

**An inquiry into the underlying causes of the
“European periphery paradox” using the framework
of National Innovation Systems**

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Submitted in accordance with the requirements for the degree of
Doctor of Philosophy

The University of Leeds

Business School

September 2018

The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others.

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Acknowledgements

Firstly, I want to thank my supervisors Professor Gary Dymski and Associate Professor Effie Kesidou for discussions, comments, guidance and support during the years of my PhD. I also want to thank other academics at the University of Leeds for guidance: Malcolm Sawyer, Emmanuella Plakoyiannaki and Dan Coffey.

Secondly, I want to thank all good friends I made here at the University of Leeds, with whom I shared my thoughts: Rob Sweeney, Hanna Szymborska, Sylvia Strava, Eirini Petratou, Maria Gavris, Rosa Canelli, Bianca Orsi, Olivia Mattos, Camilla Petrelli, Douglas Alencar, Fernando Pereira, Marcelo Bandeira, Albertus Hendarsono, Salomon Otajonar, Samuele Bibi, Martin Lima, Emilio Carnevali, Laima Spokeviciute, Kay Raveekarn, Chelsey Elisabeth Neeham, Andrea Bordianu and Lilly Norfeshiah.

Thirdly, I am very grateful to outside academics whom I met at conferences across the world; whom motivated and inspired me: Mariana Mazzucato, Susana Borrás, Charles Edquist, Peter Maskell, Slavo Radosevic, Rajan Rasiyah, Carlota Peres, Wendy Olsen, Ha-Joon Chang and Margit Kirs.

I am especially grateful to my closest friends and family members for love, patience and ongoing support throughout the years of my PhD.

Finally, I am very thankful to the University of Leeds for supporting me financially throughout my studies.

Abstract

This PhD thesis investigates underlying causes of the “European periphery paradox” by employing the National Innovation System (NIS) approach and the mixed methods methodology. The central contribution of the thesis is to the NIS literature and lies within providing new theoretical and empirical explanations for the underlying causes of systemic differences between Western and Eastern European innovation systems.

The thesis is composed of three parts. The quantitative part proposes an empirical model that incorporates the innovation diffusion concept into the analysis of NIS dynamics. The model reveals significant differences in causal relationships between innovation generation and diffusion within five different groups of NISs globally. It also reveals various social, institutional and economic factors that possibly stimulate dynamics of the NISs. The qualitative part looks for deeper contextualised explanations for factors that influence transformation of NISs in transition economies. The case study points to various institutional inefficiencies as barriers to transformation. It reveals that institutional entrepreneurship could be one of the most effective mechanisms to stimulate institutional change through internal (within organisation) and through external (policy-making level) pressures. The conceptual part of the thesis contributes to a better understanding of the institutional change process by exploring the principal-agent model in the context of an entrepreneurial university and NIS.

By incorporating the concept of innovation diffusion, the concept of institutional entrepreneurship and the principal-agent model, this thesis links macro, meso and micro levels in analysing the operations of NISs. It reveals the importance of active interrelationships between all actors of NIS and their abilities to generate, adopt and diffuse innovations locally. Furthermore, this thesis highlights the necessity of having entrepreneurial public institutions for countries seeking innovation-based growth. The thesis points to the importance of the human agency role, in particular, the role of institutional entrepreneurship, in the process of institutional change. The thesis also proposes a balanced individualised incentive system to motivate agents to contribute to the change from an ordinary to an entrepreneurial institution.

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List of abbreviations

CEE – Central Eastern European

CME – Coordinated Market Economy

EBRD – European Bank for Reconstruction and Development

EC – European Commission

EU – European Union

ICT – information and communication technologies

IS - Innovation System

IMF – International Monetary Fund

LME – Liberal Market Economy

NIS – National Innovation System

NISs - National Innovation Systems

OECD – Organisation for Economic Co-operation and Development

SME – Small and Medium Enterprises

UPSTO – United States patent and trademark office

VC – Venture Capital

VECM – Vector Error Correction Model

WTO – World Trade Organisation

Preface

This PhD dissertation is original, unpublished, independent intellectual work by the author, Jurgita Staniulyte.

Chapter 1: General introduction

1.1. Purpose and motivation

This thesis contributes to the “European periphery paradox” debate in academic literature (Karo, 2011; Kattel and Karo, 2010; Kattel and Primi, 2012) by employing the National Innovation System (NIS) approach. The “European periphery paradox” can be defined as a detachment from (or mismatch between) a general call towards innovation-based growth (and focus on innovation policy¹) and serious efforts to strengthen public and private actors (firms, institutions, universities etc.) that are essential in knowledge creation. The term “European paradox” was introduced by Dosi et al. (2006) and it was used to explain the problem of good basic research, but low commercialisation of research results in advanced European countries.

The recent economic crisis has highlighted inadequate economic convergence problems within Europe, “a stark competitiveness divide between highly productive countries and those lagging behind” (The 2014 Global Competitiveness Report). More than half of European countries belong to the European Union and follow the five Maastricht Treaty criteria (inflation, interest rates, deficits, debt, and exchange rates) which are agreed requirements for all Member States of the European Monetary Union. However, these requirements may have restricted growth and development because of different inflationary conditions and institutional arrangements in core and periphery countries (Arestis and Sawyer, 2012). These EU rules, together with the recent austerity policies, may have been a factor leading to current-account imbalances, the widening core-periphery gap within the EU and the overall decreased competitiveness of Europe (Paleta, 2012).

The recent economic crisis has changed the “paradox” by highlighting the unequal growth and core-periphery divide within Europe. The ongoing crisis forced governments to redefine strategies. A new focus on innovations related to climate change, green energy etc. and the active role of the state was seen as a way out of the crisis by many advanced European countries. However, European periphery countries had to cut spending on R&D due to increased global competitive pressures. As a result, instead of catching-up on innovative capabilities, the Central Eastern European (CEE)

¹ For this thesis, innovation policy is defined as a set of various policy instruments that explicitly or implicitly affect innovation processes and outcomes.

countries started to lag behind even more. Hence, we have the “European periphery paradox” (Kattel and Primi, 2012) where a call for innovation-based growth from the EU and an ongoing urge to focus on innovation policy is detached from the dynamics of real economies. This detachment is especially dangerous for developing or lagging countries, because it creates the impression that all policies are wrong or do not work, when in fact the problem might be at the systematic (institutional) level with weak actors or no actors to support innovation processes.

This thesis aims to contribute to the debate by reflecting on the following questions: are the internal dynamics of the national innovation systems (NISs) driven by the coevolution of innovation generation and diffusion; and are internal dynamics stimulated by various social, institutional and economic factors depending on the country’s development level and geographical location? What drives the transformation of the NIS of transition economies? How does the process of institutional change unfold?

In the quantitative Chapter 3, we develop an empirical model that reveals causal relationships between innovation generation and diffusion within five different groups of NISs globally; and various social, institutional and economic factors that possibly stimulate the relationships. The empirical results point to significant differences in internal dynamics of Eastern and Western European NISs. Therefore, in the next qualitative Chapter 4, we look for deeper contextualised explanations of factors that drive transformation, as well as factors that act as barriers behind the transformation of an NIS in transition economies.

The study reveals that institutional stickiness and rigidity act as one of the most important barriers to a faster transformation of an NIS in transition economies and points to institutional entrepreneurship as one of the most effective mechanisms that could stimulate institutional change. The NIS literature recognises the need for entrepreneurial institutions, however, very little attention is paid to understanding the process of institutional change. Therefore, the conceptual chapter 5 contributes to a better understanding of this crucial issue by exploring the principal-agent model in the context of the entrepreneurial university and NIS.

The central contribution of the thesis is to the NIS literature and lies within the theoretical and empirical explanations of the underlying causes of systemic differences between Western and Central Eastern European innovation systems. By

linking micro, meso and macro levels in analysing the operations of NISs, this thesis highlights the importance of systemic abilities to generate, adopt and diffuse innovations locally. It also reveals the importance of the role of human agency in the process of institutional change, as well as the necessity of having entrepreneurial public institutions for countries seeking to increase their overall national potential for future innovations.

1.2. What could we learn from this thesis?

The contribution of the thesis is conceptual and empirical. It separates into three chapters (Chapter 3, 4 and 5). The first chapter (or Chapter 3) employs panel data and a panel cointegration approach to identify internal drivers of national innovation systems. First, the econometric model tests whether the dynamics of NISs are driven by the coevolution of innovation generation and innovation diffusion. Second, the model tests whether the dynamics of NISs are stimulated by different social, institutional and economic factors depending on the country's development level and geographical location. A four-step panel cointegration method is used for the empirical analysis. A panel data set of 93 countries (grouped into five) for the period of 1980-2008 from an existing CANA² database is employed for the analysis.

The results of the econometric model confirm that the dynamics of NISs are driven by the coevolution of innovation generation and innovation diffusion, however, the level of dynamics varies amongst different groups of countries depending on their development level and geographical location. The analysis also confirms that different social, institutional and economic factors stimulate the innovation generation process for different groups of countries. The revealed causal relationships (or lack of thereof) between specific social, institutional and economic factors contribute to a better understanding of systemic differences amongst groups of countries. More specifically, we see major differences in the NISs of high-income Western and mid-income post-

² CANA panel dataset was created and introduced by Castellacci and Natera in 2011. It provides a rich and complete set of indicators for cross-country analyses of 134 national systems, growth and development for the period of 1980-2008. More information about the dataset could be found here: <https://www.files.ethz.ch/isn/126437/WP-783-Castellacci-Natera%20.pdf> and <http://english.nupi.no/Activities/Projects/CANA>

Soviet Eurasian countries. The results show that the internal dynamics of advanced Western countries are very strong, while the dynamics of Eastern NISs are weak.

Inspired by findings from the quantitative Chapter 3, the qualitative Chapter 4 investigates factors that drive the transformation of a transition (post-Soviet) NIS in more detail. Therefore, we design a qualitative case study based on semi-structured interviews. The goal is to deepen the understanding of transformation and to reveal hidden underlying mechanisms that reinforce it within the NIS of Lithuania. The case study aims to deliver a contextualised explanation drawing on critical realism tradition. It is based on data from 30 semi-structured in-depth interviews with major stakeholders of the Lithuanian innovation system (representatives from universities, research centres, government institutions and associations of local firms).

Transformation is a systemic change and government institutions should be the key moderators of this change. However, the case study reveals that public institutions are resistant to change and that various institutional inefficiencies still exist due to individual (human agency) factors. Based on the findings, we conclude that the NIS of Lithuania is still in transition due to various institutional inefficiencies within the public sector such as a lack of relevant organisational, managerial and entrepreneurial capabilities.

Further analysis of the interviews points to institutional entrepreneurship as the key mechanism that stimulates institutional change and the overall transformation of the NIS. Examples from current and past best practices reveal that institutional entrepreneurs reinforce institutional change through various internal (within organisation) and external pressures (better policy-making and implementation). The case study contributes to the NIS literature of transition economies by revealing the importance of the human agency role, more specifically the institutional entrepreneurship role and its relation to institutional change.

The NIS literature acknowledges the importance of entrepreneurial public institutions, however, very little attention is paid to analysing how the process of change occurs and how public institutions become entrepreneurial. Therefore, the aim of the final conceptual analysis is to understand how the process of institutional change unfolds. In the conceptual analysis, we draw on agency theory when examining incentives that may stimulate institutional change.

The principal-agent problem defines the difficulty in motivating the agent to act in the interest of principal. For the conceptual analysis of the model, we consider the framework of a public university becoming entrepreneurial and assume that the principal is a dean while the agent is a professor. With the proposed conceptual model, we explore how an individualised incentive system could increase professor's motivation to contribute to the university's mission to become entrepreneurial.

From this thesis we learn that history and geographical location determines specific paths of socio-economic development and opportunities for innovation-based growth. In order to change these paths, countries should recognise the role of meso-level (institutional) and micro-level (agency) factors and their overall impact in creating and implementing policies that specify the "rules of the game" and influence the overall dynamics of NISs. More specifically, we learn that the role of the institutional entrepreneur is essential in the process of institutional change. From the principal-agent model we learn that the individualised incentive system may be utilised by institutional entrepreneurs to motivate employees to contribute to the change from ordinary to entrepreneurial institutions.

1.3. The challenges of economic development for emerging European economies

Understanding the factors behind the large differences in income and quality of life between rich and poor nations has been an ongoing theme in academic and policy debate. A wide-ranging debate over the sources of economic development, and over which economic and social mechanisms might encourage 'catch-up' by lower-income nations, has preoccupied economists since Adam Smith's investigation of the Wealth of Nations (1776). This thesis contributes to this long-standing debate by focusing on the sources of differential economic development within Europe.

