn, build capacity, take less risks, and increase public education and engagement locally and indeed provided new transition opportunities towards low-carbon systems, confirming the previous studies of Rosenbloom et al. (2018) and Matschoss and Repo (2018).

In the context of multi-level sustainability transitions, Späth and Rohracher (2012) analyze the role of spatial dimensions in the transformation of socio-technical regimes (like the energy system) towards more sustainable configurations and conclude that considerably more attention should be paid to the interplay of local and non-local discourses and the dynamic relations between local initiatives and non-local networks because they can provide specific opportunities for the legitimization and adoption of more sustainable socio-technical systems, as clearly seen in the case study of Estonian environmental taxation (**II**). Sarrica et al. (2018, 451) emphasize three main needs: (1) better coordination between centralized and decentralized energy policies; (2) recognizing and addressing bottom-up inputs and concerns and integrating these into national/regional strategies; and (3) enhancing participation and public engagement in energy governance. This is in line with the Estonian experience of developing the environmental taxes and charges system where coordination between central and local levels, local and non-local experts' networks, bottom-up input, and public engagement of the industry and related stakeholders as emphasized by Späth and Rohracher (2012) and Sarrica et al. (2018) were considered (**II**).

Relatedly, some challenges with the local context and interaction between local, national, and the EU levels can be outlined from the case study (**II**) as well. First, the economic situation of a country that just became independent did not allow introducing high tax rates, and the interest of entrepreneurs had to be taken into account, despite the fact that the local polluting companies and users of natural resources had weak unions. The development of the system evolved hand in hand with entrepreneurs because the aim was not to raise the electricity price rapidly and harm competitiveness. Secondly, joining the EU required investments into the areas that had a transition period and national co-financing was necessary to get funding for environmental protection projects from the EU Social Cohesion Fund. Economic instruments seemed most rational because of the enormous investments needed. In addition, higher environmental goals and expectations on pollution abatement pushed for more flexible economic instruments. The main challenge for adapting the local system after joining the EU was how to meet EU standards and requirements and how to receive additional funding from EU programs to develop national competitiveness. Regarding the previous aspects, the case study also argues for the relevance of the political-institutional context (Ehnert et al. 2018) and the specific regional economic contexts in which NPI are applied (McCann and Ortega-Argilés 2014).

The environmental taxes case study (**II**) also highlights well the complexity of transitions (Loorbach et al. 2017; Smith et al. 2010; Geels 2018a, 2018b; Turnheim et al. 2015; Tõnurist 2016; Kern et al. 2019) and the role of complex networks of actors in

normative questions (Rip and Kemp 1998; Smith et al. 2005, 2010; Geels and Schot 2007). It illustrates how policy mixes and socio-technical systems co-evolve in sustainability transitions (Kern et al. 2019; Edmondson et al. 2019) – environmental taxation influences the energy sector, but the energy sector also has mechanisms to influence the development of new taxation models. As explained before, the practice of considering the needs and capabilities of local industry and individual organizations maintains that governance schemes that account for socio-technical complexities and target key players of transitions while retaining a sense of significant niche-regime-landscape reproduction processes are more likely to generate effective transition policies (Smith et al. 2010). Regarding the niche-regime-landscape reproduction processes, the Estonian case presents the destabilization of incumbent regimes (highly pollutive oil shale based energy sector), promotion of green niches (e.g. environmental taxes and charges), and the translation of ideas and practices from niches into mainstream settings (e.g. development of a new taxation model).

Hansen's and Nygaard's (2013) study adds to the Estonian experience and the role of local factors in an opposite way by illustrating the rejection of external interventions due to local context and strong opposition of local interests. They analyzed the role of transnational linkages and donor interventions in sustainability transitions of emerging countries, and based on the empirical findings, they argue that local context and path dependency play an important role. More specifically, they claim that advice on energy policy had a limited impact mainly because of strong opposing interests in maintaining the existing situation and that the short duration and unpredictability of interventions can generally be seen as an important impediment for programs in reaching their objectives.

Accordingly, the latest literature on policy transfer and sustainability transition highlights the diffusion of practices through learning and imitation. Jenkins and Hopkins (2019) analyze transitions in energy efficiency and energy demand through the emergence, diffusion, and impact of low-carbon innovation and claim that systemic reductions in energy demand are only possible through low-carbon innovation. There are also some recent studies that focus on understanding and governing learning (van Mierlo and Beers 2018) and the role of learning and best practices in municipalities and urban climate change governance (Nagorny-Koring 2019; Wolfram et al. 2019; van Mierlo and Beers 2018). Sol et al. (2017) have monitored in more detail the emergent properties of social learning in governance networks involved in sustainability transitions to better understand the role and the dynamics of these properties and to see which actors and roles can foster the effectiveness of social learning in regional transitions towards more sustainable ways of living. As a result, they found that reflexivity in particular is a critical property at moments that can make or break the process (Ibid.). These studies again clearly emphasize the role of local capacities and in addition to policy capacities and the capacity of the government (Foray 2018; Rodriguez-Pose et al. 2014), they highlight the importance of social capabilities and capacities (e.g. social learning, imitation, and best practices) that are also considered essential in the Estonian case study of environmental taxation (**II**) and smart specialization (**IV**).

Relatedly, recent studies have also analyzed the capacities for transformative climate governance (Hölscher et al. 2018a) and the competences of local and regional urban governance actors to support low-carbon transitions (Holtz et al. 2018). Shaw et al. (2018) analyze the potential of community-led actions and emphasize the critical importance of scalar politics in enabling effective climate change strategies – tackling

climate change requires a set of deeply intertwined geographical responsibilities where actors at and across different geographical scales are closely connected. This refers to the role of MLG. Involvement of local levels partly explains the successful adaptation in the case study of the environmental taxation system (**II**) and implementation failures in the case study of smart specialization (**IV**) in terms of how smart specialization was envisioned in theory (e.g. the EDP and aim to solve grand challenges). Schoon and Cox (2018, 1) argue that governance for sustainability requires long-enduring institutional arrangements, such as collaborative governance and co-management, to build more enduring governance structures and working across scales of institutions and governance groups (including nested institutions as well as communication and coordination both horizontally and vertically). Additionally, they highlight the importance of adaptation and evolution in the resolution of collective action dilemmas in complex systems with nonlinearities, unclear causal chains, and uncertain future outcomes and meanings of governance actions.

4.2 Diverging trajectories of EU and national STI policies: sustainability transitions through cleantech, public research, and smart specialization

In the comparative case study of smart specialization in Estonia and Wales, some similarities in designing and implementing the policy and strategies at national and sub-national levels can be witnessed (**IV**). However, all the other case studies of the thesis (impact of the climate change discourse on ISL – **I**; research funding – **III**; and smart specialization in a broader sense, meaning how it was aimed at the EU level and how it has been implemented – **IV**) show more diverging trajectories – challenges and problems for governing STI policies, ISL, and universities – than convergence and adaptation of EU discourses and policies. As the selected STI aspects are part of wider policies and systems for speeding up sustainability transitions, the governance challenges of these STI aspects pose micro and macro level challenges for sustainability transitions as well.

4.2.1 Climate discourse and challenges for national STI policies: experiences with cleantech, ISL, and public research systems

The Estonian case study about the impact of the global climate change discourse on the implementation of national science policy (**I**) illustrates that the introduction of policy narratives from a broad and high-level global discourse (seen as the wider landscape) to the national level (from the MLG angle) and to the socio-technical regimes (from the MLP angle) can have unintended and multi-directional effects for policy implementation. More specifically, these narratives can shape the actual policy practices and networks of actors in a complex and non-linear fashion. The broad-based policy discourses and policy changes may be easily transferred from sector to sector and from country to country (e.g. spread of environmentally friendly technologies to different countries and to various technology sectors); however, they can also accommodate diverging and contradictory approaches (e.g. environmental protection and especially pollution clean-up and end-of-pipe technologies versus green niches like cleantech that has zero to minimum effect on the environment) depending on the interested parties involved (researchers, companies, industry, investors, etc.) (Frondel et al. 2007; **I**), their innovation capabilities and the broader innovation environment (Lundvall 1992; Breschi and Malerba 1997; Smith et al. 2010; Truffer 2008), the regional economic context

(McCann and Ortega-Argilés 2014), and the political-institutional context (Ehnert et al. 2018).

The research conducted for this thesis brings out several challenges for the implementation of national science policy (focused on collaborative networks of industry and science in energy technologies) and thus for enabling socio-technical regime transitions (**I**). Therefore, it illustrates especially well the interdynamics between MLG and the MLP of globally initiated sustainability transitions and transitions of more local socio-technical regimes. The findings show that the global climate discourse has indeed led to the diversification of research agendas and collaboration networks but the shifts in research strategies often tend to be rhetorical and opportunistic, with limited evidence of novel research fields and groups in radical cleantech niches (**I**). The findings even show that to some extent scientists adapt their research topics and activities based on the broader landscape dynamics of sustainability transitions and their influence on regime shifts, like changes in funding sources (also noted by Laudel 2006; and in the case study of research funding – **III**) and the indicators of evaluation used in allocating research grants, as also found in previous studies (Abbott et al. 2010; Bornmann 2010; Erno-Kjolhede and Hansson 2011). As pointed out by Späth and Rohracher (2010) and Sarrica et al. (2018), global challenges require that discourses from supra-national institutions are translated and connected with national, regional, and local level institutions which, as noted in the case study of the energy technology ISL, has been inadequate in Estonia (**I**). Accordingly, the ambiguity of the global climate change discourse accompanied by insufficient translation of the discourse into local policy implementation and "sailing-ship effects"[20] of traditional technologies (De Liso and Filatrella 2008) have facilitated incremental innovation towards energy efficiency (**I**), instead of initiating considerable regime shifts in the energy sector. Furthermore, this has led to the lock-in of technologies (Loorbach et al. 2017; Geels 2011, 27; Unruh 2000), e.g. the case of high oil shale dependence in Estonian electricity production, and eventually to non-optimal solutions for the energy sector of Estonia (**I**). This clearly poses a structural problem for energy and environmental policy, energy security and sustainability in the long run and confirms the governance challenges of complex and frequently contested processes of socio-technical change (e.g. sustainability transitions in the energy sector) as outlined by Turnheim et al. (2015) and many others (Loorbach et al. 2017; Smith et al. 2010; Geels 2018a, 2018b; Tõnurist 2016; **I**).

If sustainability transitions through clean technologies are in question, it is important to understand the different logics of different technologies and their ISL and develop technology capacities (Tõnurist et al. 2017; Lember et al. 2018; Mergel et al. 2018) for successful policy implementation. Cleantech ISL usually have a more radical direction of innovation that requires longer time frames, but their strong business nature (Caprotti 2012; Okereke et al. 2012; Kuehr 2007; O'Rourke 2009) can inversely lead to short-term contracts. Environmental protection ISL (efficiency-oriented and additive in nature) are more incremental in their innovation direction and therefore usually have closer links to the market collaborations. If more radical cleantech is needed to disrupt the existing socio-technical regimes then research and innovation funding instruments have to also take into account these technology and network specificities, the direction of innovation

[20] "Sailing effects" are situations where the threat to the traditional technology of being displaced by new technologies spurs investments into the old technology and increases its performance (De Liso and Filatrella 2008) and through this can lead to lock-in of old technologies.

(Garcia and Calantone 2002) (not only the rate of innovation as explained by Popp et al. (2010, 878)), and the transformative nature of innovation (Johnstone 2005; **I**). The case study of the energy technology ISL (**I**) illustrates well the problems with the "winner takes it all" funding models that depend on prior performance leading to resource concentration and creating monopoly barriers to new entrants, which are problems that have been noted by many academics (Wang and Hicks 2013; Viner et al. 2004; Defazio et al. 2009; Grimpe 2012; **III**).

Many of the challenges with external policies are related to how to translate them into the local context (Sarrica et al. 2018). In terms of the MLP of sustainability transitions, how to translate the changes from the wider landscape into local socio-technical regimes and niches. From the MLG perspective, national level policy-makers can adopt the global climate change discourse in terms of the goal of long-term low-carbon energy production, but the policy implementation level and ISL might not be sufficiently involved. This is the case in Estonia: when we look at the actual implementation of the science policy, R&D has not moved hand in hand with the discursive goal (**I**). Although the broad global climate discourse has influenced funding decisions in science policy, the impact has not been as profound as expected: linear and value-neutral science policy (Wesselink et al. 2013) has strengthened some basic science research groups but also left some applied research groups dependent on industry contracts and investments (**I**). In line with Braun's (1998) argumentation, until 2016 the funding models of STI have in general maintained the existing power relations in the Estonian scientific field, as seen in the case study of the energy technology ISL (**I**) and also noted in the case study of public research funding (**III**). If more applied research teams are solely dependent on industry contracts, they can function with industrial funding only for a short period. Focusing only on short-term applied research can hollow out basic research competences and in the long run reduce the research groups' value to the industry (**I**). These findings support the studies that see industry collaboration as a threat to the sustainability of basic research (e.g. Elzinga 1985, 1987; Pelikan 1992; Slaughter and Leslie 1997; David 2000; Polster 2000; Ziman 2000; Maskell and Robinson 2001; Graham 2002; Barnett 2003; Nelson 2004). However, there are also analyses that see the close cooperation between universities and industry (Salter and Martin 2001) as an opportunity for the 'entrepreneurial university' to become the 'engine' of the knowledge economy (e.g. Clark 1998, 2004; Etzkowitz 1998a, 1998b, 2002, 2003, 2004; Etzkowitz et al. 2000; Schulte 2004; Kitagawa 2005; Shattock 2005) as claimed by Martin (2012, 544). This is also supported by the case study of the energy technology ISL (**I**), specifying more precisely that successful applied research needs to be grounded in profound basic research capabilities (Rip 2011), which are a core competence of universities and part of their main mission. Basic and applied research groups need to collaborate and thus complement each other, which of course might increase communication problems and complexity of research and innovation networks. Still, cooperation between different competences and capabilities is important – an environment where transfer of knowledge and competences is supported is essential for innovation to deliver broad-based solutions for global challenges (Irvine and Martin 1984).

As explained before, public research funding is essential for securing the sustainability and independence of research groups in both streams of research (scientifically relevant and socio-economically excellent) and also for the wider discussions of sustainability transitions where innovation policy and RDI systems are considered (e.g. Fagerberg 2018; Creutzig et al. 2018). It is clear that until 2016 the Estonian public research funding

system was an extreme case where more than 80% of research funding was project-based (**III**) and convergence with countries nearby or with the EU had not happened, and thus, the sustainability of the system was also questioned. Until 2016, the funding environment of public research in Estonia was highly complex with a large variety of different instruments coupled with a weak governance context. The subunits were free to apply for any external funds they desired (budgets where mainly compiled based on a bottom-up logic), and the central administration had not implemented steering mechanisms to limit the acquisition of funds despite the fact that they carried the financial risk (**III**). Although the overall budget of the universities under study increased from 2004 to 2013, such a funding environment created significant fluctuations of revenues for the subunits and in addition lead to tensions between the core and the subunits (**III**). First, adequacy and equity in covering and distributing indirect and overhead costs associated with the projects, especially in cases were funding programs did not allow for indirect costs (i.e. EU structural and cohesion funds). Secondly, tensions were also created by funding instruments that rely on lagged reimbursement, due to which central administration is inevitably forced to use overdraft facilities of banks and bear associated interest costs.

In sum, the thesis shows that project-based funding of public research poses many challenges for budgeting and financial management in public universities (**III**): fluctuating revenues; fragmented revenue sources, which give rise to high transaction costs, coordination problems, high complexity in managing the finances; difficulties in securing cash flows; and problems with covering indirect costs. Additionally, the main findings suggest that such arrangements have led to an internal paradox where the more successful the research groups are in obtaining project-based research funding from diverse sources, the more strained the university budget as a whole becomes. The empirical study clearly shows that governance structures with imbalanced autonomy and accountability of the subunits are not likely to be sustainable in the long term (**III**) and therefore pose challenges for wider sustainability transitions of socio-technical systems where ISL and socio-economically relevant research for tackling global challenges play an essential role.

When looking at the issue from the MLP angle, the tensions between central administration and subunits in public universities regarding the implications of project-based funding of public research (**III**), the logic of external landscape instruments (e.g. EU funding programs) conflicts with central administrative structures and logics of the existing science regime (e.g. the issue of calculating and paying indirect and overhead costs to the central administration). This implies that the features of the external mechanisms have not been sufficiently translated to central administration levels and adaption to external instruments has not happened, communication between governance levels is not flowing as it should – although this has been emphasized as an essential factor by previous studies on MLP and MLG of sustainability transitions (e.g. Sarrica et al. 2018; Späth and Rohracher 2010).

Furthermore, in the area of energy technologies and as a result of the highly competitive and project-based Estonian research funding system and wider STI policy, with no systemic vision of non-neutral and directional mission-oriented energy technology financing, the applied research groups and ISL are left to compete within the general science funding system that favors basic research (**I**; **III**). This is in line with the general research funding practices in the EU that have evolved around peer review reports promoting academic excellence (Viner et al. 2004, Sorensen and Fleming 2004;

Hicks 2012) and leaving the direction of research and innovation largely without attention (**I**). While such funding systems have given precedence to a few new and more radical cleantech niches (e.g. photovoltaic and storage technologies) that have been transferred into Austrian and German industries, this is not the result of active state policy in Estonia (**I**). The research shows more incremental innovation in environmental protection and end-of-pipe technologies and only few radical innovations, which leaves uncertain whether local GHG-emission can be reduced (**I**). Radical technologies can be applied elsewhere with global net benefit, but domestic investment to enable more radical carbon-reduction is also essential for reducing GHG and initiating a transition of the historically oil shale based highly pollutive socio-technical regime. These findings support the studies by Fleischman et al. (2011) and Schanker and Ulvestad (2011) who argue that quite often national commissions and advisory boards do not have effective mechanisms to regulate research practices and target resources in terms of long-term social considerations.

Therefore, the capabilities and willingness of individual organizations to implement R&D and their broader selection environments formed by complex processes of innovation systems (Lundvall 1992; Breschi and Malerba 1997; Smith et al. 2010; Truffer 2008) become a central concern for achieving the goals of the climate change policy and enabling sustainability transitions (**I**). To significantly reduce GHG emissions, companies have to be motivated to invest in R&D and radical innovation (Garcia and Calantone 2002). The case study of the energy technology ISL (**I**) shows that here the nature, magnitude, quality, and direction of ISL become very important. As investment decisions are not managed centrally, incentives of individual electricity utilities in the market for advancing technologies become fundamental. Short-term contracts and incremental improvements due to the lack of investment interest from the private sector can become an obstacle for ISL.

Additionally, Estonian state enterprises also face challenges regarding the legal requirements for procuring R&D that does not support innovation in terms of its open and network-like logic. According to the Estonian Public Procurement Act that entered into force in 2018, R&D is defined in narrow terms where innovation as commercialization of inventions (Sahal 1983) is not included, and according to the State Property Act state enterprises can support only project-based R&D in their area of operation. This leaves the state enterprises in a situation where it is difficult to build up sustainable ISL and innovation systems through project-based R&D projects because besides core R&D activities also additional supportive activities like networking and marketing are needed to "glue" the different activities and stakeholders together. It is quite often believed by policymakers that when the R&D phase is done, the change from R&D to innovation (where products and services are widely used on the market) should happen on its own without special supportive conditions. One solution to this problem could be to broaden the procurement requirements to RDI and also include innovation related community building, side and support activities together with universities, research units, and related support organizations for the establishment and maintenance of longer and more durable ISL and wider innovation systems.

The previous discussions about the motivation of public and private sector companies to invest and implement R&D indicates that differentiation in terms of policy is needed to capture both short-term solutions (as outphasing of traditional energy technology takes time), but also increase the use of renewable, 'clean' energy, which is needed for long-term energy security (**I**). This illustrates well the essential role of policy mixes that

require coordination between different policy fields (e.g. energy, innovation, and research funding – **I**; **III**) and incorporate future uncertainties in technical, political, and cultural spheres (Kern et al. 2019; Magro and Wilson 2019). Transformations also require directionality, identification of 'sustainable' technologies, and their prioritization, but it is important to understand that the framing, motivations, and interpretations of innovative activities and the directionality of technological trajectories are embedded in the broader societal contexts in which specific innovation systems operate (Bell 2007; Nelson 2008; Von Tunzelmann et al. 2008). Regrettably, this has not been considered while designing smart specialization strategies in Estonia (**IV**) because competitive alternatives to oil shale were not considered. In order to guide the transition from oil shale based electricity production towards clean energy, more long-term commitments from policy and funding programs are essential (**I**). This demonstrates the importance of STI policy for sustainability transitions. Here the correct policy mix becomes key in addressing many of the problems not only in R&D (e.g. challenges with funding models of public research – **III**) but also within the industry (Weber and Rohracher 2012; Schot and Steinmueller 2018) that take into account the actual effects of the influence of the climate discourse in the implementation of the STI policy (**I**). The energy technology ISL case study (**I**) illustrates best that transitions go beyond technologies and require changes not only in technical infrastructures but also in social practices and market arrangements (Kern et al 2019). Transition processes involve essential actors who decide on normative questions and operate through structured and complex relations, like the energy technology ISL, where the motives and interactions, power and politics in niches and socio-technical regimes may foster or hinder regime transitions and the geography of transitions (Rip and Kemp 1998; Smith et al. 2005, 2010; Geels and Schot 2007). Hence, the highly scientific, high technology oriented, and linear understanding (Wesselink et al. 2013) has not produced the desired effect in Estonia – due to the lack of clear and specific R&D funding goals, radical decrease in GHG emissions has not been ensured (**I**).

Recently there have been two noteworthy developments in the energy sector of Estonia. First, due to the open electricity market[21], Estonian Energy (who is the main oil shale based electricity producer in Estonia) has decreased its electricity production by a remarkable amount from the beginning of 2019. This was initiated by the increase of cleaner and cheaper energy on the market and the high CO_2 component in the electricity price of the oil shale based electricity produced by Estonian Energy. These processes have activated many political, social, and security related discussions due to the local sensitivity of the topic – in Estonia, oil shale based electricity production has historically been tied to national energy security, economic competitiveness, and regional development. The second remarkable development is the plan to desynchronize the Estonian transmission grid from the grid of the Russian Federation. Historically, the Estonian main grid has been connected to the Russian (and previously to the Soviet Union's) electricity transmission grid. Therefore, Russia has maintained and is still maintaining the frequency of the Estonian electricity grid. On the one hand, both of these cases illustrate path dependency and the lock-in of old technologies and processes that besides the main dynamics discussed in this thesis might also be related to the reluctance to develop new technologies, processes, and systems if there are comfortable or politically justified solutions at hand. This illustrates well the lock-in effect of existing

[21] Estonia is part of the leading power market in Europe called Nord Pool that is owned by the Nordic and Baltic transmission system operators – https://www.nordpoolgroup.com/.

socio-technical regimes both in terms of technological but also social and political spheres (Geels 2011; Unruh 2000; Loorbach et al. 2017). On the other hand, these new developments might open the market for new technologies of cleaner energy production and consumption and flexibility services relevant for maintaining the stability of the electricity grid. Due to the political and economic pressure, this might lead to more radical changes in the related technologies and systems of electricity production and grid management. For example, the Estonian transmission system operator Elering has developed a niche technology that enables consent-based access to energy metering data. If it is possible to scale this technology across the EU, it has the potential to enable regime changes through opening smart meter data to a variety of innovators of energy products and services.

Relatedly, the case study of the Estonian energy technology ISL (**I**) and the wider dynamics of the sector emphasize the importance of considering the policy context (Bemelmans-Videc et al. 2010) and policy-sector (Freeman 1985) while implementing broad-based externally developed discourses on the national level. This also supports the findings of Cepilovs (2017, 12), which state that the nature of the policy domain has a significant impact on the nature of policy transfer and policy learning, as well as the resulting policy outcomes.

4.2.2 Directionality of STI policies for sustainability transitions: experiences with smart specialization

Innovation policies of smart specialization with their place-based, directional, and experimental nature and potential orientation towards grand societal challenges in a complex MLG context can potentially be seen as a viable solution to the challenges and problems discussed in the previous sub-section. Magro and Wilson (2019) argue that policy mixes of smart specialization are particularly relevant for solving complex challenges such as sustainable industrial transitions that require joined-up interventions from different policy domains, but the right policy mix is strongly conditioned by the governance context in which individual policies emerge and evolve over time. This is also in line with the wider sustainability transitions literature that considers directional policy mixes and the integration of pre-existing and new policies essential for managing structural and transformative system failures (Weber and Rohracher 2012; OECD 2015; Schot and Steinmueller 2018).

Until the introduction of the smart specialization concept, in general policymaking in Estonia did not have a mission-oriented nature (Karo et al. 2014). Smart specialization was the first attempt to design and implement MOP. Therefore, in the wider STI policy and sustainability transitions context, it would have been logical that the Estonian smart specialization strategy would also have a clear focus towards sustainability through specific areas like climate, energy, transport, etc. Contrary to these expectations, the smart specialization strategy turned out differently, and the fields related to the energy transition are in a superficial way covered under two focus areas – information and communication technologies (ICT and particularly digitalization of the industry) and valorization of resources – but without a clear direction (**IV**).

Looking from the MLP and MLG angle of sustainability transitions, recently many studies have been published that focus on the challenges and problems that governments on different governance levels and with different capacities (together with their agencies and other actors involved in the innovation system) face while designing and implementing smart specialization policies and mission-oriented RDI support

programs with the aim to solve more complex societal challenges (Radosevic et al. 2017 and especially chapters 12–14; Foray 2018). Thus, besides discussing the challenges and problems, these studies also give insights about the institutional and cultural conditions that can facilitate the practical application of smart specialization (Foray 2018). The case studies on smart specialization of this thesis add to this stream of research (**IV**). Both the Estonian and Welsh case study highlight constraints of governance, limited policy and technological capacities of central governments, and challenges with involving local governments (municipalities) in designing and implementing experimental, directional, place-based, and bottom-up smart specialization strategies. This is in line with the general arguments from the literature, which state that the formulation and application of smart specialization strategies presumes good quality of governance and high-level policymaking capabilities on regional levels (Foray 2018; Rodriguez-Pose et al. 2014). This is further challenged in Estonia because regional governance on the county level was dissolved on the 1st of January 2018 (Riigi Teataja 2017). Additionally, successful smart specialization policies also assume technology capacities for effective governance and policymaking (Lember et al. 2018, Mergel et al. 2018, Tõnurist et al. 2017) with the aim to initiate green niches and manage regime shifts. Thus, the findings of this thesis (**IV**) support the claims about the weak institutional, policy, and administrative capacities of smaller states and especially Estonia (Randma-Liiv 2002; Karo and Kattel 2015; Cepilovs 2017; Karo et al. 2017).

More specifically, the Estonian and Welsh cases emphasize problems with the EDP in choosing the smart specialization fields that was not conducted in the bottom-up and organic mode in which it was initially envisioned (**IV**). Instead, sectors were chosen at the national level in quite a top-down manner hindering the emergence of the EDP and without even considering the direction and transformative nature (Johnstone 2005; Garcia and Calantone 2002) of climate and energy related technologies that are seen as essential in sustainability transitions. This can partly be explained by the ambiguity of the global climate change discourse but also the path dependency and lock-in of existing socio-technical regimes (Loorbach et al. 2017; Geels 2011; Unruh 2000), like the oil shale industry in Estonia discussed in the case study of the energy technology ISL (**I**). Accordingly, the ambiguity of the discourse poses additional challenges for policy implementation because it unites controversial concepts from pure clean technologies (that reduce resource use and pollution at the source) to end-of-pipe and pollution treatment technologies (that clean up already existing waste) (Frondel et al. 2007) within one discourse. This is challenging for MOP (like science policy and also research funding) (Foray 2018) and especially for identifying specific goals and outlining concrete activities for achieving these goals – as shown in the case study of the energy technology ISL (**I**) and also noted in the case study of smart specialization (**IV**). The case study of smart specialization illustrates that in both (the Estonian and Welsh) cases too broad areas with no clear direction where chosen with limited use of the bottom-up EDP. In Estonia, smart specialization was designed and implemented in the opposite way to its directional and non-neutral logic because the framework was designed to be so broad that all sectors and companies could be considered (**IV**). This could allude to one even wider problem of smaller countries, namely, due to closer relations designing and implementing selective policies (that disadvantage some companies and sectors) might be more challenging in smaller communities than in larger impersonal contexts.

Additionally, both of the smart specialization case studies (**IV**) highlight the limited involvement of city governments in choosing their smart specialization areas, leaving

them out of the game of strategically planning local innovation and development activities and designing and implementing place-based policies for sustainability transitions. Furthermore, form the MLG perspective, the implementation of smart specialization in Estonia has led to a somewhat paradoxical situation where through the funding mechanisms the two central cities have received most of the funding; however, the idea of smart specialization has been a more bottom-up and place-based EDP that would involve a wider group of regional and local levels. These reasons can partly explain why the smart specialization approach has not delivered upon its promise in Estonia, nor has it necessarily delivered on its promise to orient regional policy towards a more place-based and bottom-up mode (**IV**). Thus, the case studies (**IV**) also support the importance of considering the political-institutional context (Ehnert et al. 2018) and the specific regional economic contexts in which the instruments are applied (McCann and Ortega-Argilés 2014) – taking into account that the local context may potentially enable a more successful adaptation, which unfortunately has been limited in the case studies (**IV**).

In one of the latest writings, Foray (2018, 821) brings out three qualifications that should not be neglected while designing smart specialization strategies. First, he claims that most generic and horizontal policies remain essential and smart specialization should be seen as an alternative choice for prioritization. Second, he argues that innovation should not be reduced to high-tech and cutting-edge research but should be widely distributed across the variety of sectors and phases of RDI to generate innovation complementarities in existing sectors. Third, he emphasizes that the idea of transformative activities supports an open economy, openness to international investments and international value-chains, and seeking critical resources and knowledge outside the region that are not available at home. The research conducted under this thesis presents challenges with these qualifications. The main problems arise from the features of the dominant but unsustainable socio-technical regimes of the local RDI system (e.g. in the energy sector) that create path dependence and lock-in, namely, the weak ISL of radical energy technologies and the limited international focus and struggle with competition on the international level for the other, more incremental energy technology ISL (due to historical local focus instead of international during the Soviet Union times) presented in this thesis (**I**). In addition, the highly competitive and project-based funding of science in Estonia presented in the case study of research funding (**III**) with too much focus on excellence-based evaluation schemes in research funding is also a feature of the dominant regime that especially challenges the second qualification brought out by Foray (2018). More of these challenges are comprehensively explained by Karo et al. (2014) and in detail illustrated in the case study of smart specialization implementation in Estonia (**IV**; but also in other case studies as noted above and below) as features of the Estonian RDI system that pose additional challenges for smart specialization in the Estonian context. Related to Foray's (2018) three qualifications, Karo et al. (2014, 6-7) argue that, first, in Estonia before the introduction of the national technology programs, there was mainly a horizontal RDI approach with very limited specialization (**I**; **IV**) referring to the development of the smart specialization policy as the main prioritization mechanism. Second, most RDI policy support measures are competition-based, research funding is dominated by scientific excellence and applied research is left in a less advantaged position, as also presented in the empirical work of this thesis (**I**; **III**) limiting the generation of innovation complementarities in existing sectors. Third, there is institutional asymmetry between science and R&D where the stronger position is held by the academia, and there is fragmented and uneven

cooperation between regional science and business networks (**I**), hindering open economy, openness to international value-chains, and search for critical resources and knowledge outside the region. Fourth, an increasing amount of foreign (mainly EU) funding is financing Estonian research (EU SF, FP7 and Horizon2020) (**III**) and national branch ministries have a weak role in managing and financing the RDI system (**IV**), presenting a positive case for international investments and value-chains but posing challenges to national strategic management of universities and STI policy in general (**I**; **III**). Additionally and in line with Foray (2018), Karo and Kattel (2015) argue that it is not clear whether the high-tech bias and innovation-driven understanding of smart specialization is in fact the most suitable approach in less developed regions and countries because high-tech and R&D elements can tend to get over emphasized, limiting understandings of innovation and the breadth of this policy space as it is interpreted in reality.

The previously described wider context of the Estonian RDI system also enables to better understand the more specific challenges of the Estonian STI policy in the area of energy technology ISL (**I**) and research funding (**III**) explained in the previous sub-section and the unsuccessful transition of the energy sector in general. Relatedly, Magro and Wilson (2019) bring out that verticality, directionality, and the capability to foster experimentation are the key characteristics of place-based innovation policy mixes. They claim that finding the right policy mix for a given challenge is strongly conditioned by the governance context in which policies emerge, as also supported by all of the case studies of this thesis (**I**; **II**; **III**; **IV**), and that policy mix evaluation processes can play an important role in shaping innovation policy mixes through collective strategic learning (**I**). Besides evaluation, governance supports the government and other actors in developing the capabilities required to adapt the policy mix to the territorial strategy (Magro and Wilson 2019). This is seen as a weakness of the governance of smart specialization in Estonia where engaging municipal governments and developing their capabilities of creating local smart specialization strategies has been rather limited (**IV**). Not to mention the absence of the regional government level that could have a much wider and more comprehensive role in these discussions in relation to regional development, innovation, and sustainability transitions in Estonia.

Regarding examples of sustainability transitions at the municipal level, there are some studies from the recent past that focus on the urban context (Haarstad 2016; Ehnert et al. 2018; Dowling 2018) where the role of institutions, their networks, and related processes in the multi-level and horizontal governance and management of sustainability transitions are also explained and emphasized (Haarstad 2016). As an example of an in-depth, trans-disciplinary study, Borgström (2019) investigates how the MLG context in Stockholm influences the transformative capacity from the perspective of local sustainability initiatives. He concludes that even though the decentralized governance of the Stockholm region hosts a great potential in supporting citywide transformation, it is hampered by disconnects between actors, levels, and sectors and the short-term funding structure. The suggested interventions highlight the tension between enabling collaborations while safeguarding a high local diversity of initiatives and flexibility to ensure sustained space for innovation and learning (Ibid.). Van der Heijden et al. (2018) examine in great detail the role of cities in global climate governance, reflecting on the promise, limits, and politics of cities as agents of change and their interactions with their internal political dynamics and with broader governance levels in enabling or constraining urban climate governance.

These examples from sustainability transitions support the finding of the case study of implementing smart specialization in Estonia (**IV**) and support the stronger engagement of municipalities in designing and implementing smart specialization strategies where sustainability through clean technologies can play an important role in making living environments more environmentally friendly and mitigating climate change from the grass-root level. However, there are also previous examples of short-sighted local authorities and limited policymaking capacities of municipalities in CEE countries (Loewen and Raagmaa 2018), which might increase complexities and pose additional challenges for the implementation of smart specialization policies. Furthermore, the stronger involvement of municipalities is challenged in Estonia due to the fact that historically the involvement of municipalities in the development of economic development policy has been limited, which might imply the lack of necessary capabilities for developing and implementing such policies (Karo *et al.* 2017; **IV**). This refers to one of the most important challenges for Estonia and MLG of smart specialization policies more broadly. Namely, how to build capacities for directionality and experimentation in a way that also involves and empowers local governments and through this materializes the real place-based nature of smart specialization.

4.3 Summary of implications for governance and MLG of imported discourses, policies, and instruments for sustainability transitions

Based on the case studies, some general implications for MLG in the broad field of multi-level and multi-domain sustainability transitions can be summarized. First, the linear, value-neutral, and technology-centric understanding of the global climate change discourse (Wesselink et al. 2013; **I**) together with the mainly top-down logic of the global climate policy (Falkner et al. 2010; Geden 2016; Hare et al. 2010; Green et al. 2014) is no longer adequate. This is due to the developments in the understanding of the multi-level and multi-dynamic sustainability transitions that involve both bottom-up and top-down processes. Sustainability transitions have a complex, co-evolving, and nonlinear nature, they cross multiple domains and levels, incorporate competing public goods and objectives, and sustain uncertainty and inertia in existing socio-technical systems (Loorbach et al. 2017; Smith et al. 2010; Geels 2018a, 2018b; Kern et al. 2019; Turnheim et al. 2015; Tõnurist 2016). The complexity of the field is further increased by the multi-disciplinary nature of environmental technologies and the accompanying ambiguity problem of pure clean vs environmental protection and management technologies (Frondel et al. 2007; **I**), not to forget that transitions go beyond technologies (Kern et al. 2019) and also involve changes in the economic, political, social, and cultural spheres. Transition processes involve structured and complex networks of actors whose motives and interactions, power and politics on multiple governance levels influence regime transitions and the geography of transitions (Rip and Kemp 1998; Smith et al. 2005, 2010; Geels and Schot 2007). The environmental taxation case study (**II**) confirms that considering the needs and capabilities of the local industry and individual organizations and the wider innovation environment through accounting for socio-technical complexities, targeting the key players of transitions, and retaining a sense of significant niche-regime-landscape reproduction processes is essential for generating effective transition policies (Smith et al. 2010). The Estonian case (**II**) illustrates the involvement and active participation of industry and environmental activists, destabilization of incumbent regimes (highly pollutive oil shale based energy sector), promotion of green

niches (e.g. environmental taxes and charges), and the translation of ideas and practices from niches into mainstream settings (e.g. integrating novel energy taxes into the taxation model). Smith et al. (2010) argue that regime shifts occur through interactions and interlinkages between multiple developments on the landscape, regime, and niche levels. Due to inertia built into the system, structural change might be challenged by existing dominant systems that are stabilized through various lock-in mechanisms, like sunk investments, regulation, routines and practices (Loorbach et al. 2017; Geels 2011; Unruh 2000). The previously mentioned complexity of the climate change discourse related with the even more complex nature of sustainability transitions is best illustrated in the dynamics of the ISL of energy technologies (**I**) and the collaboration between policy developers and industry in the environmental taxation case study (**II**). The path dependency and lock-in nature of existing regimes is presented in the energy technology ISL (**I**) and the Estonian smart specialization case study (**IV**).

Second, the highly complex field of sustainability transitions, as explained before, clearly poses challenges for the implementation of national STI policies and especially MOP (as also seen in the case studies – **I**; **IV**) that incorporate non-neutral and directional priorities, transformative activities, experimental policy, flexibility, monitoring, and maximization of spill-overs (Foray 2018). Sustainability transitions call for systemic and radical changes that consider the direction of innovation and the transformative nature of innovation (Johnstone 2005; Garcia and Calantone 2002; **I**; **III**; **IV**) not just incremental changes towards energy efficiency and pollution treatment (Wise et al. 2014). Transitions require the identification of 'sustainable' technologies and their prioritization (Smith et al. 2010), but it is important to understand that the framing, motivations, and interpretations of innovative activities and the directionality of technological trajectories are embedded in the broader societal contexts of specific innovation systems (Bell 2007; Nelson 2008; Von Tunzelmann et al. 2008). Due to these complexities, transitions must account for the co-evolvement of policy and socio-technical systems (Kern et al. 2019; Edmondson et al. 2019). Directional policy mixes are key for managing structural and transformative system failures (Weber and Rohracher 2012), but they require coordination between innovation and other policy fields (e.g. research funding and energy sector regulations) (Kern et al. 2019; Magro and Wilson 2019) and the integration of pre-existing and new policies (Weber and Rohracher 2012; Schot and Steinmueller 2018).

All of the case studies (**I**; **II**; **III**; **IV**) confirm that policy mixes and socio-technical systems co-evolve during transitions (Kern et al. 2019; Edmondson et al. 2019) and that directional policy mixes and coordination between different policy domains but also political, social, technical, and cultural domains, is key for managing the transformation process (Weber and Rohracher 2012; Kern et al. 2019; Magro and Wilson 2019). However, the level of success, adaption, and convergence towards externally developed policies and imported instruments and how they were initially envisioned varies greatly between the cases analyzed for this thesis. As shown in the successful case of environmental taxes (**II**), the practice of developing a taxation model that consists of a mix of previously used environmental charges and imported energy taxes enabled to combine competing public objectives (environmental pollution vs economic development) and decrease the inertia of the existing socio-technical system. The Estonian environmental taxation case study (**II**) also supports the previous studies on the positive role of transition experiments (Rosenbloom et al. 2018) and governance experiments (Matschoss and Repo 2018) that integrate policy with innovation and

position experimentation within socio-technical regimes instead of strategic niches. The experience and examples of other countries with novel environmental taxes provided Estonia the opportunities to learn, build capacity, take less risks, and increase public education and engagement locally, and indeed, though on a small scale, provided new transition opportunities towards low-carbon systems (Rosenbloom et al. 2018; Matschoss and Repo 2018).

All the other case studies (**I**; **III**; **IV**) present diverging practices with unintended and multi-directional effects. The case studies reveal that the development and implementation of the selected STI policies and instruments has not considered the socio-technical complexities and significant niche-regime-landscape reproduction processes or targeted the key players of transitions, as claimed to be important by Smith et al. (2010). The energy technology ISL case study (**I**) illustrates that the value-neutral, linear, and high technology oriented STI policy with no clear mission-oriented energy technology financing has not considered ISL nor the wider energy technology ecosystem in Estonia. In addition, as shown in the energy technology ISL case study (**I**), due to limited and weak interactions and interdynamics between niches and dominant regimes it has not been possible to translate the few niches (photovoltaic and energy storage technologies) into mainstream settings (**I**). This has resulted in a situation where the most crucial transition in Estonia – the transition of the oil shale based energy sector – has not been enabled and the processes have instead led to incremental innovation and lock-in of technologies that pose structural problems for energy security and sustainability in the long run (**I**). Additionally, although these challenges would need mission-oriented, non-neutral, and directional smart specialization policies, unfortunately, sustainability transitions in the energy sector have not been considered while designing smart specialization strategies in Estonia (**IV**) as no competitive and realistic alternatives to oil shale were prioritized. This might be the result of limited bottom-up focus and use of the EDP, as well as insufficient linking of science and industrial sectors while designing smart specialization strategies in Estonia (**IV**) where, in addition, not enough attention was paid to learning, capacity building, de-risking, public education and engagement, which are considered highly relevant for successful government experiments (Rosenbloom et al. 2018). Experimentation should be positioned more within socio-technical regimes than in strategic niches (Matschoss and Repo 2018), and it should be ensured that experiments feed actor networks with shared expectations, inform the identities of the supportive coalition, and help orient interests and social norms (Smith et al. 2010).

Third, the prioritization and selection of technologies in Estonia – and through this, initiating the destabilization of incumbent regimes and promotion of radical green niches – has been left to the highly-competitive, project-based, and foreign funding based research funding schemes that are in favor of scientific excellence and prior performance but do not prioritize technologies based on national relevance (**I**; **III**; **IV**). The previously described problems have led to many practical challenges with budgeting and financial management in universities and very limited perspectives for strategic planning in universities (**III**). The energy technology ISL case study (**I**) emphasizes that in policy mixes for RDI and especially funding schemes it is relevant to consider the appropriate balance between the socio-economically relevant or the "third mission" of universities vs the scientifically excellent and primary task of universities (Martin 2012; Gulbrandsen and Slipersaeter 2007; Gibbons et al. 1994; **I**; **III**). Relatedly, the balance between project-based and long-term funding should be considered (**III**). Selection mechanisms of funding instruments should enable sustainability of research fields and the emergence of new

radical technologies while disabling contesting by existing power relations and research groups that continually do not produce new knowledge or innovation (Braun 1998; Wang and Hicks 2013; Viner et al. 2004; Defazio et al. 2009; Grimpe 2012; **I**; **III**). Additionally, if long-term effects and sustainability are in question, provision of harmonized regulative security for public and private investments is essential, and the management of investments into security of energy supply and technical energy security should be considered.

Fourth, this highly complex puzzle calls for high quality of policy, institutional, administrative, and technology capacities (Painter and Pierre 2005; Wu et al. 2015, 2018; Randma-Liiv 2002; Karo and Kattel 2015, 2018; Tõnurist et al. 2017; Lember et al. 2018; Mergel et al. 2018). In cases of limited policymaking capacities, the solutions (smart specialization) to the problem (unsustainable energy production with high CO2 component), as shown in the smart specialization case study (**IV**), might actually pose further challenges for governance and even further weaken the policymaking capacities of governments through creating additional difficulties with specific methods and tools used in policymaking (like the EDP).

Fifth, transition towards low-carbon societies requires multi-scalar and coordinated actions, which implies top-down and bottom-up processes of translation connecting international discourses, goals, and regulations with policies and discourses enacted at the national and local levels (Sarrica et al. 2018). Translating broad-based and complex global discourses to other policymaking phases (from design to implementation) (**I**) or translating the instruments to other governance levels (from global to national, from the EU level to national and sub-national levels) (**I**; **II**; **III**; **IV**) poses many challenges. To enable sustainability transitions, it is crucial that the changes are translated to the institutions and structures that are involved in the activities (Späth and Rohracher 2010; Sarrica et al. 2018) as well as the actors who are involved in policymaking and the actors of the innovation systems who are responsible for the innovative activities. If there is a change, the old processes, structures, and institutions have to be adapted. Local readiness for change and other favorable local conditions (**II**) clearly accelerate the adaptation processes and lead to smoother adaptation and convergence. The interplay of local and non-local discourses, initiatives, and networks is essential because they can enable legitimization and adoption of more sustainable socio-technical systems (Späth and Rohracher 2012), as seen in the case study of Estonian environmental taxation and as we can learn from the German and Scandinavian taxation models (**II**). Moreover, during the Estonian experience of developing environmental taxes and charges system coordination between central and local levels, local and non-local experts' networks, bottom-up input, and public engagement of the industry and related stakeholders were considered (**II**).

Sixth, the research shows that one central argument of MLG – to empower and mobilize sub-national levels and local governments (Piattoni 2010) and interdependence between governments and nongovernmental actors (e.g. ISL) at different territorial levels (Bache and Flinders 2004) – has not been realized in the studied STI policy aspects. Thus, the empirical analysis of small states conducted for this thesis shows that the local governments, university and research group levels, and ISL have not been involved in STI policy or empowered as expected in the MLG and MLP logic (**I**; **III**; **IV**). In Estonia, the involvement of these sub-national levels in STI policymaking for fostering profound sustainability transitions has been limited, with the exception of the case study of environmental taxation (**II**) where the industry and local levels were engaged in

developing the taxation model. The findings of the smart specialization case study (**IV**) suggests that municipalities should have more power in designing their smart specialization strategies in a more bottom-up and place-based manner. However, due to their historical non-involvement in national RDI and economic development policies (Karo et al. 2017) it is unclear if their capacities are sufficient for successful policymaking. Another unintended and negative effect for the regional development in Estonia revealed in the Estonian smart specialization case study (**IV**) is the evidence that smart specialization policies have strengthened the two main cities through accumulation of RDI funding and through this potentially further weakened the development of other, smaller regions (**IV**). This leads to one of the most substantial challenges for Estonia and successful implementation of smart specialization in the MLG context, namely, how to develop directionality and experimentation capacities of governments on the local levels to unlock the real potential of place-based smart specialization policies.

Finally, and related to the previously mentioned aspects, local context, actors, institutions (Kern et al. 2001; Rose 1991; Bennett 1991; Pedersen 2007; Bemelmans-Videc et al. 2010; Freeman 1985; Linder and Peters 1989; Hood 1983), openness, readiness, and willingness to adapt and previous experience with similar instruments (**II**) clearly influence the success of adaptation and convergence as well – if more favorable conditions are already in place, the probability of convergence increases. The local political-institutional context (Ehnert et al. 2018), administrative, political, and technological capacities of the government (Painter and Pierre 2005; Wu et al. 2015, 2018; Randma-Liiv 2002; Karo and Kattel 2015, 2018; Tõnurist et al. 2017; Lember et al. 2018; Mergel et al. 2018), involvement and strength of the ties with other actors of the innovation system on different levels, proper processes of policy evaluation and feedback mechanism (**I**; **II**; **IV**) play an important role in the adaption of imported discourses, policies, and instruments and enabling sustainability transitions. The case study of the energy technology ISL (**I**) particularly emphasizes the need for better policy feedback and evaluation and designing proper policy mixes that would address the challenges of RDI and the local industry.

5 IMPLICATIONS OF CASE STUDIES FOR PUBLIC POLICY AND SUSTAINABILITY TRANSITIONS

This thesis aims at bridging innovation and public policy studies and extending the previous studies of the MLP of sustainability transitions by incorporating public policy perspectives of MLG, policy transfer and convergence for analyzing the opportunities and challenges of smaller countries in adapting to external policies and imported instruments to enable sustainability transitions. The complementarities between climate, energy, environmental, and STI policy with the focus on climate change discourse and sustainability transitions as well as specific aspects of STI (ISL, taxation, smart specialization, and public research funding) are introduced to focus on nationally and internationally relevant fields.

The theoretical contribution of this thesis is the analytical framework that integrates the MLP of sustainability transitions with MLG, convergence, and the factors that influence policy transfer. The framework is further enriched with a synthesized discussion of the main implications (opportunities and challenges) of adapting to externally developed discourses, policies, and instruments as outlined in the literature of public policy, sustainability transitions, and specific STI aspects (ISL, taxation, funding of research, economic steering policies) to enable sustainability transitions. The idea of the analytical framework that connects theories of public policy, STI, and sustainability transitions in the wider global climate change context is to illustrate the high complexity of governing multi-level and multi-domain sustainability transitions through STI policies and instruments in the MLG context of the EU. Namely, it shows the contradictions in scope, scale, density, direction, and diversity of:

(1) the scientific, linear, and value-neutral global climate change discourse (Wesselink et al. 2013; Johnstone 2005);
(2) complex, co-evolving, and nonlinear sustainability transitions (Loorbach et al. 2017; Smith et al. 2010; Geels 2018a, 2018b; Turnheim et al. 2015);
(3) the mainly top-down public climate and energy policy in the EU (Egenhofer and Alessi 2013; Dirix et al. 2013; Lenschow 2002; Schmidt 2009; Ladrech 1994; Héritier et al. 2001; Urwin and Jordan 2008);
(4) and the specific bottom-up STI studies and models aimed at sustainability transitions (Hossain 2016; Schot and Geels 2008; Kemp et al. 1998; Bergek et al. 2008; Verheul and Vergragt 1995).

The developed analytical framework that bridges innovation studies and public policy in the area of sustainability transitions provides an analytical lens for analyzing this highly complex research puzzle and the opportunities and challenges of smaller EU member states arising from adapting to external policy discourses and imported policies and instruments while governing sustainability transitions.

Based on the theoretical analysis conducted in this thesis we argue that a complex theoretical framework is required to generate a more consistent understanding of how policy discourses, certain policy instruments, and their systems transfer and converge. The aim of this thesis has been to consider a wider variety of factors through the integration of MLG of policies focused on societal challenges, MLP of sustainability transitions, and the factors that influence the transfer of policy (**I**; **II**; **III**; **IV**). The MLG angle accounts for policymaking at different governance levels, their interactions, and interdependencies. The MLP of sustainability transitions considers the interactions and interdynamics between landscape, regimes, and niches in socio-technical transitions.

The mechanisms of policy transfer (exogenous convergence mechanisms, the endogenous local factors and context, and the special characteristics of the political discourses, policies, and instruments) enable to explain the adoption and convergence of imported discourses, policies, and instruments. Our analysis also argues for the importance of considering long-term and multi-directional effects of discursive policy changes (**I**) and imported policy instruments (**III**). Additionally, it is also important to look at different policymaking levels, from design and development (**II**) to implementation (**I**; **III**; **IV**) as discursive convergence does not necessarily mean convergence in implementation and practices (Pollitt 2002, 478). Therefore, the contribution of the case studies of this thesis to the wider study of policy transfer and convergence considers not only how certain discourses and instruments have converged but also more importantly how local policy discourses, policy mixes, and systems of instruments have been adopted, developed, and implemented.

Based on the previous aspects, this thesis calls for more comprehensive academic studies on how policy practices and policy implementation change through adapting to and implementing externally developed discourses, policies, and instruments on national and local levels. Hence, contextual factors, including the governance, administrative, political, and technological capacities of national, regional, and local policymakers and other relevant actors of the related STI networks, should be taken into account in policy analysis when implementing STI policies legitimized through the global climate change and sustainability transitions discourses and also EU level smart specialization and research funding debates.

Empirically, the articles examine in what form the effects outlined in the literature have emerged and what additional problems have arisen – whether local practices and policy implementation has been adapted to external discourses, policies, and instruments, leading to convergence towards the EU policies and instruments and global discourses, and what additional problems and challenges have emerged. Additionally, by analyzing and explaining the opportunities and problems that smaller countries with potentially weaker governance and policy capacities face while adapting to external broad-based (climate change, sustainability transition, smart specialization) discourses, policies, and instruments, this thesis gives empirical input to policymakers on different governance levels. For the EU policymakers, it gives insights about what to take into account while developing policies and policy instruments for sustainability transitions at the EU and more global levels and how to design them in a way that they would also work in smaller and peripheral countries. For national and local policymakers, the research conducted for this thesis enables them to potentially learn from other countries' practices in adapting to and implementing externally developed policies and instruments at the national, regional, and local levels. This might potentially increase consistency between how the policies and measures were initially designed to work and how they work in practice and also decrease uncertainty if the local policymakers are more aware of the challenges and problems that they might have to face. The main conclusions are as follows.

First, though MLG emphasizes all the governance levels and especially local governance, the thesis shows that in Estonia on the local government level policymaking in the studied policy fields is limited (STI, research funding, and smart specialization) (**III; IV**). This adds more pressure to the central government and its governance, policy, technology, and social capabilities to design and develop successful and sustainable policies for sustainability transitions that also take into account the needs of local levels.

Additionally, limited historical involvement of local governments in the development of STI policies challenges future developments if their role needs to be increased. Insufficient RDI policymaking capacities decrease both, their influence on local and regional development but also involvement in central policymaking processes. Building directionality and experimentation capacities of governments and also involving and empowering local and regional level governments in these processes remains one of the most essential challenges for Estonia while designing and implementing place-based RDI policies in the EU MLG context.

Secondly, the adaptation and convergence that has happened in the case of environmental taxation suggest that international convergence mechanisms (like policy learning, co-operative harmonization, and coercive imposition) play a significant role in small countries but might not be as decisive as quite often believed (**II**). This thesis highlights that local context, factors, actors, and institutions, their active collaboration and right timing play an essential role in the development of instrument systems and policy mixes. The local context and the related actors and factors can enable a smoother adaption to external policies (**II**) or create various problems with policy implementation and lead to multiple unintended effects and results (**I**; **III**; **IV**).

Third, the similarities in Estonia and Wales regarding the design and implementation of smart specialization strategies and policies (**IV**) suggest that a sufficient level of governance, policy and technological capacities are needed to materialize the intended effects of a broad and high level policy with specific characteristics of non-neutrality, directionality, and systemic approach. As much of the literature and research on the success (or failure) of implementing smart specialization strategies has been focused on the capacities of central governments and strengths and weaknesses of central institutions (Foray 2018, 2015; Radosevic et al. 2017; Karo and Kattel 2015), our analysis importantly emphasizes the essential role of local governments. They need to be involved and participate in designing local smart specialization strategies that also integrate sustainability transitions because through this it is possible to operationalize the essence of place-based policies. The case studies highlight that the success of smart specialization policy focused on urban sustainability transitions could be increased if bottom-up initiatives and community-led actions are integrated into the design and implementation of smart specialization strategies and policies (e.g. Späth and Rohracher 2012; Borgström 2019).

Fourth, all of the case studies (**I, II, III, IV**) confirm that ideas transform while they transfer (Pedersen 2007). To decrease unintended effects, the discourses and policies developed on international levels have to be translated into national, regional, and local levels. Besides the adverse effects that might emerge (**I; III; IV**) if local levels are left out, it is also difficult to involve the community and foster community action and start tackling climate change and the accompanying sustainability transitions from the grass-root level. There are great examples from all over the world from local demonstrations and pilots of sustainability transitions projects, but there the question quite often is how to scale these success stories to regional, national, and international levels. These experiences create strong expectations for bottom-up processes led by local governments, but these expectations are challenges due to their limited capacities of creating and leading innovative activities and RDI policies in a wider sense (**IV**).

Fifth, to integrate the ideas of sustainability into our "common sense" we need to understand that the same super wicked problems can also be seen as opportunities for development and innovation in new sectors or through restructuring and rejuvenating

old sectors and creating sustainable economic growth and jobs through these new or renewed sectors (Perez and Murray Leach 2018; Mazzucato and Perez 2015) and through these processes supporting wider sustainability transitions. The state can have a relevant role in these activities not only through socializing risk of R&D (e.g. through R&D grants) but also through socializing the benefits and profit of innovations (Mazzucato 2015) through actively and adventurously taking part in innovation – the commercialization of inventions. The state and sub-national levels of governance can also participate in transitions through supporting and conducting transition experiments (Rosenbloom et al. 2018) and governance experiments (Matschoss and Repo 2018). The "common sense" (Perez 2010) of the average person is changing towards a more environmentally friendly and sustainable way of life (from vegan to radical cleantech), though, not equally in all parts of the world. Together with the way of thinking the products and services on the market as well as the regulations and policies also change over time. Still resistance to change is natural and governments in general, from local to global levels, have the potential to take a more active role in building enabling environments for green and clean innovations to succeed.

Sixth, the diverging trajectories and challenges for networks and actors of innovation systems like ISL and universities and the non-participation of municipalities (as explained in the previous chapter of the thesis) (**I**; **III**; **IV**) on the policy implementation level pose further systematic challenges for policymakers in designing STI policies in terms of energy sustainability and security, research and industry collaborations, and innovation. The core question remains: how to design sustainable and secure energy innovation systems where research and industry collaborate effectively, research results are successfully commercialized and taken up by the market. For example, weak and non-strategic central financial management in universities coupled with extreme reliance on competitive and project-based funding instruments gives rise to tensions between the central management and the subunits and poses many additional challenges for university financial management and budgeting (**III**) and in the long run weakens the competences and sustainability of research groups and ISL as well (**I**). Due to the limits of resources, smaller states have to concentrate on products and services with high value added. For this, specialization (non-neutral and directional policies) and competences and capacities are needed, and furthermore, thoughtful funding of RDI is needed. Our analysis calls for adequate policy mixes that take into account the specificities of green and clean energy technologies and the structure of the economy. The economic structure and the composition, nature, and capabilities of local energy technology companies (from incremental innovation driven end-of-pipe and energy efficiency technologies to more radical clean technologies), as policy feedback mechanisms, may play a significant role in how the global discourse translates into policy implementation. In the long run, this has a systematic impact on the wider energy innovation system and, on the one hand, might lead to structural changes in energy transitions towards sustainability but, on the other hand, might lead to rhetorical and superficial changes, incremental innovation towards energy efficiency, and the potentially sub-optimal lock-in of old technologies. The latter is illustrated by the case study of the Estonian energy technology ISL (**I**).

Finally, and most regrettably, smart specialization as the broadest innovation policy experiment in the EU, which due to its non-neutral, directional, and systemic nature has a high potential to solve complex societal challenges, has not lived up to its promise in Estonia yet. It has not enabled one of the most crucial sustainability transitions needed

in Estonia – the energy transition from oil shale based to clean energy technologies. One reason for this might be the absence of a non-neutral and non-linear STI policy with clear mission-oriented energy technology financing. This policy would need to take into account the socio-technical complexities (e.g. historical reliance on oil shale based electricity production, strong influence on regional economic development and social processes) and significant niche-regime-landscape reproduction processes (e.g. experiments and niches within dominant regimes can more easily be translated into mainstream settings) and target the key players of transitions (e.g. ISL). Unfortunately, the prioritization and selection of technologies in Estonia – and through this, to some degree, also the destabilization of incumbent regimes and promotion of radical green niches – has been left to the EU funding based, competitive, and project-based research funding schemes that favor prior performance and scientific excellence but do not prioritize technologies based on national relevance (**I**; **III**; **IV**). The previously listed problems have led to many practical challenges in energy technology ISL (**I**) but also challenges with budgeting and financial management in universities and limited opportunities for strategic planning in universities (**III**). Other reasons are tied to the local factors, political-institutional context, involvement of local levels, and capacities of the government.

6 FUTURE RESEARCH AVENUES

While working with global level discourses, externally developed policies, and imported instruments with the aim to enable sustainability transitions, much more systematic analysis of the impact and adaptation on different levels of governance, vertically and horizontally, by looking at different phases of policymaking should be provided. Additionally, future research should analyze how collaboration, engagement, and interaction between different levels of governance, both vertically and horizontally, could improve the practical implementation of imported policies and instruments. Here the wider aim would be to govern sustainability transitions in a more efficient way to realize the knowledge and competences of previous experiences and RDI activities to achieve the EU 2050 targets and, in a much broader sense, contribute to a more sustainable way of life in general.

Much more extensive research is needed in order to highlight the actual effects of broad-based policy discourses that accompany sustainability transitions and climate change, also in terms of policy outcomes. However, due to the interdependence between global discourse, international standards, and national policy, the causality of changes and following action is hard to delineate, and as has been shown in the articles, it can have very significant and unintended effects. While a number of central implications, opportunities and challenges arising from adopting externally developed STI discourses, policies, and instruments (with the aim to enable sustainability transitions) were outlined in the analytical framework of the thesis and tested in the empirical part, the identification of further opportunities and challenges and their verification in different contexts and comparative studies clearly serves additional research attention.

More in-depth analyses are needed about the influence of STI policies and instruments on specific areas of sustainability transitions and the transitions of socio-technical systems. The evolution from a niche to a stabilized component of a regime would be a highly interesting research topic. Additionally, future studies could look at how niches are translated into mainstream settings and whether transition and government experiments are more successful if they are positioned in socio-technical regimes and not in radical niches. Furthermore, in socio-technical systems, besides supply-side technologies, more attention could be paid to demand-side solutions and consumption habits for mitigating climate change.

Relatedly, more studies are needed to describe the business model aspects of cleantech and its influence on the direction of innovation to gain more knowledge of business-oriented and radical clean technologies for speeding up sustainability transitions. For specific technologies to flourish – in a way that in addition to the public sector, the private sector would also be willing to make long-term RDI investments – a supportive environment has to be in place, the security of investments has to be ensured. The new Clean Energy package that updates the EU energy policy regulations is believed to provide a considerable amount of security, but still due to country differences in transposing EU directives into national law the wider outcomes are not yet clear.

In future research, it would also be beneficial to undertake comparative studies in order to explore how the externally developed STI discourses, policies, and instruments with the aim of solving global societal challenges in the MLG context influence the adoption and real-life implementation of policies and instruments and related systems and networks in different countries. Additionally, it would be interesting to analyze whether the local interpretations of global discourses are different, whether the effects

on energy and environmental technology ISL and accompanying practices follow similar patterns in different science systems, and whether there are differences in effects in the various sub-fields of energy and environmental technologies.

Coming to actors of innovation systems and the governance challenges, future research could also examine the interaction between strategic management and everyday management levels of related institutions. As shown in the Estonian case of public research funding, the weak strategic capacities of the central administration have deepened the problems created by project-based funding of research. In future academic studies, it would be interesting to look at countries where the central level of the university has stronger steering instruments to examine which governance arrangements help to address the potential tensions between the subunits and the core. In addition, it would be interesting to explore, in a dynamic and longer-term perspective, how project-based funding of academic research, in turn, influences the strategic management of universities: would it eventually lead to the strengthening of strategic management mechanisms within universities or, conversely, does the reliance on project-based funding tend to undermine the attempts of the central administration to develop strategic management capacities.

The research done for this thesis also calls for more comparative and empirical studies on the role of regional and local governments and their capacities to participate in innovation activities and more strategically lead and govern innovation in place-based policies for sustainability transitions. Also, how to increase the capacities of municipalities and regional governments in designing and implementing place-based STI and RDI policies aimed at sustainability transitions should be examined. The interactions between municipalities and community-led action in MLG and MLP frameworks in tackling climate change and fostering sustainability transitions through place-based policies would also deserve more attention, as well as how the success of locally effective examples could be expanded further to other levels of governance.

REFERENCES

Abbott, A., D. Cyranoski, N. Jones, B. Maher, Q. Schiermeier, and R. Van Noorden. 2010. "Metrics: Do metrics matter?" *Nature* 465, 860–862.

Adolino, J.R. and C.H. Blake. 2001. "Environmental Policy." In *Comparing Public Policies: Issues and Choices in Six Industrialized Countries.* Washington, DC: CQ Press. Ch. 11, 317–359.

Anderegg, W.R.L., J.W. Prall, J. Harold, and S.H. Schneider. 2010. "Expert credibility in climate change." *Proceedings of the National Academy of Sciences of United States of America* 107(27), 12107–12109.

Andersen, E.S. and B.-Å. Lundvall. 1988. "Small National Systems of Innovation Facing Technological Revolutions: An Analytical Framework." In C. Freeman and B.-Å. Lundvall. (eds.) *Small Countries Facing Technological Revolution*. London and New York: Pinter, 9–36.

Armstrong, H.W. and R. Read. 2003. "Microstates and Subnational Regions: Mutual Industrial Policy Lessons." *International Regional Science Review* 26, 117–141.

Bache, I. 2008. *Europeanization and Multilevel Governance: Cohesion Policy in the European Union and Britain*. Lanham: Rowman & Littlefield.

Bache, I. 2010. "Europeanization and Multi-level Governance: EU Cohesion Policy and Pre-Accession Aid in Southeast Europe." *Southeast European and Black Sea Studies* 10(1), 1–12.

Bache, I. and G. Andreou. 2010. *Cohesion Policy and Multi-level Governance in South East Europ*e. London: Routledge.

Bache, I. and M. Flinders. 2004. "Themes and Issues in Multi-level Governance." In I. Bache and M. Flinders (eds). *Multi-level Governance*. Oxford; New York: Oxford University Press, 1–15.

Baker, R. 1992. "Scale and Administrative Performance: The Governance of Small States and Microstates." In R. Baker (ed.). *Public Administration in Small and Island States*. West Hartford, CT: Kumarian Press, 5–25.

Baldacchino, G. 2019. „The competitiveness of small states: Insights on flexible specialisation." *Small States & Territories* 2(1), 41–54.

Banal-Estanol, A., I. Macho-Stadler, and D. Pérez-Castrillo. 2013. "Research output from university–industry collaborative projects." *Economic Development Quarterly* 27(1), 71–81.

Banal-Estanol, A. and I. Macho-Stadler. 2010. "Scientific and commercial incentives in R&D: research versus development?" *Journal of Economics & management strategy* 19(1), 185–221.

Barnett, R. 2003. *Beyond All Reason: Living with Ideology in the University*. Buckingham: Open University Press.

Bartlett, L. and F. Vavrus. 2017. *Rethinking case study research: A comparative approach*. New York and London: Routledge.

Bell, M. 2007. "Developments in innovation systems thinking: past, current and future applications of the innovation systems perspective." In Keynote paper to the UNIDO Expert Group meeting on Innovation Systems in Practice, Vienna, 24–25 October.

Bemelmans-Videc, M., R. Rist, and E. Vedung (eds.). 2010. *Carrots, sticks and sermons: policy instruments and their evaluation*. New Brunswick and London: Transaction Publishers.

Bennett, C.J. 1991. "What is Policy Convergence and What Causes It?" British Journal of Political Science 21 (2): 215–233.

Bergek, A., S. Jacobsson, and B.A. Sandén. 2008. "'Legitimation' and 'development of positive externalities': two key processes in the formation phase of technological innovation systems." *Technology Analysis & Strategic Management* 20(5), 575–592.

Bishop, M.L. 2012. "The political economy of small states: Enduring vulnerability?" *Review of International Political Economy* 19(5), 942–960.

Blume-Kohout, M.E., K.B. Kumar, and N. Sood. 2009. "Federal Life Sciences Funding and University R&D." NBER Working Paper No. 15146.

Borgström, S. 2019. "Balancing diversity and connectivity in multi-level governance settings for urban transformative capacity." *Ambio*, 1–15.

Bornmann, L. 2010. "Mimicry in science?" *Scientometrics* 86(1), 173–177.

Bornmann, L. 2013. "What Is Societal Impact of Research and How Can It Be Assessed? A Literature Survey." *Journal of the American Society for Information Science and Technology* 64(2), 217–233.

Braun, D. 1998. "The role of funding agencies in the cognitive development of science." *Research Policy* 27, 807–821.

Breschi, S. and F. Malerba. 1997. "Sectoral innovation systems: technological regimes, schumpeterian dynamics, and spatial boundaries." In Edquist, C. (Ed.). *Systems of Innovation: Technology, Institutions, and Organizations*. London: Pinter, 130–156.

Bräutigam, D. and M. Woolcock. 2001. "Small States in Global Economy: The Role of Institutions in Managing Vulnerability and Opportunity in Small Developing Countries." UNU/WIDER project on Globalization and the Obstacles to the Successful Integration of Small Vulnerable Economies. Discussion Paper No. 2001/37.

Busch, P.-O. and H. Jörgens. 2005a. "The International Sources of Policy Convergence: Explaining the Spread of Environmental Policy Innovations." *Journal of European Public Policy* 12(5), 860–884.

Busch, P.-O. and H. Jörgens. 2005b. "International Patterns of Environmental Policy Change and Convergence." *European Environment* 15(2), 80–101.

Byskov, M., J. Lindberg, A. Markard, and A. Dahl. 2019. "Policies, actors and sustainability transition pathways: A study of the EU's energy policy mix." *Research Policy* 48(10).

Börzel, T. and T. Risse. 2003. "Conceptualizing the Domestic Impact of Europe." In K. Featherstone and C. Radaelli (eds). *The Politics of Europeanisation*. Oxford: Oxford University Press, 57–80.

Caprotti, F. 2012. "The cultural economy of clean-tech: environmental discourse and the emergence of a new technology sector." *Transactions of the Institute of British Geographers* 37(3), 370–385.

Cepilovs, A. 2017. “Policy Learning and Policy Transfer in Policy Environments with Weak Policy Capacity: Exploring Processes and Effects in the Domains of Fiscal and Innovation Policies.” *Tallinn University of Technology Doctoral Theses Series I: Social Sciences*, No. 33.

Cherchye, L. and P.V. Abeele. 2005. “On Research Efficiency: A Micro-Analysis of Dutch University Research in Economics and Business Management.” *Research Policy* 34(4), 495–516.

Chung, C.-C. 2018. “Technological innovation systems in multi-level governance frameworks: The case of Taiwan's biodiesel innovation system (1997–2016).” *Journal of Cleaner Production 184*, 130–142.

Clark, B.R. 1998. *Creating Entrepreneurial Universities*. Oxford: Pergamon.

Clark, B.R. 2004. *Sustaining Change in Universities: Continuities in Case Studies and Concepts*. Maidenhead: Open University Press.

Clean Energy for all Europeans package. European Commission. Available at: https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans. Accessed 15.07.2019.

Cook, J., N. Oreskes, P.T. Doran, W.R.L. Anderegg, B. Verheggen, E.W. Maibach, J.S. Carlton, S. Lewandowsky, A.G. Skuce, S.A. Green, D. Nuccitelli, P. Jacobs, M. Richardson, B. Winkler, R. Painting, and K. Rice1. 2016. “Consensus on consensus: a synthesis of consensus estimates on human-caused global warming.” *Environmental Research Letters* 11(4), 048002.

Creutzig, F., J. Roy, W.F. Lamb, I.M.L. Azevedo, W. Bruine de Bruin, H. Dalkmann, O.Y. Edelenbosch, F.W. Geels, A. Grubler, C. Hepburn, E.G. Hertwich, R. Khosla, L. Mattauch, J.C. Minx, A. Ramakrishnan, N.D. Rao, J.K. Steinberger, M. Tavoni, D. Ürge-Vorsatz, and E.U. Weber. 2018. “Towards demand-side solutions for mitigating climate change.” *Nature Climate Change* 8, 260–263.

Culpepper, P.D. 2007. “Small States and Skill Specificity: Austria, Switzerland, and Interemployer Cleavages in Coordinated Capitalism.” *Comparative Political Studies* 40, 611–637.

Dale A., S. Burch, J. Robinson, and C. Strashok. 2018. “Multilevel Governance of Sustainability Transitions in Canada: Policy Alignment, Innovation, and Evaluation.” In Hughes S., E. Chu, and S. Mason (eds.) *Climate Change in Cities. The Urban Book Series*. Cham: Springer.

David, P.A. 2000. “A Tragedy of the Public Knowledge “Commons”? Global science, intellectual property and the digital technology boomerang.” SIEPR Discussion Paper no. 00–02, Stanford Institute for Economic Policy Research, Stanford University.

Defazio, D., A. Lockett, and M. Wright. 2009. “Funding incentives, collaborative dynamics and scientific productivity: Evidence from the EU framework program.” *Research Policy* 38, 293–305.

De Liso, N. and G. Filatrella. 2008. “On technology competition: A formal analysis of the ‘sailing-ship effect’.” *Economics of Innovation and New Technology* 17(6), 593–610.

del Río González, P. 2009. “The empirical analysis of the determinants for environmental technological change: A research agenda.” *Ecological Economics*, 68(3), 861–878.

De Massis, A. and J. Kotlar. 2014. “The case study method in family business research: Guidelines for qualitative scholarship.” *Journal of Family Business Strategy* 5(1), 15–29.

Denzin, N.K. and Y.S. Lincoln. 1994. *Handbook of qualitative research*. Thousand Oaks: Sage Publications.

Dirix, J., W. Peeters, J. Eyckmans, P.T. Jones, and S. Sterckx. 2013. “Strengthening bottom-up and top-down climate governance.” *Climate Policy* 13(3), 363–383.

Dolowitz, D.P. and D. Marsh. 2000. “Learning from abroad: the role of policy transfer in contemporary policy making.” *Governance* 13(1), 5–24.

Doran, P. and M. Kendall Zimmerman. 2011. “Examining the Scientific Consensus on Climate Change.” *Eos* 90(3), 22–23.

Dowling, R., P. McGuirk, and S. Maalsen. 2018. “Multiscalar governance of urban energy transitions in Australia: The cases of Sydney and Melbourne.” *Energy Research & Social Science* 44, 260–267.

Edmondson, D.L., F. Kern, and K.S. Rogge. 2019. “The co-evolution of policy mixes and socio-technical systems: Towards a conceptual framework of policy mix feedback in sustainability transitions.” *Research Policy* 48(10).

Egenhofer, C. and M. Alessi. 2013. “EU Policy on Climate Change Mitigation since Copenhagen and the Economic Crisis.” *CEPS Working Document No. 380*. Available at SSRN: https://ssrn.com/abstract=2276906.

Ehnert, F., N. Frantzeskaki, J. Barnes, S. Borgström, L. Gorissen, F. Kern, L. Strenchock, and M. Egermann. 2018. “Urban sustainability transitions in a context of multi-level governance: A comparison of four European states.” *Environmental Innovation and Societal Transitions* 26, 101–116.

Eisenhardt, K.M. 1989. “Building theories from case study research.” *The Academy of Management Review* 14(4), 532–550.

Eisenhardt, K.M. 1991. “Better Stories and Better Constructs: The Case for Rigor and Comparative Logic.” *The Academy of Management Review* 16(3), 620–627.

Elzinga, A. 1985. “Research bureaucracy and the drift of epistemic criteria.” In Wittrock, B. and Elzinga, A. (Eds). *The University Research System.* Stockholm: Almqvist and Wiksell, 191–217.

Elzinga, A. 1987. “Internal and external regulatives in research and higher education systems.” In Premfors, R. (Ed.). Disciplinary Perspectives on Higher Education and Research, Report no. 37, GSHR University of Stockholm, 5–25.

Electricity Directive. Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU. Official Journal of the European Union.

Electricity Regulation. Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity. Official Journal of the European Union.

Energy Efficiency Directive. Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency. Official Journal of the European Union.

Energy Performance in Buildings Directive. Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency. Official Journal of the European Union.

ENTSO-E. 2019. Vision on Market Design and System Operation towards 2030. Brussels: ENTSO-E.

Estonian Public Procurement Act. RT 14.06.2017

Erno-Kjolhede, E. and F. Hansson. 2011. "Measuring research performance during a changing relationship between science and society." *Research Evaluation* 20(2), 131–143.

Etzkowitz, H. 1998a. "The norms of entrepreneurial science: cognitive effects of the new university–industry linkages." *Research Policy* 27, 823–833.

Etzkowitz, H. 1998b. "The entrepreneurial university and the emergence of democratic corporatism." In Leydesdorff, L. and Etzkowitz, H. (Eds). *A Triple Helix of University–Industry–Government Relations: The Future Location of Research?* New York: Science Policy Institute, State University of New York, 141–152.

Etzkowitz, H. 2002. *MIT and the Rise of Entrepreneurial Science*. London: Routledge.

Etzkowitz, H. 2003. "Research groups as 'quasi-firms': the invention of the entrepreneurial university." *Research Policy* 32, 109–121.

Etzkowitz, H. 2004. "The evolution of the entrepreneurial university." *International Journal of Technology and Globalisation* 1, 64–77.

Etzkowitz, H. and L. Leydesdorff. 2000. "The dynamics of innovation: from national systems and 'Mode 2' to a Triple Helix of university–industry–government relations." *Research Policy* 29, 9–23.

Etzkowitz, H., A. Webster, C. Gebhardt, and B.R.C. Terra. 2000. "The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm." *Research Policy* 29, 313–330.

European Commission. 2011. A roadmap for moving to a competitive low carbon economy in 2050. Brussels: European Commission, (COM(2011)112).

European Commission. 2013. Regulation (EU) No 1303/2013 of the European Parliament and the Council of December 17, 2013 laying down common provisions on the ERDF, the ESF, the CF, the EARFD, and the EMFF and laying down general provisions on the ERDF, the ESF, the CF, and the EMFF and repealing Council Regulation (EC) No 1083/2006.

European Commission. 2017. Strengthening Innovation in Europe's Regions: Strategies for Resilient, Inclusive and Sustainable Growth. Brussels: European Commission, (COM(2017) 376 final).

European Commission. 2018. A Clean Planet for all. A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy. Brussels: European Commission, (COM(2018) 773 final).

European Commission. 2019. The European Green Deal. Brussels: European Commission, (COM(2019) 640 final).

Fagerberg, J. 2018. "Mobilizing innovation for sustainability transitions: A comment on transformative innovation policy." *Research Policy* 47(9), 1568–1576.

Falkner, R., H. Stephan, and J. Vogler. 2010. “International Climate Policy after Copenhagen: Towards a ‘Building Blocks’ Approach.” *Global Policy* 1(3), 252–262.

Fastenrath, S. and B. Braun. 2016. “Sustainability transition pathways in the building sector: Energy efficient building in Freiburg (Germany).” *Applied Geography*, 1–11.

Fleischman, A., C. Levine, L. Eckenwiler, C. Grady, D. Hammerschmidt, and J. Sugarman. 2011. “Dealing With the Long-Term Social Implications of Research.” *American Journal of Bioethics* 11(5), 5–9.

Foray, D. 2015. *Smart Specialisation: Opportunities and Challenges for Regional Innovation Policy, Regions and Cities*. London/New York: Routledge.

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., P.A. David, and B.H. Hall. 2009. “Smart specialisation: the concept.” In *Knowledge for Growth: Prospects for Science, Technology and Innovation*. Report, EUR 24047. Brussels, Belgium: European Commission.

Foray, D., P.A. David, and B.H. Hall. 2011. “Smart specialization: from academic idea to political instrument: the surprising career of a concept and the difficulties involved in its implementation.” École Polytechnique Fédérale de Lausanne, MTEI Working Paper 2011, no. 1.

Fox-Wolfgramm, S.J. 1997. “Towards developing a methodology for doing qualitative research: The dynamic-comparative case study method.” *Scandinavian Journal of Management* 13(4), 439–455.

Frantzeskaki N., M. Bach, K. Hölscher, and F. Avelino. 2018. “Introducing Sustainability Transitions’ Thinking in Urban Contexts.” In Frantzeskaki N., K. Hölscher, M. Bach, and F. Avelino (eds.) *Co-creating Sustainable Urban Futures. Future City* 11. Cham: Springer.

Freeman, G.P. 1985. “National styles and policy sectors: explaining structured variations.” Journal of Public Policy 5(4), 467–496.

Frondel, M., J. Horbach, and K. Rennings. 2007. “End-of-pipe or cleaner production? An empirical comparison of environmental innovation decisions across OECD countries.” *Business Strategy and the Environment* 16(8), 571–584.

Fuenfschilling, L., N. Frantzeskaki, and L. Coenen. 2019. “Urban Experimentation & Sustainability Transitions.” *Journal European Planning Studies* 27(2), 219–228.

Funtowicz, S.O. and J.R. Ravetz. 1993. “Science for the post-Normal age.” *Futures* 25(7), 739–755.

Garcia, R. and R. Calantone. 2002. “A critical look at technological innovation typology and innovativeness terminology: a literature review.” *Journal of product innovation management*, 19(2), 110–132.

Geden, O. 2016. “The Paris Agreement and the inherent inconsistency of climate policymaking.” *WIREs Climate Change* 7, 790–797.

Geels, F.W. 2010. “Ontologies, Socio-Technical Transitions (to Sustainability), and the Multi-Level Perspective.” *Research Policy* 39(4), 495–510.

Geels, F.W. 2011. “Survey, The multi-level perspective on sustainability transitions: Responses to seven criticisms.” *Environmental Innovation and Societal Transitions* 1(1), 24–40.

Geels, F.W. 2018a. “Disruption and low-carbon system transformation: Progress and new challenges in socio-technical transitions research and the Multi-Level Perspective.” *Research & Social Science* 37, 224–231.

Geels, F.W. 2018b. “Sustainability transitions.” *Companion to Environmental Studies,* 719–724(6).

Geels, F.W and J. Schot. 2007. “Typology of sociotechnical transition pathways.” *Research Policy* 36(3), 399–417.

Geels, F.W. and J. Schot. 2010. “The dynamics of transitions: a socio-technical perspective.” In Grin, J., J. Rotmans, and J. Schot (eds.) *Transitions to sustainable development: new directions in the study of long term transformative change*. New York: Routledge, 11–104.

Genus, A. and A.-M. Coles. 2008. “Rethinking the multi-level perspective of technological transitions.” *Research Policy* 37(9), 1436–1445.

Gerring, J. 2009. “The Case Study: What it is and What it Does.” In Boix, C. and S.C. Stokes (eds). *The Oxford Handbook of Comparative Politics*.

Gibbons, M., C. Limoges, H. Nowotony, S. Schwartzman, P. Scott, and M. Trow. 1994. *The New Production of Knowledge*. London: Sage.

Goldsmith, M. and K. Klausen. 1997. *European Integration and Local Government*. Cheltenham: Edward Elgar.

Governance Regulation. Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council. Official Journal of the European Union.

Graham, G. 2002. *Universities: The Recovery of an Idea*. Thorverton: Imprint Academic.

Green, J., T. Sterner, and G. Wagner. 2014. “A balance of bottom-up and top-down in linking climate policies.” *Nature Climate Change* 4, 1064–1067.

Grimpe, C. 2012. “Extramural Research Grants and Scientists’ Funding Strategies: Beggars Can’t Be Choosers?” *Research Policy* 41, 1448–1460.

Gulbrandsen, M. and S. Slipersaeter. 2007. “The third mission and the entrepreneurial university model. Universities and strategic knowledge creation.” In A. Bonaccorsi and C. Daraio (eds.). Universities and Strategic Knowledge Creation. Cheltenham: Edward Elgar, 112–143.

Gummesson, E. 2000. *Qualitative Methods in Management Research*. Thousand Oaks: Sage Publications.

Haarstad, H. 2016. “Where are urban energy transitions governed? Conceptualizing the complex governance arrangements for low-carbon mobility in Europe.” *Cities* 54, 4–10.

Haas, E.B. 1958. *The Uniting of Europe: Political, Social and Economic Forces 1950-1957*. Stanford UP: Stanford.

Hansen, U.E. and I. Nygaard. 2013. “Transnational Linkages and Sustainable Transitions in Emerging Countries: Exploring the Role of Donor Interventions in Niche Development.” *Environmental Innovation and Societal Transitions* 8, 1–19.

Hare, W., C. Stockwell, C. Flachsland, and S. Oberthür. 2010. “The architecture of the global climate regime: a top-down perspective.” *Climate Policy* 10(6), 600–614.

He, B.J, Z. Dong-Xue, J. Zhu, A. Darko, and Z.-H. Gou. 2018. “Promoting and implementing urban sustainability in China: An integration of sustainable initiatives at different urban scales.” *Habitat International* 82, 83–93.

Henfrey, T. and G. Penha-Lopes. 2018. “Policy and community-led action on sustainability and climate change: Paradox and possibility in the interstices.” *Environmental Innovation and Societal Transitions* 29, 52–54.

Héritier, A., C. Knill, and S. Mingers. 1996. *Ringing the Changes in Europe: Regulatory Competition and the Transformation of the State*. Berlin: de Gruyter.

Hessels, L.K and H. van Lente. 2008. “Re-thinking new knowledge production: A literature review and a research agenda.” *Research Policy* 37(4), 740–760.

Hey, J. 2002. “Luxembourg’s Foreign Policy: Does Small Size Help or Hinder?” *Innovation* 15(3), 211–225.

Hicks, D. 2012. “Performance-Based University Research Funding Systems.” *Research Policy* 41(2), 251–261.

Hoberg, G. 2001. “Globalization and policy convergence: Symposium overview.” *Journal of Comparative Policy Analysis: Research and Practice* 3, 127–132.

Hodson, M. and S. Marvin. 2010. “Can cities shape socio-technical transitions and how would we know if they were?” *Research Policy* 39, 477–485.

Hoffmann, S. 1966. “Obstinate or Obsolete? The Fate of the Nation State and the Case of Western Europe.” *Daedalus* 95, 862–915.

Hoffmann, S. 1982. “Reflections on the Nation State in Western Europe Today.” *Journal of Common Market Studies* 21(2), 21–37.

Holtz, G., C. Xia-Bauer, M. Roelfes, R. Schüle, D. Vallentin, and L. Martens. 2018. “Competences of local and regional urban governance actors to support low-carbon transitions: Development of a framework and its application to a case-study.” *Journal of Cleaner Production* 177, 846–856.

Holzinger, K. and C. Knill. 2005. “Causes and conditions of cross-national policy convergence.” *Journal of European Public Policy* 12(5), 775–797.