While there are many drivers of economic development and growth, this thesis explores factors behind the pace of innovation in the production of goods and services. Sustaining and accelerating the pace of innovation in any nation can enhance its current and future growth rates. Therefore, encouraging a surge of innovation across Europe is one way to close the gap between its richer and poorer nations. Innovation-based growth may address both short-term and long-term barriers of growth such as prolonged post-crisis recessionary conditions and an aging population across Europe.

High-quality, innovation-based growth could be a key building block for attaining long-term, sustainable, economic success in Europe.

Innovation is a result of an interconnected set of activities by various actors: the acquisition and development of knowledge that might enhance the quality of goods and services, the presence of people within the nation-state interested in developing and deploying new methods and technologies, the existence of local institutional settings that provide support for entrepreneurs in refining ideas and bringing them into existence, the availability of the capital needed to support the implementation of new processes and products, and so on. The whole process of innovation is clearly knowledge-based. Therefore, this thesis explores the set of interconnected, knowledge-based practices that generate innovation and accelerate the pace of economic growth. This focus parallels with Schumpeter's broad definition of innovation and entrepreneurship. For convenience, the whole assemblage of practices generating innovation and economic growth is understood as the "knowledge economy" (Stiglitz and Greenwald, 2014).

The attention of this thesis is on identifying the factors permitting the creation and expansion of the knowledge economy. Stiglitz and Greenwald (2014), in a major study, show that continuous learning, R&D and innovation are the most important factors for a successful knowledge economy. Recent evidence suggests that Europe lags behind in these areas. In 2012 the EU allocated only 2.1% of GDP for R&D spending, while Japan spent 3.7%, China 1.8% and the US 2.8 % (The 2014 Global Competitiveness Report). Therefore, the gap amongst regions has been widening. Decreasing productivity could also be a cause of the lack of competitiveness, therefore resulting in negative growth or stagnation in Europe. Using their assessment of the EU KLEMS data, Timmer et al. (2008) argue that European productivity slowed down because of the "slower emergence of the knowledge economy" since 1973 (Timmer et al., 2008, p. 25). Over the last 20 years, Asian countries have increased their efficiency and productivity quite significantly, but the US and especially Europe were lagging behind. Indeed, in part because of these factors, the overall rate of growth of Europe has lagged behind Asia, North America and Africa over the last 20 years.

The academic scholars recognise that the reasons behind production, technological and scientific backwardness are manifold in the case of the European periphery paradox. Some argue that major reforms such as the collapse of the Soviet

bloc, joining the EU and the 2008 financial crisis caused specific dynamics or an evolution of policies that affected structural change and development (Radosevic, 2009; Kattel and Primi, 2012). After the collapse of the Soviet bloc, the Central Eastern European (CEE) countries followed the mainstream Washington Consensus³ market-oriented approach. After 50 years of the active role of state, markets were expected to lead the structural change and development. International trade and openness were expected to create incentives for competition as well as investments for modernisation and innovation.

However, many economists agree that the free market approach did not create the right incentives for the transformation of the CEE countries. Therefore, it is important to understand the thinking behind policies for catching-up⁴ before getting into more detailed analysis of economic theories and specific factors. Kattel and Primi (2012) argue that the European periphery paradox (or a mismatch between innovation policy goals and actual capabilities of private and public actors) is a result of the application of the Washington Consensus policies. They also note, that even though the European Commission recognized these challenges of the CEE countries during initial negotiations for joining the EU, “its influence has perversely consolidated or even deepened these challenges” (ibid, p. 284). As a result, policies for development and innovation returned to the agendas of policy makers in the 2000s under the umbrella of the NIS approach, with the goal of supporting competitiveness. Scholars call this shift towards policies and a more active role of the state as a post-Washington Consensus strategy (Radosevic, 2009; Perez and Primi, 2009; Stiglitz, 2004).

Stiglitz (2004) argues that the original Washington Consensus policies were revised after better understanding of the East Asian miracle and the failures in the

³ The Washington Consensus describes a set of interrelated policies for macroeconomic stabilization and trade liberalization in state-directed economies that are largely based on the experience of Latin America in the 1980s. Attributes of the Washington Consensus are: 1. Fiscal discipline 2. Reordering of the priorities of public expenditure (from indiscriminate subsidies to basic health and education, to pro-poor subsidies) 3. Tax reform (broad tax base and moderate marginal tax rate) 4. Liberalization of interest rates 5. Competitive exchange rates 6. Trade liberalization 7. Liberalization of FDI (a comprehensive capital account liberalization was not included) 8. Privatization 9. Deregulation (easing barriers to entry and exit) 10. Property rights (enabling the informal sector to gain property at acceptable costs) (Williamson, 1990, 1999, 2004).

“The Washington Consensus represented, in part, a reaction to the failures of the state in attempting to correct those of the market” (Stiglitz, 2004, p. 3).

⁴ “The phrase ‘policies for technology catch-up’ covers a broad area of innovation policy that is closely linked to other components of industrial policy such as competition and trade” (Radosevic, 2009, p. 24).

structural adjustment of the CEE countries⁵ (World Bank, 2005). As a result, an augmented Washington Consensus⁶ emerged with new institutional economics (North, 1990 and 1991; Williamson, 1979 and 2000) and new growth or endogenous growth theory (Lucas, 1988; Romer, 1994) as intellectual basis.

The new growth theory argued for public support for R&D and horizontal industrial policy to enhance framework conditions (such as improving the climate for investments and reducing market failures). Institutions were understood as determinants of growth and wealth (Acemoglu et al., 2001; Easterly and Levine, 2003). The augmented Washington Consensus favoured policies supporting entrepreneurship which later led to strong focus on SMEs (Small and Medium Enterprises) and VC industry (Venture Capital). Innovation policies were very important in the OECD countries, but only secondary for the developing countries during the periods of the original and augmented Washington Consensus.

The augmented Washington Consensus could be characterised “as a general micro policy” which did not address the problems of developing countries as argued by Radosevic (2009). Since it did not prove to be effective, a post-Washington Consensus emerged as an alternative approach (Stiglitz, 2004; Katz, 2006; Radosevic, 2009). Radosevic (2009) notes three major features of the post-Washington Consensus: introduction of a meso-level (institutional level) analysis with the IS approach; industrial upgrading and structural change (specialization vs. diversification) at the core of growth policies; as well as acknowledging uncertainty of policy implications.

The Washington Consensus clearly distinguished between micro and macro level policies. However, during the post-Washington Consensus period “the meso level becomes the core focus for any technology catch-up policy” (Radosevic, 2009, p. 32). Katz (2006) and Radosevic (2009) argue that the extensive literature on

⁵ World Bank (2005) pointed to ‘five disappointments’: 1. Output losses during transition in the former Soviet Union and Eastern Europe; 2. The East Asian financial crisis; 3. The collapse of the Convertibility Regime in Argentina; 4. Lack of rapid growth, particularly in Latin America; 5. Continued stagnation in Sub-Saharan Africa.

⁶ The augmented Washington Consensus added additional items to the Original Washington Consensus: 11. Corporate governance 12. Anti-corruption 13. Flexible labour markets 14. World Trade Organisation agreements 15. Financial codes and standards 16. ‘Prudent’ capital-account opening 17. Non-intermediate exchange rate regimes 18. Independent central banks/inflation targeting 19. Social safety nets 20. Targeted poverty reduction (Rodrik, 2006a).

innovation systems revealed that the key problems of developing countries might be within their innovation systems.

This short revision of the evolution of policies for development and catching-up shows that the political aspect of economics is equally as important (or sometimes even more important) as the theoretical one. It also points to the appropriateness of the NIS framework in contributing to the academic debate on the European periphery paradox. All countries have some form of innovation system which may work well or badly. The NIS framework might help to explain the major differences between systems by looking at the institutional structure, the policies and the internal dynamics amongst actors of the system. Nelson (2004) argues that the concept of NIS has common characteristics with the engineering approach since it analyses innovation as an interactive process. Therefore, he calls NIS a critical social engineering approach with theoretical ambitions. The next chapter on theoretical background will explore the features of the NIS approach in more detail.

Chapter 2: Theoretical and methodological insights/ literature

2.1. Introduction

This thesis is grounded in the framework of national innovation systems which draws on evolutionary economics. Even though the concept of innovation systems was first used for the economic analysis of OECD countries, academic scholars agree that it might be very useful for developing countries as well. This is because the concept focuses on endogenous capability building through an interactive process of learning and views technical, social and economic change as one of the most important factors for economic growth and development. The purpose of this chapter is to explore how other theories relate to the NIS approach and how they might help to answer questions raised by this thesis. The chapter has the following structure: we first discuss features of the NIS approach and the most recent literature; we then review other development theories and relate them to NIS. In the following section, we identify gaps in the NIS approach and we discuss how other theories could enhance the current theoretical framework of NIS.

2.2. The national innovation system approach

Freeman, Lundvall and Nelson are acknowledged as the founding fathers of the innovation systems framework (Fagerberg and Sapprasert, 2011). The term ‘NIS’ was first used by Freeman in 1987 and was defined as “the network of institutions in public and private sectors whose activities and interactions initiate, import, and diffuse new technologies” (Freeman, 1987, p. 1). Edquist (1997) provided a broader definition of NIS: “all important economic, social, political, organisational, institutional and other factors that influence the development, diffusion and use of innovations” (Edquist, 1997, p. 14). Lundvall (1992) initially suggested a narrower definition. He argued that NIS includes “the structure of production” and “the institutional set up” which “jointly define a system of innovation” (Lundvall, 1992, p. 10).

All countries have a national innovation system, but there is no single definition of it. In academic literature, some authors use a broad definition of NIS, whilst others use a narrow one. All definitions acknowledge the active role of state, although some distinguish between formal and informal elements of NIS (Table 1). In the NIS literature of developing countries, Lundvall et al. (2009) argue for a broader

definition: a network of private and public, formal and informal institutions. This broad definition by Lundvall et al. (2009) will be used for the purpose of this thesis.

Table 1: Interaction between formal and informal elements of NIS (Schoser, 1999).

	Narrow	Broad
Formal	Science and technology organisations, institutions and formal networks	Organisations, supporting innovation in general, institutions and formal networks
Informal	Science and technology informal institutions and informal networks	Informal institutions influencing innovation in general, institutions and informal networks (defined as cultural and historical values)

The NIS framework evolved from the innovation systems (IS) framework. Early work of the IS originated in small Nordic countries (Finland, Sweden, Norway and Denmark) and helped them to prosper and to compete with large industrialised countries (the US, Japan, Germany, France, the UK) by developing a “highly developed capacity to absorb and use new technology developed elsewhere” (Lundvall et al., 2009, p. 9). Freeman (1995a) provides evidence to argue that the high rate of technological change, development and growth in the 1950s and 1960s depended less on high R&D or being first with innovation and more on the efficient diffusion of knowledge.

Development of the IS approach was influenced by the evolutionary growth theory (Nelson and Winter, 1982). The evolutionary growth theory was inspired by Schumpeterian innovation (1943) and emerged as a critique of static neoclassical growth models. Schumpeter (1943) stated that technological progress (or innovation) is the main source of growth. He also argued that technological progress could be shaped by policies and institutions, therefore, industrial policy and institutional arrangements are important factors in economic growth (ibid, p. 1943). The evolutionary theory expanded Schumpeterian innovation analysis to include institutions and organisations as the centre of economic growth analysis.

Lundvall, Nelson and Edquist are the most influential authors in the development of IS approach. Nelson (1993) argues that innovation could be analysed as an evolutionary process and not just as a direct result of technological changes within firms seeking to maximize profits. He adds that technological change is an open-ended and path-dependent process without an optimal solution and evolves randomly. The randomness of innovation nature suggests that evolutionary models of

technological change are more relevant in explaining innovation than neoclassical models (Nelson, 1993). Lundvall (1992) notes that technological change is evolutionary and draws on processes of learning, interactive learning and user-producer interactions for his NIS framework. He bases his analysis of NIS on innovation theory and contributions from Aalborg University (Denmark). Edquist (1997) contributes to the IS approach by emphasizing the collective interactive process with a wide range of private and public actors, firms and organisations.