Homsy, G.C., L. Zhilin, and M.E. Warner. 2018. “Multilevel Governance: Framing the Integration of Top-Down and Bottom-Up Policymaking.” *International Journal of Public Administration* 42(7), 572–582.

Hood, C. 1983. *The Tools of Government.* London: Macmillan.

Hooghe, L. 1996. *Cohesion Policy and European Integration: Building Multi Level Governance*. Oxford: Oxford University Press.

Hossain, M. 2016. “Grassroots innovation: A systematic review of two decades of research.” *Journal of Cleaner Production* 137(20), 973–981.

Hottenrott, H. and C. Lawson. 2012. “Research grants, sources of ideas and the effects on academic research.” Discussion paper no. 12-048, Mannheim: ZEW-Centre for European Economic Research.

Hottenrott, H. and S. Thorwarth. 2011. “Industry Funding of University Research and Scientific Productivity.” KYKLOS 64(4), 534–555.

Hölscher, K., N. Frantzeskaki, and D. Loorbach. 2018a. “Steering transformations under climate change: capacities for transformative climate governance and the case of Rotterdam, the Netherlands.” *Regional Environmental Change*, 1–15.

Hölscher, K., J.M. Wittmayer, and D. Loorbach. 2018b. “Transition versus transformation: What’s the difference?” *Environmental Innovation and Societal Transitions* 27, 1–3.

IEA. 2012. *World Energy Outlook*. Paris: IEA.

Irvine, J. and B. R. Martin. 1984. *Foresight in Science: Picking the Winners*. London: Pinter.

Jacob, B.A and L. Lefgren. 2011. “The impact of research grant funding on scientific productivity.” Journal of Public Economics 95(9), 1168–1177.

Jenkins, K.E.H and D. Hopkins (eds.). 2019. “*Transitions in Energy Efficiency and Demand: The Emergence, Diffusion and impact of Low-Carbon innovation*.” New York: Routledge.

Johnstone, N. 2005. “The innovation effects of environmental policy instruments”. In Horbach, J. (eds). *Indicator Systems for Sustainable Innovation*. Physica-Verlag, 21–41.

Johnstone, P. and P. Newell. 2018. “Sustainability transitions and the state.” *Environmental Innovation and Societal Transition* 27, 72–82.

Jordan, A. 2001. “‘New’ Environmental Policy Instruments in the UK: Policy Innovation or ‘Muddling Through’?” Paper prepared for the ECPR Joint Session of Workshops, Grenoble, France, April.

Jordan, A., R. Wurzel, A. R. Zito, and L. Bruckner. 2003. “European Convergence and the Transfer of ‘New’ Environmental Policy Instruments (NEPIs) in the European Union.” *Public Administration* 81(3), 555–574.

Jorgensen, C.E. (2003) Environmental Fiscal Reform: Perspectives for Progress in the European Union. Discussion Paper. European Environmental Bureau.

Karo, E., R. Kattel, and A. Cepilovs. 2017. “Can smart specialization and entrepreneurial discovery be organized by the Government? Lessons from central and eastern Europe.” In S. Radosevic (Eds) *Advance in Theory and Practice of Smart Specialization*. Amsterdam: Elsevier Science Publishers.

Karo, E., H. Kanep, K. Ukrainski, R. Kattel, U. Varblane, and V. Lember. 2014. “Nutikas spetsialiseerumine: kas Eesti teadus-, arendus- ja innovatsioonipoliitika kuldvõtmeke aastail 2014–2020.” *Riigikogu Toimetised* 29, 1–11.

Karo, E. and R. Kattel. 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. and R. Kattel. 2018. “Innovation and the State: Towards an Evolutionary Theory of Policy Capacity.” In Wu, X., M. Holwett and M. Ramesh (Ed.). *Policy Capacity and Governance: Assessing Governmental Competences and Capabilities in Theory and Practice*. Cham: Palgrave Macmillan, 123–150.

Katzenstein, P.J. 2003. “Small States and Small States Revisited.” *New Political Economy* 8 (1), 9–30.

Kemp, R. 1994. “Technology and the transition to environmental sustainability: The problem of technological regime shifts.” *Futures* 26(10), 1023–1046.

Kemp, R., A. Rip, and J. Schot. 2001. “Constructing transition pathways through the management of niches.” In *Path Dependence and Creation*. Garud, R. and P. Karnoe (Eds). Mahwa, NJ: Lawrence Erlbaum, 269–299.

Kemp, R., J. Schot, and R. Hoogma. 1998. “Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management.” *Technol. Anal. Strateg. Manag*. 10, 175–196.

Kelleher, J., S. Batterbury, and E. Stern. 1999. *The Thematic Evaluation of the Partnership Principle: Final Synthesis Report*. London: The Tavistock Institute Evaluation Development and Review Unit.

Keohane, R.O. 1969. “Lilliputians’ Dilemmas: Small States in International Politics.” *International Organization* 23 (2), 291–310.

Kern, F. and K.S. Rogge. 2018. “Harnessing theories of the policy process for analysing the politics of sustainability transitions: A critical survey.” *Environmental Innovation and Societal Transitions* 27, 102–117.

Kern, F. and A. Smith. 2008. “Restructuring energy systems for sustainability? Energy transition policy in the Netherlands.” *Energy Policy* 36(11), 4093–4103.

Kern, K., H. Jörgens, and M. Jänicke. 2001. “The Diffusion of Environmental Policy Innovation: A Contribution to the Globalisation of Environmental Policy.” WZB Discussion Paper No. FS II 01-302. Berlin: Social Science Research Centre.

Kern, F., K.S. Rogge, and M. Howlett. 2019. “Policy mixes for sustainability transitions: New approaches and insights through bridging innovation and policy studies.” *Research Policy* 48(10), 1–15.

Kerr, C. 1983. *The Future of Industrial Societies: Convergence or Continuing Diversity?* Cambridge, MA: Harvard University Press.

Kirzner, I. 1997. “Entrepreneurial discovery and the competitive market process: an Austrian approach.” *Journal of Economic Literature* 35(1), 60–85.

Kitagawa, F. 2005. “Entrepreneurial universities and the development of regional societies: a spatial view of the Europe of knowledge.” *Higher Education Management and Policy* 17, 64–89.

Kivimaa, P. and F. Kern. 2016. Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions.” *Research Policy* 45(1), 205–217.

Knill, C. 2005. “Introduction: Cross-national policy convergence: concepts, approaches, and explanatory factors.” *Journal of European Public Policy* 12(5), 764–774.

Knill, C. and A. Lenschow. 1998. “Change as ‘appropriate adaptation’: Administrative adjustment to European environmental policy in Britain and Germany.” *European Integration Online Papers* (EioP) 2(1).

Knill, C. and A. Lenschow. 2005. “Compliance, Communication and Competition: Patterns of EU Environmental Policy Making and Their Impact on Policy Convergence.” *European Environment* 15(2), 114–128.

Kraiko, K. 2019. Small States Strategies to Influence the EU´s Decision-Making Process. The Case of the Regulation Framework for the Free Flow of Non-Personal Data and the Estonia´s Presidency in the European Council. Master Thesis. Ragnar Nurkse Department of Innovation and Governance, Tallinn University of Technology.

Kuehr, R. 2007. “Environmental technologies – from misleading interpretations to an operational categorisation & definition.” *Journal of Cleaner Production* 15(13), 1316–1320.

Kuzemko, C., M. Lockwood, C. Mitchell, and R. Hoggett. 2016. “Governing for sustainable energy system change: Politics, contexts and contingency.” *Energy Research & Social Science* 12, 96–105.

Köhler, J., F. de Haan, G. Holtz, K. Kubeczko, E.A. Moallemi, G. Papachristos, E. Chappin. 2018. “Modelling Sustainability Transitions: An Assessment of Approaches and Challenges.” *Journal of Artificial Societies and Social Simulation* 21(1), 1–22.

Ladrech, R. 1994. “Europeanization of Domestic Politics and Institutions: The case of France.” *Journal of Common Market Studies* 32, 69–88.

Landholm, D.M., A. Holsten, F. Martellozzo, E. Dominik, J. Reusser, and P. Kropp. 2018. “Climate change mitigation potential of community-based initiatives in Europe.” *Regional Environmental Change*, 1–12.

Laudel, G. 2006. “The art of getting funded: How Scientists adapt to their funding conditions.” *Science and Public Policy* 33(7), 489–504.

Lawson, C. 2012. “Academic Patenting: The Importance of Industry Support.“ *The Journal of Technology Transfer* 38(4), 509–535.

Lember, V., R. Kattel, and P. Tõnurist. 2018. “Technological capacity in the public sector: the case of Estonia.” *International Review of Administrative Sciences* 84(2), 214–230.

Lemola, T. and J. Lievonen. 2008. “The role of innovation policy in fostering open innovation activities among companies.” A report from Vision Era.net, Finland.

Lemola, T. and P. Ylä-Anttila. 2003. “Transformation of Innovation System in a Small Country: The Case of Finland.” Paper to be presented at the First Globelics Conference in Rio de Janeiro.

Lenschow, A. 2002. “New Regulatory Approaches in 'Greening' EU Policies.” *European Law Journal* 8(1), 19–37.

Lepori, B. 2011. “Coordination modes in public funding systems.” *Research Policy* 40 (3), 355–367.

Lepori, B., M. Dinges, E. Reale, S. Slipersaeter, J. Theves, and P. Van den Besselaar. 2007. “Comparing the evolution of national research policies: What patterns of change?” *Science and Public Policy* 34(6), 372–388.

Lepori, B., J. Usher, and M. Montauti. 2013. “Budgetary allocation and organizational characteristics of higher education institutions: A review of existing studies and a framework for future research.” *Higher Education* 65(1), 59–78.

Levin, K., B. Cashore, S. Bernstein, and G. Auld. 2012. “Overcoming the Tragedy of Super Wicked Problems: Constraining our Future Selves to Ameliorate Global Climate Change.” *Policy Sciences* 45(2), 123–152.

Liefferink, D. and A. Jordan. 2005. “An “Ever Closer Union“ of National Policy? The Convergence of National Environmental Policy in the European Union.” *European Environment* 15(2), 102–113.

Lindberg, L. 1963. “The Political Dynamics of European Economic Integration.” Stanford: Stanford UP. Reproduced in M. Eilstrup-Sangiovanni (ed.). *Debates on European Integration: A Reader*. Basingstoke; New York: Palgrave Macmillan, 117–134.

Linder, S. and G. Peters. 1989. “Instruments of Government.” *Journal of Public Policy* 9, 35–58.

Loewen, B. and G. Raagmaa. 2018. “Introduction to the Special Issue: Territoriality and Governance in the Globalizing European Eastern Peripheries.” *Administrative Culture* 18(2), 89–101.

Loorbach, D., N. Frantzeskaki, and F. Avelino. 2017. “Sustainability Transitions Research: Transforming Science and Practice for Societal Change.” *Annual Review of Environment and Resources* 42, 599–626.

Lundvall, B.-Å. 1992. *National systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter.

Lundvall, B.-Å., B. Johnson, E.S. Andersen, and B. Dalum. 2002. “National Systems of Production, Innovation and Competence Building.” *Research Policy* 31, 213–231.

Macey, S.M. and M.A. Brown. 1990. “Demonstrations as a policy instrument with energy technology examples.” *Science Communication* 11, 219–236.

Magro, E. and J.R. Wilson. 2019. “Policy-mix evaluation: Governance challenges from new place-based innovation policies.” *Research Policy* 48(10).

Malatesta, S. and R. Massa. 2018. “International actors as policymakers? Discussing the influence of international actors on the environmental policies of small island states.“ *Small States & Territories* 1(1), 95–110.

Manjarrés-Henríquez, L., A. Gutiérrez-Gracia and J. Vega-Jurado. 2008. “Coexistence of university-industry relations and academic research: Barrier to or incentive for scientific productivity.” *Scientometrics* 76(3), 561–576.

March, J.G. and J.P. Olsen. 1989. *Rediscovering institutions*. New York: Free Press.

Markard, J. 2018. “The next phase of the energy transition and its implications for research and policy.” *Nature Energy* 3, 628–633.

Markard, J., R. Raven, and B. Truffer. 2012. “Sustainability transitions: An emerging field of research and its prospects.” *Research Policy* 41(6), 955–967.

Markard, J., M. Suter, and K. Ingold. 2015. “Socio-Technical Transitions and Policy Change: Advocacy Coalitions in Swiss Energy Policy.” *SPRU Working Paper Series*, SWPS 2015–13.

Marks, G. 1993. “Structural Policy and Multilevel Governance in the EC.” In A. Cafruny and G. Rosenthal (eds). *The State of the European Community: The Maastricht Debates and Beyond*. New York: Longman.

Martin, B.R. 2007. “Assessing the impact of basic research on society and the economy.” Rethinking the impact of basic research on society and the economy (WF-EST International Conference, 11 May 2007), Vienna, Austria.

Martin, B.R. 2012. “Are universities and university research under threat? Towards an evolutionary model of university speciation.” *Cambridge journal of economics* 36(3), 543–565.

Martin, B.R. and P. Tang. 2007. “The benefits from publicly funded research.” SPRU Working Paper Series 161, SPRU - Science Policy Research Unit, University of Sussex Business School.

Maskell, D. and I. Robinson. 2001. *The New Idea of a University*. Thorverton: Imprint Academic.

Matschoss, K. and P. Repo. 2018. “Governance experiments in climate action: empirical findings from the 28 European Union countries.” *Environmental Politics* 27(4), 598–620.

Mazzucato, M. 2015. *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*. London: Anthem Press.

Mazzucato, M. and C. Perez 2015. “Innovation as Growth Policy: The Challenge for Europe.” In Fagerberg, J., S. Laestadius, and B.R. Martin. *The Triple Challenge for Europe: Economic Development, Climate Change and Governance*. Oxford: Oxford University Press.

McCann, P. and R. Ortega-Argilés. 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.

Meadowcroft, J. 2009. “What about the politics? Sustainable development, transition management, and long term energy transitions.” *Policy Sciences* 42, 323–340.

Meadowcroft, J. 2011. “Engaging with the politics of sustainability transitions.” *Environmental Innovation and Societal Transitions* 1(1), 70–75.

Mergel, I., Y. Gong, and J. Bertot. 2018. “Agile government: Systematic literature review and future research.” *Government Information Quarterly* 35, 291–298.

Merkx, F., I. van der Weijden, A.-M. Oostveen, P. van den Besselaar, and J. Spaapen. 2007. “Evaluating the societal impact of research – a quick scan of an emerging field.” COS/ERiC. Den Haag, Rathenau Instituut.

Moravcsik, A. 1993. “Preferences and Power in the European Community: A Liberal Intergovernmentalist Approach.” *Journal of Common Market Studies* 31(4), 473–524.

Moravcsik, A. 1994. “Why the European Union Strengthens the State: Domestic Politics and International Cooperation.” Working Paper Series 52, Center for European Studies, Harvard University. Paper presented at the Annual Meeting of the American Political Science Association, New York.

Morgan, K. 2013. “The regional state in the era of smart specialization.” *Ekonomiaz* 83(2), 102–124.

Morgan, K. 2016. “Nurturing novelty: regional innovation policy in the age of smart specialization.” *Environment and Planning C: Politics and Space* 35(4), 569–583.

Muscio, A., D. Quaglione, and G. Vallanti. 2013. “Does government funding complement or substitute private research funding to universities?“ *Research Policy* 42, 63–75.

Nagorny-Koring, N.C. 2019. “Leading the way with examples and ideas? Governing climate change in German municipalities through best practices.” *Journal of Environmental Policy & Planning* 21(1): Learning in urban climate governance: Concepts, key issues and challenges, 46–60.

Nelson, R.R. 2004. “The market economy and the scientific commons.” *Research Policy* 33, 455–471.

Nelson, R.R. 2008. “Factors affecting the power of technological paradigms.“ *Industrial and Corporate Change* 17(3), 485–497.

Newig, J. and T.M. Koontz. 2014. “Multi-level governance, policy implementation and participation: the EU's mandated participatory planning approach to implementing environmental policy.” *Journal of European Public Policy* 21(2), 248–267.

Niederkrotenthaler, T., T.E. Dorner, and M. Maier. 2011. “Development of a practical tool to measure the impact of publications on the society based on focus group discussions with scientists.” *BMC Public Health*, 11, 588.

O’Rourke, A.R. 2009. *The emergence of clean-tech. PhD dissertation*. New Haven: Yale University.

OECD. 2015. System Innovation: Synthesis Report. Paris.

Okereke, C., B. Wittneben, and F. Bowen. 2012. “Climate Change: Challenging Business, Transforming Politics.” *Business & Society* 51 (1), 7–30.

Olsen, J.P. 2002. “The many Faces of Europeanization.” JCMS: *Journal of Common Mark et Studies* 40, 921–952.

Osunmuyiwa, O., F. Biermann, and A. Kalfagianni. 2018. “Applying the multi-level perspective on socio-technical transitions to rentier states: the case of renewable energy transitions in Nigeria.” *Journal of Environmental Policy & Planning* 20(2), 143–156.

Painter, M. and J. Pierre (Eds.). 2005. *Challenges to State Policy Capacity: Global Trends and Comparative Perspectives.* London: Palgrave Macmillan.

Parris, T.M and W.K Robert. 2003. “Characterizing a sustainability transition: Goals, targets, trends, and driving forces.” *Proceedings of the National Academy of Science of the United States of America* 100(14), 8068–8073.

Patterson, J., K. Schulz, J. Vervoort, S. van der Hel, O. Widerberg, C. Adler, M. Hurlbert, K. Anderton, M. Sethi, and A. Barau. 2017. “Exploring the governance and politics of transformations towards sustainability.” *Environmental Innovation and Societal Transitions* 24, 1–16.

Payne, A. 2004. “Small States in the Global Politics of Development.” *The Round Table* 93 (376), 623–635.

Pedersen, L. H. 2007. “Ideas Are Transformed as They Transfer: A Comparative Study of Ecotaxation in Scandinavia.” *Journal of European Public Policy* 14 (1), 59–77.

Pelikan, J. 1992. *The Idea of the University: A Re-examination*. New Haven: Yale University Press.

Penrose, E. 1960. “The growth of the firm - a case study: the Hercules Powder Company.” Business History Review 34 (1960), 1–23.

Perez, C. 2010. “Technological Revolutions and Techno-economic paradigms.” *Cambridge Journal of Economics* 34(1), 185–202.

Perez, C. and T. Murray Leach. 2018. “A Smart Green ‘European Way of Life’: the Path for Growth, Jobs and Wellbeing.” *Beyond the Technological Revolution*, Working Papers 2018-01.

Pettigrew, A. 1973. *The politics of organizational decision making*. London: Tavistock.

Piattoni, S. 2010. *The Theory of Multi-Level Governance: Conceptual, Empirical, and Normative Challenges*. Oxford University Press.

Pollack, M. 1995. “Regional Actors in an Intergovernmentalist Play: The Making and Implementation of EC Structural Policy.” In S. Mazey and C. Rhodes (eds). *The State of the European Community (III)*. Boulder, Colo: Lynne Reinner, 361–390.

Pollitt, C. 2002. “Clarifying Convergence: Striking similarities and durable differences in public management reform.” *Public Management Review* 4(1), 471–492.

Polster, C. 2000. “The future of the liberal university in the era of the global knowledge grab.” *Higher Education* 39, 19–41.

Popp, D., R.G. Newell, and A.B. Jaffe. 2010. “Energy, the environment, and technological change.” *Handbook of the Economics of Innovation* 2, 873–937.

Radosevic, S., A. Curaj, R. Gheorghiu, L. Andreescu, and I. Wade (Eds). 2017. *Advances in the Theory and Practice of Smart Specialization*. London: Academic Press, Elsevier Inc.

Ramos-Mejía, M., M.-L. Franco-Garcia, and J.M. Jauregui-Becker. 2018. “Sustainability transitions in the developing world: Challenges of socio-technical transformations unfolding in contexts of poverty.” *Environmental Science & Policy* 84, 217–223.

Randma-Liiv, T. 2002. “Small States and Bureaucracy: Challenges for Public Administration.” *Trames* 6(4), 374–389.

Randma-Liiv, T. and K. Sarapuu. 2019. “Public governance in small states: from paradoxes to research agenda.“ In Massey, A. (eds). *A Research Agenda for Public Administration*. Cheltenham, Northampton: Edward Elgar Publishing Limited, 162–179.

Regulation for the Agency for the Cooperation of Energy Regulators (ACER). Regulation (EU) 2019/942 of the European Parliament and of the Council of 5 June 2019 establishing a European Union Agency for the Cooperation of Energy Regulators. Official Journal of the European Union.

Renewable Energy Directive. Directive EU 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources. Official Journal of the European Union.

Risk-Preparedness Regulation. Regulation (EU) 2019/941 of the European Parliament and of the Council of 5 June 2019 on risk-preparedness in the electricity sector and repealing Directive 2005/89/EC. Official Journal of the European Union.

Reynaert, H., K. Steyvers, and E. Van Bever. 2011. *The Road to Europe: Main Street or Backward Alley for Local Governments in Europe?* Brugge: Vanden Broele Academics.

Riigi Teataja. 2017. “Maavalitsuste tegevuse lõpetamisest tulenev Vabariigi Valitsuse seaduse ja teiste seaduste muutmise seadus.” RT I, 04.07.2017, 1.

Rip, A. 2004. “Strategic Research, Post-modern Universities and Research Training.” *Higher Education Policy* 17, 153–166.

Rip, A. 2011. “Science Institutions and Grand Challenges of Society: A Scenario.” *Asian Research Policy Journal* 2(1), 1–9.

Rip, A. and R. Kemp. 1998. „Technological change.“ In S. Rayner and E.L. Malone (eds.). *Human Choices and Climate Change, vol. 2. Resources and Technology*. Columbus, Ohio: Battelle.

Risse, T., M. Green Cowles, and J. Caporaso. 2001. “Transforming Europe: Conclusions.” In M. Green Cowles, J. Caporaso, and T. Risse (eds). *Transforming Europe: Europeanization and Domestic Change*. Ithaca, N.Y.: Cornell University Press, 217–237.

Roberts, C. and F.W. Geels. 2019. “Conditions for politically accelerated transitions: Historical institutionalism, the multi-level perspective, and two historical case studies in transport and agriculture.” *Technological Forecasting and Social Change* 140, 221–240.

Roberts, C., F.W. Geels, M. Lockwood, P. Newell, H. Schmitz, B. Turnheim, A. Jordan. 2018. “The politics of accelerating low-carbon transitions: Towards a new research agenda.” *Energy Research & Social Science* 44, 304–311.

Rodriguez-Pose, A., M. di Cataldo, and A. Rainoldi. 2014. *The Role of Government Institutions for Smart Specialisation and Regional Development*. JRC Technical Reports, S3 Policy Brief Series, n04/2014. Luxembourg: Publication Office of the European Union.

Rogge, K.S. and K. Reichardt. 2015. “Going beyond Instrument Interactions: Towards a More Comprehensive Policy Mix Conceptualization for Environmental Technological Change.” *SPRU Working Paper Series*, No 12.

Rose, R. 1991. “What Is Lesson-drawing?” Journal of Public Policy 11 (1): 3–30.

Rosenbloom, D., J. Meadowcroft, S. Sheppard, S. Burch, and S. Williams. 2018. “Transition Experiments: Opening Up Low-Carbon Transition Pathways for Canada through Innovation and Learning.” *Canadian Public Policy* 44(4), 368–383.

Rothstein, R. 1968. *Alliances and Small Powers*. New York, London: Columbia University Press.

Sahal, D. 1983. “Invention, innovation and economic evolution.” *Technological Forecasting and Social Change* 23(3), 213–235.

Salter, A.J and B.R. Martin. 2001. “The economic benefits of publicly funded basic research: a critical review.” *Research Policy* 30(3), 509–532.

Sandholtz, W. and J. Zysman. 1989. “1992: Recasting the European Bargain.” World Politics 42(1), 95–128.

Sarrica, M., F. Biddau, S. Brondi, P. Cottone, and B.M. Mazzara. 2018. “A multi-scale examination of public discourse on energy sustainability in Italy: Empirical evidence and policy implications.” *Energy Policy* 114, 444–454.

Schanker, B.D and K.A. Ulvestad. 2011. “Targeting funding sources: a strategic mechanism of research regulation.” *American Journal of Bioethics* 11(5), 17–18.

Schmidt, V.A. 2009. “The EU and its Member States: From Bottom Up to Top Down.” In Phinnemore D. and A. Warleigh-Lack (eds). *Reflections on European Integration*. Palgrave Studies in European Union Politics. London: Palgrave Macmillan.

Schoon, M. and M.E. Cox. 2018. “Collaboration, Adaptation, and Scaling: Perspectives on Environmental Governance for Sustainability.” *Sustainability* 10(3), 679–687.

Schot, J. and F.W. Geels. 2008. “Strategic niche management and sustainable innovation journeys: Theory, findings, research agenda, and policy.” *Technology Analysis Strategic Management* 20, 537–554.

Schot, J. and W.E. Steinmueller. 2018. “Three frames for innovation policy: R&D, systems of innovation and transformative change.“ *Research Policy* 47, 1554–1567.

Schulte, P. 2004. “The entrepreneurial university: a strategy for institutional development.” *Higher Education in Europe* 29, 187–191.

Scordato, L., A. Klitkou, V.E. Tartiu, and L. Coenen. 2018. “Policy mixes for the sustainability transition of the pulp and paper industry in Sweden.” *Journal of Cleaner Production* 183, 1216–1227.

Scrase, I. and A. Smith. 2009. “The (non-)politics of managing low carbon socio-technical transitions.” *Environmental Politics* 18(5), 707–726.

Shaw, D., A. Cumbers, R. McMaster, and J. Crossan. 2018. “Scaling Up Community Action for Tackling Climate Change.” *British Journal of Management* 29, 266–278.

Shattock, M. 2005. “European universities for entrepreneurship: their role in the Europe of knowledge – the theoretical context.” *Higher Education Management and Policy* 17, 13–25.

Shove, E. and G. Walker. 2007. “CAUTION! Transitions ahead: Politics, Practice, and Sustainable Transition Management.” *Environment and Planning* A 39, 763–770.

Silva, A. and L. Stocker. 2018. “What is a transition? Exploring visual and textual definitions among sustainability transition networks.” *Global Environmental Change* 50, 60–74.

Skea, J., P. Ekins, and M. Winskel. 2011. “Introduction.” In Skea, J., P. Ekins, and M. Winskel (eds.). *Energy 2050: Making the Transition to a Secure Low Carbon Energy System*. London: Earthscan.

Slaughter, S. and L.L. Leslie. 1997. *Academic Capitalism: Politics, Policies and the Entrepreneurial University*. Baltimore: Johns Hopkins University Press.

Smith, A. and A. Stirling. 2010. “The Politics of Social-ecological Resilience and Sustainable Socio-technical Transitions.” *Ecology and Society* 15(1), 1–13.

Smith, A., A. Stirling, and F. Berkhout. 2005. “The governance of sustainable socio-technical transitions.” *Research Policy* 34(10), 1491–1510.

Smith, A., J.P. Voß, and J. Grin. 2010. “Innovation Studies and Sustainability Transitions: The Allure of the Multi-Level Perspective and its Challenges.” *Research Policy* 39(4), 435–448.

Sol, J., M.M. van der Wal, P.J. Beers, and A.E.J. Wals. 2018. “Reframing the future: the role of reflexivity in governance networks in sustainability transitions.” *Environmental Education Research* 24(9), 1383–1405.

Sorenson, O. and L. Fleming. 2004. “Science and the Diffusion of Knowledge.” *Research Policy* 33(10), 1615–1634.

Späth, P. and H. Rohracher. 2010. “'Energy regions': the transformative power of regional discourses on socio-technical futures.” *Research Policy* 39 (4), 449–458.

Späth, P. and H. Rohracher. 2012. “Local Demonstrations for Global Transitions: Dynamics across Governance Levels Fostering Sociotechnical Regime Change towards Sustainability.” *European Planning Studies* 20(3), 461–479.

Stake, R.E. 1995. *The art of case study research*. Thousand Oaks, CA: Sage Publications.

Stake, R.E. 2005. “Qualitative Case Studies.” In Denzin N.K. and Y.S. Lincoln (Eds.). *The Sage handbook of qualitative research*. 3rd Edition. London: Sage Publications Ltd, 443–466

Steen, J.V. 2012. “Modes of public funding of research and development: Towards internationally comparable indicators.” *OECD science, technology and industry working papers*, 2012/04.

Stephenson, W. 1974. “Methodology of single case studies.” *Journal of Operational Psychiatry* 5(2), 3–16.

Strehl, F., 2007. Funding systems and their effects on higher education systems - international report. Education Working Paper, No. 6, OECD, Paris.

Tatar, M. 2016. “The Impact of the European Union Cohesion Policy on Multilevel Governance in Estonia: Subnational Empowerment and Mobilisation.” *Tallinn University of Technology Doctoral Theses Series I: Social Sciences,* No. 27.

Taylor, M. 2008. “Beyond technology-push and demand-pull: lessons from California’s solar policy.” *Energy Economics*, 30, 2829–2854.

Tews, K. 2005. “The Diffusion of Environmental Policy Innovations: Cornerstones of an Analytical Framework.” *European Environment* 15(2), 63–79.

Tews, K., P.-O. Busch, and H. Jörgens. 2003. “The Diffusion of New Environmental Policy Instruments.” *European Journal of Political Research* 42(4), 569–600.

Thursby, J.G. and M.C. Thursby. 2011. Has the Bayh-Dole act compromised basic research? Research Policy 40(8), 1077–1083.

Truffer, B. 2008. “Society, Technology and Region.” *Environment and Planning* A 40, 966–985.

Turnheim, B., F. Berkhout, F. Geels, A. Hof, A. McMeekin, B. Nykvist, and D. van Vuuren. 2015. “Evaluating Sustainability Transitions Pathways: Bridging Analytical Approaches to Address Governance Challenges.” *Global Environmental Change* 35, 239–253.

Tõnurist, P. 2010. “What Is a “Small State” in a Globalizing Economy?” *Administrative Culture* 11 (1), 8–29.

Tõnurist, P. 2015. “Framework for Analysing the Role of State Owned Enterprises in Innovation Policy Management: The Case of Energy Technologies and Eesti Energia.” *Technovation* 38, 1–14.

Tõnurist, P. 2016. “Energy Technology Innovation Systems in a Transnational Perspective: Small States, Public Ownership and Diverging Policy Rationales.” *Tallinn University of Technology Doctoral Theses Series I: Social Sciences*, No. 26.

Tõnurist P., R. Kattel, and V. Lember. 2017. “Discovering innovation labs in the public sector: What they are and what they do?” *Public Management Review* 19(10), 1455–1479.

Unruh, G.C, 2000. „Understanding carbon lock-in.“ *Energy Polic*y 28, 817–830.

Urwin, K. and A. Jordan. 2008. “Does public policy support or undermine climate change adaptation? Exploring policy interplay across different scales of governance.” *Global Environmental Change* 18, 180–191.

Valdmaa, K. and T. Kalvet. 2011. “Emergence of the Clean Technologies Sector in Estonia”. In Kaija Valdmaa and Tarmo Kalvet (eds). *Emergence of the Clean Technologies Sector in the Baltic Sea Region*. Tallinn: Tallinn University of Technology, 158–244.

Van den Besselaar P. and L. Leydesdorff. 2009. “Past performance, peer review, and project selection: A case study in the social and behavioural sciences.” Research Evaluation 18(4), 273–288.

Van der Heijden, J., J. Patterson, S. Juhola, and M. Wolfram. 2018. “Special section: advancing the role of cities in climate governance – promise, limits, politics.” *Journal of Environmental Planning and Management*, 1–9.

Van Leeuwen, T.N. and H.F Moed. 2012. “Funding decisions, peer review, and scientific excellence in physical sciences, chemistry, and geosciences.” *Research Evaluation* 21(3), 189–198.

Van Mierlo, B. and P.J. Beers. 2018. “Understanding and governing learning in sustainability transitions: A review.” *Environmental Innovation and Societal Transitions*, In Press, Corrected Proof.

Verheul, H. and P.J. Vergragt. 1995. “Social experiments in the development of environmental technology: a bottom-up perspective.” *Technology Analysis & Strategic Management* 7(3), 315–326.

Von Tunzelmann, N., F. Malerba, P. Nightingale, and S. Metcalfe. 2008. “Technological paradigms: past, present and future.“ *Industrial and Corporate Change* 17 (3), 467–484.

Verbong, G. and F.W. Geels. 2007. “The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004).” *Energy Policy* 35(2), 1025–1037.

Viner, N., P. Powell, and R. Green. 2004. “Institutionalized biases in the award of research grants: a preliminary analysis revisiting the principle of accumulative advantage.” *Research Policy* 33(3), 443–454.

Vink, M.P. and P. Graziano. 2006. “Challenges of a New Research Agenda.” In P. Graziano and M.P. Vink (eds). *Europeanization: New Research Agendas*. Basingstoke: Palgrave Macmillan, 3–20.

Vital, D. 2006 [1967]. “The Inequality of States: A Study of Small Power in International Relations.“ In Ingebritsen, C., I. B. Neumann, S. Gstöhl, and J. Beyer (eds). *Small States in International Relations*. Seattle, WA: University of Washington Press, 77–88.

Von Wirth, T., L. Fuenfschilling, N. Frantzeskaki, and L. Coenen. 2019. “Impacts of urban living labs on sustainability transitions: mechanisms and strategies for systemic change through experimentation.” *Journal European Planning Studies* 27(2): Urban Experimentation & Sustainability Transitions, 229–257.

Wang, J. and D. Hicks. 2013. “Detecting structural change in university research systems: A case study of British research policy.” *Research Evaluation* 22(4), 258–268.

Weber, K.M. and W. Polt. 2014. “Assessing Mission-Oriented R&D Programs: Combining Foresight and Evaluation.” *Fteval Journal for Research and Technology Policy Evaluation* (39), 5-10.

Weber, K.M. and H. Rohracher. 2012. “Legitimizing research, technology and innovation policies for transformative change.“ *Research Policy* 41, 1037–1047.

Wesselink, A., K.S. Buchanan, P.Y. Georgiadou, and E. Turnhout. 2013. “Technical knowledge, discursive spaces and politics at the science–policy interface.” *Environmental Science & Policy* 30, 1–9.

Wieczorek, A.J. 2018. “Sustainability transitions in developing countries: Major insights and their implications for research and policy.” *Environmental Science & Policy* 84, 204–216.

Wise, R.M., I. Fazey, M. Stafford Smith, S.E. Park, H.C. Eakin, E.R.M. Archer van Garderen, and B. Campbell. 2014. "Reconceptualising Adaptation to Climate Change as Part of Pathways of Change and Response." *Global Environmental Change* 28, 325–336.

Wiseman, J., T. Edwards, and K. Luckins. 2013. "Post Carbon Pathways: A Meta-Analysis of 18 Large-Scale Post Carbon Economy Transition Strategies." *Environmental Innovation and Societal Transitions* 8, 76–93.

Wolf, F., D. Surroop, A. Singh and W. Leal. 2016. „Energy Access and security strategies in Small Island Developing States." *Energy Policy* 98, 663–673.

Wolfe, D. and A. Salter. 1997. The Socio-Economic Importance of Scientific Research to Canada. A Discussion Paper prepared for the Partnership Group for Science and Engineering, Ottawa, October.

Wolfram, M., J. van der Heijden, S. Juhola, and J. Patterson. 2019. "Learning in urban climate governance: concepts, key issues and challenges." *Journal of Environmental Policy & Planning* 21(1): Learning in urban climate governance: Concepts, key issues and challenges, 1–15.

Wu, X., M. Howlett, and M. Ramesh (Eds.). 2018. *Policy Capacity and Governance: Assessing Governmental Competences and Capabilities in Theory and Practice.* Cham: Palgrave Macmillan.

Wu, X., M. Ramesh, and M. Howlett. 2015. "Policy Capacity: A Conceptual Framework for Understanding Policy Competences and Capabilities." *Policy and Society* 34(3-4), 165–171.

Yin, R.K. 2003. *Case Study Research; Designs and Method*. 3rd ed. Thousand Oaks, CA: Sage Publications, Inc.

Ziman, J.M. 2000. *Real Science: What It is, and What It Means*. Cambridge: Cambridge University Press.

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ABSTRACT

Opportunities and challenges arising from adapting to external discourses, policies, and instruments aimed for sustainability transitions: case studies from Estonia

Climate change as a highly complex societal challenge has become one of the biggest environment-related political discourses on the global level (**I**). The dominant narrative declares that a simple 'technical-fix' through changing the technologies to cleaner ones should be possible from an objective and value-neutral scientific point of view (Wesselink et al. 2013). Due to this 'linear' and 'value-neutral' technical approach (Ibid.) and the multi-disciplinary nature of environmental technologies (**I**; Frondel et al. 2007), attention has been paid to the rate of innovation (Popp et al. 2010) but not to the overall direction and the transformative nature of innovation (Garcia and Calantone 2002; Johnstone 2005; **I**), policy implementation and the related networks, actors, and their interactions. Furthermore, in the EU the political discourse has been challenged by very ambitious carbon emission reduction targets, such as 80–95% below the levels of 1990 by 2050 (European Commission 2018, 2011). This kind of profound and radical changes require comprehensive transformations into new systems conceptualized as 'sustainability transitions' (Markard et al. 2012), which have a multi-level and multi-domain nature with both bottom-up and top-down features (Loorbach et al. 2017; Geels 2018a, 2018b, 2011, 2010; Genus and Coles 2008). Despite the highly ambitious goals and the nature of the EU policymaking, the multi-level political-institutional contexts in which sustainability transitions are initiated, shaped, or inhibited, have received limited attention (Ehnert et al. 2018).

This thesis fills a part of this gap by linking sustainability transitions, public policy, and STI studies. It reveals some of the underlying complexities and even contradicting logics between the different natures and governance theories and practices of (1) the linear, technical, and value-neutral global climate change policy discourse (Wesselink et al. 2013), (2) the multi-domain and multi-level sustainability transitions with bottom-up and top-down processes (Loorbach et al. 2017; Geels 2018a, 2018b, 2011, 2010; Genus and Coles 2008), (3) the mainly hierarchical and top-down traditional public climate policy in the EU (Egenhofer and Alessi 2013; Dirix et al. 2013; Lenschow 2002; Schmidt 2009; Ladrech 1994; Héritier et al. 2001; Urwin and Jordan 2008), and (4) the specific STI studies and models aimed for sustainability transitions that emphasize bottom-up social innovation, experimentation, and niche-innovation (Hossain 2016; Schot and Geels 2008; Kemp et al. 1998; Bergek et al. 2008; Verheul and Vergragt 1995). These complexities present wider and quite substantial STI policy problems in Europe, leading to rather specific governance and policy implementation challenges.

This thesis analyzes a selection of these problems but also some opportunities that one of the smallest member states of the EU, Estonia, has experienced when adopting generic policy discourses and specific policies and instruments developed at the global and EU levels. More specifically, the thesis focuses on sustainability through clean technologies and a selection of specific aspects of STI policy, such as ISL in energy technologies (**I**), environmental taxation models that influence the energy sector (**II**), funding of science (**III**), and economic steering policies (i.e. smart specialization policies) (**IV**) because they are seen as mechanisms for tackling the challenges and enabling transitions. In addition, looking from a broader perspective the empirical part of the thesis

also provides insights into how ideas designed at the global level evolve while moving down the governance levels and whether convergence or divergence emerges in comparison with the source of the discourse, policy, or instrument.

The following research questions that cover the selected aspects of STI policy that are related to energy and environmental policy (societal challenges, ISL, taxation, funding of R&D, and economic specialization policies) are addressed in this thesis:

- How have the imported discourses, policies, and instruments of climate change and sustainability transitions designed at the EU and global levels been developed and adapted in member countries? Have they converged or diverged from the central EU policy and their initial ideas?
- More specifically, how have the imported STI policy discourses, policies, and instruments influenced the implementation of national policies and related networks? How have they been integrated and implemented on local levels? How have they affected the national context in striving towards sustainability transitions, and how has the local context influenced the central policies?
- The individual articles, in turn, zoom in on the following research questions:
    a. How does the global climate change discourse influence the implementation of national STI policy and ISL in the field of energy technologies (**I**)?
    b. What kind of international and local factors influence the adoption and development of new policy instruments (NPIs) for sustainability transitions based on the example of the Estonian environmental taxes and charges system (**II**)?
    c. How do R&D funding models influence the sustainability of research strategies, ISL, university management, and research systems more broadly (**I**; **III**)?
    d. How can economic steering policies enable sustainability transitions? Would more focus on local governments' bottom-up entrepreneurial discovery process (EDP), mission-oriented and "place-based" strategies lead to more sustainable smart specialization (**IV**)?

The thesis consists of three original published research articles (**I**; **II**; **III**), one annexed research article (**IV**) that is under review, and the introduction of the thesis. The author of this thesis has been the sole author of the second article (**II**), the leading author of the fourth article (**IV**), the second author of the first article (**I**), and third author (**III**) of the third article. The articles rely on single case study (Stephenson 1974; Stake 2005; **I**; **II**) and comparative case study (Bartlett and Vavrus 2017; Fox-Wolfgramm 1997; Gerring 2009; **III**; **IV**) approaches due to the complexity of research objects (ISL, taxing systems, budgeting and financial management in universities, strategic planning in central and local governments), the actors, stakeholders, their perceptions and understandings involved in the processes, issues of interdependencies, interdynamics, and path dependency. Mainly qualitative research methods have been used (**I**; **II**; **III**; **IV**); however, the network analysis of the energy technology ISL also included quantitative methods (**I**).

In the analytical framework of the introduction of the thesis, first, the MLP of sustainability transitions is complemented with public policy theories of MLG, policy transfer and convergence. Second, the framework is further enriched with implications of selected STI aspects discussed in the related STI and sustainability transitions literatures. Under the implications, first, sustainability through multi-disciplinary green and clean technologies and the related challenges and opportunities for ISL and MLG are

discussed. Second, the energy sector as a complex socio-technical system that requires high-quality state capacities in areas of governance, administration, policy, and technology for effective policymaking are explained. Third, experiments in regional innovation policy and specifically the smart specialization approach as an example of a directional, place-based, and mission-oriented regional STI policy aimed for solving grand challenges like climate change as well as the accompanying opportunities and problems for governance are outlined. Fourth, public funding of research as an example of an STI policy instrument for allocating R&D funding between scientifically excellent and socio-economically relevant research in the context of sustainability transitions and the related implications for governance are explained.

The idea of such an analytical focus is to better analyze and understand the opportunities and challenges of member states arising from adapting to imported discourses, policies, and instruments while governing sustainability transitions in the EU MLG contexts. By creating this kind of a new analytical framework, theoretically, the thesis contributes to the sustainability transitions, innovation, and policy studies research through showcasing the complementarities, interlinkages, and interdynamics of these fields and, furthermore, demonstrating the implications (opportunities and challenges) of these complexities for governance and MLG of selected externally developed aspects and imported mechanisms of STI policy meant to enable transitions.