The IS approach has been used for over 30 years to study national, regional and sectoral systems, but definitions or descriptions of IS still vary between authors in academic literature. Therefore, some authors chose to define each term separately. Nelson and Rosenberg (1993) use a narrow definition of 'innovation' and restrict it to technical innovations, so naturally they argue for a 'sectoral' approach and debate over the national system. They think that the 'national' approach is too broad since institutions supporting aircrafts do not overlap with institutional systems supporting pharmaceuticals (ibid, p. 5). However, they admit that there are some institutions in the technology field that could affect all sectors and they may be international. Lundvall (1992) implies that 'innovation' could be viewed as new combinations in technological processes and production, new forms of organisations and institutional changes. He is against the 'national' innovation system approach because of increasing internationalisation and argues in favour of the IS approach. Carlsson and Stankiewicz (1995) define 'innovation' as technological change with a focus on the institutional infrastructures of technological systems. They talk about technological systems, but do not draw a clear line between national, regional or sectoral approach.

The concept of 'system' is central in national, regional and sector analysis. Fleck (1993) defines 'systems' as "complexes of elements or components, which mutually condition and constrain one another, so that the whole complex works together, with some reasonably clearly defined overall function" (ibid, p. 5). Edquist (1997) argues that the systemic character goes beyond the linear view of technological change, where R&D leads to productivity growth through innovation and diffusion.

Carlsson (1995) with Nelson and Rosenberg (1993) take different sides regarding the role of state in creating or changing innovation systems. Carlsson states that governments consciously build and enhance technological and other systems. On the other hand, Nelson with Rosenberg argue that systems of innovation cannot be

consciously created or developed by policy makers. They (Nelson and Rosenberg, 1993) define the concept 'system' as a set of institutions influencing innovation, but there is no presumption that these institutions work together. Edquist (2011) argues that the truth is in between these two extremes. He agrees that a national system as a whole cannot be created, but some elements may be consciously designed by policy.

Despite all the differences, Nelson (1993), Edquist (1997) and Lundvall (1992) stress the importance of national systems, since all policies influencing the innovation process are designed and implemented at the national level. Various NIS case studies show that nations vary in many different aspects: language, culture, institutional set-up, investment in R&D, size of public sector, standard of living and so on. Lundvall (1992) emphasises that institutions and industrial structure are two key components of NIS. However, the authors do not give clear criteria for identifying them. Lundvall (ibid) stresses that the definition of IS should be kept flexible and open. Edquist (2011) suggests including all important economic, social, political, institutional and organisational "factors which influence the development, diffusion and use of innovation" (ibid, 14). Edquist (2011) proposes the following nine common characteristics of innovation systems:

1. Innovations and learning (learning processes) are at the centre of IS.
2. The approach is holistic (no a priori exclusion) and interdisciplinary - all determinants of innovation are important (including economic, institutional, organisational, social and political factors).
3. A historical perspective is natural and important.
4. Differences between systems and non-optimality. There are substantial differences amongst the IS of different countries. There is no optimal IS because evolutionary learning causes continuous change.
5. Emphasis on interdependence (interaction between elements of the system) and non-linearity. Emphasis on demand of innovation – draws on Porter's determinants of national advantage, not just a linear input/output approach.
6. Encompasses product, technological and organisational innovations. Product and organisational innovations are closely related with technological changes since technological changes are 'socially shaped' within specific organisational capabilities.

7. Institutions are central. All systems of innovation – national, regional, sectoral emphasise the role of institutions in the innovation process.
8. Conceptually diffuse. No limits to the IS, which may be viewed as a strength and/or weakness of the approach.
9. Conceptual frameworks rather than formal theories. IS is not considered a formal theory since it cannot propose formal models showing relationships between variables.

2.3. Other perspectives on change, development, growth and innovation.

The NIS approach has various limitations and gaps like all other frameworks. In order to understand these gaps and how they could be enriched by other theories, it is important to review other development theories and understand how they relate to the NIS approach. This section of the chapter reviews how other theories view the role of the state, technological change and innovation, and the role of institutions etc. in the process of economic development and growth.

2.3.1. The classical perspective

The role of state in accelerating development and growth has been a controversial issue in different economic theories. Classical welfare economics and neoclassical theory dismiss the role of state beyond fixing market failures and providing legal support. As Chang (2003a and 2003b) notes, these theories view regulations, rules and institutions as rigidities, which might limit free markets from operating smoothly. Eighteenth-century classical economic growth theory was based on Smith's (1776) argument for minimal government intervention (*laissez faire*) to stimulate growth and only to ensure a stable legal framework.

Smith (1776) introduced the 'invisible hand', or market efficiency argument, stating that markets self-regulate and self-fix inefficiencies. Therefore, he dismissed industrial policy as an important factor which can shape markets and influence economic growth. Smith's contribution to growth theory, especially the following points, is still very important. He advocated for division of labour (to improve labour productivity) and specialisation (to achieve absolute advantage) as well as for the accumulation of capital and population growth to enhance growth. He emphasised that

population growth could be controlled in order to achieve output per capita increase in the long-run, since capital accumulation and population growth will reach the ceiling in the steady state mode where the economy cannot grow anymore (Smith, 1976, p. 82).

Later on, Ricardo (1817) developed a comparative advantage theory and model which showed that industry specialisation, combined with free trade, has positive results for national economic growth. With this theory Ricardo argued for the active role of state by focusing on the most competitive industries. Ricardo's analysis (1821) was based on a two-sector economy with constant returns to scale in the manufacturing sector and diminishing return to scale in the agricultural sector. Therefore, capital owners accumulate capital, but due to employment growth and higher productivity their profit decreases. As a result, less capital is accumulated, and the economy reaches its steady state (ibid).

The classical economic theory assumes the level of technology as a given. Technological change is usually necessary for higher productivity and returns to scale, but it is not explained at all by Smith (1776) or Ricardo (1817 and 1821). For this reason, from this thesis' point of view, the classical growth theory does not provide a basis for technological change, nor for learning or innovation analysis. However, it provides a basis for the role of the state and the efficient markets argument which will be discussed later on.

2.3.2. The neoclassical perspective

Originally, the neoclassical growth theory explains long-run steady growth by changes in labour and capital (based on the original formulation of Solow, 1956). Later on, technological change is added to the model. However, technological change is treated as an exogenous variable and remains unexplained by all neoclassical models, even though the theory argues that it is very important for growth. The model proposed by Solow (1956) and Swan (1956) is based on the technological progress rate and provides a basis for the neoclassical growth theory with the production function $Y = F(K, AL)$ at the center of the model.

According to the model, output (Y) depends on capital (K) and labour (AL), which is measured by the amount of labour and the productivity of labour determined by the available technology. The neoclassical growth model focuses on a closed

economy and assumes constant returns to scale. It also implies full employment (Solow, 1956 and 1957; Swan, 1956). Besides these market clearing conditions, focusing mostly on the accumulation of capital as the major source of growth and treating technological progress as neutral (because of scale effects as argued by Solow, 1957) could be seen as weak points of the neoclassical growth model.

The Mankiw-Romer-Weil model (Mankiw et al., 1992) provides an important contribution to neoclassical growth modelling by augmenting the Solow model to explain international differences in per capita income. The authors add human capital accumulation to the Solow growth model to analyse the 1960-1985 growth of Western European and North American countries. They claim that the predictions of the Solow model (i.e. saving and population growth increase income) are consistent with evidence and “more than half of the cross-country variation in income per capita can be explained by these two variables alone” (Mankiw et al., 1992, p. 407). They show that population growth has a larger impact on growth per capita than predicted by Solow.

In terms of growth dynamics, while the economy is not in steady state, the model predicts that countries with the same technology, population growth and accumulation rates will converge in income per capita (which is in line with Solow). However, Solow predicted that an economy would reach a half steady state in 17 years, while the Mankiw-Romer-Weil model showed that the same changes could happen in 35 years. Even though the Mankiw-Romer-Weil model supports the Solow model and provides an explanation for cross-country variance in income, it still fails to account for technological progress. As a result, endogenous growth models try to explain technological progress by adding additional economic variables.

Endogenous growth (new growth) theory developed as a critique to neoclassical exogenous growth theory by building macroeconomic models based on microeconomic foundations. As argued by Romer (1990) and Mankiw (1995) the neoclassical theory is not useful for explaining growth variations in different countries since it assumes “that different countries use roughly the same production function at a given point in time” (Mankiw, 1995, p. 281). They both argue that international differences are too big and the initial conditions of the economy matter for much longer than the model predicts, and also that variations in rates of return across countries are smaller. Mankiw also critiques unrealistic steady state prediction: how

is it possible that the steady state of growth depends on technological progress, but technology is an exogenous variable in the model?

The work of Arrow (1962), Uzawa (1965) and Sidrauski (1967) formed the basis for endogenous growth theory. They argued that economic growth is the result of endogenous (e.g. investment in human capital and knowledge), not exogenous forces. As a result, positive externalities and spillover effects from innovation cause development in the knowledge-based economy. The endogenous growth theory states that the long run growth depends on policy measures. Therefore, subsidies for R&D increase the growth rate by increasing incentives for innovation.

Two types of endogenous growth models were developed: the “AK” style models by Romer (1986 and 1987), Lucas (1988), Rebelo (1991) and the “R&D” based models by Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992). The AK models give a constant saving rate of endogenous growth (assumes exogenous savings rate) and model technological progress with a single parameter (A is measured as a level of technology). They assume that the production function does not lead to diminishing returns (Romer, 1986) because of positive spillovers from investments or improvements in technology, leading to further improvements and learning by doing (Lukas, *ibid*). The R&D models add significant contribution to growth theory because they incorporate imperfect markets (Romer, 1990) and R&D that leads to technological progress.

Back in 1962 Arrow did not account for population growth and treated it as exogenous. Consequently, Romer (1986) filled in this gap with the increasing returns model of long-run growth. Romer proposes a competitive equilibrium model with endogenous technological change and knowledge as an input in production with increasing marginal productivity. Romer emphasises knowledge as the basic form of capital which increases marginal product. He treats knowledge as a natural externality, because new knowledge created by one firm has a positive external effect on other firms (since new knowledge cannot be kept as a secret). He combines three elements: externalities, increasing returns (in production of output), and decreasing returns (in the production of new knowledge), in a model which explains “historical growth in the absence of government intervention” (Romer, 1986, p. 1004).

The Romer’s (1986) model proposes an alternative view of long-run growth which shows that large countries may always grow faster than small countries, because

growth is driven by “the accumulation of knowledge by forward-looking, profit-maximizing agents” (ibid, p. 1003). According to the model, small and developing countries may persistently experience slow growth. Therefore, the per capita income of different countries will not converge. The lack of convergence could be viewed as the first critique of the model, since it cannot be used to compare different countries. Also, Romer (1989) states that his model allows for the possibility of the aggregate production function of the economy as a whole, but at the same time he admits that the model does not account for institutional factors and government policies. He admits that the evolution of institutions and policies affect opportunities for investment and future returns, therefore, these factors should be included in the theoretical foundations of growth theory.

Lucas (1988), in his models, introduces increasing returns and human capital effects to account for sources of technological change and to address the issue of international comparison. He proposes three models: a model focusing on physical capital accumulation and technological change, a model of human capital accumulation through schooling and a model of human capital accumulation through learning by doing. He argues that with these models he found the suitable mechanics to study economic development and growth because these models take into consideration both kinds of capital: physical and human. Physical capital utilises production, and human capital increases the productivity of both labour and physical capital (Lucas, 1988, p. 38). However, Lucas is analysing a closed single economic system. As a result, all changes depend on the initial conditions and, initially poor countries will remain poor which is in line with Romer’s (1986) conclusions.

Even by introducing trade and labour mobility, Lucas (1988) does not address economic development and international comparison questions as he claims to do. This is because, changes in human capital are no longer internal with labour mobility. By moving to a wealthier country and by earning more money, an employee “will increase wealth of a country in which he is employed” (Lucas, 1988, p. 40). Lucas admits that his models do not capture one pattern to which all economies conform. He also admits that the models do not capture multiple forces that change growth patterns within countries. His models only capture some mechanics affecting these forces, but a more systematic analysis could give more insights into growth and development theories and models.

In 1990, Romer introduces the endogenous technological change model. He treats technology as an intentional investment by profit-maximising agents in a monopolistic competition. The model has four inputs: capital measured as consumption goods; labour measured as skills by counts of people; human capital as a cumulative effect of formal education and on-the-job training, which is a more limited measure compared to Lucas' (1988) model; and an index of the level of technology (Romer, 1990). The model suggests that free international trade can accelerate growth and that an economy with a large population will have faster growth. It also suggests that low levels of human capital (measured as formal education and on-the-job training) may explain why growth is slow in closed, underdeveloped economies (Romer, 1990, p. 99). This model highlights the role of national capabilities for growth and development. However, as argued by Castellacci and Natera (2013), it neglects structural analysis of a country's innovation dynamics and change.