Through different case studies and analytical lenses, the articles analyze how wider policy discourses and specific public policy measures developed at the EU and global levels have influenced STI, energy and environmental policy design and implementation, and STI networks and actors of energy technologies in Estonia (i.e. ISL – **I**; taxing systems – **II**; budgeting and financial management in public universities – **III**; involvement of the local government in developing smart specialization strategies – **IV**). The thesis emphasizes the uniqueness of energy and green technologies and the importance of understanding the differences of different technologies and related socio-institutional settings. Moreover, the thesis argues for the need to develop technological capacities of governance for designing and implementing effective and sustainable STI policies to enable climate change mitigation and sustainability transitions in practice, i.e. to understand the interlinkages and successfully guide the changes of the different levels of socio-technical transitions (niche, regime, landscape).

The empirical part of this thesis together with the empirical studies of the articles contribute to the academic debate on the MLP and MLG of sustainability transitions through providing insights about converging or diverging local reactions and countermeasure trends of smaller countries in adapting to external policies, policy discourses, and instruments to govern sustainability transitions in the MLG context. The implications for MLG of sustainability transitions from the MLP viewpoint are summarized in the following explanation.

First, although MLG emphasizes the empowerment of local governance, the thesis shows that in Estonia on the local level policymaking is limited in the studied policy domains (STI, research funding, and smart specialization) (**III; IV**). The thesis argues for the importance of building directionality and experimentation capacities of governments in designing and implementing place-based RDI policies and involving local and regional level governments in these processes as well.

Second, the findings suggest that the local context and the related actors and factors (openness to new ideas, previous experience with similar measures, right timing, involvement of key players of regime transitions, etc.) can enable a smoother adaption

to external policies (**II**) or, in the absence of these, create various problems with policy implementation and lead to multiple unintended effects and results (**I**; **III**; **IV**).

Third, the similarities of Estonia and Wales regarding the design and implementation of smart specialization strategies and policies (**IV**) emphasize that a sufficient level of governance, policy and technological capacities are needed to make use of the intended effects of non-neutral, directional, and systemic place-based policies. More precisely, our analysis highlights the essential role of local governments that need to have sufficient RDI capacities and need to be involved in the design and implementation of local smart specialization strategies that integrate sustainability transitions because through this it is possible to operationalize the essence of place-based policies (i.e. policies that can successfully direct local opportunities and short-comings, making great use of the first and diminish the latter).

Fourth, all of the case studies (**I, II, III, IV**) confirm that to decrease unintended effects of policy transfer, the discourses and policies developed on the international levels have to be translated into national, regional, and local levels. However, as there are also great examples of local demonstrations and pilots of sustainability transitions, the question there is how to scale these success stories to regional, national, and international levels and enable the translation of practices from local levels to national and global ones. These experiences create high expectations for bottom-up processes led by local governments that are challenged by the limited capacities of these local governments in creating and leading innovative activities and economic development policies in a wider sense (**IV**).

Fifth, ideas of sustainability need to be integrated into our "common sense" and for that we need to understand that the same super wicked problems can be seen as opportunities for development in new sectors and for rejuvenation of old sectors and through this creating sustainable economic growth and jobs in these new or renewed sectors (Perez and Murray Leach 2018; Mazzucato and Perez 2015). The state can have a relevant role in these activities through socializing the benefits of innovations (Mazzucato 2015) by actively and adventurously taking part in innovation and supporting and conducting transition experiments (Rosenbloom et al. 2018) and governance experiments (Matschoss and Repo 2018).

Sixth, the diverging trajectories and challenges of ISL, universities and non-participation of municipalities (**I**; **III**; **IV**) in policy implementation pose further systematic challenges for policymakers in designing STI policies in terms of energy sustainability and security, sustainable research and industry collaborations and innovation. Our analysis calls for non-neutral and directional policy mixes that take into account the specificities of green and clean energy technologies and the structure of the economy, e.g. while designing RDI funding instruments and support measures for sectors with products and services with high added value. We argue that the economic structure, mix, nature, and capabilities of local energy technology companies (from end-of-pipe and energy efficiency technologies of incremental innovation to more radical clean technologies) as policy feedback mechanisms, play a significant role in how the global discourse translates into policy implementation, and in the long run this might have a systematic impact on the wider energy innovation system. Considering this feedback might lead to structural changes in energy transitions towards sustainability and ignoring this information might lead to rhetorical changes and incremental innovation towards energy efficiency and the potentially sub-optimal lock-in of old technologies.

Finally, and most regrettably, this is illustrated by the case study of the Estonian energy technology ISL (**I**) and the smart specialization case study (IV) where the latter, as a remarkable innovation policy experiment in the EU with the high potential to solve complex societal challenges, has not yet lived up to its promise in Estonia. It has not enabled the energy transition from oil shale based to clean energy technologies in Estonia. The reason for this might be the absence of a non-neutral and non-linear STI policy with clear mission-oriented energy technology financing that accounts for the socio-technical complexities (e.g. historical reliance on oil shale based electricity production, strong influence on regional economic development and social processes) and significant niche-regime-landscape reproduction processes and targets the key players of transitions (e.g. ISL). Unfortunately, the prioritization of technologies in Estonia – and through this, to some degree, also the destabilization of incumbent regimes and promotion of radical green niches – has been left to the competitive and project-based research funding environment of Estonia dictated by EU programs and preferring prior performance and scientific excellence with little if any connection to national relevance (**I**; **III; IV**). The previously listed problems have led to many practical challenges in energy technology ISL (**I**) but also challenges with budgeting and financial management and limited opportunities for strategic planning in universities (**III**).

This thesis calls for much more systematic analysis of the impact and adaptation of external discourses, policies, and instruments on different levels of governance, vertically and horizontally, by looking at different phases of policymaking and how more collaboration, engagement, and interaction between different levels and domains could potentially improve the practical implementation of imported discourses, policies, and instruments.

More in-depth analyses are needed about the influence of STI policies and instruments on specific areas of sustainability transitions and the transitions of socio-technical systems. Future studies could look at how niches are translated into mainstream settings and whether there are specific characteristics of transition and government experiments that determine their success. Relatedly, more studies are needed to examine the business model aspects of cleantech and how they influence the direction of innovation for speeding up sustainability transitions.

In terms of research funding, future research could examine countries where the central level of the university has stronger steering instruments to analyze which governance arrangements help to address the potential tensions between the subunits and the core. In addition, it would be interesting to explore, in a dynamic and longer-term perspective, how project-based funding of academic research influences the strategic management of universities.

In future research, it would also be beneficial to undertake comparative studies in different countries and contexts. It would be interesting to analyze whether the local interpretations of global discourses are different, whether the effects on energy and environmental technology ISL and accompanying practices follow similar patterns in different science systems, and whether there are differences in effects in the various sub-fields of energy and environmental technologies. More comparative and empirical studies are also needed about the role of regional and local governments and their capacities to participate in innovation activities and more strategically lead and govern innovation in place-based policies for sustainability transitions and how to increase these capacities.

LÜHIKOKKUVÕTE

Jätkusuutlikkusele ülemineku võimalused ja väljakutsed väliste diskursuste, poliitikate ja instrumentidega kohandumisel: juhtumianalüüsid Eestist

Kliimamuutused kui ülikeerukad sotsiaalsed väljakutsed on globaalselt muutunud üheks suurimaks keskkonnaga seotud poliitiliseks diskursuseks (**I**). Domineeriv, peamiselt vaid objektiivsest ja 'väärtusneutraalsest' teaduslikust vaatenurgast (Wesselink et al. 2013) lähtuv narratiiv kuulutab, et lihtne 'tehniline lahendus' kliimamuutustele on võimalik läbi tehnoloogiate vahetamise puhtamate vastu. Tänu sellisele 'lineaarsele' ja 'väärtusneutraalsele' tehnilisele lähenemisele (Ibid.) ning keskkonnatehnoloogiate multidistsiplinaarsele olemusele (**I**; Frondel et al. 2007), on vastavas globaalses diskursuses palju rohkem tähelepanu pööratud innovatsiooni kiirusele (Popp et al. 2010) kui innovatsiooni suunale ja selle kõikemuutvale iseloomule (Garcia and Calantone 2002; Johnstone 2005; **I**). Vähe tähelepanu on pööratud ka poliitikate rakendamisele ja seotud võrgustikele, osapooltele ja nendevahelistele suhetele. Lisaks esitavad Euroopa Liidu ambitsioonikad süsinikuemissiooni vähendamise eesmärgid kliimamuutuste poliitilisele diskursusele suure väljakutse – 2050. aastaks peaks emissioon jääma 80–95% alla 1990. aasta taseme (European Commission 2018, 2011). Et saavutada nii radikaalseid muutusi, on vaja põhjalikke üleminekuid uutele kestvamatele süsteemidele, mida nimetatakse 'jätkusuutlikkusele üleminekuteks' (Markard et al. 2012) või 'üleminekuteks jätkusuutlikkusele' või 'kestvatele süsteemidele üleminekuteks', mis oma olemuselt on mitmetasandilised ja valdkondade ülesed ning hõlmavad nii 'ülevalt alla' kui ka 'alt üles' protsesse (Loorbach et al. 2017; Geels 2018a, 2018b, 2011, 2010; Genus and Coles 2008). Vaatamata Euroopa Liidu üliambitsioonikatele eesmärkidele ja poliitikakujundamise iseloomule, on Euroopa Liidu mitmetasandilist poliitilist ja institutsionaalset kontekst, kus jätkusuutlikkusele üleminekuid algatatakse, kujundatakse või takistatakse, käsitletud eelnevates teadusuuringutes väga piiratud ulatuses (Ehnert et al. 2018).

Käesolev doktoritöö täidab osa sellest tühimikust, ühendades jätkusuutlikkusele üleminekud, avaliku poliitika ning teadus-, tehnoloogia- ja innovatsiooniuuringud. Doktoritöö toob välja mõned põhilised keerukused ja vastukäivad loogikad järgnevate kontseptsioonide baasolemuse ning seotud valitsemisteooriate ja –praktikate vahel: (1) lineaarne, tehniline ja väärtusneutraalne globaalne kliimamuutuste poliitiline diskursus (Wesselink et al. 2013); (2) 'ülevalt alla' ja 'alt üles' protsessidega valdkondade ülesed ja mitmetasandilised üleminekud jätkusuutlikkusele (Loorbach et al. 2017; Geels 2018a, 2018b, 2011, 2010; Genus and Coles 2008); (3) peamiselt hierarhiline ja 'ülevalt alla' toimiv traditsiooniline avalik kliimapoliitika Euroopa Liidus (Egenhofer and Alessi 2013; Dirix et al. 2013; Lenschow 2002; Schmidt 2009; Ladrech 1994; Héritier et al. 2001; Urwin and Jordan 2008); ning (4) spetsiifilised jätkusuutlikkusele üleminekuteks suunatud teadus-, (tehnoloogia)arendus- ja innovatsiooni (TAI) uuringud ning mudelid, mis rõhutavad 'alt üles' toimivat sotsiaalset innovatsiooni, eksperimenteerimist ja nišipõhist innovatsiooni (Hossain 2016; Schot and Geels 2008; Kemp et al. 1998; Bergek et al. 2008; Verheul and Vergragt 1995). Kirjeldatud keerukused näitlikustavad laiemaid ja sisulisi TAI poliitika probleeme Euroopas, mis omakorda viivad veelgi spetsiifilisemate valitsemise ja poliitika rakendamise väljakutseteni.

Doktoritöö analüüsib valikut nendest väljakutsetest, aga ka võimalustest, mida Eesti kui üks väiksemaid Euroopa Liidu liikmesriike on kogenud, võttes omaks poliitika

diskursuseid, poliitikaid ja poliitika instrumente, mida on disainitud Eesti riigi välistel valitsemistasanditel, globaalsel ja Euroopa Liidu tasandil. Konkreetsemalt keskendub doktoritöö jätkusuutlikkusele läbi puhaste tehnoloogiate ja valitud spetsiifiliste TAI poliitika aspektide, nagu tööstuse ja teaduse koostöövõrgustikud energiatehnoloogiate valdkonnas (**I**), keskkonna maksustamise mudelid, mis mõjutavad energiasektorit (**II**), teaduse rahastamine (**III**) ja majanduslikud juhtimispoliitikad nutika spetsialiseerumise näitel (**IV**). Vastavad TAI poliitika aspektid ja meetmed on välja valitud, sest neid nähakse enim levinud instrumentidena, mis aitavad võidelda kliimamuutustega ja seeläbi võimaldavad üleminekuid jätkusuutlikumatele süsteemidele. Lisaks pakub doktoritöö empiiriline osa ülevaadet, kuidas globaalsel tasandil kujundatud ideed arenevad valitsemistasanditel allapoole liikudes ning kas need toovad kaasa diskursuste, poliitikate ja meetmete ühtlustumise või eristumise võrreldes algse lähenemisega.

Doktoritöö analüüsib järgnevaid uurimisküsimusi, mis katavad valitud TAI poliitika aspektid energia- ja keskkonnapoliitika valdkondades (sotsiaalsed väljakutsed, tööstuse ja teaduse koostöövõrgustikud, maksustamine, teaduse ja innovatsiooni rahastamine ning majandusliku spetsialiseerumise poliitikad):

- Kuidas on globaalsel ja Euroopa Liidu tasandil kujundatud kliimamuutuste ja jätkusuutlikkusele üleminekute diskursused, poliitikad ja poliitikameetmed arenenud ja kohanenud liikmesriikides? Kas nad on ühtlustunud või eristunud Euroopa Liidu kesksest poliitikast ja selle algsetest ideedest?
- Kuidas on imporditud TAI poliitika diskursused, poliitikad ja poliitika instrumendid mõjutanud kohalikke poliitikaid ja seotud innovatsioonivõrgustikke? Kuidas on neid integreeritud ja rakendatud kohalikul tasandil? Kas nad on suunanud kohalikku konteksti liikumaks jätkusuutlikumate süsteemide poole ning kuidas on kohalik kontekst mõjutanud tsentraalseid poliitikaid?
- Doktoritöö artiklid vaatavad järgmisi spetsiifilisemaid uurimisküsimusi:
    a. Kuidas mõjutab globaalne kliimamuutuste diskursus riiklike TAI poliitikate rakendamist ning tööstuse ja teaduse koostöövõrgustikke energiatehnoloogiate valdkonnas (**I**)?
    b. Missugused rahvusvahelised ja kohalikud tegurid mõjutavad jätkusuutlikele süsteemidele üleminekule suunatud uute poliitikameetmete omaksvõtmist ja arenemist Eesti keskkonnamaksude ja –tasude süsteemi kujunemise näitel (**II**)?
    c. Kuidas mõjutavad TAI rahastusmudelid teadusstrateegiate, tööstuse ja teaduse koostöövõrgustike, ülikoolide juhtimise ja laiemalt teadussüsteemide jätkusuutlikkust (**I**; **III**)?
    d. Kuidas saavad majanduslikud juhtimispoliitikad võimaldada üleminekuid jätkusuutlikele süsteemidele? Kas kohalike omavalitsuste suurem keskendumine ‘alt üles’ toimivale ettevõtlikule avastusprotsessile, missioonile orienteeritud ja kohapõhistele strateegiatele, võiks viia jätkusuutlikuma nutika spetsialiseerumiseni (**IV**)?

Doktoritöö koosneb kolmest avaldatud teadusartiklist (**I**; **II**; **III**), ühest lisas olevast teadusartiklist, mis on ajakirjas ülevaatamisel (**IV**) ja doktoritöö sissejuhatusest. Doktoritöö autor on teise artikli ainuke autor (**II**), juhtivautor neljandas artiklis (**IV**), teine autor esimeses artiklis (**I**) ja kolmas autor kolmandas artiklis (**III**). Artiklid toetuvad üksikjuhtumite (Stephenson 1974; Stake 2005; **I**; **II**) ja võrdleva juhtumianalüüsi lähenemisele (Bartlett and Vavrus 2017; Fox-Wolfgramm 1997; Gerring 2009; **III**; **IV**).

Vastav lähenemine on valitud tulenevalt uurimisobjektide komplekssusest (tööstuse ja teaduse koostöövõrgustikud, maksusüsteemid, eelarvestamine ja finantsjuhtimine ülikoolides, strateegiline innovatsioonijuhtimine keskvalitsuses ja kohalikes omavalitsustes) ja seotud protsessidest huvitatud osapoolte (sh. ka nende tõlgenduste ja arusaamade) paljususest, vastastikustest dünaamikatest ja sõltuvustest ning rajasõltuvusest. Peamiselt on kasutatud kvalitatiivseid uurimismeetodeid (**I**; **II**; **III**; **IV**). Energiatehnoloogiate tööstuse ja teaduse koostöö võrgustikuanalüüs sisaldas ka kvantitatiivseid meetodeid (**I**).

Doktoritöö aluseks on sissejuhatuses arendatud analüütiline raamistik, milles esiteks täiendatakse jätkusuutlikkusele üleminekute mitmetasandilist vaadet avaliku poliitika teooriatega mitmetasandilisest valitsemisest, poliitikate siirdest ja konvergentsist ehk ühtlustumisest. Teiseks, rikastatakse raamistikku valitud TAI ja jätkusuutlikkusele üleminekute kirjandusest pärit järeldustega. Järelduste all selgitatakse esmalt jätkusuutlikkusele üleminekuid läbi multidistsiplinaarsete roheliste tehnoloogiate ning mis väljakutseid ja võimalusi need tööstuse ja teaduse koostöövõrgustikele ja mitmetasandilisele valitsemisele kaasa toovad. Teiseks, arutletakse energiasektori kui keeruka sotsiaal-tehnilise süsteemi olemuse üle, mis vajab efektiivseks poliitikate kujundamiseks kõrgetasemelisi riiklikke pädevusi valitsemise, administreerimise, poliitika ja tehnoloogia valdkonnas. Kolmandaks, käsitletakse nutika spetsialiseerumise kui suunatud, kohapõhise ja missioonile orienteeritud regionaalse TAI poliitika (eesmärgiga lahendada globaalseid väljakutseid nagu kliimamuutused) probleeme ja väljakutseid mitmetasandilisele valitsemisele. Neljandaks, selgitatakse jätkusuutlikele süsteemidele ülemineku kontekstis teaduse avalikku rahastamist eesmärgiga jaotada ressursse teaduslikult ekstsellentse ja sotsiaal-majanduslikult vajaliku teaduse vahel koos seotud järeldustega valitsemisele.

Vastava analüütilise fookuse mõte on põhjalikumalt analüüsida ja mõista liikmesriikide võimalusi ja väljakutseid, mis on tekkinud sisse toodud diskursuste, poliitikate ja instrumentidega kohandumisel, juhtides üleminekuid kestvatele süsteemidele Euroopa Liidu mitmetasandilise valitsemise kontekstis. Teoreetiliselt panustab loodud analüütiline raamistik jätkusuutlikkusele üleminekute, innovatsiooni- ja poliitikauuringute teaduskirjandusse läbi nimetatud kontseptsioonide vaheliste sõltuvuste, seoste ja dünaamikate esitlemise ning komplekssusest tulenevate mitmetasandilisele valitsemisele suunatud võimaluste ja väljakutsete demonstreerimise.

Doktoritöö artiklid analüüsivad läbi erinevate juhtumianalüüside ja analüütiliste vaatenurkade, kuidas globaalsed ja Euroopa Liidu tasandil poliitilised diskursused ning spetsiifilised TAI aspektid ja meetmed mõjutavad Eesti TAI, energia ja keskkonnapoliitikate disainimist ja rakendamist ning TAI võrgustikke ja osapooli energiatehnoloogiate valdkonnas (tööstuse ja teaduse koostöövõrgustikud – **I**; maksustamise süsteemid – **II**; eelarvestamine ja finantsjuhtimine avalikes ülikoolides – **III**; kohalike omavalitsuste kaasamine nutika spetsialiseerumise strateegiate arendamisel – **IV**). Doktoritöö rõhutab energia ja puhaste tehnoloogiate unikaalsust ning tehnoloogiate vaheliste erisuste ja seotud sotsiaal-institutsionaalsete taustsüsteemide mõistmise vajadust. Eelnevast tulenevalt toob doktoritöö välja ka valitsemise tehnoloogiliste kompetentside arendamise vajaduse, et kujundada ja rakendada efektiivseid ja jätkusuutlikke TAI poliitikaid ning edukalt suunata sotsiaal-tehnilisi üleminekuid niššide, režiimide ja laiema taustsüsteemi vahel, leevendamaks kliimamuutusi ja võimaldamaks üleminekuid jätkusuutlikumatele süsteemidele ka praktikas.

Doktoritöö empiiriline osa panustab jätkusuutlikkusele üleminekute mitmetasandilise lähenemise ja mitmetasandilise valitsemise akadeemilisse debatti, pakkudes ülevaadet ühtlustuvatest ja eristuvatest kohalikest reaktsioonidest ning väikeriikide trendidest kohanemaks väliste poliitikate, nende diskursuste ja meetmetega, et juhtida kestvatele süsteemidele üleminekuid Euroopa Liidu mitmetasandilise valitsemise kontekstis. Järgnevalt on välja toodud jätkusuutlikele süsteemidele üleminekute võimalused ja väljakutsed mitmetasandilise valitsemise vaatenurgast.

Esiteks, kuigi mitmetasandiline valitsemine rõhutab kohalike omavalitsuste tugevdamist, näitavad doktoritöö tulemused, et analüüsitud valdkondades (TAI, teaduse rahastamine ja nutikas spetsialiseerumine) on Eestis kohaliku omavalitsuse tasandil poliitikate kujundamises osalemine piiratud (**III; IV**). Doktoritöö toob välja, et on vaja arendada suunatud ja eksperimentaalsete poliitikate läbiviimiseks vajalikke kompetentse, et kujundada ja rakendada kohapõhiseid TAI poliitikaid, ning kaasata kohaliku ja regionaalse tasandi omavalitsusi nendesse protsessidesse.

Teiseks, doktoritöö avastused näitavad, et kohalik kontekst, seotud osapooled ja tegurid (nt. avatus uutele ideedele, eelnev kogemus sarnaste meetmetega, õige ajastus, režiimi üleminekute võtmeosalejate kaasamine) võivad pakkuda sujuvamat kohandumist väliste poliitikatega (**II**). Soodustavate tegurite puudumine võib aga tekitada erinevaid probleeme poliitika rakendamisega ning tuua kaasa mitmeid ettearvamatuid mõjusid ja tulemusi (**I**; **III**; **IV**).

Kolmandaks, Eesti ja Walesi sarnased praktikad nutika spetsialiseerumise strateegiate kujundamise ja rakendamisega (**IV**) rõhutavad piisavalt hea valitsemise, poliitika ja tehnoloogia kompetentside taseme vajalikkust, et osata disainida ja rakendada selgete väärtustega, suunatud ja süsteemseid kohapõhiseid poliitikaid. Konkreetsemalt tõstab analüüs esile kohalike omavalitsuste olulise rolli omada piisavaid TAI kompetentse ning olla kaasatud kohalike nutika spetsialiseerumise strateegiate disainimisse ja rakendamisse, mis on seotud jätkusuutlikele süsteemidele üleminekutega, sest vaid nii on võimalik kasutada ära kohapõhiste poliitikate põhiolemust (need on poliitikad, mis suudavad edukalt juhtida kohalikke võimalusi ja puudujääke, kasutades ära esimesi ja vähendades viimaseid).

Neljandaks, kõik doktoritöö artiklid (**I, II, III, IV**) kinnitavad, et kui soovitakse vähendada mujal kujundatud diskursuste, poliitikate ja meetmete siirde ettearvamatuid mõjusid, tuleb need integreerida riiklikku, regionaalsesse ja kohalikku konteksti. Kuna on täheldatud ka häid näiteid kohalikest jätkusuutlikkusele üleminekute pilootprojektidest, oleks oluline uurida, kuidas neid edulugusid saaks laiendada regionaalsele, riiklikule ja rahvusvahelisele tasandile ning võimaldada ka praktikate vastupidist integreerimist ja siiret kohalikult tasandilt riiklikule ja globaalsele. Samas, need kogemused loovad kõrgeid ootusi kohalike omavalitsuste juhitud 'alt üles' protsessidele, mis esitab väljakutse kohalike omavalitsuste piiratud kompetentsidele innovaatiliste tegevuste loomisel ja juhtimisel ning innovatsioonipoliitika kujundamisel laiemas mõttes (**IV**).

Viiendaks, jätkusuutlikkuse ideed peavad saama meie igapäeva mõtlemise osaks. Selleks on omakorda vaja mõista, et neid samu ülikeerukaid probleeme võib vaadelda ka kui võimalusi arenguks uutes valdkondades ja uuendusteks vanades sektorites, luues seeläbi jätkusuutlikku majanduskasvu ja töökohti uutes ning uuenenud sektorites (Perez and Murray Leach 2018; Mazzucato and Perez 2015). Riik võib omada olulist rolli nendes tegevustes sotsialiseerides ehk riigistades innovatsiooni positiivsed tulemused (Mazzucato 2015) läbi aktiivselt innovatsioonis osalemise ja toetades ülemineku

eksperimente (Rosenbloom et al. 2018) ja valitsemise eksperimente (Matschoss and Repo 2018).

Kuuendaks, tööstuse ja teaduse koostöö probleemid ja väljakutsed ning kohalike omavalitsuste vähene osalemine (**I**; **III**; **IV**) TAI poliitikate rakendamisel tekitavad edasisi süstemaatilisi probleeme poliitikakujundajatele TAI poliitikate disainimisel energia jätkusuutlikkuse ja varustuskindluse, jätkusuutliku teaduse ja tööstuse koostöö ning innovatsiooni vallas. Käesolev analüüs toetab defineeritud väärtustega ja suunatud poliitikameetmestikke, mis arvestavad rohe- ja puhaste energiatehnoloogiate erisustega ja majanduse struktuuriga, nt kui disainitakse TAI toetusmeetmeid kõrge väärtusega toodete ja teenuste sektoritele. Doktoritöö tulemused näitavad, et majanduse struktuur, kohalike energiatehnoloogia ettevõtete mitmekesisus, nende olemus ja kompetentsid (inkrementaalset innovatsiooni kajastavatest puhastustehnoloogiatest ja energia efektiivsuse tehnoloogiatest kuni radikaalsete puhaste tehnoloogiateni) kui poliitikate kujundamise edasiside mehhanismid, mängivad olulist rolli selles, kuidas globaalne kliimadiskursus integreeritakse kohalike poliitikate arendamisse ja rakendamisse. Pikas perspektiivis võib sellel olla süsteemne mõju laiemale energiatehnoloogiate innovatsioonisüsteemile. Edasisidega arvestamine võib viia strukturaalsete muudatusteni energeetikasüsteemide üleminekutes jätkusuutlikumale toimimisele. Vastava informatsiooni eiramine võib teisest küljest viia ka retooriliste ja inkrementaalsete muudatusteni, innovatsioonini vaid madala energia efektiivsuse suunas ning potentsiaalselt ka vanadesse tehnoloogiatesse lukustumiseni, mis takistavad uute tehnoloogiate laiemat levimist ja süsteemide üleminekut kestvamale toimimisele.

Eelnevat illustreerivad hästi Eesti energiatehnoloogiate tööstuse ja teaduse koostöövõrgustike juhtumianalüüs (**I**) ning nutika spetsialiseerumise juhtumianalüüs (**IV**). Kahjuks ei ole viimane kui Euroopa Liidu märkimisväärne innovatsioonipoliitika eksperiment (potentsiaaliga lahendada ülikeerukaid sotsiaalseid väljakutseid) Eestis oodatud tulemusi kaasa toonud. Nutikas spetsialiseerumine ei ole võimaldanud energiasektori üleminekut põlevkivipõhistelt tehnoloogiatelt puhastele tehnoloogiatele. Selle põhjuseks võib olla väärtuspõhiste ja mittelineaarsete TAI poliitikate puudumine, millel oleks selge missioonipõhine energiatehnoloogiate rahastamine ja mis arvestaksid sotsiaal-tehniliste keerukustega (e.g. ajalooline sõltuvus põlevkivipõhisest elektritootmisest, tugev mõju regionaalsele majandusarengule ja sotsiaalsed protsessid). Lisaks peaksid need võtma arvesse ka olulisi nišš-režiim-taustsüsteem taastootmise protsesse ja kaasama üleminekute võtmeosalisi (nt teaduse ja tööstuse koostöövõrgustikke). Kahjuks on Eestis tehnoloogiate prioritiseerimine ning läbi selle osaliselt ka turgu valitsevate režiimide destabiliseerimine ja radikaalsete roheliste niššide toetamine jäetud konkurentsi ja projektipõhise teadusrahastamise mõjusfääri, mis juhindub Euroopa Liidu rahastusprogrammidest ning soosib eelnevaid teadustulemusi ja teaduslikku ekstsellentsust, omades vähe seoseid riiklikult vajalike sotsiaal-tehniliste süsteemide uuendamise edendamisega (**I**; **III; IV**). Eelnevalt väljatoodud probleemid on viinud mitmete praktiliste väljakutseteni energiatehnoloogiate tööstuse ja teaduse koostöövõrgustikes (**I**), aga ka probleemideni ülikoolide eelarvestamises ja finantsjuhtimises ning piiratud võimalusteni strateegiliselt ülikoole juhtida (**III**).

Tulevastes uuringutes soovitab käesolev doktoritöö süsteemselt analüüsida väliste diskursuste, poliitikate ja instrumentide kohandumist ning mõju erinevatel valitsemise tasanditel, vertikaalselt ja horisontaalselt, vaadates erinevaid poliitikakujundamise faase ning uurides ka kuidas suurem koostöö, kaasamine ja suhtlemine erinevate tasandite ja

valdkondade vahel võiks potentsiaalselt parandada imporditud diskursuste, poliitikate ja instrumentide rakendamist praktikas.

Rohkem oleks vaja põhjalikke analüüse, mis uurivad TAI poliitikate ja instrumentide mõju konkreetsetele jätkusuutlikkuse valdkondadele ja sotsiaal-tehniliste süsteemide üleminekutele. Tulevikus võiksid uuringud analüüsida, kuidas tõlkida nišše peavoolu taustsüsteemidesse ning kas jätkusuutlikel üleminekutel ja valitsuse eksperimentidel on omadusi, mis suurendaksid nende edukat elluviimist. Lisaks on vaja rohkem uuringuid, mis analüüsiksid puhaste tehnoloogiate ärimudeleid ning kuidas need omakorda mõjutavad innovatsiooni suunda, et kiirendada jätkusuutlikele süsteemidele üleminekut.

Teaduse rahastamise kontekstis, võiks tulevikus analüüsida riike, kus ülikoolide kesksetel tasanditel on tugevamad strateegilise suunamise hoovad, et põhjalikumalt uurida, missugused valitsemise lahendused aitavad adresseerida potentsiaalseid pingeid osakondade ja kesktasandi vahel. Lisaks oleks huvitav uurida pikemas perspektiivis seda, kuidas projektipõhine teaduse rahastamine mõjutab ülikoolide strateegilist juhtimist.

Tulevikus oleks kasulik teha ka võrdlevaid analüüse erinevates riikides ja kontekstides. Oleks huvitav uurida, kas mõju energia ja keskkonnatehnoloogiate tööstuse ja teaduse koostööle ning kaasnevad praktikad järgivad sarnaseid mustreid erinevates teadussüsteemides. Lisaks, kas kohalikud tõlgendused globaalsetest diskursustest on erinevad ning kas ja kuidas mõjud sarnanevad erinevates energia- ja keskkonnatehnoloogiate alamvaldkondades. Rohkem võrdlevaid empiirilisi uuringuid oleks vaja läbi viia ka regionaalsete ja kohalike omavalitsuste rollist. Näiteks, analüüsides nende kompetentse osaleda innovatsioonialastes tegevustes ning strateegilisemalt suunata ja juhtida innovatsiooni kohapõhistes poliitikates, mis võimaldaksid jätkusuutlikele süsteemidele üleminekuid, ning kuidas oleks võimalik ka kohalike omavalitsuste vastavaid TAI kompetentse suurenda.

APPENDIX

Pubication I

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Impact of Climate Discourse on National Scientific Networks in Energy Technologies: The Case of Estonian Science and Industry Linkages

PIRET TÕNURIST, KAIJA VALDMAA, RINGA RAUDLA

Abstract

This article examines how the global climate change discourse influences the implementation of national science policy in the area of energy technology, with a focus on industry and science collaborations and networks. We develop a set of theoretical propositions about how the issues in the global discourse are likely to influence research agendas and networks, the nature of industry-science linkages and the direction of innovation. The plausibility of these propositions is examined, using Estonia as a case study. We find that the global climate discourse has indeed led to the diversification of research agendas and networks, but the shifts in research strategies often tend to be rhetorical and opportunistic. The ambiguity of the global climate change discourse has also facilitated incremental innovation towards energy efficiency and the potentially sub-optimal lock-in of technologies. In sum, the Estonian case illustrates how the introduction of policy narratives from the global climate change discourse to the national level can shape the actual policy practices and also networks of actors in a complex and non-linear fashion, with unintended effects.

Keywords: climate change, environmental technologies, clean technologies, energy technologies, science policy, innovation, policy feedback

1. Introduction

In the scholarly literature on climate change, the discursive construction of problems and the ensuing policy changes have received increasing attention (Dayton 2000; Lorenzoni and Benson 2014; Reusswig 2010). In particular, using the insights from discursive institutionalism (e.g. Schmidt 2008; 2010), it is argued that in order to understand and explain policy change, we have to examine the effects of discourse and the role it plays in bringing about changes (e.g. Lorenzoni and Benson 2014; Hope and Raudla 2012). According to discursive institutionalism (DI), the term "discourse" covers the substantive content of ideas and also the interactive processes in which the ideas are construed and communicated (Schmidt 2008; 2010). While a variety of approaches in social sciences have explored the role of discourse in politics and policy (see, e.g., Leipold and Winkel 2017 for an overview), DI also pays attention to how policy discourses become *institutionalized*. Although the role of discourse in explaining policy change has been examined in many studies by now, there are fewer studies that look at how discourse affects policy *implementation* at different levels of governance (for exceptions,

see, e.g., den Besten et al. 2014). This paper hence seeks to contribute to the DI discussions about how a discourse that has evolved at the global level can influence the implementation of a policy in a specific policy domain at the national level.[1]

In particular, the goal of the article is to analyze the effects of the global climate change discourse on the implementation of national policies. As the solutions to climate change are high-technology-centered (Wesselink et al. 2013), we selected the science policy domain for our analysis (Shackley and Wynne 1995; Demeritt 2006). Within the broader *domain* of science policy, we zoom in on the specific policy *field* of energy technologies, since it is regarded to be the most important sub-field of climate-related technologies (e.g. Kuehr 2007; Ekins 2010). Given that the global climate change discourse entails competing sub-discourses – with one narrative focusing on environmental problem-solving and another being more business-oriented – it would be insightful to examine how these competing approaches influence the actual policy implementation in a specific country. Our paper argues that the introduction of policy narratives from the global climate change discourse to the national level can influence the actual policy practices and also networks of actors in a complex and non-linear fashion, with various unintended effects.

When looking at the effects of the discourse on policy implementation it is important to explore how different aspects of the discourse influence the *networks* of actors involved in the policy domain, since it is the interactions within those networks that can play an important role in influencing the eventual policy outcomes. This is particularly pertinent in the domain of science policy due to the high inter-dependence between industry and R&D facilities. The existing studies that have looked at the effects of the climate change discourse on science policy have primarily focused on climate technology transfer as part of low-carbon, renewable technology diffusion (Karakosta et al. 2010) but have ignored the effects on the dynamics of networks, which encompass a broad range of actors engaged in these climate-related technologies (policy makers, enterprises, research institutes, universities etc.) and are responsible for the actual innovative activities (Taylor 2008). Studies in evolutionary economics (Schmidt et al. 2012) have tried to address parts of this research gap, but the interdependence of R&D goals and the direction of innovation have not received enough attention. Also, these studies have not focused on the role of discourse in shaping the developments. Furthermore, when it comes to energy technologies they are usually studied from a technology-centric approach by innovation scholars (e.g. technology innovation systems, e.g. Gallagher et al. 2012), which does not fit the multi-disciplinary logic of climate-related technologies. Especially regarding clean technologies, multi-disciplinary scientific networks are rarely studied, and more emphasis has been put on company collaborations (Caprotti 2012).

Thus, in this paper we will focus on the dynamics of collaborative scientific networks (in particular industry and science collaboration (ISC) or industry-science linkages (ISL)). In the theoretical part of the paper we will develop a set of propositions about the effects of the global climate change discourse on the implementation of science policy in the field of energy technologies. The plausibility of these propositions will then be examined by looking at the case of Estonia. The case study of Estonia presents an opportunity to explore the effects of the changes in the global policy discourse in a small-country context that, first, had no significant environmental policy prior to the 1990s; and, second, had, until the beginning of the 2000s, a mono-technological energy sector with a very high GHG impact. Thus, it would allow us to

1 "A policy domain" is "a component of the political system that is organized around substantive issues" (Burstein 1991, 328).

trace the effects of the global climate change discourse on local policy implementation in a particularly pure form.

The paper proceeds as follows. In section 2, we identify the main trends in the global climate policy discourse that are relevant for the scientific networks in the field of energy technology and develop a set of propositions about how the discursive elements are likely to affect the implementation of science policy in energy technologies. In section 3, we present the methodology used for the Estonian case study (descriptive network analysis, structured interviews, analysis of documents and projects), followed by the empirical analysis in section 4. Section 5 provides a concluding discussion.

2. Global climate change discourse and shifts in the implementation of national science policy

2.1 Global climate change discourse: relevant aspects for science policy in energy technologies

According to the global climate change discourse, human activities (including the burning of fossil fuels and clearing of forests) have led to the concentration of green-house gases (GHGs) in the atmosphere, which, in turn, is affecting the global climate (for overviews, see, e.g., Dayton 2000; Reusswig 2010). Thus, according to the global discourse, which has become institutionalized in the Kyoto Protocol, governments should take steps to reduce the emission of GHGs. There are, by now, numerous studies which discuss the emergence, institutionalization and impacts of the global climate change discourse (Caprotti 2012; Wittneben et al. 2012). In this paper, we zoom in on those aspects of the global climate change discourse that are likely to affect the implementation of science policy in the field of energy technologies.

A core element of the global climate change discourse is advocating for the development and adoption of more energy- and other resource-efficient technologies that have a reduced or zero effect on the environment. There are, however, several issues with the dominant global climate change discourse that are likely to influence the implementation of science policy in the field of energy technologies.

First, the problem of climate change has been framed as a "global issue", in need of "global solutions" (Miller 2004) and rethinking the whole system (Johnson and Suskewicz 2009). Such discursive constructions, however, have increased ambiguity on the national policy level in terms of the course of actions that should be taken (see Figure 1 for the core elements of the global climate change discourse).

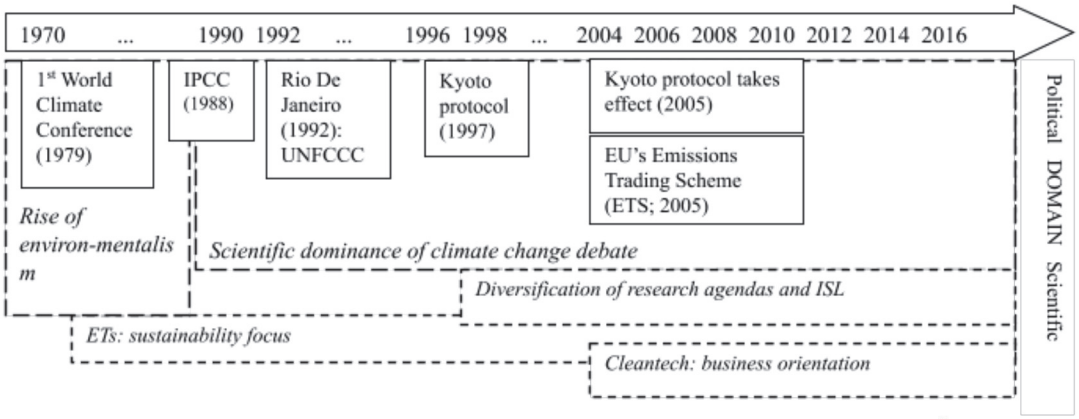

Figure 1: **Climate change: main political agreements and evolution of trends/elements in the global climate change discourse**

Second, one of the main deficiencies in the dominant discourse is the fact that through the Intergovernmental Panel on Climate Change (IPCC) and the Kyoto Protocol it has become a very linear discourse concentrated around science policy (e.g. Pielke 2010; Beck 2011), as opposed to also encompassing technology policy (and interactions between science and technology). The dominant narrative is that since it is scientifically proven that some technologies produce more greenhouse gases that have a clear effect on the climate, if we change the technologies it is possible to reduce the emission of GHGs. In other words, it has been argued that a simple "technical fix" is possible from an objective, value-neutral scientific approach (Wesselink et al. 2013), and too little attention has been paid to various policy goals, political commitment, and allocated means. The various policy goals can encompass more socially oriented objectives, like cleaner environment or equal resources for all (including future generations), or more business-focused goals, like fostering new innovative and clean energy technology sectors for boosting the implementation of basic science, or supporting fossil fuel power plants for the stability of the energy system. All of these policy directions can have either a short- or a long-term focus (depending on the level of political commitment) and can receive direct or indirect financial support, short- or long-term investment security – which all influence science, technology and innovation policy around energy technologies.

Although the time period of this analysis covers 1998 to 2012, a more recent development, the Paris Agreement (UNFCCC 2015) adopted in 2015 under the UNFCCC for tackling climate change beyond 2020, deserves special attention as it is one clear result in the long line of the Conferences of the Parties (COPs) of UNFCCC comparable to the Kyoto protocol and, for example in the context of EU strongly related with the Energy Union priority, making energy more secure, affordable and sustainable for all (European Commission 2017). Even more remarkable is the new EU energy legislative framework – the Clean Energy for All Europeans package – which has been concluded on all aspects, and the updated 8 legislative acts will be formally adopted in the first part of 2019 (European Commission 2019). The main aim of the package is to facilitate the clean energy transition of the 21st century, make a significant step towards the creation of the Energy Union and deliver on the EU's Paris Agreement commitments.

Third, although the global climate change discourse includes clear social goals – at least when it comes to GHG-reduction – it also entails considerable ambiguity with regard to what technologies would fall under climate-related technologies and climate-crisis led innovation (see Figure 2). Specifically, we can encounter terms like "clean", "green" or even "eco" and "sustainable" technologies (e.g. UNCED 1992; OECD 1995; Kuehr 2007). Within the "climate crisis"led innovation debate these terms are sometimes used interchangeably (Kuehr 2007; Carrillo-Hermosilla et al. 2010; Schiederig et al. 2012), while they may actually signify very different technologies, in terms of their nature (high vs low tech), maturity level and investments required. This ambiguity of the global discourse, in turn, is likely to influence the implementation of energy technology policy at the national level.