Endogenous growth theory provides an important contribution by acknowledging that many factors contribute to growth and innovation. It helps to better explain technological progress by offering interdependence links (e.g. between growth and R&D or education and growth) in one economy, but becomes too complex and unmeasurable empirically if used for multiple countries (Sardadvar, 2011; Krugman, 2013). Pack (1994) notes that endogenous growth models are still neoclassical models, they only continue testing previous models by adding additional variables, but they do not question or test endogenous growth theory itself. Mankiw (1995) states that endogenous growth models still do not help macroeconomists to better understand international differences.

Both Pack (1994) and Mankiw (1995) agree that endogenous growth models have too many assumptions about international production functions. Both authors note that these models look good in theory but not in practice since many variables, such as knowledge, are unmeasurable. Mankiw suggests a different assumption for growth analysis: that all countries have the same access to knowledge, but they have different abilities or needs to "take advantage of this knowledge by investing in physical and human capital" (Mankiw, 1995, p. 301). Mankiw's proposal is in line with the concept of absorptive capacity used in innovation analysis to understand the abilities of firms and nations to absorb innovation, as noted by Abramovitz (1986 and 1995) and Dahlman with Nelson (1995).

On the empirical side of neoclassical cross-country growth models, Mankiw (1995) and Pack (1994) emphasise simultaneity, multi-collinearity and degrees of freedom problems. “Right hand side variables are not exogenous, but jointly determined with the rate of growth” (Mankiw, 1995, p. 303), which could lead to a positive correlation between investment and growth, for example. Therefore, cross-country data analysis does not show the real direction of causality between growth and investment (ibid). Multi-collinearity shows a strong correlation amongst the right-side variable: e.g. high-income countries have high investment, high enrolment in schools and more developed financial markets. Pack also argues that there are not enough degrees of freedom to answer all the questions about growth and that there is not an easy solution to the problem. Therefore, results usually depend on what variables economists choose to exclude. Mankiw states that relying on any cross-country estimate would only lead to harmful policy which, according to him, is worse than no policy at all.

Neoclassical growth theory sheds light on many important factors contributing to economic growth and innovation, however, it neglects the role of the state in innovation and leaves it to competitive markets and rational individuals. Endogenous growth theory contribution in understanding the internal factors of innovation is especially important. It reveals important links between education, learning by doing, population growth, R&D and growth. Despite this, it still fails to develop a systematic point of view in endogenous growth models. It fails to identify factors that change system-wide, national innovation capabilities and absorptive capacities because it overlooks the networks between institutions, policies and people. These factors are hard to incorporate into formal mechanistic models. Therefore, qualitative methods could be incorporated into the analysis and may provide additional useful information.

2.3.3. Industrial policy, varieties of capitalism and national competitive advantage perspectives

There are a few alternative approaches in academic literature that favour the active role of the state in development, growth, competitiveness and innovation through policies and institutions. As argued by Wade (2011) and Warwick (2013) there is evidence of renewed interest in industrial policy, but there is also a great deal of confusion about what is meant by the term ‘industrial policy’. Wade notes that

definitions have changed together with historical industrialisation and innovation processes but, in the simplest way, an industrial policy is a government effort to influence (or not to influence) an economy vertically or horizontally. Also, as argued by Bosch (2014) the term ‘industrial policy’ is often used as a synonym for the EU competition policy since it overarches to mergers, state aid regulation and promotion of inward direct investment.

Warwick (2013) suggests a comparative advantage-following or a comparative advantage-developing industrial policy approach, depending on an economy’s catching-up or the frontier mode. He defines industrial policy as “any type of intervention or government policy that attempts to improve the business environment or to alter the structure of economic activity toward sectors, technologies or tasks that are expected to offer better prospects for economic growth or societal welfare than would occur in the absence of such intervention” (Warwick, 2013, p. 16). On the other hand, Milberg, Jiang and Gereffi (2013) argue that the traditional view of industrial policy changed with the expansion of global value chains (GVCs) since the 1990s. They propose vertically specialized industrialisation to accommodate industrial upgrading within GVCs, with less focus on the national economy and more focus on the international networks of firms.

Wade (2011) focuses on a different industrial policy perspective. He advocates an industrial policy as a support for meso-level networks since international organisations like the World Trade Organisation (WTO) consider only hard policies (protection, subsidies, and quotas) illegal. He defines industrial policy as “focused neither on the individual firm nor on the geographic region but on networks of firms” (Wade, 2011, p. 223). Wade argues that as a support for meso-level networks, industrial policy could be used by middle-income countries to get out of a ‘middle income trap’. However, as argued by Botta (2014) and Pianta (2014) Europe-wide industrial policy is not very effective because of large differences amongst countries. Individual national industrial policy might not be effective since, by definition, it does not consider all agents and networks involved in the innovation process.

Bosch (2014) notes that the current Europe 2020 strategy places innovation at the core of industrial policy and uses the Horizon 2020 program as the main financial instrument to provide 80 billion euros (in 2014-2020) for research and innovation through its industrial leadership pillar (The European Commission, 2013). The EU

countries have to compete in order to get the funding in key priority areas. However, Pianta (2014) argues that these rules do not account for the different capabilities of various member states that enable them to participate in these research projects, to adopt, and to implement the proposed practices. These EU policies ignore current internal differences and problems of member states, their financial capabilities and the possible shortage of experienced staff to participate in Horizon programs, as noted by Botta (2014) and Pianta (2014).

Porter (1990) with Hall and Soskice (2001) offer very different perspectives on national competitiveness compared to industrial policy approach. Porter argues that national difference is the key for competitive success, therefore, it is up to the national government, industry and firm to increase it. Hall and Soskice also note that countries do not converge to one model of capitalism. They argue that specific institutional arrangement creates the national comparative institutional advantage. Porter (1990) offers a national diamond approach for the analysis of national competitive advantage and innovation potential.

The four angles of the diamond include factor conditions, demand conditions, related and supporting industries, and firm strategy, structure and rivalry. Porter defines factor conditions as skilled labour and infrastructure. Demand conditions are defined as the national demand for products and services of a particular industry. The presence or absence of related suppliers and supporting industries are considered as well. Conditions of national policies relating to opening, organising and managing companies, together with domestic rivalry amongst firms, compose the last determinant of the national diamond.

Porter (1990) argues that dynamic determinants of the diamond and links amongst them shape the speed of improvements and the direction of innovation in firms and industries. He analyses national diamonds of ten developed countries to explain their competitive advantage in the chosen industries. He starts with competitiveness of individual industry and then builds up to national economy competitiveness as a whole. With this analysis, Porter shows that national attributes are very important for the competitive advantage of a nation. He urges firms, industries and governments to understand that changes come from within a country and not from “outside help that eliminates the need to improve” (Porter, 1990, p. 735). Porter argues that globalisation did not diminish the role of national governments in economic

upgrading. He notes, that only a choice, to react or not to react to globalisation by upgrading, could change standards of living.

The varieties of capitalism approach proposed by Hall and Soskice (2001) distinguish between two types of capitalism: the coordinated market economy (CME) and the liberal market economy (LME). They argue that these two approaches mostly differ in institutional settings and policies and therefore have different comparative advantages in human capital formation, production and innovation. Hall and Soskice stress the importance of institutional structure and argue that the value of one institution is enhanced by the value of the other. The CMEs (such as Germany and the Nordics) invest in competencies and resolve coordination problems through interactions between firms, industries and supportive institutions. Hall and Soskice address the following features of the CME model: the financial system provides firms with access to ‘patient finance’; the internal structure of a firm supports networking, production strategies of a firm depend on a highly skilled labour force; a firm relies on education and training systems from trade unions or industry employee associations; a firm depends on inter-company relations to facilitate diffusion of technology.

Hall and Soskice (2001) note that firms in the LME model (practiced in the US and the UK) achieve growth by relying on market relations to solve all coordination problems, while CME rely more on non-market institutional coordination. Therefore, the authors argue that these differences in institutional structure provide different comparative institutional advantages for innovation. CMEs are better in incremental innovation⁷, since the workforce is very skilled to come up with innovations, while the LME’s institutional structure limits incremental innovations, therefore, LME countries are better at radical innovations⁸. To illustrate these differences, Hall and Soskice provide innovation analysis of Germany and the US and prove that “Germany

⁷ Incremental innovation concerns an existing product, service, process, organisation or method whose performance has been significantly enhanced or upgraded. This can take two forms: a simple product may be improved (in terms of improved performance or lower cost) through use of higher performance components or materials; or a complex product comprising a number of integrated technical subsystems may be improved by partial changes to one of the subsystems.

⁸ A radical (or disruptive) innovation is an innovation that has a significant impact on a market and on the economic activity of firms in that market. This concept focuses on the impact of innovations as opposed to their novelty.

specialises in technological developments that are just the reverse of those in the USA” (ibid, p. 41).

While the varieties of capitalism (Hall and Soskice, 2001) and Porter’s (1990) national competitive advantage approaches broaden analysis by incorporating institutional network, policies and culture into the analysis, they do not elaborate on the possibilities of institutional evolution and change. Both approaches state that each country has a very specific institutional setting that cannot be replicated by any other country. These approaches are not very helpful for my thesis since I assume that institutions, policies and networks could change and could become more effective in facilitating innovation.

2.3.4. Development perspective

The innovation systems approach draws on a few similar debates and issues raised by development economics many years ago. However, the position of development economics was weakened by the neoclassical growth theory favouring efficient markets and free trade during the second half of the twentieth century. Neoclassical economists used theoretical models to explain growth, but completely dismissed analysis of structures and mechanisms lying behind economic development. Therefore, for the purpose of the thesis, it is worth revisiting some ideas from the theory of development economics.

The field of development economics evolved in the 1940s and 1950s with Rosenstain - Rodan (1943), Dobb (1951), Lewis (1954), Hirschman (1958). These scholars debated about balanced versus imbalanced growth, and Marxian capitalist accumulation versus more liberal high productivity-focused growth advocated by Lewis (1954). The role of state versus markets, free trade versus protected markets, and industrialisation as necessity towards modernisation of economy are the three key issues debated by development economists. Most development economists agree on the importance of import substitution and are in favour of the active role of the state in protecting infant industries to increase sector competitiveness. In addition, in 1983 Sen proposes the capabilities approach that suggests that a state should also be responsible for social change in a society.

Sen (1983) raises an important issue in development theory by linking human wellbeing with development and growth. Sen introduces personal capabilities and

freedoms as important attributes of development. He argues that experiences and abilities to do certain things (e.g. getting in to a good university) matter more for people in comparison to owning or earning money. He urges governments to consider freedoms, opportunities and personal abilities in order to achieve better outcomes in economic policies. The innovation systems approach also draws on Sen's ideas. Gu and Lundvall (2006a and 2006b) show parallels between economic growth and welfare in their analysis of China following Sen's (ibid) capabilities approach. They argue that the Chinese government has been protecting domestic competences, developing "independent innovations" and working on "harmonious growth" to increase capabilities and wellbeing (access to education, health services, clean air and water).

Even though development ideas were weakened by the emergence of the neoclassical growth theory, Sen (1983) notes that successful countries still followed the development advice and experienced export led growth after practicing import substitution. Chang (2003a and 2003b) and Mazzucato (2013) agree with Sen (ibid) and provide examples of historical data confirming that the most advanced world economies (the UK, the USA, Germany, France, Sweden, Belgium, the Netherlands, Switzerland, Japan and East Asian countries) used protectionist policies successfully in the 19th and 20th centuries to grow their industries.

A study by Maddison (1989) of the largest OECD economies (based on 1950-1987 data) showed that the fastest per capita growth was in Japan (6%), Austria (3.9%), Germany (3.8%), Italy (3.7%), Finland (3.6%), Norway (3.4%), and France (3.2%). These countries practiced significant degrees of protectionism like tariff protection and subsidies to promote targeted industries. They also set up state-owned enterprises or public-private joint ventures for risky projects, regulated foreign direct investments, and implemented many other measures of industrial policy during this period (Chang 1994, 2003a, 2003b and 2008).

The role of government policy in development, growth and innovation has always been very important. The state has been the key player during the industrialisation period by protecting local industries as previously argued. The state is still important in the 21st century innovation focused knowledge economy. The state still creates and shapes markets, and acts as an entrepreneur, conflict manager and innovator. Chang (2003b) argues that the two roles – entrepreneur and conflict

manager - are especially important in the process of development and structural change. As the entrepreneur, the state provides a vision for a change and also institutional structure to facilitate coordination. As the conflict manager, the state acts like a guarantor of property rights and as a designer and executor of public policy.

Chang (2003b, p. 69) provides the role of state examples from two types of capitalism: the Anglo-Saxon variety of capitalism (LME) and the industrial policy capitalism like East Asia and the Nordics (CME). He notes that both types of capitalism use the state as an entrepreneur and a conflict manager. The first role is more important in liberal market economies while the second one in the coordinated market economies. However, as Chang states, it is obvious that the state is able to perform both of these functions successfully. Chang (2003b) argues that “the state is bound to play critical roles” in modern global innovation economies and by dismissing these roles, countries “will delay the emergence of a coherent coordination structure” and make the economy unable to change without considerable waste and/or social division” (ibid, p. 70).

Stiglitz and Greenwald (2014) as well as Mazzucato (2014) provide convincing rationales for the role of government in knowledge development, growth and innovation. Stiglitz and Greenwald focus on the role of the state in knowledge creation, while Mazzucato on the role of the state as entrepreneur. Stiglitz and Greenwald argue in favour of the active role of government, since “markets on their own do not create a learning society” (2014, p. 19). They provide convincing arguments for infant economy protection and argue that public policies should move beyond creating a learning economy to creating a learning society and a learning mind-set.

Stiglitz and Greenwald (2014) urge countries to tailor their industrial, innovation, education, and labour policies to promote learning societies based on their local needs. The contribution by Stiglitz and Greenwald (2014) is important because it goes beyond the role of government in fixing market failures. Mazzucato (2013) also argues in favour of an entrepreneurial active state and provides the US-based evidence to support her arguments. She focuses on case studies from the IT, biotech and pharmaceutical sectors and shows that the state has been a successful entrepreneur in R&D processes to generate innovations. Mazzucato advocates for a strong, national,

public sector role in Europe to allow weaker countries to make strategic industry investments that Germany and other advanced countries did in the previous century.

The role of the state as a controversial issue in academic literature could be explained by an increasing focus on econometrics. Krugman (1995) argues that the development economist could not present arguments in a language understandable to the mainstream economist, and endogenous or new growth theory should have helped. Following this idea, Stiglitz and Greenwald (2014) try to merge development and innovation (as knowledge creation) ideas into theoretical endogenous growth models in their recent work. They draw on Arrow's endogenous growth theory to argue that creating a learning society should be one of the main objectives of public policy. Their analysis provides the basis for a new theory of the firm and a new way of thinking about static and dynamic comparative advantage. The authors argue that most of the learning in societies happens within firms: they lay out simple models which identify learning spillovers and show that monopolies are more innovative compared to duopolies or even more competitive markets. They also create dynamic models to show that innovation could be welfare-enhancing by lowering unemployment and inequality.

However, the analysis provided by Stiglitz and Greenwald (2014) reveals some weaknesses of endogenous growth theory. They advocate for the active role of the government in stimulating knowledge creation, innovation and growth, but they develop the theory of a firm and fail to show links to policies or institutions. Their proposed models are at the micro-level, however, the role of government is discussed at the macro level. A meso-level analysis of links and structures between them is missing and could make these theoretical models more useful.

2.4. How does the NIS approach relate to other theories?

Some economists argue that the NIS approach could enrich development and growth theories by expanding the overall understanding of knowledge creation and competence building, and by revealing links between micro and macro-level factors (Arocena and Sutz, 2003; Archibugi and Pietrobelli, 2003; Lundvall et al., 2009). The NIS approach is linked with Sen's (1983) message that material growth does not equal welfare or well-being growth, therefore, one may argue that an efficient use of intellectual capital depends on social capital. Therefore, Lundvall et al. propose to

focus on competences of people and organisations to absorb, diffuse and create knowledge. Lundvall et al. (2009) also advocate for a ‘third way’ or meso-level (institutional/ organisational level) analysis of economic structures and institutions in order to assess how they shape capacity building.

The NIS approach could be viewed as an alternative analytical framework for the standard neoclassical economics and a critique of the “neglect of dynamic processes related to innovation and learning when analysing economic growth and development” (Nelson, 2004, p. 4). Nelson (2004) argues that the NIS concept shares common characteristics with the engineering approach since it analyses innovation as an interactive process. NIS is a grounded theory since it is based on accumulation of empirical studies. It is also a critical theory, since it was established as a critique of the Washington consensus international competitiveness concept that was determined by relative wage cost in OECD countries (Freeman, 1982). Therefore, Nelson (2004) calls NIS a critical social engineering approach with theoretical ambitions.

Nelson (2004) separates the two most important accomplishments of the NIS. Firstly, it helps to explain international differences by drawing attention to national policies enhancing non-price competitiveness. Secondly, it focuses on “system” dimension in innovation and industrial development, since innovation is not a linear, but rather an interactive process. Nelson (2004, p. 6) argues that the NIS concept shifted policy towards “building linkages and strengthening absorptive capacity of users” by “promoting learning and utilising knowledge more widely”.

Dosi and Nelson (1994) argue that the innovation systems approach gives new rationales for government policies and interventions besides just fixing market failures as argued by neoclassical economists. Innovation destroys old jobs, but it also creates new employment opportunities, therefore, Nelson (2004) argues that the systems of innovation approach is very relevant, since it helps to address and offset negative aspects of innovation towards employment.

Carlsson (2007) argues that endogenous growth theory focuses on the role of knowledge in macroeconomic growth, but it leaves knowledge in a black box of the aggregate production function. The innovation system approach, in his opinion, analyses the microeconomic context within the box, especially by focusing on the role of institutions within the system. He gives three reasons why innovation systems analysis is better: “it makes it necessary to specify the components (and therefore the

boundaries) of the system; the relationships among various components in the system that need to be analysed; the attributes or characteristics of the components that need to be specified (Carlsson, 1998, p. 158).

After reviewing various links between the NIS and other theories, we might summarise four emerging intersections: the role of the state; institutional analysis; system setting; learning and capabilities. The push for change is at the core of all these intersections due to the evolutionary roots of the NIS approach. However, there are still only a few attempts to identify factors that influence internal dynamics of NISs, to explain how the process of institutional change unfolds, and how to motivate employees to act in the interest of an organisation and to support the change from an ordinary to an entrepreneurial institution. This thesis attempts to fill in these gaps by employing the innovation diffusion conceptual model, the concept of institutional entrepreneurship and the principal-agent model, and by linking macro, meso and micro levels together (Table 2).

Table 2: Identified gaps within NIS literature and explanations of how each chapter fills in these gaps.

Identified gaps within the NIS literature	How each chapter fills in these gaps?
The current literature does not explain factors that influence the internal dynamics of different NISs.	By incorporating the innovation diffusion conceptual model, Chapter 3 develops a conceptual and empirical model which tests the internal dynamics of NIS as coevolution between innovation diffusion and innovation. The model also reveals that different social, institutional and economic factors may influence the dynamics of different groups (types) of NISs. This chapter focuses on system-level analysis.
The current literature does not explain how the process of institutional change unfolds and what factors could reinforce the transformation of a transition NIS.	Chapter 4 employs the concept of institutional entrepreneurship and reveals that institutional entrepreneurs may stimulate institutional change within transition NISs. This chapter focuses on meso-level analysis.
The current literature does not explain how to motivate employees to act in the interest of an institution trying to change from ordinary to entrepreneurial.	Chapter 5 employs the principal - agent model in the setting of institutional change from ordinary to entrepreneurial university. The conceptual propositions explain how a balanced and individualised incentive system may increase the effort of agents to act in the interest of the principal. This chapter focuses on micro-level analysis.

Innovation generation and innovation diffusion are the two main functions of any NIS (Edquist, 2005), however, there is no clear definition of the diffusion concept in the existing NIS literature. The innovation diffusion conceptual model proposed by Rogers (2003) is used extensively in the business management field. It provides theoretical insights to argue that innovation should be analysed as a multi-level and multi-stage process that is communicated through various channels of social systems. Rogers argues that innovation diffusion shows an ability of a system to reinvent drawing on existing inventions. Such an ability to diffuse could be the key for a long-term, sustainable, innovation generation. Drawing upon these arguments, we analyse the dynamics of different groups (types) of NISs as interrelationships amongst multiple outputs of innovation in Chapter 3.

Institutional theory analyses how organisations legitimize the “rules of the game” and acknowledges that organisational practices depend on cultural values, the history of organisations and traditions of industries (Meyer and Rowan, 1977; Zucker, 1977 and 1988; Pfeffer, 1984). Traditional institutional theorists argue that an existing institutional environment restricts structure, organisational behaviour and evolution of institutions (Meyer and Rowan, 1977; Jepperson, 1991; Scott, 1995; Hoffman, 1999). In contrast to the institutional embeddedness argument, the stream of institutional entrepreneurship literature argues, that new institutions could be created and old institutions could be changed (DiMaggio, 1988; Beckert, 1999; Garud et al., 2002). Chapter 4 employs the concept of institutional entrepreneurship in the setting of a transition NIS.

The concept of institutional entrepreneurship is already acknowledged as a change mechanism (Greenwood et al., 2008), however, institutional entrepreneurship at the meso or at the organisational level still receives scarce attention in institutional theory, organisation management, and entrepreneurship literature (Battilana et al., 2009; Bruton et al., 2010; Benneworth et al., 2016). DiMaggio (1988) defines the concept of institutional entrepreneurship as an initiative to shape and change institutions. DiMaggio states that institutional change is possible if individual actors are organised, motivated, entrepreneurial and able to see opportunities in institutions that they highly value. Beckert (1999) argues that institutional entrepreneurs are able to dis-embed themselves from the existing institutional constraints in order to change existing institutions or create new ones. Garud et al. (2002) propose to look at

institutional entrepreneurs as champions that lead and strategise collective actions that change innovative technology fields.

Agency theory was developed in information economics literature in order to analyse the relationship (or contract) between two parties: the principal who delegates and the agent who performs the work (Arrow, 1971; Ross, 1973; Fama and Jensen, 1983; Jensen and Meckling, 1976). Agency theory emphasises the need to measure performance and is usually described in cases (Demski and Feltham, 1978). Agency theory tries to resolve two problems that may occur in the relationship between the principal and the agent. The agency problem may arise when the principal and the agent have different goals, and when it is difficult for the principal to verify what the agent is doing.

These difficulties for the principal are caused by asymmetric information in the relationship and may encourage moral hazard (Arrow, 1968; Prendergast, 1999; Perrow, 1986). The principal may solve the problem of asymmetrical information by providing incentives that would encourage the agent to reveal unknown information. Even though the principal-agent theory was developed for the analysis of private firms, it could be very useful for a better understanding of motivation in public service organisations (Gailmard, 2010 and 2014). Chapter 5 of this thesis employs the principal-agent model in the setting of institutional change from an ordinary to an entrepreneurial university.

By incorporating the innovation diffusion conceptual model, this thesis is able to identify systemic differences amongst different groups of NISs globally, and to reveal specific factors that may influence the internal dynamics of NISs. By drawing on institutional and agency theories, this thesis is able to contribute to the NIS literature in explaining the relationship between meso and micro levels in the process of institutional change. Drawing from Eisenhardt's (1988) arguments of complementarity between institutional and agency theories in the organisational setting, Table 3 compares key ideas, assumptions, and domains of problems and levels of analysis for both theories. Chapter 5 of this thesis analyses how to reach efficiency (or specific goals) by employing the principal-agent model while Chapter 4 focuses on legitimising change towards better efficiency of organisations.

Table 3: Comparison of agency and institutional theories. Source: Eisenhardt (1988).

	Agency Theory	Institutional Theory
Level of analysis	Individual - micro	Organisational - meso
Key idea	Organisational practices arise from efficient organisation	Organisational practices arise from imitative forces and firm traditions
Basis of organisation	Efficiency	Legitimacy
View of people	Self-interested rationalists	Legitimacy seeking satisficers
Role of environment	Organisational practices should fit environment	A source of practices to which organisation confirms
Problem domain	Control problems	Organisational practices
Independent variables	Outcome uncertainty, span of control, programmability	Traditions, social and political beliefs, legislation, founding conditions.
Assumptions	People are self-interested, rational and risk-averse	People satisfice (adopt), conform to external norms

2.5. Methodology: critical realism and mixed methods

Based on the theoretical insights from the literature review, we may argue that the performance of NISs depends on the abilities at various levels: individual, firm, institution, sector etc. In order to understand these multiple layers of reality and relationships amongst them, we follow the critical realism tradition and use a mixed methods approach in designing and conducting the research of the thesis. The critical realism point of view allows us to go deeper beyond numbers and simple rational explanations.

Critical Realists argue that reality is socially constructed (Bhaskar, 1978). A traditional positivist view, on the other hand, focuses only on empirical evidence and is often criticised by practitioners as purely academic and as “significantly removed from practitioners and their problems” (Tapp, 2004, p. 493). The critical realism point of view allows us to consider the local social phenomenon, underlying mechanisms, history and context in the analysis of factors influencing the dynamics and performance of NISs.