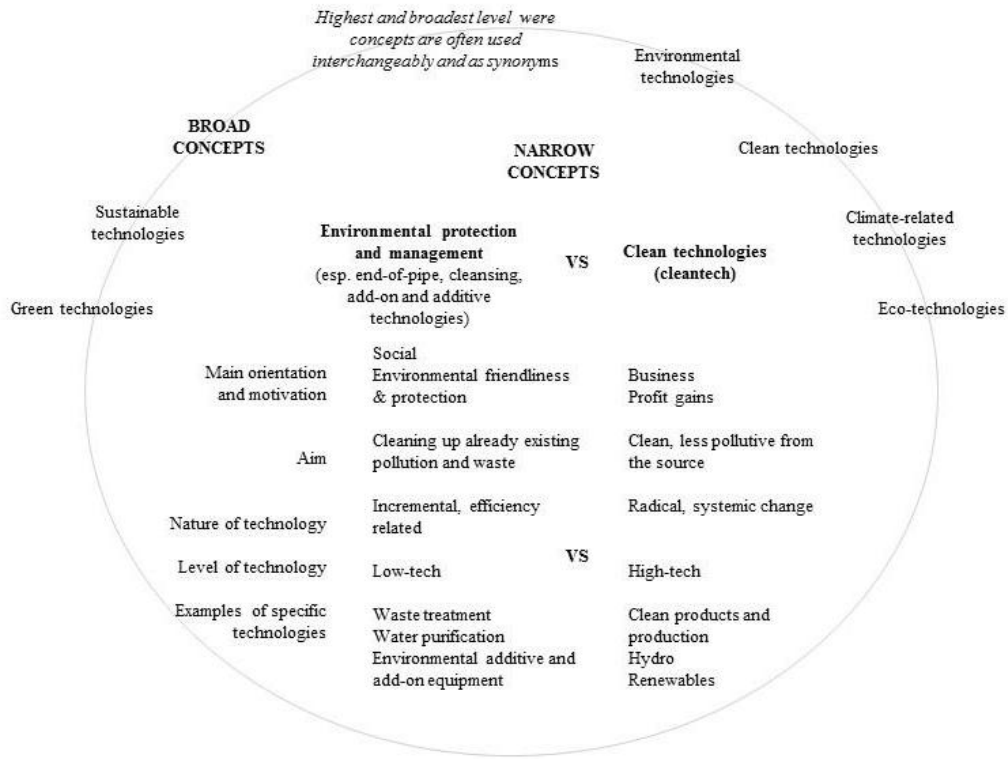

Figure 2: **Links between different concepts of environmental technologies, their level of technological intensiveness, radical and incremental innovation, etc**.

Fourth, the global climate change discourse entails competing sub-discourses: one narrative focuses on environmental problem-solving and another is more business-oriented (Caprotti 2012; Okereke et al. 2012; Kuehr 2007; O'Rourke 2009). These narratives, in turn, have different implications for what kind of innovations should be fostered. Following the environmental problem-solving narrative would mean that the focus should be on social goals and the development of *environmental protection and management technologies* ("environmental protection technologies" from now on) and more precisely *end-of-pipe* type (aimed at cleaning already existing pollution and waste), while the business profit-centered narrative

would favor the focus on technologies that are already clean from their source – *clean technologies* or *cleantech* in short. Due to the ambiguity of terminology pertaining to the different technologies (as explained in the previous paragraph), these different narratives, with their different underlying logics, may not necessarily be explicitly acknowledged in national level policy-making, which may lead to ambiguity in what kind of innovations and research should, in fact, be fostered to combat climate change. However, these different approaches can lead to very different results of innovation, both in terms of cost efficiency and ethical concerns (e.g. equity across generations in terms of available energy resources).

In the existing studies, only limited attention has been paid to how the global climate change discourse would influence the implementation of science policy. Some find that the global climate change-led discourse has not changed the academic world formally to a large degree, maintaining that environmental innovation research is still in its infancy (Andersen 2008, 3), while others argue that the climate-crisis debate has increased the role of so-called sustainability science (Komiyama and Takeuchi 2006), which is more the case in the fields of *environmental protection technologies* rather than *cleantech.* In the following, we will discuss in more detail what the implications of the above-mentioned issues in the global climate change discourse are likely to be for scientific networks/ISL in the field of energy technologies.

2.2 Diversification effects and shifts in research strategies

The ambiguity of the broad terms like "climate-related", "sustainable", "green" or "environmental" technologies (which are used interchangeably as broad synonyms in this article) and not defining specific technologies under these loose areas in the global climate change discourse can lead to the same ambiguity in designing and implementing technology programs at the national level. Specifically, the ambiguity problem of "clean" vs "environmental protection and management" technologies in the global climate discourse (described above) can carry over to the policy field - as technology programs are also usually concentrating on broad areas like "climate-related" technologies. Such a broad approach, however, can become a challenge for the traditionally mission-oriented government policies like science policy (and science funding). The mission-oriented nature of policy means that it sets specific goals and outlines concrete activities to achieve these goals.

More specifically, we can make the following predictions about the effects of the global climate change discourse on the implementation of science policy in energy technologies. Due to the ambiguity in the global climate change discourse about what technologies should be fostered to combat climate change (UNCED 1992; OECD 1995; Kuehr 2007; Ekins 2010), most technological innovations are assumed to lead to higher efficiency and some environmental benefits. In practice this means that researchers usually define their own industry and technology categories to describe the "green" or "clean" sector. We can also observe that fields like ICT, chemistry, and material sciences have moved closer to environmental sustainability with the rise of green chemistry, green ICT, and green material technologies. Our first set of predictions is, hence, that the discursive ambiguity at the global level would lead to the *diversification of research agendas and ISL* at the national level. Due to the multi-disciplinary nature of the technologies under the "umbrella" of climate change, there is likely to be a diversification effect in the research areas of energy technology (Proposition 1.1). This means that a very wide range of research in terms of fields, but also levels (from basic to applied),

can be undertaken under the broad area of climate change and environmental sustainability. The research topics can range from low-tech environmental protection technologies like end-of-pipe and additive technologies to totally pure high-tech clean technologies like hydro technologies. In addition to the diversification of research topics, we would also expect a diversification effect in the collaboration networks and ISL (Proposition 1.2). The diversification effect means that collaboration networks and ISL can have very diverse structures and working logics: basic vs applied, low vs high tech, short- vs long-term, close to the market vs far from the market. What structures and logics are used in specific ISLs (also what business model and direction of innovation is taken) depends on the research areas of ISL (social orientation vs business focus and incremental vs radical innovation direction taken) (see further explanations in sections 2.3 and 2.4).

Second, the global climate change discourse is likely to influence the priorities expressed in the national level science policy – i.e. the funding programs would specifically emphasize that funding is provided for research that helps to mitigate or combat climate change (Bailey et al. 2011; Bailey and Wilson 2009). In the implementation of science policy, in turn, this can lead to the adoption of different strategies by the research groups. On the one hand, we can expect that research groups genuinely change their research agenda and also form new research networks, according to the research funding priorities expressed in national policies, which emphasize the development of technologies that help to combat climate change (Proposition 2.1). On the other hand, we can expect that the existing research groups respond strategically to the funding incentives and try to show, rhetorically, that the research they are doing is connected to climate change (thus, for example, traditional energy research groups would adjust their activities, at least nominally, to show that they are doing research on environmental or clean technologies) (Proposition 2.2).

2.3 New business models and corporate influence: social vs business focus

It is important to differentiate the newest concept that has been used above – "*cleantech*" - from other environmental technologies (focused mainly on environmental protection and ethics) due to its business-model orientation (see Caprotti 2012). Its main idea is that the end result should be qualitatively "cleaner" and more resource efficient, which may not be the case of traditional ETs first popularized in the 1970s and 1980s (Schot 1992). Examples of traditional ETs include environmental protection technologies like end-of-pipe technologies (pollution treatment) (Yarime 2003) or environmental additive equipment[2], which may actually speed up resource depletion (Frondel et al. 2007).

The rapid emergence of the concept of *cleantech* in the US at the beginning of the 2000s can be linked to purposeful activities of a small range of institutional entrepreneurs within the global climate change discourse, promoting a "business model" that pulls together a range of technologies that have both economic and environmental value (Cleantech Group 2007; O'Rourke 2009; Cleantech.org 2015). Since this new sector is multi-disciplinary and relies strongly on networks and different interdependent institutions, it has significant implications for the implementation of science policy.

2 Under environmental additive equipment or environmental additive technology we mean add-on measures and solutions that do not reduce resource use and/or pollution at the source by using cleaner products and production methods (like cleantech does) but instead curbs pollution emissions by implementing add-on measures – this is what end-of-pipe technologies do (Frondel et al. 2007).

Consequently, if we look at the members of ISL and recall the difference in the global discourse about business-oriented cleantech vs socially motivated environmental protection, there may be very different firms taking up "greening" activities (e.g. cleantech vs environmental protection) responding to the climate change discourse, signaling their own interests to policy makers and bringing in specific goals, motivation and technical capabilities to ISL (Kemp and Foxon 2007). This leads us to our third set of propositions, which argue that the nature of ISL can vary considerably, depending on the motivation and nature of the collaborating company (i.e. whether it comes from environmentally motivated "traditional" environmental protection technology or the more recent, business-model-based *cleantech*).

Especially during the last decade, a firm-centric and market-driven approach to value capture has emerged in the global discourse, which is a highly profit-oriented approach ("do well by doing good", Richtel 2007). From the social perspective, it is not important which reasons are behind the adoption of clean technologies in response to climate change (whether they are purely environmental or more profit-oriented); thus, regularly the motivations of firms are not discussed in analyses of eco-innovations (Berkhout 2005). However, from the perspective of potential policy feedback and influence on science policy/direction of R&D (e.g. from the perspective of ISL, the incentives to invest, technologies and time-frames), the different motives (environmental protection vs business orientation) can play a considerable role. On the one hand, ISL with the *cleantech* sector can be expected to be *longer* and more durable due to the more complex, transformative investment into high-tech (Proposition 3.1). On the other hand, an opposite effect could be expected due to the strong *business nature* of *cleantech* ventures – meaning a push for ready-to-market collaboration with research units and, thus, short-term contracts between research units and industry (Proposition 3.2). When the ETs in question within an ISL are additive and efficiency-related (especially in the case of end-of-pipe technologies), collaborations close to the market can be expected because additive (also add-on) technologies are more incremental and do not need as much R&D and innovation as radical *cleantech* (Proposition 3.3) (links between incremental and radical innovation and ET-s are explained in the next section).

2.4 Direction of innovation: incremental vs radical change

The energy sector depends on complex and often very expensive technologies for which it is hard to make adoption decisions before acquiring the technology (Cowan and Daim 2011). It is not characterized by rapid technological change, but is among one of the lowest innovation-intensity sectors in the world (Jamasb and Pollitt 2011), where similar technologies have dominated the sector over a century. This makes the long-term direction of R&D (its transformative nature) more essential than the rate of innovativeness (market adoption, etc.) that is generally analyzed in connection to ETs. The problem with translating radical changes from basic science into workable solutions in a sector with many network barriers is substantial.[3] Yet, due to the "linear" and "value-neutral" technical approach of the global climate change discourse (Wesselink et al. 2013) and the multi-disciplinary nature of ETs, far more attention has been paid to the *rate* of innovation rather than the overall *direction* or the transformative[4] nature of innovation (Johnstone 2005, 21) in the global climate discourse.

3 The multitude of systemic problems of technology diffusion in the energy sector is well described in Negro et al. (2012).

4 Incremental innovation entails step-by-step additive improvements that do not distrupt the underlying system. Radical innovation disrupts the system and thus, in most cases gives it a new technological, organisational or other direction (Garcia and Calantone 2002). The rate of innovation does not refer to incremental or radical change but the level of activity taking place (Popp et al. 2010, 878); it often includes measures such as new products reaching the market, yearly patent volumes or market penetration rates. It would be, however, important to also look at how transformative the underlying technologies are: do they really switch the overall value chain to carbon neutrality or not, do they have the potential to distrupt the status quo (i.e. provide a new direction for the functioning of the energy system)?

However, a distinction between *incremental* and *radical* innovations should be made in assessing the change in the direction of overall innovation produced by the policy momentum related to the global climate discourse. It plays a significant role in discussing ETs in the energy sector, especially when technological solutions for the reduction of carbon emissions are considered. As such, environmental technologies can encompass both product innovations (Ekins 2010) and simply additive (end-of-pipe) and process-integrated technologies (Hemmelskamp 1997). In other words, the innovation can range from more radical cleantech, where new and cleaner or totally clean (from their source) technologies are introduced, to more incremental environmental protection and end-of-pipe technologies, which are add-on or additive technologies that clean up already existing waste and pollution (also called cleansing technologies), but they do not have to be "cleaner" in their essence. Whether science policy is focusing on cleantech or end-of-pipe technologies may have very different effects on the long-term direction of innovation. Thus, for example, end-of-pipe technologies in energy technologies such as the carbon capture and storage (CCS) may be reinforcing lock-into fossil fuels (Unruh and Carrillo-Hermosilla 2006; Markusson 2011). Also, if policy implementation focuses only on incremental innovation and low-ambition end-of-pipe and additive technologies there might be no chance for radically new energy technologies to emerge.

Coming to our last set of propositions, as innovation activities differ depending on the specific conditions of existing competition, market strategy and on the maturity of the technology involved, and most importantly, depending on the nature of technology researched – end-of-pipe technology focused on incremental and cleantech on more radical innovation (Kuehr 2007; Markusson 2011; Hellström 2007) – also different directions of innovation can be expected of ISLs in the *energy sector*. On the one hand, in the implementation of science policy in the field of energy technologies, in cleantech, totally new ISLs might emerge that have a radical direction of innovation (Proposition 4.1). On the other hand, ISLs in traditional cleansing, efficiency-related and additive end-of-pipe energy technologies are likely to have an incremental innovation direction (Proposition 4.2). Radical changes in innovation directions have a higher probability to produce new products and processes that are cleaner in their essence, while incremental changes in direction are likely to contribute to "sailing effects" of traditional energy technologies. The "sailing effect" creates a situation where the threat to the traditional technology of being displaced by new technology triggers investments in the old established technology, increasing its performance (De Liso and Filatrella 2008). This, in turn, can also lead to lock-in of technologies and non-optimal solutions for the energy sector.

The distinction between incremental innovation (end-of-pipe technology focus) and radical innovation (cleantech focus) under the broad range of ETs is important to understand because radical innovation – clean technologies – may require large up-front investments. As such, it should present more lucrative business opportunities, but it would also be much more capital intensive and there would be longer time frames connected to such investments, which can be far from commercialization. Hence, since it is radical in nature, many *cleantech* start-ups are university spin-offs (e.g. van Geenhuizen and Soetanto 2012). This, moreover, means that non-emitting technologies (being also a synonym of clean technologies) have far steeper learning curves (Junginger 2010), and support measures are needed to catch up with the profitability of current technologies (Azar and Sandén 2011).

3. Research methods

In order to examine the effects of the global climate change discourse on the implementation of science policy in the field of technology policy in Estonia - specifically on research topics, collaboration and networks, and ISL - we adopted the research strategy of a case study. Using a case-study approach to explore our research question is appropriate given that it allows us to explore a range of different factors at play in a holistic way and also to take into account the country context (del Río González 2009; Yin 2013). A variety of data sources also helps to describe economic and social relationships between firms and R&D units and the change in the direction of technologies that is central to our research interest. In line with the case-study approach, we used a variety of data sources in our analysis, including existing studies, secondary data, structured interviews, media articles, policy and project documents, and network analysis. Our analysis covers the time period from 1998 to 2012.[5] As more rigorous environmental goals strongly entered the Estonian energy sector with joining the EU in 2004 (Tõnurist 2015), the change in policy paradigm is best captured by the aforementioned timeframes. In addition, as Estonia achieved its renewable energy goal of 2020 (25% in gross final energy consumption) already in 2011 (Eurostat 2019) it created additional academic interest in how the dynamics in the ISL reflect the statistics. For the structured in-depth interviews, the 11 most salient research groups in energy technologies and their collaboration networks with companies in the ETs/clean technology sector in Estonia were chosen. 11 interviews with representatives from energy-technology research groups were conducted from April to May 2013; 4 interviews were carried out with the representatives of the R&D departments in the three main technology universities[6] in Estonia in October 2013; 20 interviews with Estonian cleantech companies were conducted in June and July 2011. The length of the interviews was 1-3 hours. The research groups were selected on the basis of one criterion: they all had received public funding at some point between 1998 and 2012. The interviews included questions about research areas and ISL (including other contacts with companies, such as internship programs, lectures, board membership etc.), the strength of ties, and changes in the strategic behavior and the content of research activities. The network analysis was carried out based on personal and project records of the largest technology-oriented universities in Estonia from 1998 to 2012. A network was created on the basis of all research collaboration: the nodes illustrate individual scientists and firms and the edges R&D projects and contracts between them (see the descriptive Figures A.1-A.5 in the Appendices). This makes the networks bipartite or two-mode as it is important to keep the data about researchers at the individual level, because changes in the composition of research groups are not uncommon. Networks were later weighted for the monetary value and length of contracts to control for the strength of ties. This consolidated the networks and diminished the significance of very small contracts, while the main structure and trends of the network remained. Since the strength of ties and informal communication are difficult to analyze through project data alone, we used the interview data to triangulate the information gathered

5 The empirical data for this analysis was collected under different research projects in 2011 and 2013: 1) the project of "Public funding of research activities in Estonia" under the national Research and Innovation Policy Monitoring Programme initiated by the Estonian Ministry of Education and Research between 2011 and 2015; 2) the Central Baltic INTERREG IV A project "Enabling a Global Vision for the Baltic Clean-tech industry" (Global Vision) from 2011 to 2013.

6 Our study covered the largest technology oriented universities in Estonia – TalTech, Tartu University (TU), the Estonian University of Life Sciences (EULS) – and a separate research institute (National Institute of Chemical Physics and Biophysics). TalTech is the main contributor of energy technologies in Estonia, while in other universities singular RE-centered research units have emerged during the 1990s.

from documents. In the interviews, we found that monetary value was not the best measure to describe collaboration strength as the former was more linked to the size of the private partner. Thus, we relied more on the self-reported information of scientists to determine the strength of relationships. In addition, document analysis was carried out to compose a profile for each research group. The documents included government funded research proposals, project reports, co-publication analysis and career data from the electronic database, the Estonian Science Information System (ESIS). These profiles were created to have a more in-depth view on the strategic activities of research groups and also to account for shifts over time, which is difficult to outline solely through network analysis.

4. The case of climate-change discourse and energy technologies in Estonia

4.1 The Estonian energy policy context

Estonia is the only country in the world where the principal source of electricity (up to 80%) is the burning of oil shale (kukersite) (see Table 1). The country has been the largest oil shale producer and consumer in the world since the 1960s, but it has come with a considerable environmental impact, which was the largest in the 1980s and has declined since (Raukas and Punning 2009; Mõtlep et al. 2010; Blinova et al. 2012). The energy sector is the main source of GHG emissions in Estonia (see Figure 3).

Table 1: **Energy balance sheet in Estonia** (TJ) (Statistics of Estonia, 15 May 2013)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Production of primary energy	132389	131999	140265	162400	154123	160563	155265	180852	175374	172995	205080	208863
... oil shale	108330	106183	111103	132096	124121	129423	125022	146747	142956	134455	161401	166731
... oil peat	3345	3427	6416	3531	2678	3550	4726	4405	2174	3492	3680	3308
... fire wood	20617	22279	22608	26592	27132	27170	25044	29119	29593	34060	38668	36154
... other fuels	76	82	112	113	84	150	150	176	82	169	237	178
... hydro and wind	21	28	26	68	108	270	323	405	569	819	1094	1433

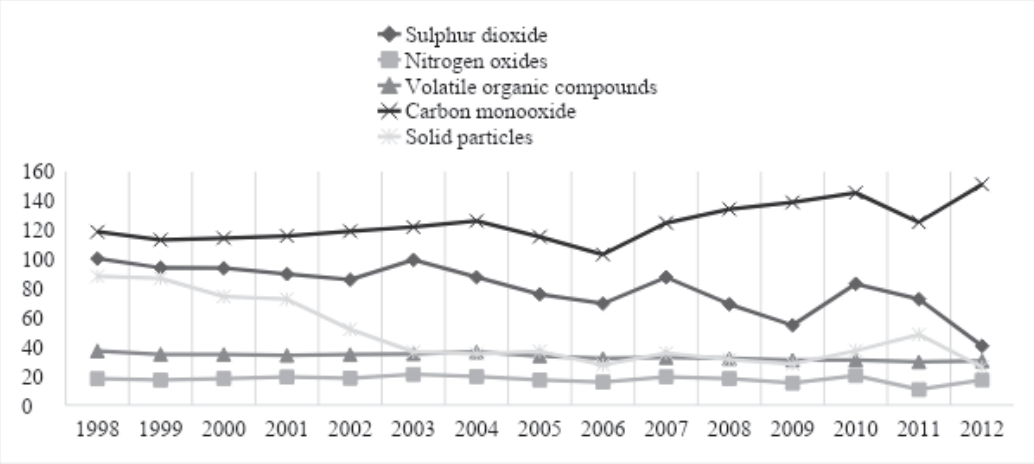

Figure 3: **Air pollution by pollutant from stationary sources** (tons) (Statistics Estonia, 9 March 2019)

On the whole, Estonia has been implementing environmental policies since the late 1980s. Environmental issues entered the policy debate first with the fight against the opening of new mineral mines for heavy industry (e.g. the so-called Phosphorite War, 1987-1988) through which calls for environmental sovereignty developed hand in hand with the general independence struggle of Estonia. This inspired the early adoption of the first environmental protection law in 1990, and environmental pollution levies were established; however, they were not substantial enough to change the energy sector, which was under the control of the government (Valdmaa 2014). In 1995, the country ratified the United Nations Framework Convention on Climate Change (UNFCCC), but legally the year 1998 marked the change in climate policy. As part of the accession process to the EU, the Integrated Pollution and Prevention Control Directive (IPPC) and the EU's clean air policy (Directive 96/62/EEC) were adopted in Estonia in 1998, but the former only took effect later. Also the Kyoto protocol was signed by the country in 1998 and ratified in 2002. However, as indicated in the energy-related policy documents in 1992-2002, the government was mainly concerned with energy security and pricing – rendering environmental concerns secondary. Only with joining the EU in 2004 did the climate change based policy discussion become more prevalent: in April 2004, the National Program of GHG Emission Reduction for 2003-2012 was adopted, and it was the first document that also included the Kyoto target as its main objective. Estonia imposed a CO_2 tax in 2005 and in 2006, and the new Environmental Charges Act was enforced. Feed-in tariffs for RE were introduced based on electricity prices, although at first with low coefficients in the closed market situation (Streimikiene et al. 2007). Several other fiscal measures (including excise duties on fossil fuels) and subsidies were also created by the government after 2004 (an overview of which is available in the Estonia's Fifth National Communication to the UN (Estonian Environmental Research Centre 2009)). While measures aiming at the renewable energy sources diversified, the largest investments in the energy sector remained in oil shale as concerns over energy security prevailed. The government has subsidized heavily the oil shale based electricity production to reduce GHGs: second-generation units with higher efficiency rates have been built, and fluidized bed combustion (CFB) technology (which this expected to minimize environmental pollution) has been implemented (e.g. Dementjeva and Siirde 2010).

The possible future decline in the proportion of oil shale in electricity production could be facilitated by the rise in the use of wind energy, natural gas and biomass (Roos et al. 2012). This would have to be supported by scientific research and public research funding. During the time under review basic research funding measures have been available for the sector; however, there has been a gap in support measures for proof of concept and prototyping in the Estonian R&D system. Thus, the measures have been fragmented in their mission orientation towards climate change, giving more support to high technologies rather than applied innovations needed in the local context.

4.2 Change in ISL in energy technologies

There are approximately 15 considerable research groups in energy technology in Estonia. Our network analysis showed a heavy concentration of influential research groups in energy technologies in TalTech (see Figure A.1 in the Appendix describing the whole network by Eigenvector centrality). The network analysis also showed that the competence regarding the *traditional* energy technologies (oil shale combustion and chemistry) lie with TalTech.

The traditional energy research groups are located in three departments (Faculty of Power Engineering, Chemical and Materials Technology and Mechanical Engineering). In other universities, including Tartu University and EULS, energy technology research groups were not found to be closely linked to the field of traditional energy studies – these research groups were based on strong basic research in *other* fields (material sciences and life sciences) that were found to have *applications* in the field of energy (in Tartu, photovoltaic elements and in EULS, biomass).

Coming to energy technology ISL, there is one general remark that should be made before we examine the propositions. When we look at how the cooperation with the industry and enterprises has generally changed, then based on the network analysis and the content analysis of project reports, we can see that for most traditional energy technology groups their ties with the industry weakened from the 1990s onward, and especially during the period of interest (1998-2012). On the one hand, this is because before the 1990s, the ISL were linked with Soviet Union public enterprises. On the other hand, the research groups needed time to adapt to the new collaboration logics of ETs (described in sections 2.2-2.4), which will be explained below. In the following, we will examine whether the propositions developed in section 2 hold true in the case of Estonia.

First, we can observe a clear diversification effect in terms of research areas (confirming Proposition 1.1) as the central research groups in energy technologies (also in oil shale technologies) have started to include climate change, RE and ETs-related projects in their agenda after the beginning of 2000s, when the multi-disciplinary ETs (discussed in section 2.2) emerged in the climate change discourse (see Figures A.1 and A.2 in the Appendices, which visualize how research groups start to concentrate and traditional fossil fuel based research groups start to integrate RE and ET narratives in their research areas). This is more apparent among research groups that have been more actively involved in industry contracts. This development also reflects the popularization of ETs in the business sector since the beginning of the 2000s, with the increasing initiative of solving environmental problems (but with profit orientation) coming from the companies. Also, the collaboration networks have diversified (confirming Proposition 1.2): for example, the central research groups (also in oil shale technologies) have started to involve more smaller, private companies with short-term contracts, more applied and close-to-the-market projects, in addition to long-term, far-from-the-market projects with a single state-owned energy company, which had previously been the trend.

Though the analysis of research project applications and reports showed clear diversification effects in research topics and networks, the conducted interviews also indicated considerable inertia in research fields and groups (disconfirming Proposition 2.1): even though ETs-related activities received more attention and new funding opportunites compared with the agendas before the 2000s, *no* totally new research groups in areas of "pure" clean technologies as a reaction to funding based on "climate change" emerged. In addition, while many research groups in more traditional energy technology fields perceived a bias in funding towards RE, the interviewed research group leaders emphasized that ISL collaboration projects were led by companies and their restriction-based demand for ETs (see Propositions 3.2 and 3.3), but no significant RE R&D goals or preferences were put in place by funding programs. Instead, the interviews showed that research groups, especially in traditional energy fields (oil shale technology), who incorporated ETs goals to their agenda, did not change their core research

areas (confirming Proposition 2.2). This can be expected from research groups dealing with technologies at the end of their life cycles, and it contributes to paradoxes that stand in the way of fundamental changes in the energy sector.

The analysis of the research project applications and reports from 1998 to 2012 and the dynamics of the topics and group members indicates that during the early part of the covered period, some current core research groups grew out of basic research in material technology, with possible applications in the photovoltaic industry. These groups were the main parties that could be seen as working towards clean energy before the 2000s. However, most RE-related research before 2004 was fundamental in nature, and in terms of ISL, the collaboration between industry and universities was clearly one-dimensional – undertaken with one or few familiar partners and including only traditional, efficiency and some environmental projects. After 2004, however, it changed and became multi-dimensional (see the descriptive Figures A.4-A.5 in the Appendices). As the goals of the Estonian environmental policy and also the national level discourse changed between 1998 and 2004, research projects also started to include more environmental concerns about emission reduction and pollution avoidance. According to project reports and interviews there was new interest from the industry (also oil shale based production facilities) to start collaborations with research groups solely based on ETs (in accordance with Proposition 2.2), confirming that traditional energy research groups changed their activities to include ETs (if not fully clean technologies) to respond to funding incentives.

Another interesting finding is that when we look at the proportions of R&D funding between clean/environmental technologies and traditional fossil fuel focused energy technologies, then the top few research groups now receive proportionally more financing then the rest. This may be largely coming from the bias in the Estonian research funding system, which prefers basic science to applied science and gives preference to high technology. Consequently, research groups that focus on applied research have become weaker and rely on short-term private funding, especially in the energy sector. By concentrating on broad areas and defining no clear specific R&D goals in energy technologies in Estonia, the normative weight was put on the value-neutral scientific endeavor, very much in accordance with the main trends in the global climate change discourse discussed in section 2.

The third set of propositions developed in section 2 argued that the qualitative nature of the emerged networks in scientific collaboration differs depending on the motivations and nature of the collaborating company, which in turn is influenced by the technology at hand (cleantech vs environmental protection and especially end-of-pipe technologies).

According to the interviewed scientists, only the dominant companies in the market (in the Estonian case the state-owned enterprise Eesti Energia and the Viru Chemistry Group) or university spin-off companies were interested in the application of basic science also in the traditional, fossil fuel based fields. However, substantial R&D collaboration in the core areas of the energy companies in general was very rare and occurred mainly in the field of *cleantech* (for example in photovoltaic batteries). To some degree this supports Proposition 3.1 in terms of longer and durable transformative investment in *cleantech* (as explained before, there were only few radical cleantech ISL with some state-owned enterprises and university spin-offs, who had better access to resources and were closer to the universities), but as we had only few cases to describe such long-term relationships, it is not possible to fully confirm Proposition 3.1.

However, as understood by the interviewed scientists, and also found by Valdmaa and Kalvet (2011), most of the companies that have contracts with Estonian research groups want simple environmental impact assessments or solutions that need to be worked out fast and can be easily integrated into the previous technology. The interviewed companies made maximally six months to year-long contracts and wanted immediate results and market applicability or introduction to the production process (supporting Propositions 3.2 and 3.3). Similarly to Proposition 3.1, due to only few cleantech cases, and as the projects were implemented in a very short time (maximum 5-6 years in RE), no clear assessment of Proposition 3.2 can thus be made: the business-oriented *cleantech* approach with strong push for ready-to-market corporations with research units and short-term contracts was not clearly observed. Still, when ISL based on additive projects were concerned, the collaboration took a very short-term, close-to-the-market format, clearly confirming Proposition 3.3.

The interviews additionally showed that while industry giants want to keep themselves informed about the work of Estonian scientists in their related energy area, the companies are not willing to pay for basic research that cannot be implemented in the short term (see additional information about the Estonian energy sector in Tõnurist 2015). Research groups that have been working with and for the industry usually have continued this trend. Only in cases when they have not managed to get public funding have some groups started more active cooperation with the industry. However, this was only the case if they previously also had some contacts with the industry.

Furthermore, in non-traditional energy technology fields, the application of technology remains far from the market due to the dominance of smaller firms in the field and the scale on which the sector requires solutions, not to mention systemic barriers incumbents have put in place. Cleantech firms lack the necessary investment needed to test the R&D on scale. Consequently, local research in areas outside of traditional energy production may remain on a theoretical level, or wider international networks have to be used to popularize or sell the results of this more theoretical research. As such, there were some university spin-offs that contributed to radical cleantech ISL (e.g. photovoltaic technologies and ultracapacitors energy-storing technologies), but they were still an exception to the rule (thus providing only partial support to Proposition 4.1). There was more clear evidence in support of Proposition 4.2: when ISL based on additive projects were concerned, the collaboration took a very short-term, close-to-the-market format, in turn contributing to the "sailing effects" of traditional energy technologies, potentially leading to lock-in of non-optimal solutions for the energy sector, making it more difficult to radically change the energy sector and reduce GHG in a considerable amount. Clearly more cooperation is related to incremental innovation and rudimentary analyses/testing done for the companies. In general, one can expect a direct influence from the structure of the energy sector of the country to the direction of research. Research groups that are mainly dealing with basic research and with more radical innovations are less attractive to the industry because of the long development period, capital intensiveness and high uncertainty (also found by Valdmaa and Kalvet 2011). The summary of whether the theoretical propositions held in the Estonian case are presented in Table 2 below.

Table 2: **Summary of main findings**

Propositions	**Findings**
Prop.1 Diversification effects	
Prop. 1.1 Diversification of research areas	Corroborated
Prop. 1.2 Diversification of ISL	Corroborated
Prop. 2 Shifts in research strategies	
Prop. 2.1 Emergence of new research groups	Not corroborated*
Prop. 2.2 Opportunistic adjustment of research agendas by research groups in traditional energy technology	Corroborated
Prop. 3 Qualitative difference in subsequent collaborative ties between science and industry: social vs business orientation	
Prop. 3.1 *Cleantech* ISL is longer and more durable	Not corroborated*
Prop. 3.2 *Cleantech ISL has a strong business nature and short-term contracts*	Not corroborated*
Prop. 3.3 Incremental ETs projects (efficiency and additive nature) imply projects close to the market	Corroborated
Prop. 4 Direction of innovation: incremental vs radical	
Prop. 4.1 New cleantech ISL has radical innovation direction	Not corroborated*
Prop. 4.2 Efficiency related and additive environmental protection technologies have an incremental innovation direction contributing to "sailing effects" and lock-in of technologies	Corroborated

* More research needed.

5. Discussion and conclusions

The global climate change discourse has influenced policy-making at all levels of governance. However, the impact of the global discourse on national policies, real practices, and the interactions of involved actors has been under-researched. Our paper brings these issues to the forefront and maintains that policy changes based on a broad and high-level global discourse can have unintended and multi-directional effects in the implementation of science policy and, more specifically, in the domain of energy technology. This argument is elaborated through an overview of the main issues within the global climate change discourse and how these issues are likely to influence science and industry collaboration and also the direction of innovation. We argue that while the broad-based policy discourses and policy changes may be easily transferrable from country to country and from sector to

sector (meaning the spread of ETs to different countries and to various technology sectors), they can also accommodate diverging, almost contradictory approaches (e.g. *cleatech* vs *environmental protection and especially end-of-pipe technologies*) due to feedback from different interested parties (researchers, companies, investors, etc.).

In the theoretical framework we explained how the global discourse relates to policy practices and how issues with the discource can influence the implementation of science policy in the domain of energy technologies. Based on a review of the global climate change policy discourse we developed four main groups of propositions connected to the change in the research activities in both firms and research institutes, and we examined the applicability of these propositions in the case of Estonia. The propositions and their applicability have been outlined in Table 2. First, we show that the global climate change discourse has led to the *diversification effect of research agendas and ISL* (corroborating Propositions 1.1 and 1.2). Second, in terms of *shifts in research strategies in response to the global climate change discourse,* we found no evidence of the emergence of totally new groups in cleantech (not confirming Proposition 2.1), while the traditional energy technology research groups have adjusted their research, at least formally, and included the ETs agenda in their research (confirming Proposition 2.2). Third, we expected that the form, quality and motivation of collaboration networks depends on the technology researched: i.e. whether it addresses the socially-oriented environmental protection or the business-focused cleantech part of the global climate change discourse. Based on the Estonian case, however, Proposition 3.1, arguing that cleantech ISL is longer and more durable, and Proposition 3.2, stating that cleantech ISL has a strong business nature and short-term contracts, were not corroborated because of the small number of examples under study. But Proposition 3.3, claiming that environmental protection ISL (efficiency-oriented and additive in nature), have collaborations close to the market was clearly corroborated. Forth, with regard to the *possible direction of innovation – incremental vs radical* – our expectation that cleantech has a radical innovation direction (Proposition 4.1) could not be corroborated due to the limited number of cases under study. However, Proposition 4.2, which emphasized that efficiency-related and additive environmental protection technologies have an incremental innovation direction, contributing to sailing effects and lock-in of technologies and non-optimal solutions for the Estonian local energy sector, was corraborated.

Thus, our analysis shows that when examining the effects of the climate change discourse, it is important to zoom in on the policy implementation level, as well. Even though the national level policy makers have adopted the global climate change discourse in terms of the goal of long-term low-carbon energy production, when we look at the actual implementation of science policy, R&D has not moved hand in hand with the discursive goal. Although the broad global climate discourse has influenced funding decisions in science policy, the impact has not been as profound as expected: value-neutral scientific policy has strengthened some more basic science research groups but also left some more applied groups dependent on industry investment. If more applied research teams are solely dependent on industry contracts, they can function with outside-industrial funding only for a short period, and this is not sustainable regarding the development of the research field. Doing more applied, short-term research hollows out the basic research competences of the group, and in the long run this also reduces the research groups' value to the industry. Successful applied research has to be grounded in profound basic research capabilities – a core competence of universities.

As shown in the case of Estonia, with no clear mission-oriented energy technology financing, the applied research groups and ISL are left to compete within the general science funding system that favors basic research. While this funding system has given precedence to new *cleantech* fields (e.g. photovoltaic and storage technologies), this is not the result of active state policy in the field of energy, and it is very uncertain whether the local GHG-emission output will diminish (the technology can of course be applied elsewhere with global net benefit, but also domestic investment to carbon reduction is essential for reducing GHG). In many cases the willingness of companies to implement R&D becomes the central concern of the actual goals of climate change related policy goals. If companies are not motivated to do R&D and tend to focus more on incremental than radical innovation, there are also limited effects to GHG emission reduction. Here the nature, magnitude, quality and direction of ISL become very important. As investment decisions are not managed centrally, incentives to individual electricity utilities in the market for advancing technologies become more important. Some of these projects may not attract investment from the private sector, and the companies and their collaboration networks with research groups – as shown above – may enforce different dynamics altogether (short-termism, incrementalism, etc.). This indicates that differentiation in terms of policy is needed to capture both short-term solutions (as outphasing of traditional energy technology takes time), but also greater use of renewable, "clean" energy, which is needed for long-term energy security. In order to make a change from oil shale based electricity production towards clean energy, more long-term commitments from policy and funding programs are necessary. Here the correct policy mix becomes the key in addressing many of the problems not only in R&D but also within the industry that take into account the actual effects of the influence of discource in implementation. Hence, the highly scientific/high-technology-oriented and linear understanding has not produced the desired effect in Estonia. Due to the lack of clear and specific R&D funding goals, a radical decrease in GHG emissions has not ensued.

To conclude, our analysis shows the importance of accounting for long-term and multi-directional effects of discursive policy changes and the need for an adequate policy mix depending on the technologies in question and the structure of the economy. The economic structure and the composition, nature and capabilities of the companies in the local industry, as policy feedback mechanisms, may play a significant role in what discourse translates into during implementation.

In future research, more studies are needed to describe the business-model aspect of *cleantech* and its influence on the direction of innovation. Also, it would be useful to undertake comparative studies in order to explore how the global climate change discourse has influenced policy implementation in different countries and to analyze whether the local interpretations of global discourses are different, whether the effects on energy technology ISL and other issues follow similar patterns in different science system, and whether there are also differences in effects in the various sub-fields of energy technologies. Besides, since major restructurings have taken place in all Estonian universities from 2013 onwards, it would also be highly interesting to analyze how these changes have influenced research topics and ISL.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article

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References

Andersen, Maj Munch. 2008. "Eco-Innovation: Towards a Taxonomy and a Theory." In DRUID Conference *Entrepreneurship and Innovation*.

Azar, Christian and Björn A. Sandén. 2011. "The Elusive Quest for Technology-Neutral Policies." *Environmental Innovation and Societal Transitions* 1(1), 135-139.

Bailey, Ian, Andy Gouldson and Peter Newell. 2011. "Ecological Modernisation and the Governance of Carbon: A Critical Analysis." *Antipode* 43(3), 682-703.

Bailey, Ian and Geoff A. Wilson. 2009. "Theorising Transitional Pathways in Response to Climate Change: Technocentrism, Ecocentrism, and the Carbon Economy." *Environment and Planning* 41(10), 2324-2341.

Beck, Silke. 2011. "Moving beyond the Linear Model of Expertise? IPCC and the Test of Adaptation." *Regional Environmental Change* 11(2), 297-306.

Berkhout, Frans. 2005. "Rationales for Adaptation in EU Climate Change Policies." *Climate Policy* 5(3), 377-391.

Blinova, Irina, Liidia Bityukova, Kaja Kasemets, Angela Ivask, Aleksandr Käkinen, Imbi Kurvet, … Anne Kahru. 2012. "Environmental Hazard of Oil Shale Combustion Fly Ash." *Journal of Hazardous Materials* 229, 192-200.

Burstein, Paul. 1991. "Policy Domains: Organization, Culture, and Policy Outcomes." *Annual Review of Sociology* 17(1), 327-350.

Caprotti, Federico. 2012. "The Cultural Economy of Clean-Tech: Environmental Discourse and the Emergence of a New Technology Sector." *Transactions of the Institute of British Geographers* 37(3), 370-385.

Carrillo-Hermosilla, Javier, Pablo del Río and Totti Könnölä. 2010. "Diversity of Eco-Innovations: Reflections from Selected Case Studies." *Journal of Cleaner Production* 18(10), 1073-1083.

Cleantech Group. 2007. "Clean-tech defined." Available at http://www.clean-tech.com/what-is-clean-tech (last accessed 10 June 2011).

Cleantech.org. 2015. "What is Cleantech." Available at http://www.cleantech.org/what-is-cleantech/ (last accessed 23 September 2018).

Cowan, Kelly R. and Tugrul U. Daim. 2011. "Review of Technology Acquisition and Adoption Research in the Energy Sector." *Technology in Society* 33(3), 183-199.

Dayton, B.W. 2000. "Policy Frames, Policy Making and the Global Climate Change Discourse." In Helen Addams and John Proops (eds). *Social Discourse and Environmental Policy: An Application of Q Methodology.* Cheltenham: Edward Elgar Publishing, 1, 71-99.

De Liso, Nicola and Giovanni Filatrella. 2008. "On Technology Competition: A Formal Analysis of the 'Sailing-Ship Effect'." *Economics of Innovation and New Technology* 17(6), 593-610.

del Río González, Pablo. 2009. "The Empirical Analysis of the Determinants for Environmental Technological Change: A Research Agenda." *Ecological Economics* 68(3), 861-878.

Dementjeva, Nadežda and Andres Siirde. 2010. "Analysis of Current Estonian Energy Situation and Adaptability of LEAP Model for Estonian Energy Sector." *Energetika* 56(1), 75-84.

Demeritt, David. 2006. "Science Studies, Climate Change and the Prospects for Constructivist Critique." *Economy and Society* 35(3), 453-479.

den Besten, Jan Willem, Bas Arts and Patrick Verkooijen. 2014. "The Evolution of REDD+: An Analysis of Discursive-Institutional Dynamics." *Environmental Science & Policy* 35, 40-48.

Ekins, Paul. 2010. "Eco-Innovation for Environmental Sustainability: Concepts, Progress and Policies." *International Economics & Economic Policy* 7, 267-290.

Estonian Environmental Research Centre. 2009. Estonia's Fifth National Communication to the UN under the UNFCCC. Available at https://unfccc.int/resource/docs/natc/est_nc5.pdf (last accessed 9 March 2019)

European Commission. 2017. Third Report on the State of the Energy Union. Brussels: European Commission. COM(2017) 688 final.

European Commission. 2019. "Clean Energy for all Europeans." Available at https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans (last accessed 9 March 2019).

Eurostat. 2019. "Share of Renewable Energy in Gross Final Energy Consumption." Available at https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=t2020_31 (last accessed 8 March 2019).

Frondel, Manuel, Jens Horbach and Klaus Rennings. 2007. "End-of-Pipe or Cleaner Production? An Empirical Comparison of Environmental Innovation Decisions across OECD Countries." *Business Strategy and the Environment* 16(8), 571-584.

Gallagher, Kelly Sims, Arnulf Grübler, Laura Kuhl, Gregory Nemet and Charlie Wilson. 2012. "The Energy Technology Innovation System." *Annual Review of Environment and Resources* 37, 137-162.