Critical realism is considered a relatively new philosophical tradition offering an alternative to the established positivism and interpretivism paradigms. The critical realism differs from other paradigms in its assumptions about reality of the world. Bhaskar (1978) argues for three domains of reality: empirical (reality that can be experienced directly or indirectly), the actual (an aspect that occurs, but may not be

experienced), and the real (defined as the structures and mechanism that explain a phenomenon). Critical Realists argue that mechanisms cannot be seen directly via empirical investigation. Therefore, the main goal of research is not to identify laws (as proposed by positivism) or identify beliefs of actors (as argued by interpretivism), but to develop deeper explanations of the underlying levels behind a phenomenon.

Critical Realists argue that the real world operates as a multi-dimensional open system, therefore, they urge to solve the issue of a closed system within traditional paradigms. Olsen (2002) notes that positivists focus only on observable events and ignore prior frameworks that may have influenced the events. Collier (1994) argues that positivist methods fail to account for interactions amongst the mechanisms and contexts in which they operate. Lawson (1997) notes that various effects occur due to the interaction amongst human agency, mechanism and social structure. The causal mechanisms may have an important impact, but this will depend on the conditions in which they operate. Therefore, instead of focusing on empirical generalisation, Lawson (2003) proposes to focus on understanding the tendencies or path-dependencies that are produced by underlying mechanisms.

The logic behind critical realism is justified by 'retroduction' which could be defined as moving from the level of observation to the level of propositions about underlying structures and mechanisms that explain the phenomenon (Olsen and Morgan, 2005; Mingers, 2003). Olsen and Morgan note that 'retroduction' is the mode of the analysis when events are analysed with questions surrounding what may have or must have caused them. Lawson (1989) argues that retroductive reasoning is a scientific research, because mechanisms may be justified via model building, metaphors or analogies in order to explain the phenomenon. Critical Realists argue that the best explanations are those that provide the best explanatory power, but are always open to revisions if an alternative and better explanation occurs (Sayer 2002).

Critical Realists frame explanations of the phenomena in terms of underlying mechanisms which could be the capabilities (powers, tendencies or properties) of real entities that initiate or restrict change in a system (Bunge, 1997). In other words, "no mechanism, no explanation" (Miller, 2015). Bunge (2004) argues that a researcher may hypothesise about mechanisms by exploring the relevant system even though the evidence of mechanisms from the empirical data may not be straightforward, the propositions about mechanisms may be based on prior theory, other background

knowledge and models etc. Miller (2015, p.178) argues that the assumed “continuity of mechanisms within system (or across a set of systems) provides a basis for theoretical explanations – and models - of empirical phenomenon”. Specific strata (layer or level) is also important for Critical Realists in explaining reality, since mechanisms identified at other levels may not account for mechanisms operating at a particular stratum (Bhaskar, 1998a).

Critical Realists argue that a combination of qualitative and quantitative methods could be the most effective approach to understanding reality, because such an approach may reveal completely different aspects of the same factor of the study (Dow, 2001; Olsen, 2002; Downward et al., 2002; Downward and Mearman, 2007; McEvoy and Richards, 2006). Although using a mixed methods approach is widely advocated, there is still a lot of confusion about ontological and epistemological issues and Table 4 provides distinctions between the two methods. The purpose and strength of the quantitative method lies in providing reliable comparisons and accurate descriptions, identifying patterns and testing the causal mechanisms that operate in specific conditions.

However, one method should not be used to validate the results of another (Olsen and Morgan, 2005; Downward and Mearman, 2007). The identified patterns from quantitative methods may be investigated further by qualitative methods. Critical Realists argue that the main strength of qualitative methods lies in being time and context specific, as well as being open-ended, which may allow new themes to emerge that may not have been anticipated before constructing the study (Lawson, 1989; Olsen, 2002; Olsen and Morgan, 2005). Qualitative methods may help to shed light on complex relationships and contexts that are unlikely to be noted by standardised measures and predetermined groups/ categories.

Table 4: Traditional distinctions of qualitative and quantitative methods. Source: McEvoy and Richards, 2006).

	Quantitative methods	Qualitative methods
Ontology	Tangible reality	Intangible reality
Epistemology	Regularities established via empirical research and deductive/inductive reasoning	Knowledge constructed via social interaction/ hermeneutic understanding
Methodology	Hypothesis testing	In depth fieldwork
Data analysis	Verification/falsification	Interpretation of meaning

Chapter 3: Internal dynamics of national innovation systems: a panel cointegration approach

3.1. Introduction

National governments and international organisations (IMF, OECD, EU) are increasingly concerned with sustainable national growth and competitiveness. Many economists argue that only a high-quality innovation-based growth, not just any growth could lead to a long-term sustainable economic success (Lee and Narjako, 2015; Stiglitz and Greenwald, 2014; Weresa, 2014; Mazzucato, 2013; Lundvall et al., 2009). But how to achieve sustainable innovation-based growth?

The academic literature recognises that NISs vary in ‘local’ framework conditions which influence innovation outputs. However, it is still not clear what specific factors (and how) shape these internal dynamics. NIS studies focus on components of the system and the interactions amongst them, therefore, the main motivation for this chapter is understanding the internal dynamics and evolution of these components. The proposed empirical innovation diffusion model recognises the dynamics of NIS as a coevolution between innovation generation and innovation diffusion.

Innovation generation and innovation diffusion are the two main functions of any NIS (Edquist, 2005), however, there is no clear definition of the diffusion concept in the existing NIS literature. The innovation diffusion conceptual model proposed by Rogers (2003) provides theoretical insights to argue that innovation should be analysed as a multi-level and multi-stage process that is communicated through various channels of the social system. Rogers argues that innovation diffusion shows an ability of a system to reinvent while drawing upon existing inventions. Such an ability to diffuse could be the key for a long-term, sustainable innovation generation. Drawing from these arguments, we propose to analyse the internal dynamics of different groups of NISs quantitatively as interrelationships between multiple outputs of innovation. We also argue that various social, institutional and economic factors may stimulate the overall dynamics of different groups of NISs.

Quantitative NIS studies are still relatively new due to the lack of long-run data and relevant econometric methods to measure and investigate innovation as a dynamic

process, however, the most recent trend in innovation studies is to quantify the analysis of the NIS. For example, Castellacci and Natera (2013) investigate NIS dynamics as a coevolution between innovative capability and absorptive capacity, however, their capabilities approach may be too limited to fully explore the concept of NIS dynamics. More specifically, Castellacci and Natera (2013) completely exclude social cohesion and quality of institutions indicators as exogenous since they are “not Granger-caused by any other factors” (ibid, p. 586). However, we believe that these two indicators are simply too important to be excluded from the analysis of any NIS dynamics as noted by all systems of innovation scholars. The authors also compose input variables from two or more indicators to analyse the relationship between absorptive and innovative capabilities. As a result, it is not clear which specific variables have feedback effects on capabilities for specific country groups.

Due to the possible shortcomings of the capabilities approach, this study proposes to focus on the relationship between innovation generation and diffusion as a measure of the internal dynamics of the NIS. This chapter investigates the following research questions: are the internal dynamics of national innovation systems driven by coevolution of innovation generation and innovation diffusion? Also, are the dynamics of NISs stimulated by different social, institutional and economic factors depending on the country’s development level and geographical location of the NIS?

The chapter attempts to answer these two research questions by testing coevolution amongst four innovation proxies and various social, institutional and economic variables. The panel data of 93 countries for the period of 1980-2008 from the existing CANA database by Castellacci and Natera (2011) is used for the empirical analysis. Countries are clustered into five groups based on income, development level and geographical location. In this paper we use the same data set and econometric approach as Castellacci and Natera (2013).

The overall results confirm that the internal dynamics of 93 NISs are driven by the coevolution of innovation generation and innovation diffusion. Different social, institutional and economic factors stimulate or limit innovation generation and diffusion processes in different country groups depending on their development level and the specifications of the national systems. These results indicate that the more advanced countries have a stronger relationship between innovation generation and innovation diffusion within their NISs compared to mid and low-income countries.

Such results may have important policy implications by indicating a strong or weak role of the state in the dynamics of NIS. More specifically, we could argue that, the more advanced countries have stronger interactions amongst innovation, trade, education and labour/ industrial policies resulting in better innovation outcomes. While policies in mid and low-income countries may not be coordinated, as a result, some structural and institutional factors may be limiting the interrelationship between innovation generation and diffusion within local NISs.

In summary, the chapter contributes to the NIS literature by proposing a conceptual and empirical model that may be used by national governments and academics to analyse internal dynamics of NISs. The results of the model may indicate causal relationships amongst relevant policies. The findings may also reveal the impact of relevant policies on specific social, institutional and economic factors that limit or enhance innovation generation and diffusion within the system.

The chapter is organised in the following order. Part two explores the recent literature concerning national competitiveness and innovation. Part three describes methodological approach and proposed hypotheses. Part four describes data and indicators used for the empirical analysis. Part five describes the econometric method. Part six explores empirical results. Part seven concludes the theoretical and empirical analysis of this Chapter and proposes steps for further research.

3.2. Literature review

Currently, two main streams emerge in the most recent quantitative NIS literature: one focusing on the efficiency of NIS and the other on capabilities. Literature of endogenous growth theory (Romer, 1990) and Porter's (1990) competitive advantage theory provide a basis for the econometric studies of NIS, growth and innovation performance. As emphasised by the endogenous growth theory, R&D has a crucial role in national innovation performance and the most recent study by Loof and Savin (2015) confirms that R&D is significant for all NISs.

However, Loof and Savin (2015) note that the level of significance and the efficiency of NIS depends on the ability of a system to facilitate and support research and innovation activities. Loof and Savin (2015) argue that it is very important to understand what happens between inputs and outputs during the innovation process. There are many 'hidden' elements besides R&D that 'transform' knowledge into

innovation as noted by Mahroum and Alsaal (2013). The combination of these elements is usually referred to as ‘capabilities’ and there is extensive literature on capability building and innovation.

Many studies analyse capability building at a firm or industry level, but only limited attention is devoted to drivers of national innovation systems. The role of capabilities is very complex within any innovation system and it may be studied from many different angles, as noted by Borrás and Edquist (2014). The concepts of ‘core competences’, ‘dynamic capabilities’, ‘absorptive’ and ‘innovative’ capacities are the most widespread in current literature. The following few studies explore different capabilities as determinants of innovation output at a regional or national level and reveal some ‘hidden’ elements: Fagerberg et al. (2014); Castellacci and Natera (2013); Filippetti and Peyrache (2011); Fagerberg and Srholec (2008).

Fagerberg and Srholec (2008) focus on the role of capabilities for economic development through innovation. They analyse four different types of capabilities: the development of the innovation system, the quality of governance, the character of the political system and the degree of openness of the economy. The study reveals that innovation systems capabilities and governance capabilities are especially important for economic development. Castellacci and Natera (2013) propose to analyse dynamics of NIS as the coevolution between innovative capability and absorptive capacity. The study confirms the coevolution for the whole sample of 87 countries. The overall results reveal that relationships between variables differ depending on specific characteristics and the development level of NIS.

Castellacci and Natera provide a great analytical contribution to innovation studies by employing the panel cointegration approach. However, we believe, that their capabilities approach might be too limited to fully explore the concept of NIS dynamics. For example, Castellacci and Natera (2013) compose input variables from two or more indicators to analyse the relationship between absorptive and innovative capabilities. As a result, it is not clear which specific variables have feedback effects on capabilities for specific country groups. More importantly, they completely exclude social cohesion and quality of institutions indicators as exogenous since they are “not Granger-caused by any other factors”.

Filippetti and Peyrache (2011) study the dynamics and convergence of technological capabilities in different countries. They conclude that convergence

occurred to some extent, but some countries still have unbalanced aspects of technological capabilities. The more recent 2014 study by Fagerberg, Feldman and Srholec argues that social capabilities, such as a well-developed public knowledge infrastructure, an egalitarian distribution of income, a participatory democracy and prevalence of public safety enhance the growth of technological capabilities.

Another important stream of recent quantitative NIS literature evaluates the efficiency of a system (Mahroum and Al-Saleh, 2013; Loof and Savin, 2015; Chang, 2015) by looking beyond capabilities. Mahroum and Al-Saleh (2013) propose a more holistic view of national innovative capabilities. They argue for the analysis of innovation through adoption rather than through a traditional focus just on capabilities. They propose an innovation efficacy index and cluster countries into four groups based on the national innovation capacity to adopt and perform. Chang (2015) also contributes to the existing NIS efficiency literature by proposing a three-stage performance measurement model of NIS. He proposes considering the R&D efficiency (knowledge creation), the diffusion efficiency (knowledge spillover), and the economic efficiency (knowledge utilisation) of a system. They rank and cluster 41 countries based on the overall efficiency index.