Garcia, Rosanna and Roger Calantone. 2002. "A Critical Look at Technological Innovation Typology and Innovativeness Terminology: A Literature Review." *Journal of Product Innovation Management* 19(2), 110-132.

Hellström, Tomas. 2007. "Dimensions of Environmentally Sustainable Innovation: The Structure of Eco-Innovation Concepts." *Sustainable Development* 15, 148-159.

Hemmelskamp, Jens. 1997. "Environmental Policy Instruments and their Effects on Innovation." *European Planning Studies* 5(2), 177-194.

Hope, Mat and Ringa Raudla. 2012. "Discursive Institutionalism and Policy Stasis in Simple and Compound Polities: The Cases of Estonian Fiscal Policy and United States Climate Change Policy." *Policy Studies* 33(5), 399-418.

Jamasb, Toorai and Michael G. Pollitt. 2011. "Electricity Sector Liberalisation and Innovation: An Analysis of the UK's Patenting Activities." *Research Policy* 40(2), 309-324.

Johnson, Mark W. and Josh Suskewicz. 2009. "How to Jump-Start the Clean Tech Economy." *Harvard Business Review* 87(11), 52-60.

Johnstone, Nick. 2005. "The Innovation Effects of Environmental Policy Instruments." In Jens Horbach (eds). *Indicator Systems for Sustainable Innovation*. New York: Physica-Verlag, 21-41.

Junginger, Martin. 2010. *Technological Learning in the Energy Sector*: *Lessons for Policy, Industry and Science*. Cheltenham: Edward Elgar Publishing.

Karakosta, Charikleia, Haris Doukas and John Psarras. 2010. "Technology Transfer through Climate Change: Setting a Sustainable Energy Pattern." *Renewable and Sustainable Energy Reviews* 14(6), 1546-1557.

Kemp, René and Tim Foxon. 2007. "Typology of Eco-Innovation." Project Paper: Measuring Eco-Innovation.

Komiyama, Hiroshi and Kazuhiko Takeuchi. 2006. "Sustainability Science: Building a New Discipline." *Sustainable Science* 1, 1-6.

Kuehr, Ruediger. 2007. "Environmental Technologies: From Misleading Interpretations to an Operational Categorisation & Definition." *Journal of Cleaner Production* 15(13), 1316-1320.

Leipold, Sina and Georg Winkel. 2017. "Discursive Agency: (Re-)Conceptualizing Actors and Practices in the Analysis of Discursive Policymaking." *Policy Studies Journal* 45(3), 510-534.

Lorenzoni, Irene and David Benson. 2014. "Radical Institutional Change in Environmental Governance: Explaining the Origins of the UK Climate Change Act 2008 through Discursive and Streams Perspectives." *Global Environmental Change* 29, 10-21.

Markusson, Nils. 2011. "Unpacking the Black Box of Cleaner Technology." *Journal of Cleaner Production* 19(4), 29-302.

Miller, Clark A. 2004. "Climate Science and the Making of a Global Political Order". In Sheila Jasanoff (eds). *States of Knowledge: The Co-Production of Science and the Social Order*. London: Routledge, 46-66.

Mõtlep, Riho, Terje Sild, Erik Puura and Kalle Kirsimäe. 2010. "Composition, Diagenetic Transformation and Alkalinity Potential of Oil Shale Ash Sediments." *Journal of Hazardous Materials*, 184(1), 567-573.

Negro, S.O., Floortje Alkemade and Marko P. Hekkert. 2012. "Why does renewable energy diffuse so slowly? A review of innovation System Problems." *Renewable and Sustainable Energy Reviews* 16(6), 3836-3846.

O'Rourke, Anastasia R. 2009. *The Emergence of Clean-Tech.* PhD dissertation. New Haven: Yale University.

OECD. 1995. *Promoting Cleaner Production in Developing Countries: The Role of Development Co-Operation.* Paris: OECD Publishing.

Okereke, Chukwumerije, Bettina Wittneben and Frances Bowen. 2012. "Climate Change: Challenging Business, Transforming Politics." *Business & Society* 51(1), 7-30.

Pielke, Roger. 2010. "Tales from the Climate-Change Crossroads." *Nature* 464(7287), 352-353.

Pielke, Roger. 2012. "Basic Research as a Political Symbol." *Minerva* 50(3), 339-361.

Popp, David, Richard G. Newell and Adam B. Jaffe. 2010. "Energy, the Environment, and Technological Change." *Handbook of the Economics of Innovation* 2, 873-937.

Raukas, Anto and Jaan-Mati Punning. 2009. "Environmental Problems in the Estonian Oil Shale Industry." *Energy & Environmental Science* 2(7), 723-728.

Reusswig, Fritz. 2010. "The New Climate Change Discourse: A Challenge for Environmental Sociology." In Matthias Gross and Harald Heinrichs (eds.). *Environmental Sociology*. Dordrecht: Springer, 39-57.

Richtel, Matt. 2007. "Start-up Fervor Shifts to Energy in Silicon Valley." *The New York Times* March 14, 2007.

Roos, Inge, Sulev Soosaar, Anna Volkova and Dalia Streimikene. 2012. "Greenhouse Gas Emission Reduction Perspectives in the Baltic States in Frames of EU Energy and Climate Policy." *Renewable and Sustainable Energy Reviews* 16(4), 2133-2146.

Schiederig, Tim, Frank Tietze and Cornelius Herstatt. 2012. "Green Innovation in Technology and Innovation Management: An Exploratory Literature Review." *R&D Management* 42(2), 180-192.

Schmidt, Tobias S., Malte Schneider, Karoline S. Rogge, Martin J.A. Schuetz and Volker H. Hoffmann. 2012. "The Effects of Climate Policy on the Rate and Direction of Innovation: A Survey of the EU ETS and the Electricity Sector." *Environmental Innovation and Societal Transitions* 2, 23-48.

Schmidt, Vivien A. 2008. "Discursive Institutionalism: The Explanatory Power of Ideas and Discourse." *Annual Review of Political Science* 11, 303-326.

Schmidt, Vivien A. 2010. "Taking Ideas and Discourse Seriously: Explaining Change through Discursive Institutionalism as the Fourth 'new Institutionalism'." *European Political Science Review* 2(1), 1-25.

Schot, Johan W. 1992. "Constructive Technology Assessment and Technology Dynamics: The Case of Clean Technologies." *Science, Technology, & Human Values* 17(1), 36-56.

Shackley, Simon and Brian Wynne. 1995. "Global Climate Change: The Mutual Construction of an Emergent Science-Policy Domain." *Science and Public Policy* 22(4), 218-230.

Streimikiene, D., R. Ciegis and D. Grundey. 2007. "Energy Indicators for Sustainable Development in Baltic States." *Renewable and Sustainable Energy Reviews* 11(5), 877-893.

Taylor, Margaret. 2008. "Beyond Technology-Push and Demand-Pull: Lessons from California's Solar Policy." *Energy Economics* 30, 2829-2854.

Tõnurist, Piret. 2015. "The Role of State Owned Enterprises in Innovation Policy Management: A New Approach to Innovation Policy Analysis." *Technovation* 38, 1-14.

UNCED. 1992. *Agenda 21, Rio Declaration No, Rest Principles*. New York: United Nations.

UNFCCC. 2015. Adoption of the Paris Agreement. FCCC/CP/2015/L.9/Rev.1. Paris: UNFCCC.

Unruh, Gregory C. and Javier Carrillo-Hermosilla. 2006. "Globalizing Carbon Lock-in." *Energy Policy* 34(10), 1185-1197.

Valdmaa, Kaija. 2014. "Development of the Environmental Taxes and Charges System in Estonia: International Convergence Mechanisms and Local Factors." *Policy Studies* 35(4), 339-356.

Valdmaa, Kaija and Tarmo Kalvet. 2011. "Emergence of the Clean Technologies Sector in Estonia." In Kaija Valdmaa and Tarmo Kalvet (eds). *Emergence of the Clean Technologies Sector in the Baltic Sea Region*. Tallinn: Tallinn University of Technology, 158-244.

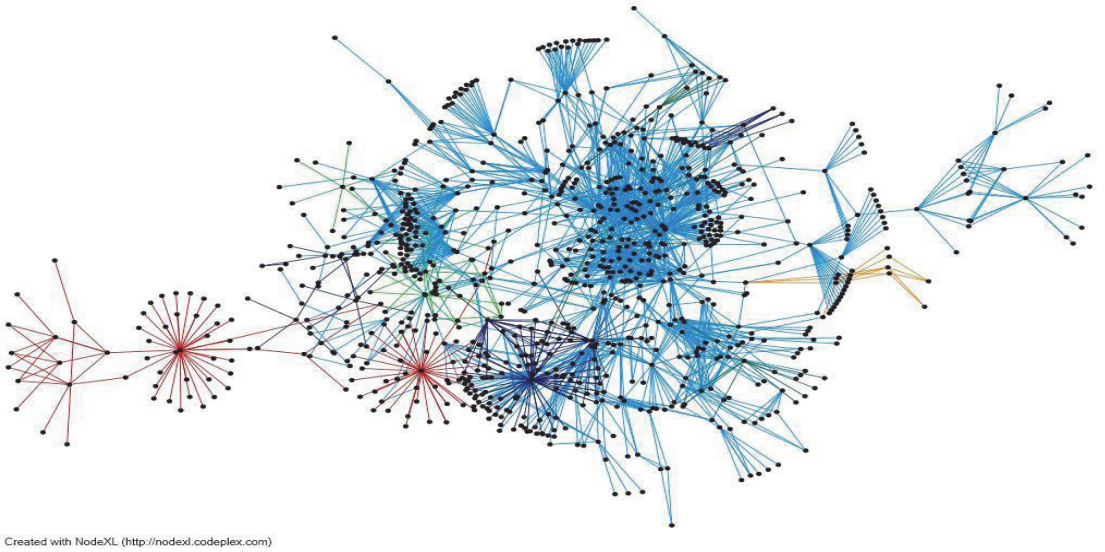
van Geenhuizen, Marina and Danny P. Soetanto. 2012. "Open Innovation among University Spin-off Firms: What is in it for them, and what can Cities do?" *Innovation: The European Journal of Social Science Research* 25(2), 191-207.

Wesselink, Anna, Karen S. Buchanan, P. Yola Georgiadou and Esther Turnhout. 2013. "Technical Knowledge, Discursive Spaces and Politics at the Science: Policy Interface." *Environmental Science & Policy* 30, 1-9.

Wittneben, Bettina B.F., Chukwumerije Okereke, Subhabrata Bobby Banerjee and David L. Levy. 2012. "Climate Change and the Emergence of New Organizational Landscapes." *Organization Studies* 33(11), 1431-1450.

Yarime, Masaru. 2003. *From End-of-Pipe to Clean Technology. Effects of Environmental Regulation on Technological Change in the Chlor-Alkali Industry in Japan and Western Europe.* PhD dissertation. Maastricht: Maastricht University.

Yin, Robert K. 2003. *Case Study Research: Design and Methods*. 3rd edition. Thousand Oaks: Sage Publications.



Appendix Figure A.1: Energy technology network in Estonia 1998-2012 (based on project information)*

Source: Authors, NodeXL.*Within the descriptive figure the edge color denotes the university (blue and green TalTech (an institute joined the university later); dark purple Tartu University; maroon EULS and brown National Institute of Chemical Physics and Biophysics). The size of the vertices is dependent on Eigenfactor centrality, thus making it dependent on the influence of a vertex within the network (see Yu et al. 1965). The figure has been created with the Harel-Koren Fast Multiscale algorithm.

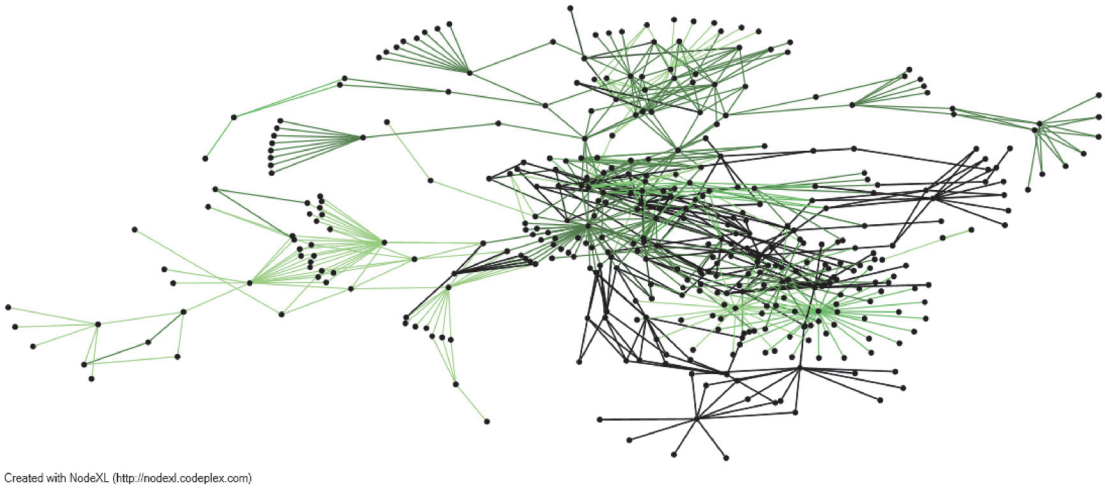


Figure A.2: Energy technology network by type of technology 1997-2004 (public and private funding).

**From here onward the color coding is a spectrum from black to light green that are collated in the following manner: "black" denotes traditional energy technologies (1), sailing technologies (extending traditional projects) (2), efficiency projects (3), environment-centered projects (4) and RE projects "light green" (5). All the figures has been created with the Harel-Koren Fast Multiscale algorithm.

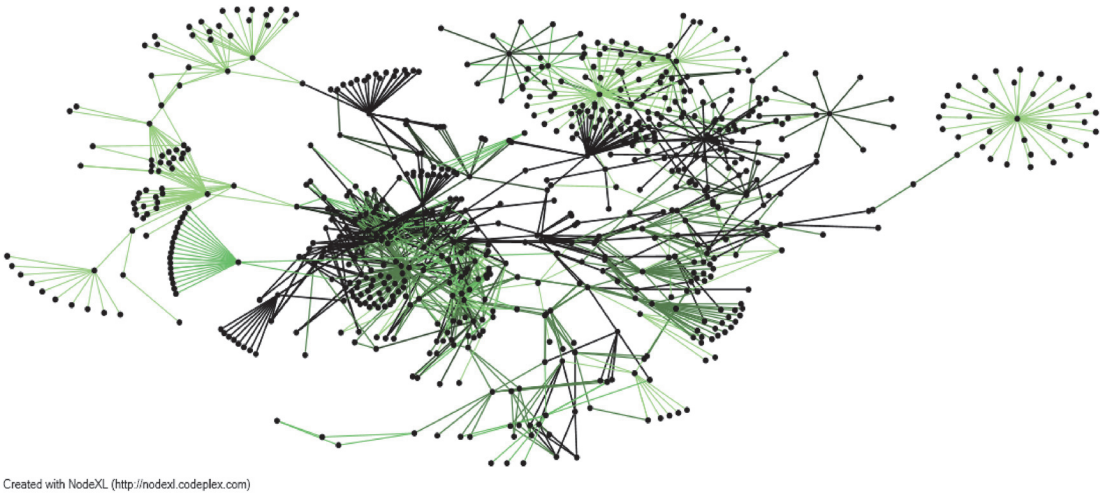


Figure A.3: Energy technology network by type of technology 2005-2012 (public and private funding)

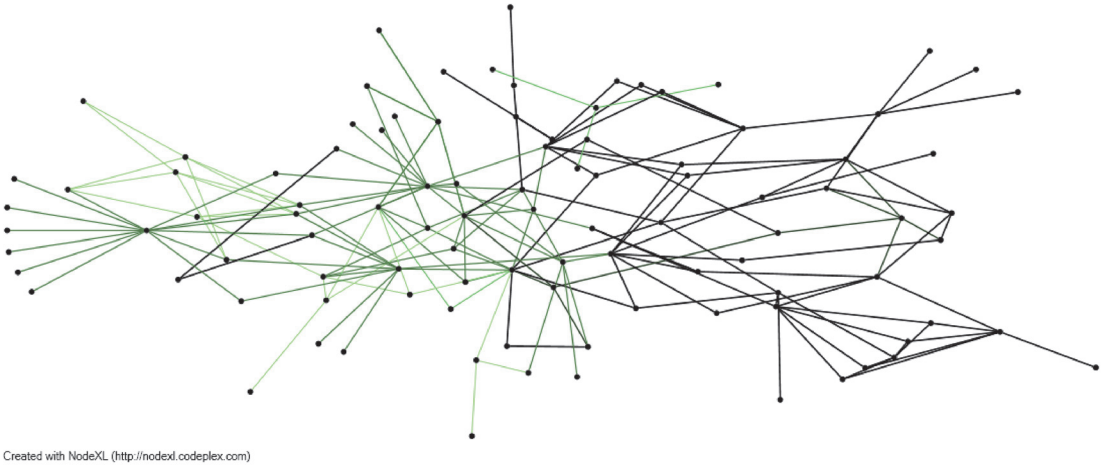


Figure A.4: Energy technology network (contracts with private companies) by type of technology 1998-2004

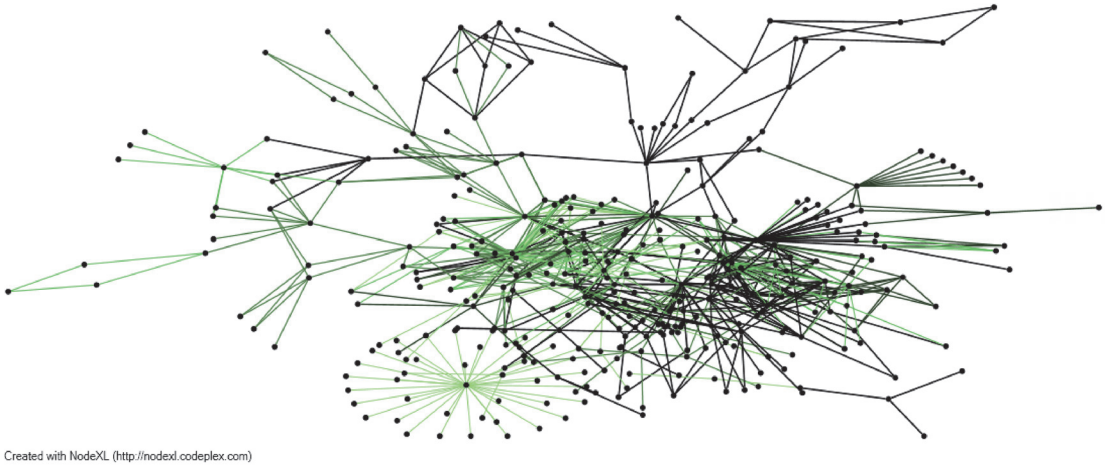


Figure A.5: Energy technology network (contracts with private companies) by type of technology 2005-2012

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Development of the environmental taxes and charges system in Estonia: international convergence mechanisms and local factors

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It is often claimed that the development of new policy areas (e.g. environmental policy, innovation policy) in Central and Eastern European (CEE) countries was initiated and influenced by international events and organizations (e.g. the European Union, International Monetary Fund, and United Nations) in the 1990s when these countries became independent and opened up to the Western world. This article seeks to clarify the importance and role of exogenous and endogenous explanatory factors in the adoption and development of new policy instruments (NPIs). This article proposes an adjusted theoretical framework of convergence mechanisms and a brief systemized overview of local factors to analyze and explain to what extent international factors influenced the development process of new fiscal instruments in practice in CEE countries with the example of the establishment of the environmental taxes and charges system in Estonia. Based on qualitative interviews with Estonian environmental policy experts as well as law and document analysis, this article concludes that the Estonian case study highlights the significance of policy learning, harmonization, and coercive imposition but most apparently, and contrary to common belief, different domestic factors have played a more essential role in shaping the NPIs.

Keywords: international convergence mechanisms; local factors; spread and development of new policy instruments (environmental taxes and charges system); CEE countries

Introduction

Until the end of the twentieth century, 'command and control' instruments (laws, standards, etc.) have been the most popular environmental policy instruments (EPIs), also called the traditional EPIs. The beginning of the twenty-first century brought the rise of more flexible and effective measures, innovative, and new EPIs including also the economic instruments and among them environmental taxes and charges. Together with other new policy instruments (NPIs) they started to attract the attention of policy researchers interested in the spread and convergence of policy goals, principles, and instruments between different countries and regions. Tews, Busch, and Jörgens (2003), Jordan et al. (2003), Busch and Jörgens (2005a, 2005b), and Kern, Jörgens, and Jänicke (2001) have analyzed the spread and diffusion of new EPIs in rich detail. The rapid international implementation of these NPIs generated the interest and necessity to understand the causal factors driving these internationally spreading processes. These

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causal factors are the international convergence mechanisms (co-operative harmonization, coercive imposition, and interdependent but uncoordinated diffusion) of NPIs that will be analyzed in the following in more detail. However, it has to be kept in mind that the complete design of policy instruments is influenced also by the domestic context including culture, history, and institutions (Rose 1991, 21 and in detail Bennett 1991) and the special characteristics of the NPIs (Tews, Busch, and Jörgens 2003).

The goal of this article is to clarify the importance and role of exogenous and endogenous explanatory factors that have influenced the adoption and development of NPIs in Central and Eastern European (CEE) countries with the example of the development of the environmental taxes and charges system in Estonia. The main focus is not only on international convergence mechanisms (as these are believed to play an important role in the CEE countries), but also a short overview of local factors is brought out and analyzed. The second additional aim is to shed light upon and create an integrated approach to the formation process of the environmental taxes and charges system in Estonia with the example of instruments influencing the energy sector. The use of similar instruments in different countries and regions raises several questions, and the developments in Estonia make it possible to analyze these issues in the CEE context. First, how influential are international factors (convergence mechanisms) from the perspective of domestic policy-makers and experts? Second, what kind of domestic features could have also affected the formation of the system? Third, which factors have been the prevalent causes?

The Estonian case is interesting because the local context makes it possible to test the general belief whether international actors and factors (e.g. International Monetary Fund [IMF], United Nations [UN] but more specifically the European Union (EU) and Europeanization) have had an important role in the development of environmental policies in CEE countries because these countries were closed to the West until the beginning of the 1990s and had to build up new independent systems on their own taking more after the West because of their reluctance to the Soviet system. This could mean that international convergence mechanisms can be expected to have played an essential role in the formation of environmental taxes and charges systems in these countries as part of environmental policy. Therefore, the Estonian in-depth context analysis could serve as a typical case study analysis.

On the one hand, it must be stressed that the conclusions from this single-country case study belong to this specific case and cannot necessarily be generalized to other similar cases in all matters. On the other hand, an in-depth case study makes it possible to analyze in more detail the interaction between different explanatory factors and causal mechanisms that affect the developments and outcomes. Therefore, this analysis can also serve as an input to future comparative studies that examine the factors influencing the spread of NPIs in various countries in the environmental area.

In general, the existing literature brings out three broad factors that are considered to play a role in the development, spread and convergence of new EPIs, and also the formation of complex systems (or packages) of policy instruments: international factors or convergence mechanisms (Busch and Jörgens 2005a, 2005b; Jordan et al. 2003; Kern, Jörgens, and Jänicke 2001; Tews, Busch, and Jörgens 2003; Tews 2005), the domestic context (Rose 1991, 21 and in detail Bennett 1991), and the special characteristics of the NPIs (Tews, Busch, and Jörgens 2003). Because of space limitations, the focus is on international and domestic factors. Due to the same reason, and also in order to focus the analysis, only the main environmental taxes and charges related to the energy sector are

under investigation. The energy industry is a useful sector to analyze because on the one hand, it is the largest producer of pollution but on the other, the sector is strongly related to national and international security issues. The climate change discussion, renewable energy, and so on are internationally important topics, and therefore international influence could potentially play a more substantial role in the domestic development of the energy-sector regulations.

To analyze and understand the influence of international and local factors on the development process of the Estonian environmental taxes and charges system qualitative interviews with open-ended questions were conducted among local environmental policy experts (see Appendix 1) using the snowball method. In addition, an analysis of documents (laws, regulations, their explanatory notes, and other documents) was used to supplement the findings of interviews with more factual data. For comparative reasons also descriptive international experience was used based on a brief literature analysis.

This article is organized as follows. The relationship between specific international convergence mechanisms and the development and spread of environmental taxes and charges together with a brief overview of domestic factors influencing the adoption of new policy ideas is examined in Section 2. Section 3 draws upon a historical analysis of the adoption and development trajectories of the environmental taxes and charges system in Estonia focusing on the factors explaining the system's formation. Section 4 discusses the Estonian case in light of the theoretical framework and examines the influence of different factors on the formation process. Section 5 draws conclusions.

Literature review and theoretical framework

Convergence mechanisms

Studies analyzing the international diffusion and convergence of new EPIs can broadly be divided into three types:

- Transfer of environmental policy and innovative instruments in the EU (Jordan et al. 2003), where the focus is on the introduction and implementation dynamics in the EU and the role of policy transfer in this process.
- The relationship between the diffusion of new EPIs, environmental policy change, and convergence, its sources and patterns (Busch and Jörgens 2005a, 2005b; Busch, Jörgens, and Tews 2005), based on the three mechanisms (co-operative harmonization, coercive imposition, and interdependent but uncoordinated diffusion).
- Voluntary diffusion of environmental policy innovations (Kern, Jörgens, and Jänicke 2001; Tews, Busch, and Jörgens 2003; Tews 2005), where states start using certain policies, by learning, emulating, or imitating.

In this study only one new group of EPIs (environmental taxes and charges) is explored; therefore, concentrating on multiple explanatory factors that have shaped the development and spread of the instruments under study is essential to broaden the scope of the analysis. It is important to note that the international factors affecting the spread of NPIs that are explored in this analysis are also the different means of policy diffusion in the broader sense. In addition, they are also the specific convergence mechanisms by Busch and Jörgens (2005a, 2005b), whose approach is taken as the basis for this analysis. According to Knill (2005, 766), the same concepts form the wide approach of policy

diffusion that links the spread of policy ideas between countries with three specific causal factors that drive these developments. These mechanisms consider the impact of different actors (e.g. EU and other interstate and supranational organizations), but they also take into consideration the activities, power, and consequent instruments of these actors in the general spreading and convergence processes. Besides the dynamics of the international system, policy transfer and the scope of convergence are significantly influenced also by the local context and factors from the institutional, social, and historical perspective (see, e.g. Pedersen 2007) that will be analyzed briefly in the following, and also by the specific characteristics of the instruments that are, however, outside the scope of this analysis.[1]

Specific convergence mechanisms

Busch and Jörgens (2005a, 863–867) have developed the following typology of the international causes of new EPIs' convergence including three classes of factors.[2] This is useful to systematize the impact of international processes on domestic policy-making and supporting convergence (Busch and Jörgens 2005a, 862): (1) co-operative harmonization of local practise by means of international legal agreements and supranational law; (2) coercive imposition of political practices through economic, political, and even military threat, intervention, or conditionality; and (3) interdependent but uncoordinated diffusion of practices by means of cross-national imitation, emulation, and learning (see Table 1).

Table 1. The international sources of policy convergence.

Mechanisms	Diffusion	Harmonization	Imposition
Mode of operation	Persuasion, emulation, learning Decentralized decision-making	Negotiation, enforcement and monitoring Centralized and joint decision-making	Coercion, economic or political conditionality Decentralized decision-making
Principal motivations of national policy-makers to adopt external policy models	Search for effective solutions for domestic problems Gain international and external legitimacy	Manage effectively transboundary challenges and at the same time dissatisfaction with solutions to transboundary challenges provided for by unilateral action Avoid negative externalities (e.g. trade distortions) Realize positive gains (e.g. access to new markets)	Export fundamental values and principles as well as policies perceived to be successful Access to economic and political resources (e.g. join international decision-making bodies or gain financial support) Avoid negative consequences (e.g. sanctions)
Degree of influence on design of policy innovation and decision to adopt it	Low →		High

Source: Busch and Jörgens (2005a, 867).

Busch and Jörgens (2005a, 862) have distinguished between the three types according to their mode of operation, primary motivation of policy-makers to adopt policies, and the freedom of action and independence they grant national policy-makers to influence the policy content and to decide on the adoption of policies. Busch and Jörgens (2005a, 866) stress that these mechanisms are three ideal types and their borders are rather blurred in the real world. In addition, Bennett (1991, 230–231) claims that most likely the influence of the three different mechanisms can vary throughout the life cycle of a NPI.

Relationship between the development and spread of environmental taxes and charges and the specific convergence mechanisms: brief international practice

When environmental protection came into the world's agenda in the 1970s, countries also started to look for more flexible and effective instruments that would supplement or even displace the old and rigid 'command and control' measures. Mainly because of the specific characteristics of environmental taxes and charges and the overall reluctance against taxes their implementation was delayed until the end of the 1980s, when the Nordic countries started to experiment with the NPIs. However, Pigou's (1912, 1920 [1932]) theories from 1912 about integrating a tax equal to the cost of pollution (negative externality) into the price were known worldwide.

The rise of economic instruments and consciousness of environmental problems is proved by multiple international agreements[3] that enact the goals for pollution reduction for individual member states, and also the activity of international organizations (e.g. EU, Organization for Economic Co-operation and Development [OECD], and UN) to promote environmental protection and the use of more flexible economic and informational EPIs. Though in many cases, it is just a rhetorical evidence because little is known about the real practices and outcomes that are also much more complicated to analyze. Tews (2005, 67–68) brings out that the global spread of new EPIs and domestic activation in the same field falls into the same period when environmental questions were most considerable in international communication for the first time – the two UN environmental conferences *Human Environment* in Stockholm in 1972 and *Environment and Development* in Rio de Janeiro in 1992. The latter can be seen as more important for the international diffusion of environmental taxes and charges because cost-covering and earmarked user charges were introduced in the 1970s, incentive taxes in the 1980s, fiscal environmental taxes at the beginning of the 1990s, and the overall spreading process of the new EPIs was activated in the middle of the 1990s (European Environmental Agency [EEA] 1996, 21–24; OECD 1999, 11–12; see Figure 1). Although, as Baumol and Oates (1989) conclude, the demand for environmental taxes was felt even in the 1970s, but the previous developments confirm that being aware of environmental problems and also knowing effective solutions is not enough. The Scandinavian, and a bit later also the Western European, practice with adopting energy taxes shows that a sufficiently high economic level of development is also a necessary prerequisite. On the other hand, the implementation of environmental taxes and charges might also be motivated by the need for environmental investments and additional revenues for the state budget. This is the case in the CEE countries because these countries needed resources to manage environmental problems and build up the new independent system.

The first group of instruments (cost-covering user charges) were introduced in a few countries in the 1970s with the aim to cover the administrative costs of regulative instruments (EEA 1996, 21, Figure 1). In addition, the need to manage environmental

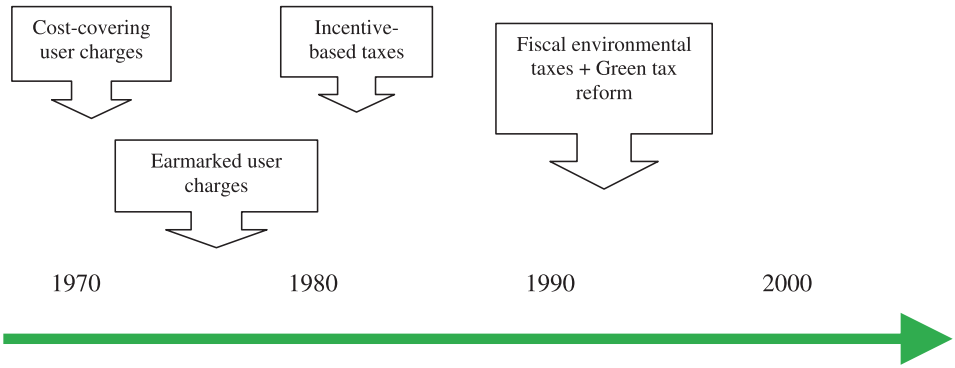

Figure 1. A general illustration of the chronological development of environmental taxes.

exploitation and fund environmental projects (due to huge domestic environmental problems) could also have been essential incentives. Besides, the evolving literature about the efficiency of pollution taxes also strengthened its position in international discussions. However, the activity of international organizations in the field is not apparent during this period because there are no analyses or comparative publications available. For example, the first OECD overview about economic instruments in member states' environmental policy was established in 1989 (OECD 1989). We can assume that the adoption of these new EPIs was related to the emerged necessity to manage environmental problems more effectively and cover the costs of administrating the field. Inventing compensation mechanisms that would motivate polluters to contaminate the environment less and improve their technology is more characteristic of the incentive-based taxes introduced in the 1980s. According to Busch and Jörgens's three-fold typology of NPIs' international causes of convergence, the development and spread of the new EPIs under study would be related to voluntary diffusion because no concrete political or economic obligation is apparent on the international level. More likely it is the case of general consciousness of domestic needs and later learning and imitating other countries' practices.

The adoption of incentive-based consumer taxes and fiscal environmental taxes during the change of the 1980s and 1990s and the wider diffusion during the 1990s and 2000s can be more clearly related to the awareness and understanding of common transboundary problems with environmental pollution. Countries started to look for unified international alternatives to solve the problems related with regulatory competition (Dunoff 2007, 91–94). The progression in adopting fiscal environmental taxes could be linked with the spread of environmental tax reforms at the beginning of the 1990s with the aim to increase environmental taxes in order to decrease other taxes, for example, labour taxes (European Commission [EC] 2005, 74). Holzinger, Knill, and Sommerer (2008, 583–584) explain that environmental policies move toward stricter regulations and standards and become more similar (this is steered by leading countries in the field), and convergence is mainly influenced by international harmonization of policies (e.g. EU) and communication and interaction networks between countries. This is the case with EU energy taxes and their coerciveness to member states without much freedom to influence the design and implementation of the instruments. The adoption of energy taxation requirements among EU member states is, therefore, a good example of Busch and Jörgens's (2005a) mechanisms of harmonization and coercive imposition. We can assume

that the more a country is obliged to and dependent on an organization, union, and so on, in which it is a member, the more binding are the mechanisms of convergence and the outcomes therefore more homogenized. EU directives are comprehensive to all member states, but different convergence mechanisms are apparent in adopting the same instruments across old and new member states: in the case of old states, which have taken part in the elaboration of the directive, legal harmonization is evident because these countries were involved in the design of the EU policies; in the case of new member states that joined in 2004 and 2007, coercive imposition is apparent because they did not have any opportunities to affect the policy-making process. In this way, the autonomy of local policy-makers to adopt NPIs is strictly constrained although the EU also considered the individual situation of the new member states in the adoption time schedule.

Domestic factors influencing the adoption of NPIs

The national context and culture can be expected to play a very essential role in the adoption of NPIs. It is definitely easier to harmonize similar goals and policies already in place. Communication networks play the same essential role and make it possible to spread best practices and learn from the experience of others in a continuous dialog. Tews, Busch, and Jörgens (2003, 575) argue that specific national capacities are needed to adopt innovative EPIs. The demand for and feasibility of NPIs is influenced by the political, economic, societal, and institutional capacities of any particular country (Kern, Jörgens, and Jänicke 2001, 8). In addition, Botcheva and Martin (2001, 13) argue that cross-national variations in the existence, organization, and opportunities for access of domestic pressure groups may affect the impact of so-called 'international aspirational institutions.' Tews, Busch, and Jörgens (2003, 575) claim that those aspirational institutions matter only in countries where well-organized interest groups and adequate opportunities for access exist because these groups may use international norms to put pressure on their governments for policy change.

The national capacities are especially related to the legacy of past policies, administrative traditions, regulatory structures, and policy styles. The emphasis on 'administrative fit' or the 'logic of appropriateness' (March and Olsen 1989) is based on the general assumption 'that institutionally grown structures and routines prevent easy adaptation to exogenous pressure' (Knill and Lenschow 1998, 2). Hoberg (2001, 127) and Jordan (2001, 20) see these issues even as forces promoting divergence. Kern, Jörgens, and Jänicke (2001) argue that national institutional arrangements serve as filters to the adoption of NPIs – they may prevent or even delay the adoption of path-deviant policies, but mainly they will be responsible for variations in the degree of convergence, affecting policy similarities in policy ideas and approaches, the utilization of particular policy instruments, or the qualitative level of regulation (Tews, Busch, and Jörgens 2003, 576). Therefore, a global convergence of policies will never exclude divergent national adaptations (Tews, Busch, and Jörgens 2003, 576) or, as Rose (1991, 21) claims, 'we would never expect a program to transfer from one government to another without history, culture and institutions being taken into account.'

Tews, Busch, and Jörgens (2003, 576) come to the conclusion that domestic factors play a significant role in policy adoption (more in the early stage of the diffusion process but also at a later stage, or they might even be resisted altogether), but the influence may differ for each policy adoption during the whole process as domestic factors may be

overshadowed by international dynamics of the norms themselves. Also domestic factors help to explain national variations in the design of NPIs.

The development of the environmental taxes and charges system in Estonia from the end of the 1980s

Based on the interviews with environmental experts (see Appendix 1) and document analysis, specific explanatory factors that have influenced the adoption and development of the Estonian environmental taxes and charges system and taxes and charges related to the energy sector in particular,[4] are brought out and analyzed in a historical sequence. The analysis is divided between environmental charges and taxes because their aims, implementations, and causal factors in their development have been different. The periodization is based on the main turning points in the development trajectories.

Environmental charges

The end of the 1980s and the 1990s

The initial version of Estonia's environmental charges system was developed during 1989–1990 as the first attempt to regulate the use of state-owned natural resources and also to economically influence contaminative activities and more sustainable use of natural resources. The initiators were deputy minister Endel Koljat and later the next deputy minister Eva Kraav (interviews A, B, and I). The idea was also supported by the Estonian Soviet Socialist Republic Committee of Forest Economy and Nature Protection. In addition, high public awareness of environmental problems and willingness to deal with these issues in Estonia was also proven by the existence of the Nature Protection Fund established in 1984, which probably was the first of its kind in the Soviet Union (SU). Some charges in the form of fines were also used in Soviet Estonia to protect the sea from pollution (interviews F, G, and H).

During the change from the 1980s to the 1990s, old EU countries did not pay much attention to environmental charges (interviews A, E, and I). They were more focused on taxes for increasing state budgets. Also the OECD's interest and support for charges was weak. For Estonia, still the most decisive example was the environmental charges system developed and implemented in Western Germany, about which the Finnish researcher Markku Wallin wrote a relevant and substantial brochure that was used in Estonia (interview A). In addition, the theory of regulative taxes by Arthur Pigou was known and taken into account.

During the period when Estonia became independent nature protection became very popular because it enabled active people to converge and express their antipathy toward the prevailing system (e.g. the phosphorite war[5]). Regardless of the rhetoric, the practice showed that there were still enormous problems with pollution from industries (the oil shale electricity production, cement and paper production, etc.), army bases, agriculture, and problems with water and sewage systems just to name the main fields (interviews D and E).

Differently from environmental taxes used in the West, the aim of introducing environmental charges was understandably to generate resources for financing environmental protection projects[6] and to fight against environmental problems in the independent Republic of Estonia (all interviewees). The instrument was also attractive to politicians as the young independent state needed resources for building up the system. Though environmental

protection projects in the 1990s were quite often funded by neighboring countries like Finland and Sweden, there was still a need for national cofinancing that was taken from the gathered charges (interviews E and F). The need for environmental accounting and monitoring can be seen as an additional cause and aim of developing the system (interviews D and J).

On the one hand, another favourable condition was that local polluting companies and users of natural resources were weak and had no unions (interview I). On the other hand, the economic situation did not allow introducing high rates, and the interest of entrepreneurs had to be taken into account. The dialog was between the green movement and researchers on one side and the entrepreneurs on the other. All necessary interest group opinions had to be considered, the elaboration and development of the environmental charges system evolved hand in hand with entrepreneurs (interview I). The aim was not to raise the electricity price rapidly and harm competitiveness. The government tried to consider the interests of companies because too high charge rates would have decreased economic growth and, therefore, initially the rates were planned to be very low.

The 2000s and the turning point in 2005

In the 2000s, besides the examples and practices of neighbor countries and the environmental leaders in the EU, also the OECD's support and suggestions in spreading the positive experience and best practices in using economic instruments in environmental policy were held relevant in the development of Estonia's environmental taxes and charges system (interview I). However, in the Estonian context the importance of other countries' best practices should not be overestimated because clear transfer of policies cannot be detected (interviews A, E, F, I, and J). In addition, as other countries were behind in the use of environmental charges there was not much to take over (interview A). Another international factor that has affected the development of environmental charges is related to the fact that Estonia is a member of different international agreements[7] with which it has taken voluntary obligations to decrease pollution and meet the set criteria. In many cases, the use of charges to meet these requirements has been regarded as most rational (interviews D and E).

The turning point in the development of environmental charge rates came in 2005 when the Ministry of Environment and the Ministry of Finance were governed by the same party (interviews E and I). This situation made it possible to increase the tax rates significantly in 2006 to a sufficient rate. The former developments clearly show the advantages of a small state: faster and easier discussions and agreements, and designing and implementation of new ideas and solutions.

Joining the EU affected the development of environmental charges in Estonia in four ways. First, obligations had to be fulfilled and the areas that got a transition period needed investments (interview E). Though the EU does not prescribe what kind of instruments member states have to use, it still imposes requirements, standards, rates, and levels that have to be met by member states. The states can choose by themselves which mechanisms they use to obtain the overall goals. Economic instruments (charges in particular) seemed most tempting and also rational because of the huge investments needed to meet the expected levels. Second, but linked to the first, because of the increasing need for investments after joining the EU, the function of environmental charges was also to use the collected revenue for the national co-financing that was

needed to get funding for environmental protection projects from the EU Social Cohesion Fund (interview E). Third, information flows between member states made it possible to learn from the experience of others in the context of rates and bases of charges. Estonia took after and cooperated with Germany, Denmark, the Czech Republic, France, Latvia, and Lithuania (interviews A, B, and I). Fourth, stricter and more complicated regulations and requirements make it hard for states to use only pure 'command and control' instruments (interview E). This pushes for more flexible and 'softer' measures to influence behavior. Therefore, though the EU does not interfere with the member states' tax systems, it still influences them by setting standards and with a uniform legal system, and in the case of new member states also with the allocation of financial support.

The analysis of how the law of environmental charges has developed since 1990 shows that the general principles of environmental charges have stayed quite the same.[8] However, during this period the names and rates of the environmental charges have changed, the exceptions to the oil shale power sector have decreased and, as the biggest effort, the voluminous 'Environmental charges law' was published and came into force in 2005. After the implementation of the unified Environmental charges law, changes have encompassed charge rates (the EU affiliation treaty enacts transition periods in environmental protection) and provisions of calculating and paying the charges due to day-to-day necessities.[9] To sum up we can say that the general system of environmental charges was in place from the beginning of the 1990s, and the main changes have affected the charge rates and organizing the legislation.

Energy taxes

The fuel and electricity excise duty have not been acknowledged as environmental taxes in Estonia, although the EC, the OECD, and the International Environmental Agency regard them as such (EC 2005, 77; interviews C and K). Differently from environmental charges the revenue from the excise taxes goes to the general budget according to the 'Alcohol, tobacco, fuel and electricity excise duty law' and their main aim is to accumulate revenues for the state budget. In Estonia, all excise duties are organized and managed under the Ministry of Finance.[10]

The end of the 1980s and the 1990s

At the end of the 1980s the discussion on environmental taxes was on the agenda of almost all developed countries, though it differed in scale and scope. It was also on the agenda of the SU with leading professors Goffman and Lemeshev (interview A). In Estonia, the fuel excise duty was established in 1993 with the implementation of the 'Motor fuel excise duty law,' which in the following years changed to the 'Fuel excise duty law.' The fuel excise duty was introduced to get resources for road construction (interviews E and K). Because the tax is a very common tax for covering state expenditure its introduction and development has not attracted so much interest and created so much dispute as environmental charges.

The 2000s and the accession to the EU

After joining the EU, all energy taxes moved under the control of the EU energy taxation requirements (excise duties are regulated under the EC Council Directive 92/12/EEC, and

energy taxation is regulated under the EC Council Directive 2003/96/EC[11]). Therefore, local policy-makers and interest groups had no real power in designing the instruments (interviews B, C, G, I, J, and K). From the EC's proposal in 1992, the EU has strived toward the harmonization of energy taxes (Tews, Busch, and Jörgens 2003, 586). This has culminated in the establishment of the energy taxation directive with the aim to restructure the community framework for the taxation of energy products and electricity to decrease competition distortion, which comes from taxing energy products with different rates between different energy products and across different countries (EC 2005, 74). The establishment of the energy excise duty in Estonia in 2008 was directly motivated by the EU directives. First, the revenue from the energy tax was supposed to go to the Environmental Investment Centre (like the previous CO_2 charge which was replaced by the electricity duty and was used for environmental protection), but quite soon it was channeled directly to the state budget for political reasons, for example, to balance the budget (interview K).

In 2002, the 'Fuel excise duty law' was united with the 'Alcohol, tobacco, fuel and electricity excise duty law.' In general, the changes have affected tax rates, tax bases, and also the administrative system and legal framework. The electricity excise duty was established at the beginning of 2008 with the Council Directive 2003/96/EC that also initiated changes in the related laws. To prevent double taxation, electricity producers started to pay electricity excise duty equal to the previously paid CO_2 tax. Though Estonia got a transition period in the field of energy taxation to slowly establish the minimum rates, the fuel and electricity duties are still directly related to the EU directives and, therefore, the Estonian policy-makers do not obtain the common autonomy in deciding over the development of the instruments.

The EU has enacted the 'polluter pays' principle and environmental responsibility, but in general it does not oblige member states to implement certain environmental taxes or charges. Except in the context of excise duties, they are needed for the uniform regulation of the (energy) market. On the one hand, taxation is a completely domestic issue where the EU does not interfere. On the other hand, regarding the Common Market the EU is interested in harmonizing consumption taxes (including also fuel and electricity duties) with the aim of providing equal competition. Considering that energy taxes account for the highest share among environmental taxes and charges it is quite understandable why the EU pursues the harmonization of minimum rates. The harmonization of other environmental taxes and especially charges is more complicated because countries face different environmental problems, for example, oil shale in Estonia, nuclear energy in Sweden; the Scandinavian countries do not have the same problems with waste water as Eastern Europe, and so on. Besides, countries differ in their ability to meet payments, which is an additional reason why the implementation of uniform pollutants, activities, and rates would not be reasonable or rational.

Discussion

In general, the study shows that the initial development of environmental taxes and charges in Estonia was most affected by domestic factors: accumulating revenue for the state budget in the case of excise duties and accumulating revenue for managing environmental problems and more idealistically an aspiration to obtain the right level of charge rates that would support environmental protection in the case of environmental charges. The best practices of Nordic countries, Germany, and others have been important

but secondary. On the one hand, during the establishment of the Republic of Estonia many experts came to get acquainted with the Estonian taxes and charges system, and international support was offered (OECD, IMF). Also Estonian experts went to analyze foreign systems abroad to adopt best practices. On the other hand, the new state needed revenues to the state budget. Environmental protection was also very popular during the regime change because it made it possible to stand against the Soviet system. The influence of local environmental pressure groups has been relevant. Therefore, political factors should not be underestimated. The previous is in accordance with the literature on the importance of national factors and 'administrative fit' in the explanation of the adoption, rejection, and frequent national variations of NPIs (Tews, Busch, and Jörgens 2003; Rose 1991; Knill and Lenschow 1998; March and Olsen 1989; Hoberg 2001; Jordan 2001; Kern, Jörgens, and Jänicke 2001).

Similarly to the Nordic countries, where the implementation of economic instruments has been a natural development, in Estonia environmental charges have emerged quite naturally. The implementation process has directly been influenced by domestic environmental problems (e.g. air and water pollution) and political factors (e.g. path dependency – past practices with similar instruments). However, policy-makers were also aware of the rising popularity of economic instruments on the international level. This is in line with international practices of the adoption of the first charges with the aim to cover the cost of environmental pollution and regulative instruments (EEA 1996, 21). Although environmental pressures were strong, no direct obligation from other states, international associations, or organizations was apparent. The EU has only indirectly influenced the increase of charge rates and objects after the EU accession. The EU sets the standards, but the member state decides which measures to adopt to achieve the goal – environmental charges are not obliged by the EU.

To sum up, it can be argued that in the case of Estonia the developments with environmental charges are more related to the diffusion of ideas and the adjustment of concrete measures into the local system and context. In Busch and Jörgens's (2005a) terms, the development and implementation of these NPIs can be related to voluntary diffusion, although direct policy transfer could not be witnessed. To a certain extent West Germany and Scandinavian countries were taken as an example, but a similar system based mainly on charges does not exist there to date. These problems that are solved with charges in Estonia are solved in the EU with command and control mechanisms – with EU requirements. In that sense Estonia can even be seen as a leader country in using environmental charges.

In the case of energy taxes, due to the influence of the EU, we can distinguish between two periods: before and after the EU accession – before the main influencing factors were domestic needs and problems detected in everyday life, and after the EU accession, meeting the obligations and requirements of the EU has shaped the design (rates and objects) of the taxes. In general, energy excise duties have dominated in the EU because they provide high tax revenue for state budgets.

As in international practice the adoption of the fuel excise duty in 1993 contributed to voluntary diffusion of NPIs because similarly to environmental charges the other two convergence mechanisms (co-operative harmonization or coercive imposition) by Busch and Jörgens (2005a) cannot be identified. Still the same NPI was already used in, for example, Scandinavian countries. The main reason for the introduction of this measure came from the need to get additional revenue into the state budget and fund road construction. Besides the spread of ideas also the transfer of concrete measures from more

experienced countries can be assumed because the idea and operation of fuel excise duty are internationally quite similar.

Since becoming an EU candidate, co-operative harmonization has taken the leading role, and in the case of the electricity excise duty, coercive imposition dominates the developments because Estonia has not been enabled to affect the design of these policies, which have been implemented in a binding form – local policy-makers did not have the usual autonomy in taking over the corresponding EU policies. Similarly to the international practice, Estonia (belonging to the EU) has to take into consideration coercive directives. Particularly the Estonian fuel and electricity excise duty was influenced by the Council Directive of EU 2003/96/EC energy taxation directive that rearranged the community's framework in the field of energy products and electricity taxation. Although Estonia joined the EU voluntarily, the EU has authority over the member states based on directives and regulations and offers economic and political incentives in return.

Conclusions

Nowadays it is impossible to ignore the growing impact of international actors, processes, and institutions on domestic policy formation and change due to the impact of globalization, expanding collective (environmental) problems, and the need for uniform regulation in solving these problems. The spread and convergence of new EPIs cannot only be explained by the countries' independent but same reaction to similar emerging environmental problems or the flaws of traditional ('command and control') instruments. However, it is a fact that in reality there are no exactly unique contexts and that is why transferred ideas cannot bring along exactly the same results. Therefore, there is a need to better understand the interactions between certain ideas and certain contexts; it is necessary to analyze the role of international convergence mechanisms and domestic factors in the adoption and spread of NPIs. However, the final formation of the system is also influenced by the special characteristics of the NPIs.

These tendencies can be linked to the general discussion about policy convergence and divergence in the European countries: whether closer interaction and communication have influenced countries to adopt similar policies and practices or have closer relations revealed systemic differences in policy rhetoric and outcomes between related jurisdictions. The main aim of this article was to clarify the importance of international convergence mechanisms of NPIs (uncoordinated diffusion, co-operative harmonization, and coercive imposition) and domestic factors in the adoption and development of the environmental taxes and charges system in Estonia. The second but not less essential aim was to shed light upon the formation process of the environmental taxes and charges system in Estonia with the example of instruments influencing the energy sector.

The article explored the impact of convergence mechanisms and local factors on the adoption and development of environmental taxes and charges as one group of new EPIs. For comparative reasons, a short analytical overview of the relationship between the spread and formation of the same instruments and specific convergence mechanisms in international practices was brought forth. In the empirical part, the exogenous and endogenous explanatory factors influencing the formation of environmental taxes and charges in the Estonian energy sector are identified through qualitative interviews with environmental policy experts and law and document analysis. This article not only

focused on estimating the importance of international causes but also the importance of local factors in adopting NPIs and shaping the environmental charges and taxes system.

The Estonian case analysis revealed that similarly to general international trends the most evident convergence mechanism of the three influencing the formation of environmental charges is interdependent but uncoordinated diffusion. The adoption of the instruments took place under intense political and environmental pressures and was possible mainly because of the suitability of the political and social situation and domestic problems of that time. Therefore, domestic factors are considered to be more important in the initial development of the instruments. Learning from the other countries and the activity of the international organizations was second-rate. Drawing on the previous statements, the Estonian case study shows that the initiatives to start dealing with environmental policy and managing environmental problems at the state level came from domestic factors not from international tendencies as usually believed in the context of CEE countries. The Estonian in-depth context analysis is therefore a distinctive case study analysis meaning that although international factors have influenced the policy-making of young CEE countries in many policy areas (also environmental policy), the analysis shows that the initial development of the environmental taxes and charges system in Estonia has been influenced predominantly by local factors and path dependency. Still, after the EU accession the need to achieve prescribed standards has influenced environmental policy and its instruments with the increase of the charge rates, differentiation and the addition of new tax objects and bases; however, the EU does not oblige member states to use environmental charges in particular. Moving to taxes, the fuel excise duty was introduced to finance the construction of highways in Estonia. Similarly to environmental charges only voluntary diffusion, learning, and emulation are evident as other mechanisms of convergence cannot be identified. However, in the further development of the fuel excise duty and the introduction and development of the electricity excise duty a clear impact of the EU through mechanisms of legal harmonization and coercive imposition is evident because local policy-makers had little if any independence and freedom in influencing the design and implementation of these instruments. Besides the role of international and local factors, the Estonian case study also shed some light on the relationship between the characteristics of the instruments (e.g. tax bases, rates, and their changes) and the development of the system (e.g. starting with low rates, widening the tax base, and increasing the rates gradually during the years to not harm the economy).

To conclude, this analysis shows clearly that to generate a consistent understanding of how certain policy instruments and their systems have been adopted and developed, a broader and more complex theoretical framework is required. Therefore, the contribution of this case to the wider study of policy convergence regarding not only how certain instruments have converged but also more importantly how the systems of instruments have developed, the integration of factors is essential. The exogenous convergence mechanisms, the endogenous local factors and context, and the special characteristics of the instruments need to be considered.

Hereafter, when the development of a system of instruments (not only the convergence of instruments) is an interest of research, the triple impact of international factors, domestic factors, and characteristics of NPIs in a comparative study of countries about the spread and convergence of NPIs would be a further considerable point of analysis. As this article dealt with the convergence of environmental taxes and charges in the aspect of their adaption and

initial development; henceforth, the convergence from policy rhetoric to real actions and nature should also be analyzed.

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Notes

1. Tews, Busch, and Jörgens (2003), Tews (2005), and Kern, Jörgens, and Jänicke (2001) have focused on the analysis of the three broad factors in the field of new EPIs' spread and diffusion.
2. Convergence mechanisms have been explored the same way in the following works: Busch and Jörgens (2005b), Bennett (1991), Dolowitz and Marsh (2000), Tews (2005), Liefferink and Jordan (2005), and Knill and Lenschow (2005).
3. For example, the Vienna Convention together with the Montreal Protocol on substances that deplete the ozone layer, and the UN Framework Convention on climate change with the Kyoto Protocol.
4. See Statistics Estonia classification – http://www.stat.ee/environmental-taxes and Grüner et al. (2009).
5. For further reading, see, for example, 'Estonica' the Encyclopedia about Estonia – http://www.estonica.org/en/Phosphorite_War/.
6. Main investments went to water and waste management (Statistics Estonia 2009, 16).
7. Since the 1990s, the Estonian Ministry of Environment has initiated the contracting of 55 international environmental protection agreements, see – http://www.envir.ee/67252.
8. The analysis was conducted in the Estonian Official State Gazette – a database of all legal documents in Estonia (https://www.riigiteataja.ee/).
9. For further information about the developments in environmental taxes and charges rates, see Statistics Estonia study 'Environmental taxes' (2009, 100–107).
10. See the Ministry of Finance Home Page (http://www.fin.ee/index.php?id=2021).
11. The Commission also proposed appropriate transitional arrangements for Accession Countries that were subsequently adopted by the Council of Ministers in the form of two directives (Council Directive 2004/74/EC and Council Directive 2004/75/EC) amending Council Directive 2003/96/EC.

Notes on contributor

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References

Baumol, W. J., and W. E. Oates. 1989. *The Theory of Environmental Policy*. Cambridge: Cambridge University Press.

Bennett, C. J. 1991. "What is Policy Convergence and What Causes It?" *British Journal of Political Science* 21 (2): 215–233. doi:10.1017/S0007123400006116.

Botcheva, L., and L. L. Martin. 2001. "Institutional Effects on State Behavior: Convergence and Divergence." *International Studies Quarterly* 45 (1): 1–26. doi:10.1111/0020-8833.00180.

Busch, P.-O., and H. Jörgens. 2005a. "The International Sources of Policy Convergence: Explaining the Spread of Environmental Policy Innovations." *Journal of European Public Policy* 12 (5): 860–884. doi:10.1080/13501760500161514.

Busch, P.-O., and H. Jörgens. 2005b. "International Patterns of Environmental Policy Change and Convergence." *European Environment* 15 (2): 80–101. doi:10.1002/eet.374.

Busch, P.-O., H. Jörgens, and K. Tews. 2005. "The Global Diffusion of Regulatory Instruments: The Making of a New International Environmental Regime." *The Annals of the American Academy of Political and Social Science* 598 (1): 146–167. doi:10.1177/0002716204272355.

Council Directive 2003/96/EC of 27 October 2003. "Restructuring the Community Framework for the Taxation of Energy Products and Electricity [online]." Accessed October 10, 2011. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32003L0096:en:HTML.

Council Directive 2004/74/EC of 29 April 2004. "Amending Directive 2003/96/EC as Regards the Possibility for Certain Member States to Apply, in Respect of Energy Products and Electricity, Temporary Exemptions or Reductions in the Levels of Taxation [online]." Accessed October 10, 2011. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:157:0087:0099:en:PDF.

Council Directive 2004/75/EC of 29 April 2004. "Amending Directive 2003/96/EC as Regards the Possibility for Cyprus to Apply, in Respect of Energy Products and Electricity, Temporary Exemptions or Reductions in the Levels of Taxation [online]." Accessed October 10, 2011. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:157:0100:0105:en:PDF.

Council Directive 92/12/EEC of 25 February 1992. "On the General Arrangements for Products Subject to Excise Duty and on the Holding, Movement and Monitoring of Such Products [online]." Accessed October 10, 2011. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0012:EN:HTML.

Dolowitz, D. P., and D. Marsh. 2000. "Learning from Abroad: The Role of Policy Transfer in Contemporary Policy Making." *Governance* 13 (1): 5–23. doi:10.1111/0952-1895.00121.

Dunoff, J. L. 2007. "Levels of Environmental Governance." In *The Oxford Handbook of International Environmental Law*, edited by D. Bodansky, J. Brunnee, and E. Hey, 85–106. Oxford: Oxford University Press.

EEA. 1996. "Environmental Taxes: Implementation and Environmental Effectiveness." Environmental Issues Series No. 1. Copenhagen: European Environmental Agency [online]. Accessed October 15, 2011. http://www.eea.europa.eu/publications/92-9167-000-6.

Environmental Taxes. 2009. "Environmental Protection and Supervision." Statistics Estonia Homepage [online]. Accessed October 15, 2011. http://www.stat.ee/environmental-taxes.

European Commission. 2005. "Trends in Environmental Taxes." In *Structures of the Taxation Systems in the European Union. Taxation and Customs Union*, 74–85 [online]. Accessed October 15, 2011. http://ec.europa.eu/taxation_customs/resources/documents/taxation/gen_info/economic_analysis/tax_structures/Structures2005.pdf.

Grüner, E., K. Salu, K. Oras, and T. Nõmmann. 2009. "Environmental Taxes – Economic Instruments for Environmental Protection." *Quarterly Bulletin of Statistics Estonia* 3: 6–15.

Hoberg, G. 2001. "Trade, Harmonization, and Domestic Autonomy in Environmental Policy." *Journal of Comparative Policy Analysis: Research and Practice* 3: 191–217. doi:10.1080/13876980108412660.

Holzinger, K., C. Knill, and T. Sommerer. 2008. "Environmental Policy Convergence: The Impact of International Harmonization, Transnational Communication and Regulatory Competition." *International Organization* 62 (4): 553–587. doi:10.1017/S002081830808020X.

Jordan, A. 2001. "'New' Environmental Policy Instruments in the UK: Policy Innovation or 'Muddling Through'?" Paper prepared for the ECPR Joint Session of Workshops, Grenoble, France, April.

Jordan, A., R. Wurzel, A. R. Zito, and L. Bruckner. 2003. "European Convergence and the Transfer of 'New' Environmental Policy Instruments (NEPIs) in the European Union." *Public Administration* 81 (3): 555–574. doi:10.1111/1467-9299.00361.

Kern, K., H. Jörgens, and M. Jänicke. 2001. "The Diffusion of Environmental Policy Innovation: A Contribution to the Globalisation of Environmental Policy." WZB Discussion Paper No. FS II 01-302. Berlin: Social Science Research Centre.

Knill, C. 2005. "Introduction: Cross-national Policy Convergence: Concepts, Approaches, and Explanatory Factors." *Journal of European Public Policy* 12 (5): 764–774. doi:10.1080/13501760500161332.

Knill, C., and A. Lenschow. 1998. "Change as 'Appropriate Adaptation': Administrative Adjustment to European Environmental Policy in Britain and Germany." *European Integration Online Papers* (*EioP*) 2 (1) [online]. Accessed May 6, 2010. http://eiop.or.at/eiop/texte/1998–001.htm.

Knill, C., and A. Lenschow. 2005. "Compliance, Communication and Competition: Patterns of EU Environmental Policy Making and Their Impact on Policy Convergence." *European Environment* 15 (2): 114–128. doi:10.1002/eet.376.

Liefferink, D., and A. Jordan. 2005. "An 'Ever Closer Union' of National Policy? The Convergence of National Environmental Policy in the European Union." *European Environment* 15 (2): 102–113. doi:10.1002/eet.377.

March, J. G., and J. P. Olsen. 1989. *Rediscovering Institutions*. New York: Free Press.

Ministry of Environment. 2005. *International Cooperation. International Agreements* [online]. Accessed May 10, 2010. http://www.envir.ee/67252.

Ministry of Finance Home Page. *Taxation. Excise Duties. Fuel and Electricity Excise Duty* [online]. Accessed October 16, 2011. http://www.fin.ee/index.php?id=2021.

OECD. 1989. *Economic Instruments for Environmental Protection*. Paris: OECD.

OECD. 1999. "Economic Instruments for Pollution Control and Natural Resource Management in OECD Countries: A Survey." Working Party on Economic and Environmental Policy Integration. Paris: OECD [online]. Accessed May 11, 2010. http://smap.ew.eea.europa.eu/media_server/files/w/a/Eco_Instr__Pollution_Control_OECD.pdf.

Pedersen, L. H. 2007. "Ideas Are Transformed as They Transfer: A Comparative Study of Ecotaxation in Scandinavia." *Journal of European Public Policy* 14 (1): 59–77. doi:10.1080/13501760601071653.

Pigou, A. C. 1912. *Wealth and Welfare*. London: Macmillan.

Pigou, A. C. 1920 [1932]. *The Economics of Welfare*. 4th ed. London: Macmillan.

Rose, R. 1991. "What Is Lesson-drawing?" *Journal of Public Policy* 11 (1): 3–30. doi:10.1017/S0143814X00004918.

Statistics Estonia. 2009. *Environmental Taxes*. Final report of Eurostat's Grant Agreement No. 71401.2007.014-2007.486. Tallinn: Statistics Estonia.

Tews, K. 2005. "The Diffusion of Environmental Policy Innovations: Cornerstones of an Analytical Framework." *European Environment* 15 (2): 63–79. doi:10.1002/eet.378.

Tews, K., P.-O. Busch, and H. Jörgens. 2003. "The Diffusion of New Environmental Policy Instruments." *European Journal of Political Research* 42 (4): 569–600. doi:10.1111/1475-6765.00096.

Appendix 1. List of interviewees

Kraav, Eva. Adviser on Environmental Economics and Control, Ministry of the Environment. 9 March–20 April 2010. E-mail correspondence.

Tammemäe, Olavi. Deputy of Vice Chancellor of the Department of Environmental Management, Ministry of the Environment. 31 March 2010. Authors tape recording and notes.

Meos, Sjusanna. Chief Specialist of the Environmental Taxes Bureau, Ministry of the Environment. 31 March 2010. Authors tape recording and notes.

Raudsepp, Rein. Adviser of the Department of Environmental Management, Ministry of the Environment. 31 March 2010. Authors tape recording and notes.

Eek, Peeter. Director of the Department of Waste and Waste Management, Ministry of the Environment. 31 March 2010. Authors tape recording and notes.

Ojava, Pavel. Leading Inspector of the Environmental Protection Department, the Environmental Inspectorate. 1 April 2010. Authors tape recording and notes.

Rajasalu, Rene. Leading Inspector of the Environmental Protection Department, the Environmental Inspectorate. 1 April 2010. Authors tape recording and notes.

Sildnik, Reeli. Leading Inspector of the Environmental Protection Department, the Environmental Inspectorate. 1 April 2010. Authors tape recording and notes.
Kralik, Silja. Former director of the Department of Development, Ministry of the Environment (2002–2009). 16 April 2010. Authors tape recording, notes and e-mail exchange.
Nõmmann, Tea. Director of the Stockholm Environmental Institute in Tallinn. 20 April 2010. Authors notes and e-mail exchange.
Annuk, Enn-Toivo. Chief Specialist of the Customs Inspection, Estonian Tax and Customs Board. 08–11 April 2010. Authors notes and e-mail exchange.

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Implications of project-based funding of research on budgeting and financial management in public universities

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Abstract The main goal of the paper is to explore—both theoretically and empirically—the implications of project-based research funding for budgeting and financial management at public universities. The theoretical contribution of the paper is to provide a synthesized discussion of the possible impacts of project-based funding on university financial management and budgeting. In the empirical part of the study, the cases of the two largest public universities in Estonia are used to uncover whether and in what form the effects outlined in the theoretical discussion have emerged. The study concludes that project-based funding of research gives rise to the following challenges: fluctuating revenues, fragmented revenue sources, high transaction costs, coordination problems, high complexity in managing the finances, difficulties in securing cash flows, and problems in covering indirect costs. The Estonian experience also indicates that extreme reliance on project-based funding of research—when combined with certain features of funding instruments and weak steering capacities of the central administration—can lead to a paradoxical situation: the more successful the research groups are in obtaining project-based funding from diverse sources, the more strained becomes the budget of the university as a whole.

Keywords Research funding · Budgeting · Financial management · Universities

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Introduction

Modern universities function in increasingly competitive and entrepreneurial environments, and this has also affected their funding patterns. Broadly speaking, public funding for research can be allocated to universities via two main mechanisms (see, e.g., Auranen and Nieminen 2010; Lepori et al. 2007, 2009). First, the funds can be channelled to public universities in the form of *core funding* (also called "institutional" funding), either as part of a basic operational grant (meant to cover both research and teaching) or as a separate grant aimed for research (Liefner 2003). Core funding is usually not limited in time, and the central administrations of the universities have discretion over how to distribute the funds internally between the individual subunits. Second, funds can be allocated directly to research groups via *project-based* mechanisms (i.e. for a limited time period, on the basis of a project proposal describing the foreseen research activities). Project-based funding can be allocated either via competitive mechanisms or direct contracts (Lepori et al. 2007).

Recent years have witnessed an increasing competition for publicly funded academic research at universities and growing emphasis on project-based funding (as opposed to core funding) in Europe (Geuna 2001; Lepori et al. 2007, 2009). The goals of funding research via competitive project-based mechanisms are to increase the quality of scientific work, promote efficiency in the use of resources, and provide funds for new initiatives (e.g. Geuna 2001; Laudel 2006a, b; Liefner 2003). Such a funding mode reflects the ideas of New Public Management, with its focus on devolved decision-making, competition, managerialism, and efficiency (Auranen and Nieminen 2010; Parker 2013) but also the project-based implementation of research, and structural and cohesion policies of the European Union (Lepori et al. 2007).

By now, there are numerous studies dedicated to describing the features of different systems of research funding and how they have changed over time (e.g. Geuna 2001) and how funding systems have influenced the content, quality, and development of research (e.g. Auranen and Nieminen 2010; Geuna 2001; Laudel 2006a, b). Although the reliance on (competitive) project-based funding of academic research at universities is an increasing trend and it is plausible that this would also influence budgeting within universities, there has been *no* academic study that would systematically examine the effects of such funding on *budgeting* and *financial management* within universities (as pointed out by Lepori et al. 2013). While there are a number of studies that have explored how system-level changes in the distribution of *core funding* between public universities in a country have influenced the distribution of funding between the subunits within a university (e.g. Jongbloed and van der Knoop 1999; Lopez 2006), the implications and challenges of *project-based funding* of research for budgeting and financial management of universities have received almost no attention in the academic literature so far.

Our study aims to address this gap. It focuses on the following research question: what are the implications of competitive project-based research funding for budgeting and financial management at universities? In order to keep the scope of the article manageable, we focus specifically on *research* funding (and not on funding allocated to universities for teaching activities) and on *public universities* (rather than other types of research organizations).

The *theoretical* contribution of the article is to provide—drawing on the literatures of grant-based funding of organizations and university budgeting—a synthesized discussion of the *possible impacts* of project-based funding of academic research for university financial management and budgeting. In the *empirical* part of the study, the cases of the two

largest public universities in Estonia will be used to uncover *whether* and *in what form* the effects outlined in the theoretical discussion have emerged and whether any additional problems have arisen (and how they have been addressed).

The Estonian case can be viewed as an "extreme case" among the European countries given the high percentage of research funding that is project based. Steen's (2012) study of selected OECD countries shows that national project-based research funding to higher education sector hardly ever reaches beyond 50 % in Europe. In Estonia, however, more than 80 % of research funding is project-based (Estonian Ministry of Education and Research). In the two universities covered in this study, *project-based* funding constitutes ca 45–50 % of the total university budget and more than 95 % of the research budget (as of 2013). In other European countries, project-based funding makes up about 20 % of total university revenues (including teaching, research, and other revenues), on average (Lepori et al. 2007, 2013). Thus, it can be expected that the issues that are likely to emerge with project-based funding of research can be observed in Estonia in an especially "pure" form. Given that the reliance on project-based funding of academic research is an increasing trend (in Europe but also elsewhere), the Estonian case can provide useful insights for other countries and universities as well. The paper is structured as follows. Second section outlines the analytical framework, third section presents the findings of the empirical study, and fourth section concludes.

Analytical framework

As Lepori et al. (2013, p. 59) put it, "it is impossible to overestimate budgeting in public and private organizations". Indeed, budgeting—by influencing the division of resources within the organization and shaping individual incentives—constitutes one of the main elements in the organizational control system, aimed at reducing uncertainty and facilitating coordination (Jongbloed and van der Knoop 1999; Lepori et al. 2013). Given that budgeting plays an important role in managing the "resource interface" with the external environment in a university, it can be expected, drawing on resource dependence theory (see, e.g., Pfeffer and Salancik 1978), that changes in the funding environment would bring about shifts in the internal budgeting systems as well.

Motives in multi-layered context

Given that a university is a multi-layered organization—with the central administration and the individual subunits (research groups, institutes, departments, faculties) constituting the main actors in the budget process—it is worth asking what the general motives of these different actors are with regard to the acquisition of project-based funding of research.

According to the literature discussing "academic capitalism" and "financialization" of higher education and research, the success and prestige of university are increasingly linked to its ability to garner external funds (e.g. Parker 2013; Slaughter and Rhoades 2004; Ylijoki 2003). Following that perspective, it can be conjectured that the "core" of the university (i.e. the central administration) would support and expect external grant acquisition by the individual departments, given that it increases the total budget and also the prestige of the university (e.g. Laudel 2006b; Lepori et al. 2009; Parker 2013). In particular, the central administration would be supportive of the individual departments obtaining grants that signal academic excellence and enhance the reputation of the

university as a whole in the eyes of the academic community (e.g. grants for which there is a very high level of competition). The core would want to facilitate the application for grants that are large, long term, and generate positive spillover effects. The stance of the central administration vis-a-vis project funding generated by the research groups would also depend on whether and how much of the acquired funds flow into the "central" budget of the university as a whole: the higher the overhead, the more the central administration would support the acquisition of grants.

Based on the perspective of *agency theory*, which views the central administration as the "principal" and the subunits as "agents" (Eisenhardt 1989; Liefner 2003), however, the incentives of the subunits and the central core of the university may be misaligned or conflicting. In a situation of asymmetric information, the central administration may lack sufficient mechanisms to monitor the behaviour of the subunits (Jongbloed and van der Knoop 1999). In particular, if the "core" of the university is weak and lacks instruments for steering the departments strategically, the central administration may start viewing excessive "grant-generation" as problematic if it feels that the funds are not used for purposes that serve the interests of the university as a whole. And, conversely, if the central administration is able to maintain control over strategic decision-making and direction, it may view the devolution of budgetary decision-making to departments as less of a threat.

The motives of the *subunits* in the university to obtain project-based funding depend on various factors. First, it depends on whether grant income is necessary for covering the basic costs of personnel and equipment—or whether the institutional (core) funding distributed by the central administration already provides sufficient revenues for covering such expenses. From the perspective of *resource dependence* theory (see, e.g., Pfeffer and Salancik 1978), if the project-based income is necessary for financing the "basic operation" of the subunits, they are likely to engage in active grant-seeking, in order to secure their survival. Second, according to university budgeting literature that has viewed the budget processes through *power* perspective—and has discussed which factors increase the sources of power of departments in the intra-university bargaining process (see, e.g., Salancik and Pfeffer 1974; Thomas 2000)—one would also predict that the individual departments and research groups would be motivated to maximize their grant income. This is because externally acquired research grants are seen to enhance the power of individual departments within the intra-university bargaining games and give them a stronger power position in other areas of decision-making as well (including how intra-university funds are distributed) (see, e.g., Salancik and Pfeffer 1974). Third, the incentives to maximize grant income are likely to depend on the extent to which the central administration "taxes" the grant income—in the form of overheads, for example—or intervenes in decisions over how the funds are used (Jongbloed and van der Knoop 1999; Lang 1999; Whalen 1991; Zierdt 2009). Finally, the incentives of the subunits to apply for external funds are likely to be shaped by whether and how the core of the university support their efforts (e.g. in the form of providing administrative assistance and financial guarantees when necessary).

Implications of project-based research funding for budgeting and financial management in universities

It can be conjectured—drawing on both the resource dependence and principal-agent perspectives discussed in the previous section—that if the subunits feel that they are responsible for generating a significant bulk of their budget "on their own", it would create pressures to devolve more budgetary decision-making powers to the subunits and to adopt decentralized forms of budgeting (e.g. responsibility centre budgeting or revenue

responsibility budgeting or variants thereof) (Lang 1999; Whalen 1991; Zierdt 2009). In the case of responsibility centre budgeting or revenue centre budgeting, the subunits of the university are responsible for their own revenues and expenditures (including overheads and indirect costs); they are also able to keep the surpluses they generate and carry them over to the next budget year(s) (see, e.g., Lang 1999; Whalen 1991). How exactly the division of roles between the central administration of the university and the subunits would look like in the context of project-based funding of research is likely to depend on the other features of governance in the university. Based on the principal-agent perspective, it can be predicted that the weaker the core and the fewer steering instruments it has in its disposal, the more challenges are likely to emerge for the financial management and budgeting in the context of project-based funding of research.

As the grant-(based) funding literature has emphasized, one of the major implications of extensive reliance on external grants is the *volatility* of funding, resulting in *fluctuating* revenues from year to year (or even within 1 year) (e.g. Carroll and Stater 2009; Froelich 1999; Morris 2003). The higher the dependence on project-based financing, the higher the volatility is likely to be. Thus, if a significant portion of the university budget is made up of research projects obtained by the subunits and it is hard to predict how many projects (and of what size) would be received by them, it would be very difficult to make accurate budgetary *forecasts*—both at the central and at the subunit level.

Studies focusing on the impacts of grant-based funding on the financial management and budgeting of non-profit organizations have argued that the strategy of *revenue diversification* can help to reduce the overall volatility of revenues (e.g. Carroll and Stater 2009; Froelich 1999). Similar behaviour can be expected of the departments and research groups within universities (Morris 2003; Morris and Rip 2006), especially if they are highly dependent on external grants for covering their basic operational expenses. While the diversification of revenue sources can be used to address the potential volatility of any one source, such a strategy is likely to increase *transaction costs*, given that obtaining funds from any source requires the actors to apply for funds, negotiate and conclude contracts, monitor the implementation of the project, and submit reports to the funder (see, e.g., Froelich 1999; Laudel 2006a; Morris and Rip 2006). These additional administrative burdens, in turn, may necessitate the hiring of professional (financial) managers to provide administrative support (Froelich 1999; Morris and Rip 2006). Thus, an important issue that is likely to emerge in the context of project-based funding of academic research is how to cover these transaction costs and on whom they should fall.

In addition to the transaction costs involved in dealing with the funders, it can be conjectured—based on the grant-funding literature—that the more diversified the department's research budget is, the higher is the *complexity* of managing multiple revenue streams (Froelich 1999). The more revenue sources there are, the more challenging becomes the coordination of resource use within and also between organizational units. In addition to increased complexity and high administrative costs, extensive reliance on grant-based funding may force the subunits into *hodgepodge budgeting*—characterized by ingenuity and opportunistic behaviour by the organizational actors—in order to survive in an uncertain resource environment (Douglas and Hartley 2004).

Even if the organizations pursue the strategy of revenue diversification, a grant-based funding model means that there may be periods when they do not have sufficient incoming revenues to cover the current costs. This problem is likely to be particularly acute for the subunits within the university if their borrowing possibilities are limited. Thus, an important question that has to be considered is how the subunit can survive the financial gap. One way to address the problems arising from volatility of revenues is for the subunits to

create their "rainy day funds", "reserves", or "financial buffers" (Carroll and Stater 2009). In a multi-layered context of a university, another possibility would be for the central administration of the university to provide "temporary relief" to the subunits that face such a gap in financing (Lang 1999).

Grant-based funding literature has also referred to the problems with *cash-flow management* that project- or contract-based funding can create when the funding instruments are based on lagged reimbursement (Froelich 1999). In the university context, this poses the question of who (the subunit or the "core") should provide finances in order to smooth the cash flow and who should bear the corresponding costs (e.g. the costs of credit) and residual financial risks, should they arise.

The existing discussions on project-based research funding have also pointed to the potential challenges associated with covering the *full* costs of research if the funding conditions do not support the attribution of *indirect costs* (e.g. the costs of maintaining research infrastructure, library) to the research grants obtained (Geuna 2001). As Geuna (2001) points out, the researchers are likely to have only a limited notion of the "actual" costs of their research and tend to pay attention only to the direct costs. Thus, the question of how to distribute indirect costs between the central administration and the subunits can give rise to significant internal conflicts within the universities (see, e.g., Lang 1999).

The empirical study

In order to uncover the implications of increasing reliance on project-based funding of research for the financial management and budgeting at universities, we focused on the two largest public universities in Estonia—University of Tartu (UT) and Tallinn University of Technology (TUT). The sources of data for the case studies included official documents, budgets of the universities, and semi-structured interviews conducted with 7 officials of the central administrations of the universities (working in the finance and R&D departments) and 32 researchers (leaders of research groups from the fields of biotechnology, IT, environmental technologies, and energy technologies). These four fields were chosen because they partly overlap with national science and innovation policy priorities (and are therefore eligible for the widest range of funding sources). The interviews were conducted between 1 April 2013 and 15 October 2013 and lasted between 1.5 and 3 h.

The system of funding academic research in Estonia

In 1997–1998, a major shift took place in the Estonian science funding system which had hitherto been predominantly institutional (Lepori et al. 2009). After 1998, essentially all research funding became competitive, peer-review based and allocated to research groups via research projects. From 2005 onwards, *some* institutional funding for research (called base-line funding) has been allocated to the public universities by the Ministry of Education and Research (MER) but as we will see below these sums have been very small. In the run-up to the EU accession in 2004, Estonian researchers could also start applying for EU structural and cohesion funding and fully participate in the EU's research networks and programmes. After the accession to the EU, the utilization of EU funding for research accelerated and the number of competitive funding schemes increased rapidly. As a result, the research funding environment the universities and research groups face is highly complex and characterized by a plethora of different instruments. For the purposes of our

analysis, the sources of research funding can be divided into following categories: (1) base-line funding allocated by MER to universities; (2) targeted funding for research groups financed by MER via the Estonian Research Council (ERC); (3) personal research grants financed by MER via ERC (formerly Estonian Science Foundation); (4) international contracts and grants (including funding from the EU Framework Programmes); (5) EU Structural Funds; (6) domestic R&D contracts with the public and private sector (see also Masso and Ukrainski 2009).

The effects of the above-mentioned developments in the funding environment on the composition of the budgets of TU and TUT can be observed in Figs. 1 and 2. As Fig. 1 shows, in both universities, the size of the research budgets has increased significantly between 2004 and 2013 (tripling in size in TU and quadrupling in TUT). As indicated by Fig. 2, the base-line funding for research makes up only a small percentage of the research budget. In 2013, for example, it amounted to <5 % of the research revenues in both universities. In other words, by 2013, in both universities, *project-based funding* constituted more than 95 % of the research budget and 45–50 % of the total university budget. Based on the rapid increase in the volume of the research budgets of these two universities between 2004 and 2013, one could view these cases as "success cases". The next subsection demonstrates, however, that although the overall budget of the university may have increased, such a funding environment may create significant fluctuations of revenues for the subunits and also lead to tensions between the core and the subunits.

Implications of project-based funding for budgeting and financial management

As a result of extensive reliance on project-based funding of research, the budgetary systems in the Estonian public universities comprise of two parallel processes. On the one hand, the "teaching budget" (i.e. the general grant from the government meant to cover teaching activities) is distributed in a top-down manner between the faculties, after a sum for covering overhead and indirect costs has been subtracted. On the other hand, the "research budget" emerges in a bottom-up fashion, whereby the research groups' projects make up the research budget of a department and departments' research budgets, in turn, are summed up into the "research budget" of the university as a whole. The only part of the research budget that is distributed top-down is the base-line research funding the university receives directly from MER.

Based on the existing literature, one would expect that such a funding environment would lead to the adoption of responsibility-centre budgeting within the universities. The two cases do indeed demonstrate that resulting from the fact that departments within the university have to generate their own "research budgets" they have (essentially) become "budget centres", responsible for bringing in a bulk of their own revenues, but with a lot of freedom in managing their expenditures as well (including decisions about the number of employees and the levels of salaries within the department). The university central administrations have established minimum levels of salaries for different positions but no ceilings. Thus, when the research groups obtain additional funding they can also use it for increasing salaries or hiring additional employees. The main aspect of the departments' budgets monitored by the central administration is that the department should not run a deficit (i.e. its expenditures have to be covered by accrued revenues). The devolved budgeting in the universities covered by this study, however, has *not* taken a form of full-blown "responsibility centre budgeting" [as described by Whalen (1991), Lang (1999)], given that the subunits' budget expenditures encompass direct costs but no costs associated

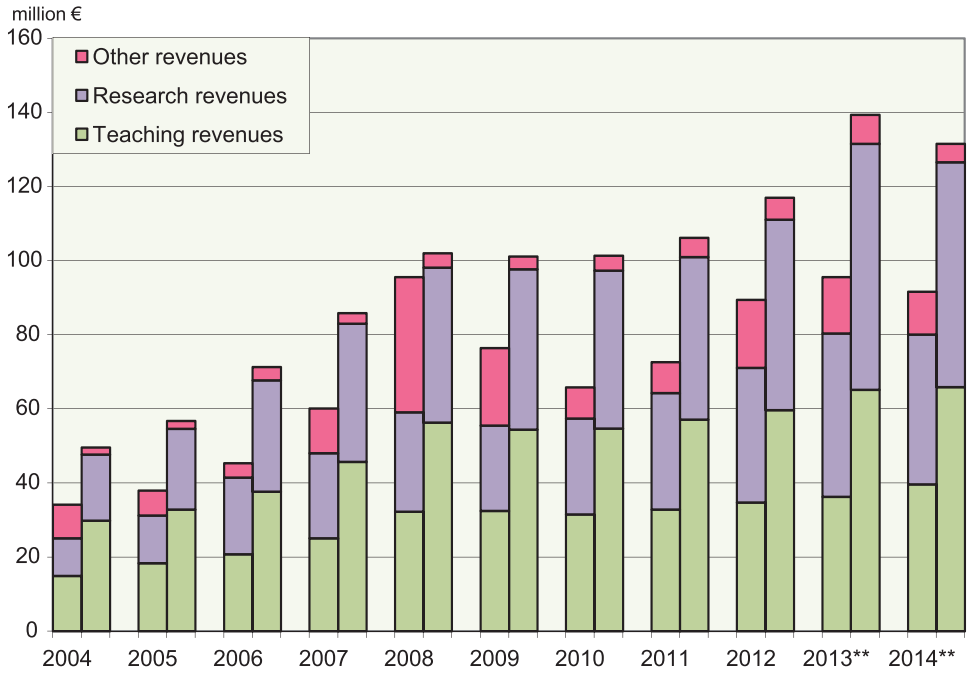

Fig. 1 Operating revenues in TUT and UT*. For every year the first column represents the revenues in TUT and the second in UT. **Budgetary estimation

with the physical plant and other indirect costs. Although the subunits pay "taxes" to the centre from the project revenues in order to cover (at least some) indirect and overhead costs, these are not based on the calculation of full costs of research activities of these subunits.