These two papers, by Mahroum and Al-Saleh (2013) and Chang (2015), provide new aspects to NIS studies by focusing on the process of innovation through adoption and diffusion rather than just capabilities. However, they also overlook the role of specific policies and specific relationships amongst various input factors by focusing on indexes, rankings and comparison of the different NISs. Edquist and Borrás (2015) argue that the role of policies emerging through social cohesion, different types of education, training frameworks and institutional arrangements still remains understudied. Mahroum and Al-Saleh (2013) note that it is very hard to analyse policy effectiveness when R&D and patents remain the two most important measures of innovation. Therefore, we see a few opportunities to advance the most recent analysis of NIS.

The existing literature gap is threefold. The current empirical NIS studies do not fully unpack specific social, institutional and structural arrangements that support or limit innovation activities, since they all use composite indicators or indexes. Some NIS studies focus only on innovation generation and do not incorporate innovation diffusion conceptually and empirically. Others that do incorporate innovation

adoption or diffusion concepts, focus on the overall system efficiency evaluation, not on specific relationships amongst factors. As a result, most NIS studies do not explain specific factors limiting or supporting innovative activities, therefore, they are not able to guide evidence-based policy making.

3.3. Conceptual framework and proposed hypotheses

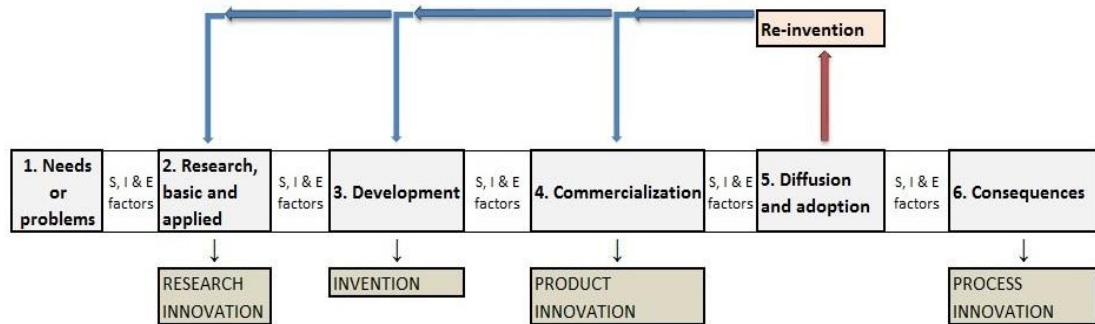
This section presents the theoretical framework for our empirical analysis of the internal dynamics of NIS. Our model focuses on the time series dimension and our objective is to provide a foundation for the analysis of the internal dynamics of a specific type or group of NISs rather than just comparing the different systems in a static sense. In order to explain internal dynamics of NISs, we extend the innovation diffusion model by Rogers (2003). The model is used in the business management field, but is not adopted by economists due to the lack of data measuring innovation diffusion.

We believe that the conceptual innovation diffusion model (Rogers, 2003) enhances the analysis of NISs by providing a concrete ‘structure’ for the innovation generation process. Rogers identifies six stages of innovation generation and recognises different players and factors at different stages that move innovation forward until it is fully adopted and distributed to other firms, industries and countries. Based on this theoretical insight, Rogers suggests that innovation should be analysed as a multi-stage and a multi-level process which is communicated through various channels amongst members of a social system. He argues, that innovation diffusion shows the ability of a system to reinvent drawing on existing inventions, which is the key for a long-term sustainable innovation generation.

Inspired by Rogers’ arguments, we extend his conceptual model and propose additional insights to enhance analysis of the internal dynamics of NISs. Our theoretical framework is presented in Graph 1. It is explained and tested empirically based on two arguments. Firstly, we argue, that the internal dynamics of the NIS may depend on a long-run relationship between innovation generation and innovation diffusion within the system. We use four different measures of innovation, such as invention, research innovation, product innovation, and process innovation, following Shumpeter’s (1943) wide definition of innovation. Secondly, we argue that various

social, institutional and economic factors (such as skills, education quality, support from local institutions, funds for research etc.) may influence innovation generation.

Graph 1: The innovation diffusion model (following Rogers, 2003) extended by four innovation outcomes, and by social, institutional and economic (S, I, E) factors that may influence the internal dynamics of NISs.



In our conceptual analysis we define the dynamics of NIS as a coevolution between innovation generation and innovation diffusion. We extend Rogers’ (2003) conceptual innovation diffusion model by proposing to test interrelationships between four different types of innovation in the analysis of dynamics of NIS. As illustrated by Graph 1, any successful innovation generation process goes through six main stages.

Firstly, there is a problem or a need for a solution. During the second stage, an individual or a firm may perform basic or applied research (at this stage we may have scientific research innovation). During the third stage, the firm may develop a prototype of a product and apply for a patent (we may have invention at this stage). During the fourth stage, the new product may be produced / commercialised (we may have an actual product innovation). During the fifth stage, this new product may be diffused to other firms within the same industry or adopted by other industries. This new product may increase productivity and lead to process innovation at the sixth stage.

This innovation generation process might stop here, or it may start a new cycle of innovation. At the diffusion and adoption stage, any new product or process may be completely reinvented and go through another cycle or research, development,

patenting, commercialisation, adoption and diffusion. These continuous cycles of reinvention, when new inventions draw on existing ones, represent the internal dynamics of the NIS. Based on the arguments of the theoretical model, illustrated by Graph 1, we propose the following first hypothesis:

Hypothesis 1: Research innovation, product innovation, process innovation and investments in R&D have long run two-way relationships with inventions.

$$\text{Inventions} = F(\text{Research Innovation, Process Innovation, Product Innovation, Investments in R\&D}) \quad (1)$$

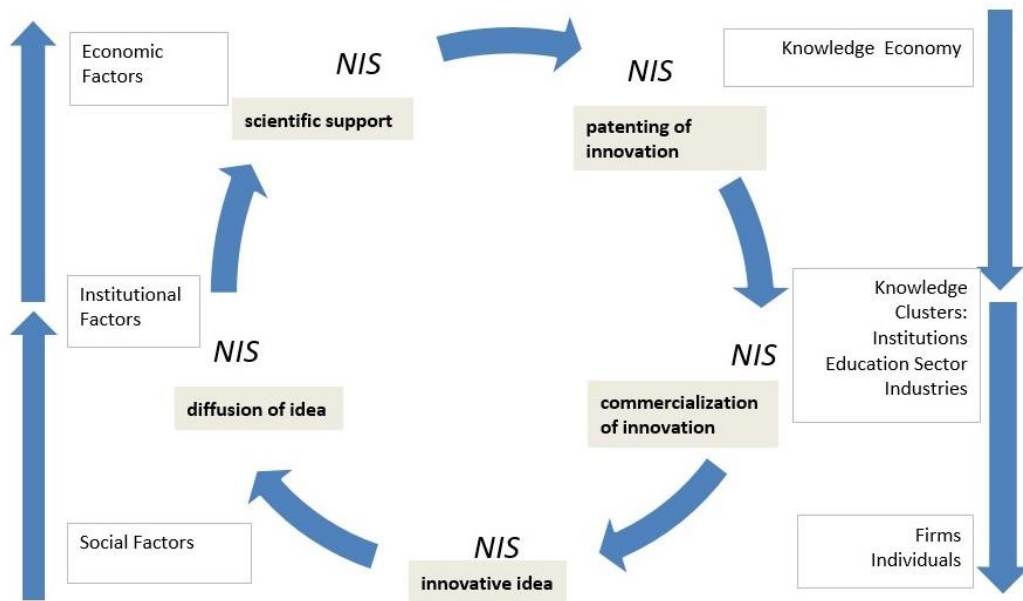
$$I_t = \alpha_{l,t-1} RI_{l,t-1} + \dots + \alpha_{p,t-p} RI_{p,t-p} + \alpha_{l,t-1} PCI_{l,t-1} + \dots + \alpha_{p,t-p} PCI_{p,t-p} + \alpha_{l,t-1} PDI_{l,t-1} + \dots + \alpha_{p,t-p} PDI_{p,t-p} + \alpha_{l,t-1} RDI_{l,t-1} + \dots + \alpha_{p,t-p} RDI_{p,t-p} + \varepsilon_t + \mu_t$$

Why is innovation diffusion so important within any NIS? Because a patented invention by itself does not directly lead to economic growth. Only further innovation diffusion, reinvention and spillovers to other industries within the system may create new jobs, industries and continuous income. The ability of the NIS to diffuse innovation and support reinventions and spillovers leads to sustainable innovation-based growth. Mazzucato (2013) provides a good example of such practice: the creation of iPods, iPhones, and iPads. She notes that they were created using many already existing inventions like the Internet, GPS, liquid crystal display, multi-touch screen etc. commissioned by the US government for military use. All these inventions were created for military use and did not create much income for the US economy, but the diffusion of them to IT, phone, car and other industries created new products as well as jobs, income and growth. Therefore, we may argue that only multiple outputs of innovation may represent the overall dynamics and the innovation generation potential of a NIS.

Moving forward with our conceptual analysis, we argue that various social institutional and economic factors may influence innovation generation within NIS. As illustrated by Graph 2, a presence or absence of an innovative idea might be influenced by social factors such as social cohesion, education quality and skills. The diffusion of the innovative idea might be supported or limited by various institutional

factors such as quality of local infrastructure and institutions. Economic factors, such as availability of R&D funds for the scientific research, might influence further steps leading to patenting of innovation. The actual commercialisation of the innovation might also be influenced by various economic and institutional factors such as domestic credit availability to local firms, consulting services, legal advice and support from local government agencies and associations of local firms.

Graph 2: Illustration of various social, institutional and economic factors that may influence innovation generation within NIS.



Based on the supporting arguments from the previous paragraph, that reveal the importance of various social, institutional and economic factors to innovation generation (Graph 2), we propose the following second hypothesis:

Hypothesis 2: Social, institutional and economic factors have long-run causal relationships with inventions.

$$\text{Inventions} = F(\text{Social, Institutional, Economic factors}) \quad (2)$$

$$I_t = \alpha_{S1} S_{t-1} + \dots + \alpha_{Sp} S_{t-p} + \alpha_{I1} I_{t-1} + \dots + \alpha_{Ip} I_{t-p} + \alpha_{E1} E_{t-1} + \dots + \alpha_{Ep} E_{t-p} + \varepsilon_t + \mu_t$$

We may argue that the panel cointegration approach fulfils the definition of NIS not only technically, but also conceptually, since NIS is understood as a system of various interrelationships amongst public, private, formal and informal actors. Technically, the panel cointegration demonstrates dynamics of the NISs by testing for the two-way dynamic relationships amongst the variables. This two-way relationship is considered dynamic because the cointegration approach tests causality between pairs, one way at the time. These tests are a part of a system that examines all possible pairs and directions. The dynamism is also captured in the panel cointegration approach by the fact that this method considers changes across time and across countries. The dynamism part refers to the fact that this is a longitudinal analysis.

During the first hypothesis testing we examine how different types of innovations interrelate together within NISs. Conceptually we test if research, process, product innovations and R&D investments have a direct effect on inventions; we also test if inventions have direct effect on the four types of innovations and R&D. Furthermore, we test if the four types of innovations and R&D have direct effect on each other. During the second hypothesis testing we examine how various social, institutional and economic factors interact within NISs; and how the factors influence inventions. We test if two-way or one-way relationships exist amongst social, institutional and economic factors themselves and if (and how) they are affected by inventions. Such ‘circular’ testing of relationships between all possible pairs and directions makes the cointegration a dynamic rather than linear approach. Hence, the approach is very useful to analyse the internal dynamics of NISs.

3. 4. Data and indicators

Panel data of 93 countries from the existing CANA database (by Castellacci and Natera, 2011) is used to test our two hypotheses. This database was constructed by combining data from various existing data sources and by applying the multiple imputation method in order to avoid any missing values for the period of 1980-2008. The CANA dataset provides a rich material for the analysis of NISs at six dimensions: innovative and technological capabilities, education and human capital, infrastructure, economic competitiveness, social capital, political and institutional factors.