Tensions created by project-based funding of research between the central administration and the subunits

As was conjectured in the theoretical section, in a situation where the survival of the research group (or even the whole department) depends on the project funding it manages to generate, the scientists and research groups are highly motivated to apply for external funds. Based on the interviews, most of the research groups follow a "maximization" strategy—and try to obtain funding from all different sources. As one of the interviewees put it, "it is like with a lottery: you want to have as many tickets as possible". Such revenue-maximization strategies by most research groups, however, have led to significant tensions between the central administration and the subunits.

First, the interviews with the research groups and the central administrators demonstrated that increasing reliance on project-based funding of research has raised the question of how to cover and distribute the indirect and overhead costs associated with the projects. The two universities covered by this study have developed different systems for dealing with the indirect costs related to the projects. At UT, the charging of indirect costs is "project based": a certain portion of the indirect costs financed by the project (usually 12 % of the project costs) has to be paid to the "central budget" of the university. At TUT, since 2009, each academic unit has to pay a fixed sum per year, irrespective of the total

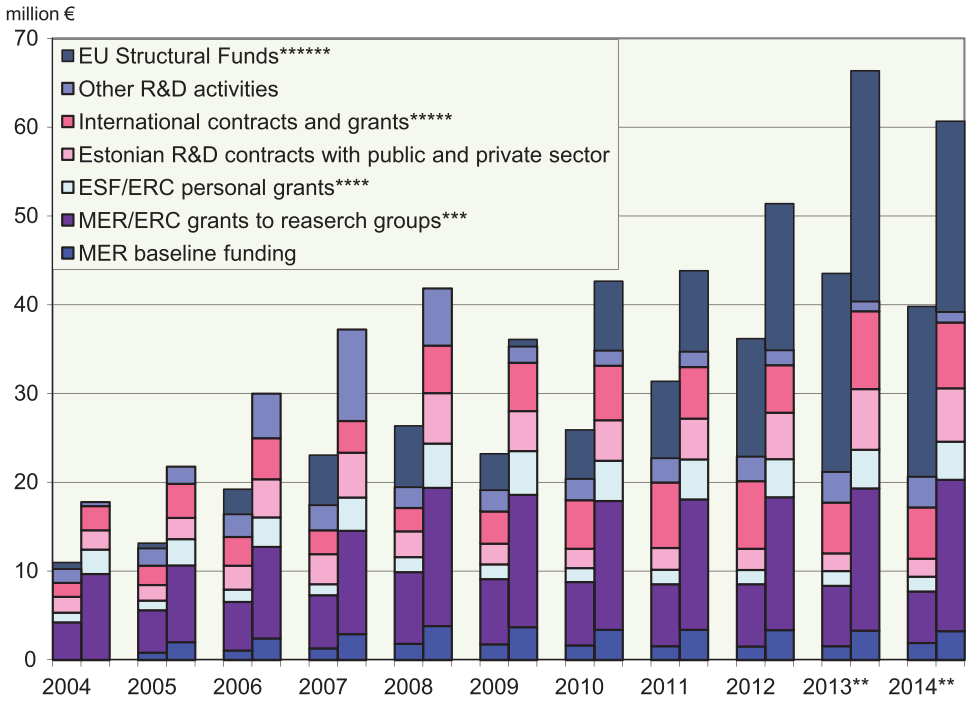

Fig. 2 Research revenues in TUT and UT*. For every year the first column represents the revenues in TUT and the second in UT. **Budgetary estimation. ***Includes also targeted financing of PhD theses (until 2004) and infrastructure expenditures. Until 2012 named MER target financing. From 2013 new grants named ERC institutional research grants. Both are project based. ****Until 2012 named ESF grants. From 2013 new grants named ERC personal research grants. *****Including EU framework programme projects. ******In UT, these revenues are separately calculated only from 2009 (before they were included under other *revenue lines*). They include funds allocated by Enterprise Estonia, Environmental Investment Centre, Estonian Agricultural Registers and Information Board, Mobilitas Postdoctoral Researchers and Top Researchers Programme, ERMOS Postdoctoral Researchers Programme, Archimedes Foundation

funding generated by projects in any given year. As one of the representatives of the central administration from TUT explained, the reason behind shifting from the project-based charging of the overheads to the fixed sums was that "it had been unpleasant and difficult for the central administration to constantly argue and negotiate about the overheads and it was hoped that the fixed sums would alleviate this constant need to haggle".

As conjectured in the theoretical discussion, the issue of indirect costs has given rise to significant tensions between the subunits and the centre in Estonian universities: the central administration feels that the subunits are not paying enough to cover the actual indirect costs, while the subunits often believe that they are being overcharged. Though many of the interviewed research group leaders felt that it was justified to pay overheads to the "central budget", a number of them noted that the central administration of university uses these overhead payments "just to increase their size" and to "subsidize faculties that do not bring in enough money themselves". In the interviews, the representatives of central administration emphasized, in turn, that the research groups are "not cognizant of the size of the indirect costs and how their projects add to these costs". Some of these tensions could potentially be addressed via more transparent communication about the size and breakdown of the overhead costs that the university as a whole has to finance. However, a

more fundamental problem emerges with those funding instruments that do *not* allow the grantees to use project funds for covering overheads—like it is with projects financed by the EU structural and cohesion funds, but also, increasingly, with contracts with firms and ministries. In the case of such funding instruments, the research groups cannot pay money from the project to the central "overhead fund" but, at the same time, the project activities may still create actual overhead costs for the university (e.g. in the form of increased utilities, more work for the accounting unit). The central administrators of the universities, however, feel helpless in addressing this situation. As one of the interviewed administrators explained it, "We cannot tell the research groups not to apply for this kind of funding. The attitude in Estonia is that the scientist is like a holy man who cannot be touched and hence if they want to apply for project funding, they should be allowed to do so".

The second major source of tensions is the use of funding instruments that rely on *lagged reimbursement*. For example, in the case of project funding obtained from the EU structural and cohesion funds, the payments are only made ex post, on the basis of incurred costs. For the departmental level, this means that there are significant gaps in the cash flows, and since the departments *cannot* incur external loans, they have to rely on the central university budget for "smoothing" the real-time cash flow. That, in turn, means that the central administrations of the universities have to use overdraft facilities in their banks and bear interest costs associated with it. In addition, as explained by one of the financial managers, given the unforeseen slowness of the implementing authorities in checking the project reports, the financial burden of the interest cost has turned to be significantly larger than expected. Furthermore, when the project reports of the research groups turn out to be unsatisfactory, the funding agencies can refuse to reimburse (some or all of) the project costs and this can create unforeseen financial risks for the university budget as a whole. Again, the central administrators we interviewed felt helpless in addressing this issue. As one of the interviewed financial managers put it, "All our efforts to persuade the research groups not to apply for these funds have failed—they say we try to constrain academic freedom and go ahead with it anyway". Conversely, the interviewed researchers confirmed that they would view interference from the university administration with regard to project acquisition as unacceptable.

As the above discussion shows, in a governance context characterized by the combination of the following characteristics—the freedom of subunits to apply for external funds and the unwillingness of the central administration to use any steering mechanisms to limit the acquisition of funds despite the fact that it carries the residual financial risks—heavy reliance on project-based funding of research can lead to significant conflicts between the core and the subunits. Such arrangements have created an internal paradox within the universities: the more successful the research groups are in obtaining project-based research funding from diverse sources, the more strained becomes the university budget as a whole. Such a governance structure, characterized by imbalanced autonomy and accountability of the subunits, is not likely to be sustainable in the long term.

In order to solve the above-mentioned tensions over the indirect and interest costs, two possible solutions could be considered. On the one hand, at the university level, the strategic core of the university could develop incentive structures that would give research groups incentives to apply primarily for those types of funding that would also cover indirect costs (e.g. by making the distribution of internal university funding dependent on following this criterion). Also, the research groups could be made responsible for covering (at least) a part of the interest costs (in order to provide incentives for proper reporting). On the other hand, solutions can be offered at the policy level. In order to secure sufficient coverage of indirect costs arising from projects and the need to use overdraft facilities, the

size of core funding allocated to the universities could take into account, in a more precise way, the types of external funding generated by the university. Also, the overall R&D policy of the government could follow the principle that public agencies' contracts with research groups should cover the indirect costs.

Living with a thousand grants: hodgepodge budgeting

As the experience of the two Estonian public universities demonstrates, project-based financing of research has created several challenges for budgeting at the departmental level, including high fragmentation of funding sources, fluctuation of revenues, and high transaction costs.

In a situation where a significant (and increasing) portion of a department's budget depends on funds generated by research projects, the revenues have become highly *fragmented*. As the interviews indicated, the research groups often fund their work from at least 5–6 different projects (the largest number of different projects used for funding research was 30). At the departmental level, such fragmentation of revenues has led to coordination problems between the department head and research groups.

While the revenue-diversification strategy has enabled some of the departments to enjoy constantly increasing revenues over the past 10 years, more than half of the interviewed research group leaders have experienced *fluctuations* (i.e. alternating increases and falls) in the resource levels. Fluctuating revenues make it difficult for the departments—and also for the university as a whole—to undertake any longer-term financial planning. Furthermore, in a situation where the "survival" of the research group depends on the money they manage to bring in via projects, such fluctuations can create "existential problems". In more drastic cases, the fall in revenues has meant that research groups had to be dissolved. In most cases, such fluctuations meant significant adjustments to the salaries of the scientists (30 % salary reductions were mentioned by several research group leaders) and layoffs. Such flexibility in making adjustments is enabled by the very flexible work contracts in Estonia: in the university, most contracts are temporary and salaries adjustable. As mentioned by many interviewees, however, such an unstable financial environment makes the scientific career unattractive to young people and may undermine the sustainability of the research fields. The interviews indicated that dependence on EU structural and cohesion funding can make research groups particularly vulnerable to revenue fluctuations. For example, for the years 2014–2015, those research groups who have received significant project funding from the EU funds over the past 4–5 years predicted significant drops in revenues, given that at the beginning of the new programming period many calls are not open yet and it takes time for the programmes to be implemented.

Given that the research groups (and departments) are nested within a university, there is a possibility for the central administration to use funds from the "central" budget to keep research groups afloat. As emerged from the interviews, the central administrations have provided such temporary "financial relief" to the research groups deemed (strategically) important for the university and perceived to have the capacity to generate their own project funding in the future. These temporary "survival funds", however, have enabled the research groups to maintain only a minimum size (and pay minimum salaries) for 1 or 2 years. If, after this period, the group does not manage to generate its own funding, it would have to be dissolved (or diffused).

Another issue associated with project-based funding the subunits have to address is how to secure *co-financing* (or matching funds) for those projects that require it (like is the case with most EU funds, for example). When asked who is responsible for providing co-

financing, almost all research group leaders answered that it is up to the research groups themselves. In the eyes of the central administrations, they do help the research groups with co-funding (at least to some extent) via distributing (at least part) of the core funding received from the MER to the faculties. The core research funding allocated to the faculties, however, is either not used for co-funding purposes or it is not enough for covering all the co-financing needs. Thus, the research groups (and departments) have had to come up with "creative" ways to fulfil the co-financing requirements. As emerged from the interviews, the main strategies are the following: (1) using the funding received from more flexible instruments; (2) channelling the overheads from other projects; and (3) designating those faculty members who receive their salary from the university's "teaching budget" as project staff (even if they do not actually contribute to the project), so that their salary could be shown as co-funding. These strategies, however, add another layer of complexity to departmental budgeting and reduce overall transparency of financial management.

As predicted in the theoretical discussion, all interviewed research group leaders and central administrators agreed that project-based funding of research has significantly increased *transaction costs* because of the necessity to write project applications, negotiate contracts, monitor implementation, and submit reports. Among the administrative requirements that most of the interviewees considered excessive and disproportionately burdensome were procurement regulations (which apply even to small purchases) and time sheets (indicating how many hours the researchers contribute to the various projects they are involved in). Many interviewees emphasized that the time sheets are "completely meaningless since they do not reflect the reality and nobody can control their content". Several research groups have used the help of consulting firms to prepare the project applications and manage the financial reporting. Other research groups (especially the "wealthier" ones) have hired their own project and financial managers (and also accountants) who take care of the administrative side of the projects. Still, a significant proportion of the administrative tasks (especially writing applications and reports) remain the duty of the research groups. The interviewed research group heads pointed out that they use about 25–50 % of their working time for project administration. One possible solution to reduce the overall administrative burden on the research groups is for the central administration to take over some of the duties. However, given the sheer amount of administrative tasks involved, both the research groups and the administration considered it unrealistic that the existing core could take over a more significant portion of the costs. Thus, major solutions to reducing the administrative costs should be taken at the system level by reviewing and revising the imposed requirements.

Concluding remarks

The goal of this article was to analyse the implications of project-based funding of academic research for budgeting and financial management of universities. Drawing on the existing literature on grant-based funding of organizations, it was conjectured that high reliance on project-based funding of academic research may have the following effects: (1) fluctuating revenues; (2) fragmented revenue sources, which give rise to high transaction costs, coordination problems, and high complexity in managing the finances; (3) difficulties in securing cash flows; and (4) problems in covering indirect costs. The empirical study of the two largest public universities in Estonia demonstrates that *all* of these issues were perceived to present serious challenges for budgeting and financial management.

With regard to some of the problems (like gaps in cash flows and funding), the *multi-layered* structure of the university can provide some alleviation (e.g. by smoothing the cash flow and by providing temporary "survival" funds) and hence help the subunits to weather the effects of project-based funding more easily than would be the case with small(er) non-profit organizations and independent research institutes. Still, given that the financial relief offered by the "centre" to the research groups in Estonian universities is only temporary, the subunits are ultimately responsible for their own survival.

The case studies also show that, as predicted by the principal-agent perspective, if the central administration lacks the instruments to steer the departments strategically, extensive reliance on project-based funding of academic research in the university can give rise to tensions between the core and the subunits. In the two universities covered by the study, the departments have an extensive freedom to apply for grants and also a level of high autonomy in using the funds. At the same time, although the central administration has to carry the residual financial risks associated with project funding, they are unwilling to exert any pressure on the subunits to limit the acquisition of projects because of their limited steering capacities and the cultural norms protecting the "academic freedom" of the scientists (which is seen to cover also the "freedom to apply for funds"). These governance arrangements have led to significant conflicts between the central administration and the subunits. In a context where the subunits need external funds for basic survival, they are strongly motivated to maximize project-based funding. The central administration, however, is starting to view the large number of projects acquired as problematic, given that they bring about additional costs for the central university budget (e.g. transaction costs for administration, uncovered indirect costs, and interest costs involved in using overdraft facilities). Thus, the existing governance structures, combined with the features of some of the funding instruments (lagged reimbursement and insufficient coverage of indirect costs), have created an internal paradox within the universities: the more successful the research groups are in obtaining project-based research funding from diverse sources, the more strained becomes the university budget as a whole. Such a governance structure, characterized by imbalanced financial autonomy and accountability of the subunits, is not likely to be sustainable in the long term.

In future research, it would be very useful to examine closer the interactions between the interactions of strategic management and financial management of the universities that have to operate in a context of project-based funding of research. As shown by the Estonian case, the weak strategic capacities of the central administration have, at least to some extent, aggravated the challenges created by project-based funding of research. It would be interesting, in the future studies, to look at countries where the core of the university has stronger steering instruments in its disposal and to examine which governance arrangements help to address the potential tensions between the subunits and the core. In addition, it would be highly interesting to explore, in a dynamic, longer-term perspective, how project-based funding of academic research, in turn, *influences* the strategic management of the universities: does it eventually lead to the strengthening of the strategic management mechanisms within the university or, conversely, does the reliance on project-based funding tend to undermine the attempts of the central administration to develop its strategic management capacities.

Finally, it is important to keep in mind that while this particular study has focused on the challenges and tensions created by project-based funding of research, it can be expected that in those systems where core funding plays a predominant role, other types of tensions and problems can emerge for budgeting and financial management of the universities (e.g. the distribution of funds based on university politics rather than scientific

merit and increased conflicts between departments). Indeed, in the two universities covered in this study, the research groups complained that they did not know how exactly the base-line funding is distributed within the university and voiced suspicions about possible favouritism. Further comparative studies are needed in order to explore what kind of combinations of core and project-based funding of research would help to address these challenges in the most optimal way.

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References

Auranen, O., & Nieminen, M. (2010). University research funding and publication performance—An international comparison. *Research Policy, 39*(6), 822–834.

Carroll, D. A., & Stater, K. J. (2009). Revenue diversification in nonprofit organizations: Does it lead to financial stability? *Journal of Public Administration Research and Theory, 19*(4), 947–966.

Douglas, J. W., & Hartley, R. E. (2004). Sustaining drug courts in Arizona and South Carolina: An experience in hodgepodge budgeting. *Justice System Journal, 25*(1), 75–86.

Eisenhardt, K. (1989). Agency theory: An assessment and review. *Academy of Management Review, 14*, 57–74.

Froelich, K. A. (1999). Diversification of revenue strategies: Evolving resource dependence in nonprofit organizations. *Nonprofit and voluntary sector quarterly, 28*(3), 246–268.

Geuna, A. (2001). The changing rationale for european university research funding: Are there negative unintended consequences? *Journal of Economic Issues, 35*(3), 607–632.

Jongbloed, B., & van der Knoop, H. (1999). "Budgeting at the institutional level: Responding to internal pressures and external opportunities". In B. Jongbloed, P. Maassen, & G. Neave (Eds.), *From the eye of the storm. Higher education's changing institutions* (pp. 141–164). Dordrecht: Springer.

Lang, D. W. (1999). Responsibility centre budgeting and responsibility centre management in theory and practice. *Higher Education Management, 11*(3), 81–112.

Laudel, G. (2006a). The art of getting funded: How scientists adapt to their funding conditions. *Science and Public Policy, 33*(7), 489–504.

Laudel, G. (2006b). The 'quality myth': Promoting and hindering conditions for acquiring research funds. *Higher Education, 52*(3), 375–403.

Lepori, B., Dinges, M., Reale, E., Slipersaeter, S., Theves, J., & Van den Besselaar, P. (2007). Comparing the evolution of national research policies: What patterns of change? *Science and Public Policy, 34*(6), 372–388.

Lepori, B., Masso, J., Jabłecka, J., Sima, K., & Ukrainski, K. (2009). Comparing the organization of public research funding in central and eastern european countries. *Science and Public Policy, 36*(9), 667–681.

Lepori, B., Usher, J., & Montauti, M. (2013). Budgetary allocation and organizational characteristics of higher education institutions: A review of existing studies and a framework for future research. *Higher Education, 65*(1), 59–78.

Liefner, I. (2003). Funding, resource allocation, and performance in higher education systems. *Higher Education, 46*(4), 469–489.

López, M. J. G. (2006). Towards decentralized and goal-oriented models of institutional resource allocation: The Spanish case. *Higher Education, 51*(4), 589–617.

Masso, J., & Ukrainski, K. (2009). Competition for public project funding in a small research system: The case of Estonia. *Science and Public Policy, 36*(9), 683–695.

Morris, N. (2003). Academic researchers as 'agents' of science policy. *Science and Public Policy, 30*(5), 359–370.

Morris, N., & Rip, A. (2006). Scientists' coping strategies in an evolving research system: The case of life scientists in the UK. *Science and Public Policy, 33*(4), 253–263.

Parker, L. D. (2013). Contemporary University strategising: The financial imperative. *Financial Accountability and Management, 29*(1), 1–25.

Pfeffer, J., & Salancik, G. R. (1978). *The external control of organizations*. New York: Harper and Row.

Salancik, G. R., & Pfeffer, J. (1974). The bases and use of power in organisational decision making: The case of a university. *Administrative Science Quarterly, 19*, 453–473.

Slaughter, S., & Rhoades, G. (2004). *Academic capitalism and the new economy: Markets, state, and higher education*. Baltimore: JHU Press.

Steen, J. V. (2012) "Modes of public funding of research and development: Towards internationally comparable indicators." OECD science, technology and industry working papers, 2012/04.

Thomas, H. (2000). Power in the resource allocation process: The impact of 'rational' systems. *Journal of Higher Education Policy and Management, 22*(2), 127–137.

Whalen, E. L. (1991). *Responsibility center budgeting: An approach to decentralized management for institutions of higher education*. Bloomington, IN: Indiana University Press.

Ylijoki, O. H. (2003). Entangled in academic capitalism? A case-study on changing ideals and practices of university research. *Higher Education, 45*(3), 307–335.

Zierdt, G. L. (2009). Responsibility-centred budgeting: An emerging trend in higher education budget reform. *Journal of Higher Education Policy and Management, 31*(4), 345–353.

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

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Abstract

This paper examines the implementation of smart specialisation in Europe and exposes challenges around moving to a more strategic (directional and non-neutral), place-based and bottom-up mode of regional innovation policy. The analysis focuses on two small nations of Europe – Wales and Estonia – and discusses the challenges that they experience with designing and implementing directional and non-neutral policies of smart specialisation. 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 specialisation has not necessarily delivered on the promise to orient regional policy to a more sustainable, place-based and bottom-up approach. Thus, leading to a situation where local problems but also opportunities have been overlooked, local smart specialisation agendas have instead been shaped by centrally chosen broad values and directions in a top-down manner.

Keywords: Smart Specialisation, Entrepreneurial Discovery Process, Place-Based Policy, Strategic Innovation Policy

Introduction

Smart specialisation and its implementation in the European Union (EU) under Research and Innovation Strategies for Smart Specialisation (RIS3) has been much discussed within the academic community (e.g. McCann & Ortega-Argiles 2015; Ranga 2018). There is a dynamic body of research exploring case studies of various regions across Europe (Radosevic 2017), from Central and Eastern European (CEE) countries (Reimeris 2016; Healy 2016; Karo *et al.* 2017) to Northern Europe (Dubois *et al.* 2017). There are also theoretical and conceptual contributions setting out the core theoretical and practical elements (Foray *et al.* 2011; Foray 2018). 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 to examine how effective the RIS3 approach has been in driving towards more sustainable and inclusive growth in Europe 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 challenges with its implementation. A critical body of literature is emerging, drawing out the issues with smart specialisation when it moves from blueprint to real life policy (Marlow & Richardson 2016; Lundström & Mäenpää 2017; Kroll 2019). 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 what have been the accompanying problems and challenges. Specifically, we focus on the aspects of smart specialisation 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 the existing literature of the specific cases, and other studies from around Europe. Methodologically, our longitudinal case studies draw on interviews with policy actors and regional stakeholders, observations of 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 peripheral (in the European sense) 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, we bring out some of the key conceptual challenges of the approach. 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 where confirmed, disproved or complemented by the empirical findings, reflecting on what our study adds to the field of research on smart specialisation. 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 Specialisation Approach

Smart specialisation 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 (Martin & Sunley 2003; Hospers 2006). 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 few of them managed to improve their knowledge base, they had difficulties to turn it into economic convergence (Foray 2016). The proposal was 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 specialisation 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 specialisation 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 mobilise regional stakeholders around a shared vision based on pre-existing strengths (European Commission, 2011). EDP is based on wider

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 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 most potential to transform the economy (Foray *et al.* 2011).

In the EU although smart specialisation emerged first 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, 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 policymaking 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 specialisation 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 was incorporated into the early regional innovation policies in the 1990s (Landabaso 1997; Mytelka & Smith 2003). 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 "one-size-fits-all" approach to policymaking. 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 Hosper'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 of 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 (Foray *et al.* 2011; European Commission 2011; McCann & Ortega-Argilés 2014; Foray 2016). The fact that EDP aims to identify the unique characteristics and assets of a region, in an attempt to avoid replication of limited 'trendy' sectors where these assets do not exist, distinguishes smart specialisation from previous approaches (Coffano & Foray 2014).

Thus, we view RIS3 as an effort to address perceived problems in 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 that could be considered as opportunities or challenges depending on how they are addressed, inherent in the strategic and place-based approach to policy-making, 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 policymaking 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), is 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 Specialisation Approach

According to Estensoro and Larrea (2016) research about the difficulties of implementing RIS3 as well as paths for overcoming these emerged from 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 specialisation in the context of systemic failures of regional innovation systems (Grillitsch 2016). More specific challenges and shortcomings follow that have received attention in the previous literature.

First, the EDP shows up as one problematic element of smart specialisation. In practice, it has been argued as "hard to do" (Coffano & Foray 2014) and challenging for various regions (Kroll 2015; Estensoro & Larrea 2016). The bottom-up approach to policymaking 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 with the need to engage with local elites in a collaborative manner, whilst ensuring they do not assume monopolistic behaviours. Rather than initiating a true and novel EDP, policymakers have been found to be interpreting RIS3 so that it fits existing policy routines, and continues pre-existing approaches in which much investment has been made in previous Structural Funding rounds (Pugh 2014; Karo & Kattel 2015; Karo *et al.* 2017). The inception of smart specialisation 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, 1563), challenges arise from path-dependency of policy that is pertinent in all regions because smart specialisation 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 policymaking communities built up over time, which can be very context specific. Therefore, to fully understand contemporary smart specialisation, 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-organising feedback mechanisms already exist along the lines of smart specialisation and 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 Czech Republic and Romania (Healey 2016; Karo *et al*. 2017).

Quite often, these countries do not have a clear regional governance level to administer and actualise RIS3 strategies. In the other extreme are regions with semi-autonomous or complex status operating in inherently multi-level innovation policy environments (Magro & Wilson 2013; Kroll 2017). There can also be a mismatch between the functional and political-administrative regions (Capello & Kroll 2016). All these studies emphasise the problem regarding the presence and adequate level of suitable governance capacities. This claim is amplified by the historic centralisation of industrial and R&D policy routines in CEE countries, and traditional lack of a regional and sectoral focus that could lead to a friction between the past logic of long-term national strategies and regional specialisation built on current comparative advantages (Technopolis 2006; Charles *et al.* 2012; Karo & Kattel 2015). In addition, Querejeta & Wilson (2013, 13) emphasise the importance of analysis that looks beyond regional boundaries which considers specialisations 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 specialisation approach, which is the confusing guidance, especially at the inception of the approach, and the contradictory empirical contributions (Kroll 2015; Estensoro & Larrea 2016).

Fourth, challenges arise because of the strong innovation logic underpinning RIS3 (Foray *et al.* 2011), and countries tending to overemphasise 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 & Kroll (2016) argue that focus 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.*).

Taking together this conceptual section and structuring the empirical section, after a small introduction to 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 specialisation?
2) Did they experience any challenges with implementing RIS3?
3) What were the potential reasons behind these challenges and did they entail any notable effects?

Materials and methods

The following analysis is not an exact comparison between Wales and Estonia, but rather a discussion of elements of smart specialisation 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; Yin 2003; Eisenhardt & Graebner 2007; Simons 2009) 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 surprisingly 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 2011-2013 and 2019. They 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 in its implementation. In addition, policy review was conducted from the early 1990s to the present day. 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 in building up our cases. We also undertook observations of 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 Specialisation

The case of Wales

Wales is a semi-autonomous "home nation" of the United Kingdom (UK), located to the west of England. Since devolution in 1999 Wales has its own legislature and executive, which have power and capabilities over 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 current Brexit negotiations. Wales is a post-industrial nation, suffering from the aftermath of the declining of coal mining and heavy industry over the last forty years (Cooke 2003; Thomas & Henderson 2011). This was first partly replaced by manufacturing, often through the setting up of 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; Pickernell 2011; Johnes 2012). 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 longitudinal view of 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 a more local (sub-regional) approach to economic development has 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 at 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 specialisation approaches and "methodology" (Welsh Government

2013, 8). However, Pugh (2014) traces this back to the mid-2000´s, and the *Economic Renewal Programme* (Welsh Assembly Government 2010), identifying six sectors upon which to focus governmental support. These were rationalised 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 rationalisation 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 government, business, universities, and the third sector to meet regularly and help shape policy for their sector, but these have since dissipated. Participants in the panels 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 panels, and challenges around fitting in this extra work beyond 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 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 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 summarised as a mismatch between the high-tech and innovation push approach taken in the programmes implemented, and the more low-tech and SME dominated nature of the Welsh economy (full analysis of this mismatch can be found in Pugh 2017 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, 120) finds the solution to Wales' problematic state-centric governance structures featuring lack of strategic leadership, a lack of engagement and poor monitoring and evaluation processes (NAW 2012), in a move towards a

"transformational" and place-based strategy, furthering the steps made in the smart specialisation 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 specialisation 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 policymaking is that the Welsh Government reinforces the commitment to regional working by creating 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 a centrally driven sector approach has been accompanied by a more local and place-based effort to make 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 specialisation's founding principles, 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 specialisation 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 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 they do not gain so much volume in export figures. The main challenges have been related to structural

changes which 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 specialised 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 centralised governance model as a keen follower of Washington consensus policies with no established industrial policy (Karo & Kattel 2015). Estonia is a unitary state with 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 specialisation and a qualitative collection of expert opinions to specify the potential of research and economy – that did not necessarily ground on a uniform understanding of the smart specialisation 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, cyber security, 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 house, 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 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 moved to the agency under the Ministry of Finance which can further fragmentise 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 specialisation strategies because according to their role they have higher innovation capacities.

The national perspective and lack of regional focus has led to broadly defined RIS3 growth areas that cover the whole economy, contradicting the logic of smart specialisation (Karo *et al.* 2017; Foray 2018). 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 & Kattel 2015; Karo *et al.* 2017). 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 organised and more actively participating in the development of the national RDI policy (Karo *et al.* 2014; Karo & Kattel 2015; Karo *et al.* 2017). Throughout the years the national government has directed large amounts of structural funds into universities without much prioritisation, which has created a 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 emphasise 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) where scientific excellency 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), undermining the EDP. The scientific excellency in Estonia lies in clinical medicine, molecular biology and genetics, physics, plant and animal science, and ecology which have only a loose connection with the main export sectors of Estonia (Karo *et al.* 2017; Lauri & 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 supports only 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 smallness of the country (Karo *et al.* 2017). Place-based policy would assume 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 sub-national 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 was consulted, which acts as a national overarching organisation.

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 that the lack of regional focus has led to a situation where most of the RIS3 funding ends up in Tallinn and Tartu areas as indicated by other interviewees and supported by the analysis of smart specialisation 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: 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

[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/.

according to the needs of Tallinn City. However, no national funding was linked to it and the focus of Tallinn Enterprise Department has mostly been on supporting newly established companies by providing consulting and incubation. Tartu City and its partners started their strategy development even before the national one, following the example of Brainport Eindhoven. However, their specialisation 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 of the differences from Eindhoven, seen as a shortcoming, was that the municipalities did not agree on how to finance the implementation of the strategy: besides Tartu City, nobody was ready to pool in financial resources. Different 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, 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 specialisation 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 public sector innovation procurement scheme which is also available for local municipalities.

Discussion and conclusion

This article is situated against the emerging body of work on smart specialisation with the broad aim of increasing the 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 EDP (Coffano & Foray 2014) confirming the first challenges of smart specialisation. In Wales, EDP was hindered by a strong role of the central government that implemented RIS3 with a top-down manner. This was a result of path-dependency in policymaking (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 emphasises well the importance of productively integrating pre-existing and new policies (Schot & Steinmueller 2018), which has been limited, and therefore also confirming the second challenge of smart specialisation – that its implementation depends on the competencies and familiarities of existing policy-making communities.

Challenges with 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 through times the central government has exercised close control and strong steer in the RDI policy. The inclusion of private sector stakeholders, as one of the possible challenges pointed out by Estensoro & Larrea (2016), has been a serious issue in Estonia related to a low demand for R&D from their side hindering EDP. In addition and complementing the main challenge, the inclusion of local municipalities, which would enable to consider local needs, has been extremely limited, also in previous RDI policies. Meanwhile, the stakeholders from the academia have throughout the years received significant amount of funding and actively participated in RIS3-related processes, which might imply to 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 EDP and the 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 specialisation. 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 administrative and functional borders 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 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 the 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 organisations (e.g. companies, universities, hospitals) located there. Recently, Wales has shifted its focus on its sub-regional needs which needs further attention. However, it is still combined with a strong role of the central government.

Another similarity between the cases is that the chosen specialisations are not only broad but are focused on high-tech sectors, which is seen problematic in countries that outside capital cores do not have exceptionally high technology or R&D intensive economies. This affirms the fourth shortcoming of the smart specialisation 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 spill-over effect to the rest of the economy as also pointed out by Capello & Kroll (2016) and Tõnurist *et al.* (2019). In Wales a 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; 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 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 but also on different sub-levels of governance. Furthermore, the problems with implementing strategic policies might potentially refer to an even wider challenge for small countries, namely that due to the smallness and more personal relations it is more challenging to design and implement selective, directional and non-neutral policies that might unfavour some previously supported sectors and actors.

To conclude, RIS3 was not originally conceived as a strategy for imposing specialisation 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 (Esensoro & Larrea 2016). Accordingly, in neither of the case studies much evidence of 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 competences to develop non-neutral and directional policies in a systems approach 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 which 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 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 held a 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 Horizon Europe framework programme, which has set "Climate-neutral and Smart Cities" as one of its core missions (European Commission 2019), and 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.

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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, 134-152.

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.

Camagni, R., & Capello, R. (2013). Toward Smart Innovation Policies. *Growth and Change*, 44, 355-389.

Capello, R., & Kroll, H. (2016). From theory to practice in smart specialization strategy: emerging limits and possible future trajectories. *European Planning Studies,* 24, 1393-1406.

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.

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). London: 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.

Dubois, A., Kristensen, I., & Terras, J. (2017). Outsmarting geography: implementing territorial innovation strategies in sparsely populated regions. *European Planning Studies*, 25, 1316-1333.

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *Academy of Management Review*, 14(4), 532-550.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory Building from Cases: Opportunities and Challenges. *The Academy of Management Journal*, 50(1), 25-32.

Espenberg, S., Nõmmela, K., Karo, E., Juuse, E., Lees, K., Sepp, V., Vahaste-Pruul, S., & Romanainen, J. (2018). Kasvualade edenemise uuring. Available 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.

Estonian Ministry of Education and Research. (2007). Knowledge-based Estonia, Estonian Research and Development and Innovation Strategy 2007-2013. Available: 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 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. Available https://www.hm.ee/sites/default/files/tai_rakendusplaan_0.pdf.

European Commission. (2010a). Regional Policy Contributing to Smart Growth in Europe 2020. Brussels: European Commission, (COM(2010) 553 final, SEC(2010) 1183).

European Commission. (2010b). *Investing in Europe: Fifth Cohesion Report on Economic*, *Social and Territorial Cohesion*. Brussels: European Commission.

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.* Brussels: European Commission.

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. Brussels: European Commission.

European Commission. (2019). Orientations: towards the first Strategic Plan for Horizon Europe. Brussels: European Commission.

Fagerberg, J. (2018). Mobilizing innovation for sustainability transitions: A comment on transformative innovation policy. *Research Policy* 47(9), 1568-1576.

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.

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. Brussels: 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.

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., 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.

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.

Grillitsch, M. (2016). Institutions, smart specialisation dynamics and policy. *Environment and Planning C: Government and Policy*, 34(1), 22-37.

Healy, A. (2016). Smart specialization in a centralized state: strengthening the regional contribution in North East Romania. *European Planning Studies*, 24(8), 1527-1543.

Hospers, G.-J., (2006). Silicon Somewhere?: Assessing the usefulness of best practices in regional policy. *Policy Studies*, 27, 1-15.

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.

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.

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

Karo, E. (2019). The Future and Societal Importance of Estonian Research and Development. In Ü. Niinemets, E. Karo, R. Kattel, & R. Villems (*Eds*.), *Estonian Research 2019* (pp. 49-61). Tartu, Tallinn, Brussels: Estonian Research Council.

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., & 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, & I. Wade (*Eds*.), *Advances in the Theory of Smart Specialization* (pp. 269-292). London: 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.

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). London: 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, 932-951.

Landabaso, M. (1997). The promotion of innovation in regional policy: Proposals for a regional innovation strategy 1. *Entrepreneurship and Regional Development*, 9, 1-24.

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, Tallinn, Brussels: Estonian Research Council.

Lundström, N., & Mäenpää, A. (2017). Wicked game of smart specialization: a player's handbook. *European Planning Studies,* 25, 1357-1374.

Magro, E., & Wilson, J. R. (2013). Complex innovation policy systems: Towards an evaluation mix. *Research Policy* 42, 1647-1656.

Magro, E. & Wilson, J. R. (2019). Policy-mix evaluation: Governance challenges from new place-based innovation policies. *Research Policy*, 48(10).

Marlow, D., & Richardson, K. (2016). How smart is England's approach to smart specialization? A policy paper. *European Planning Studies*, 24, 1478-1493.

Martin, R., & Sunley, P. (2003). Deconstructing clusters: chaotic concept or policy panacea? *Journal of Economic Geography*, 3, 5-35.

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

McCann, P., & Ortega-Argiles, R. (2015). Smart Specialization, Regional Growth and Application to European Union Cohesion Policy. *Regional Studies*, 49(8), 1291-1302.

Morgan, K. (1997). The learning region: Institutions, innovation, and regional renewal. *Regional Studies*, 31(5), 491-503.

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). London: Routledge.

Morgan, K. (2013). The regional state in the era of smart specialisation. *Ekonomiaz*, 83(2), 103-126.

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.

Morgan, K. (2018). Will Wales' Economic Strategies Weather the Post-Brexit Storm?, *GW4 Opinion,* January 18, 2018. Available at 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, 1467-1479.

National Assembly for Wales. (2012). The Effectiveness of European Structural Funds in Wales. Finance Committee, National Assembly for Wales, Cardiff.

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.

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

Pugh, R. E. (2014). 'Old wine in new bottles?' Smart specialisation in Wales. *Regional Studies, Regional Science*, 1(1), 152-157.

Pugh, R. (2017). Universities and economic development in lagging regions: 'triple helix' policy in Wales. *Regional Studies*, 51(7), 982-993

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.

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.Querejeta, M., & Wilson, J. (2013). What can experience with clusters teach us about fostering regional smart specialisation? *Ekonomiaz*, 83(2), 127-174.

Ranga, M. (2018). Smart specialization as a strategy to develop early-stage regional innovation systems. *European Planning Studies*, 26, 2125-2146.

Raudla, R., Karo, E., Valdmaa, K. and Kattel, R. (2015). Implications of project-based funding of research on budgeting and financial management in public universities. *Higher Education*, 70(6), 957-971.

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). London: Academic Press.

Reimeris, R. (2016). New rules, same game: the case of Lithuanian Smart specialization. *European Planning Studies*, 24(8), 1561-1583.

Rodriguez-Pose, A., di Cataldo, M., & Rainoldi, A. (2014). The Role of Government Institutions for Smart Specialisation and Regional Development. *S3 Policy Brief Series,* No. 04/2014.

Schot, J. & W.E. Steinmueller. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, 47, 1554-1567.

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, Belgium.

Thomas, M., & Henderson, T. (2012). Regional Innovation Strategies: The Challenge for Less-Favoured Regions. In K. Morgan & C. Nauwelears (Eds.), *Regional Innovation Strategies: The Challenge for Less-Favoured Regions*. London: Routledge.

Tõnurist, P., Valdmaa, K. and 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.

Tödtling, F., & Trippl, M. (2005). One size fits all?: Towards a differentiated regional innovation policy approach. *Research Policy*, 34(8), 1203-1219.

Welsh Assembly Government. (2010). *The Economic Renewal Programme.* Cardiff.

Welsh Government. (2012). *Science for Wales.* Cardiff.

Welsh Government. (2013). *Innovation Wales.* Cardiff.

Yin R. (2003). *Case Study Research Design and Methods*, third edition. London: Sage.

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Education

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1993–2005 Pärnu Gymnasium, High school (with honors)

Language competence

English – Fluent
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Professional employment

2020– Present Product Owner of Estfeed, Elering AS
2016–2019 Project Manager of Estfeed, Elering AS
2014–2016 Greentech Sector Manager, Tallinn Science Park Tehnopol and PAKRI Science and Industrial Park
2011–2014 Junior Researcher, Tallinn University of Technology, Faculty of Social Sciences, Ragnar Nurkse School of Innovation and Governance
2010–2017 Assistant (part time), Tallinn University of Technology, Faculty of Social Sciences, Ragnar Nurkse School of Innovation and Governance

Defended dissertations

Kaija Valdmaa, Master´s degree, 2010, (sup) Leno Saarniit, Keskkonnamaksude ja -tasude kujunemine Eestis: ühtlustumise mehhanismide tähtsus, energiatööstust mõjutavate meetmete näitel (The development of environmental taxes and charges system in Estonia: the relevance of convergence mechanisms), Tallinn University of Technology Faculty of Social Sciences, Ragnar Nurkse School of Innovation and Governance

Honours and awards

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2007, Kaija Valdmaa, Tallinn University of Technology Development Fund, AS EMT grant

Supervised dissertations

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Selected projects

2011–2015 Research and Innovation Policy Monitoring Programme 2011–2015 (TIPS), initiated by the Estonian Ministry of Education and Research

2007–2013 Enabling a Global Vision for the Baltic cleantech industry (Global Vision), Central Baltic programme area INTERREG IVA programme

Publications

Raudla, R., E. Karo, R. Kattel, and K. Valdmaa. 2014. "Detsentraliseeritud konkurentsipõhise teadusrahastuse mõju finantsjuhtimisele Eesti ülikoolides." *Tehnoloogia & Valitsemine: Ragnar Nurkse instituudi poliitikaanalüüsid* 3, 1−23.

Valdmaa, K. and T. Kalvet (Eds.). 2011. *Emergence of the Clean Technologies Sector in the Baltic Sea Region*. Tallinn: Tallinn University of Technology.

Valdmaa, K. and T. Kalvet. 2011. "Emergence of the Clean Technologies Sector in Estonia." In Valdmaa, K. and Kalvet, T. (Eds.). *Emergence of the Clean Technologies Sector in the Baltic Sea Region*. Tallinn: Tallinn University of Technology, 158–244.

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2020– praeguseni Estfeedi tootejuht, Elering AS
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2011–2014 Nooremteadur, Tallinna Tehnikaülikool, Ragnar Nurkse innovatsiooni ja valitsemise instituut
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Teaduspreemiad ja -tunnustused

2010, Kaija Valdmaa, Tallinna Tehnikaülikooli Üliõpilaste teadustööde konkurss, sotsiaalteaduste valdkond, magistri kategooria, II koht
2007, Kaija Valdmaa, SA TTÜ Arengufond, AS EMT stipendium

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Riina Ramst, magistrikraad, 2012, (juh) Kaija Valdmaa, Ökoinnovatsiooni stimuleerimine riiklike meetmete abil: elektromobiilsus Eestis, Tallinna Tehnikaülikool, Sotsiaalteaduskond, Ragnar Nurkse innovatsiooni ja valitsemise instituut.

Valitud projektid

2011–2015 Teadus- ja innovatsioonipoliitika seireprogramm TIPS, Haridus- ja Teadusministeerium

2007–2013 Enabling a Global Vision for the Baltic cleantech industry 2011–2014 (global Vision or GV project), Central Baltic programme area INTERREG IVA programme 2007–2013

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Valdmaa, K. and T. Kalvet (Eds.). 2011. *Emergence of the Clean Technologies Sector in the Baltic Sea Region*. Tallinn: Tallinn University of Technology.

Valdmaa, K. and T. Kalvet. 2011. "Emergence of the Clean Technologies Sector in Estonia." In Valdmaa, K. and Kalvet, T. (Eds.). *Emergence of the Clean Technologies Sector in the Baltic Sea Region*. Tallinn: Tallinn University of Technology, 158–244.