Based on our conceptual analysis we identify *four innovation proxies*: process innovation measured by labour productivity, product innovation measured by high-

tech exports, research innovation measured by scientific journal publications and inventions measured by patents (Table 1A in the Appendix section on p. 77-79 provides more detailed definitions and the scope of all variables used the in our first hypothesis testing):

- **Labour productivity** is used as a measure of **process innovation**. It may be viewed as a controversial proxy because of the way it is calculated. However, Pires and Garcia (2012) argue that productivity is responsible for technical efficiency, innovation and growth differences between countries. Recent econometric studies (by Faustino and Matos, 2015; Lee and Narjako, 2015; Felsenstein, 2015) also justify our decision to use it for our first hypothesis testing by confirming a two-way positive relationship between productivity and exports, as well as productivity and R&D. These studies argue that productivity may represent process innovation. We use labour productivity as a separate proxy because we believe that process innovation might be unrepresented by other more traditional innovation measures like patents or high-tech exports.
- The number of **scientific and technical journal publications** is used as a proxy for **research innovation**. Castellacci and Natera (2013) propose to analyse scientific publications as a result of research and innovation activities by a public system. Cai (2011), Pan et al. (2010) and Chang (2015) use them as a proxy for knowledge generation and diffusion in NIS efficiency analysis. Scientific publications may be a very important research innovation outcome as already discussed in our conceptual innovation diffusion context. However, it is not directly captured by any traditional innovation proxies, since there are many steps and factors leading from scientific results/ publications to actual patented products.
- We use **high-tech exports** as a measure of **product innovation**, since it is a ratio of total manufacturing exports in our dataset. It is one of the most popular measures of innovation and efficiency of NIS (Naser and Afzal, 2014; Faustino and Matos, 2015) despite the criticism that large global multinational organisations may be responsible for the most part of product innovations in low income countries. Naser and Afzal (2014) consider high-tech exports as a commercialisation of valuable knowledge creation. High-tech exports may

incorporate many aspects of private and public sector efficiency and may draw on previous innovation outcomes of research or process innovation. Therefore, it is important to understand the relationships amongst innovation, productivity and exports, as argued by Faustino and Matos (2015).

- The number of *UPSTO patents* is the most popular proxy for *inventions*. It may be considered as the ‘widest’ measure of innovation since it may incorporate all other previously discussed innovation outcomes like research, process and product innovations in some industries. The number of patents was also used as a measure of innovative activities by private firms (Castellacci and Natera, 2013), overall innovation system efficiency (Loof and Savin, 2015; Cai, 2011) or as a measure of technical NIS efficiency (Pan et al., 2010). By the official definition, the United States Patent and Trademark Office (UPSTO) recognises three types of patents: utility, design and plant. UPSTO patents may be a very useful measure of inventions in some, but not all industries. Some industries, like services, food and beverage, textiles and plastics do not use many patents. Therefore, for the purpose of this paper, the number of UPSTO patents is used as a measure of inventions in high-patent industries.
- We use total *R&D expenditures* as a proxy for *investment in R&D*. It has been used as the main input variable in all innovation studies. Endogenous growth theory emphasised the crucial role of R&D to national innovation performance many years ago. The most recent empirical study of R&D efficiency by Johansson et al. (2015) confirms that R&D is significant for all types of NISs. However, Johansson et al. argue, that the level of significance and the efficiency of R&D depends on the ability of the NIS to facilitate and support research and development activities.

Therefore, we propose to analyse *various social, institutional and economic factors* that may create a specific national environment, and enhance or limit the overall innovation outcome (Table 2A in the Appendix section provides more detailed definitions and the scope of all variables used in the second hypothesis testing):

- *Social input indicators* represent four dimensions: *education quality and basic skills* measured by primary school pupil teacher ratio; *capabilities* measured by gross secondary, gross tertiary enrolment ratios and average years

of schooling; *advanced research skills* measured by government, business and education sector R&D performance; *social cohesion* measured by GINI index, trust level and feeling of happiness. High quality education may increase entrepreneurial, creative and innovative capabilities as argued by Iacopetta (2010) and Hanushek with Woessmann (2009). Iacopetta argues that human capital indicators are especially important for the innovation potential of transition economies and may stimulate a shift from imitation to innovation-based growth. Mahroum and Al-Saleh (2013) argue that the quality of education and research skills are responsible for the capacity of a nation to innovate. Algan and Cahuc (2014) argue that opportunities for education, the overall capabilities and innovation potential may be significantly influenced by social cohesion and social values.

- *Institutional input factors* represent three dimensions: *quality of local infrastructure* measured by gross fixed capital formation, the number of internet users and the financial sector efficiency; *quality of local institutions* measured by the time spent enforcing contracts and corruption perception level; *democratic freedom* measured by the freedom of press index. A few NIS studies analyse the relationship between innovation and institutions (Piana et al., 2015; Tebaldi and Elmslie, 2013). Both papers confirm that firm level innovation performance depends on local institutional settings. Tebaldi and Elmslie also note that human capital factors may significantly impact institutional quality. Capability-focused NIS studies also confirm that the high quality of local institutions and relevant infrastructure improvements may enhance entrepreneurial activities and support innovation, while slow turnaround times of local institutions and high corruption levels may limit entrepreneurial activities, growth and the overall national innovation potential.
- *Economic input factors* represent three dimensions: *education support* measured by public expenditures on education; *trade support* measured by the trade openness indicator; *finance availability* measured by domestic credit available from the local banking sector. Higher public expenditures on education may lead to better skills and overall personal capabilities as argued by Weresa (2014), while a strong trading position may open external sources of knowledge and enhance the innovative capabilities of local firms and

institutions. Domestic credit availability by the banking sector may increase the capabilities of firms to develop and commercialise innovations (Mahroum and Al-Saleh, 2013).

3. 5. Econometric method

The panel cointegration approach is a relatively new method in empirical innovation and growth analysis. However, it is very relevant for the dynamics of NIS studies, because it is able to uncover stable long-run relationships that coevolve over time between pairs of variables. In our specific time series context, the panel cointegration method analyses relationships between stationary time series by analysing both long-run relationships and short-run adjustments. We are especially interested in two-way long-run relationships that represent cointegrating causal relationship of a system.

The methodology of the panel cointegration approach includes four steps: panel unit root test, Pedroni cointegration, panel vector error correction (VECM), and Granger causality analysis. Panel root tests help to verify whether or not panels are stationary at the first order difference, which is the main pre-condition for the panel cointegration method. The Pedroni cointegration seven tests check whether any long-term relationships exist amongst variables by looking at within and amongst the dimensions of the panel. The panel vector error correction model helps to estimate both the long-run relationship and the short-term adjustment processes. Granger causality analysis investigates the direction of causality amongst variables and enables detection of one-way and two-way relationships. To summarise, this four-step econometric methodology is an attempt to operationalise the concept of coevolution within the panel cointegration context. The coevolution amongst variables is defined by the following: an existing long-run relationship; and an existing two-way causal relationship between variables.

First, all four steps are performed to test the first hypothesis for the whole sample of the 93 countries. Then, the countries are grouped into five clusters based on the income, development level and geographical location. Again, all four panel cointegration steps are performed to test the first hypothesis for each group. The second hypothesis testing is performed following the same four steps for the whole sample and for each country group. We estimate the model for each country group

separately in order to avoid heterogeneity problems. Table 3 below presents the list of the 93 countries grouped into five clusters: advanced high-income economies (OECD), mid-income East Asian countries, mid-income Eurasian countries (post-Communist), mid-income Latin American and low-income less-advanced African and S. Asian countries.

Table 3: The list of 93 countries grouped into five clusters.

<p><u>23 Advanced high-income countries (advanced OECD):</u> Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States.</p> <p><u>10 Mid-income I East Asian countries:</u> Cambodia, China, Indonesia, Malaysia, Mongolia, Philippines, Singapore, South Korea, Thailand and Vietnam.</p> <p><u>19 Mid-income II Latin America countries:</u> Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay and Venezuela.</p> <p><u>23 Mid-income III Eurasia, former Soviet Union countries:</u> Albania, Armenia, Azerbaijan, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Poland, Romania, Russia, Slovakia, Slovenia, Tajikistan, Ukraine and Uzbekistan.</p> <p><u>19 Low-income, less developed Africa and South Asia countries:</u> Algeria, Botswana, Burkina Faso, Ethiopia, India, Iran, Jordan, Lesotho, Madagascar, Mauritius, Morocco, Mozambique, Pakistan, Senegal, South Africa, Sri Lanka, Tunisia, Uganda, Zambia.</p>

3.6. Empirical results

3.6.1. Results of the first hypothesis testing

(H1: Research innovation, product innovation, process innovation and investments in R&D have long run two-way relationships with inventions)

This section presents selected econometric results for the whole sample of the 93 countries as well as selected results for the five country groups. **First**, a set of panel unit root tests is performed for each variable. The Breitung test is the most relevant for our balanced panel with small T (time period) and large N (number of panels). It is the most appropriate even with very small datasets where N=25 and T=25 (Breitung

and Das, 2005). However, as a sensitivity analysis, we perform a few more panel unit root tests for all variables. Table 4 presents the results with 5 lag specification for all variables that are used to test our first hypothesis. The results at the first order difference confirm that all variables are stationary which satisfies the main precondition for the panel cointegration econometric method.

Second, we run the Pedroni cointegration tests to investigate the possibility of a long-run relationship amongst the five variables used in the first hypothesis. The Pedroni cointegration is composed of seven tests investigating cointegration at within and between dimensions of panels (Pedroni, 1999). Table 5 presents the results for the seven tests of the Pedroni cointegration performed for the variables that are used to test the first hypothesis. In our case, six out of seven tests show highly significant results. Therefore, due to the majority tests we reject the null hypothesis and accept the alternative, which confirms the cointegration or existence of one or more long-run relationships amongst the five measures of innovation and investments in R&D.

Table 4: Results of the panel unit root tests at the first order difference with 5 lag specification. Note: *** indicate 1% significance level.

Tests	patents	rdgdp	htexports	lproductivity	spublications
Levin, Lin & Chu t	-50.201***	-41.6031***	-39.6705***	-35.6932***	-11.8491***
Im, Pesaran and Shin W stat	-47.1598***	-41.3484***	-43.076***	-39.0706***	-6.1866***
ADF Fisher Chi square	2717.1847***	2091.8853***	1740.9687***	1516.7817***	269.6184***
PP Fisher Chi square	7620.7743***	3284.891***	2040.0689***	1662.5808***	2238.4157***
Breitung t	-4.7331***	-7.7692***	-11.4693***	-14.7597***	1.6975***
Hadri Z stat	-2.6266***	-1.5163***	-0.1382***	2.5341	0.5207***

Table 5: Perdoni cointegration test with 5 lag specification. Note: *** indicate 1% significance.

7 Tests	Results
Panel v-Statistic	4.6109***
Panel rho-Statistic	-3.6926***
Panel PP-Statistic	-8.5236***
Panel ADF-Statistic	-2.7887***
Group rho-Statistic	-5.2614***
Group PP-Statistic	-24.2475***
Group ADF-Statistic	1.5286

The third step in our econometric analysis is a panel vector correction model (VECM) and an estimation of the long-run cointegration equation. The VECM model of five variables tests our first hypothesis with the 5 lag specification. The model reports the relationship that could be written as the following:

$$\begin{aligned}
 \text{Inventions (patents)} = & + 2.2488 \quad (\text{product innovation}) \\
 & + 0.0643 \quad (\text{process innovation}) \\
 & + 137619.11 \quad (\text{research innovation}) \\
 & + 86.1173 \quad (\text{investments in R\&D})
 \end{aligned}$$

These VECM results from 93 countries confirm our first hypothesis that research, product, process innovation and R&D investments have a positive impact on inventions. In order to understand the strength and direction of these relationships, we may look at the long-run and short-run cointegrating equations presented in Table 6. These results indicate that product innovation (measured by high-tech exports), research innovation (measured by scientific publications) and R&D investments have highly significant long-run relationships with inventions (measured by patents). The short-run coefficients show that process innovation adjusts and goes back to the long-run path when disturbed by external shocks, while research innovation deviates permanently from its long-run path due to external shocks. These results are very important since they econometrically confirm that the dynamics of NISs are driven by innovation diffusion within the system. Four different types of innovation outcomes draw on each other as well as on R&D investments while moving through different innovation generation and diffusion stages.

Table 6: VECM cointegration equations with 5 lag specifications. Note: ***, * indicate 1% and 10% significance levels for t statistics.

	Long-run cointegration equation	Short-run cointegration equation	R-squared
PATENTS	1	-0.0024 (0.00146) [-1.70356]	0.16394
HTEXPORTS	-2.2488 (0.61277) [-3.66984]***	0.00085 (0.00097) [0.87034]	0.06807
LPRODUCTIVITY	-0.06431 (0.40372) [-0.15932]	-0.00266 (0.00029) [-9.03303]***	0.05319
SPUBLICATIONS	-137619.11460 (43633.75245) [-3.15396]***	0.00000 (0.00000) [-8.67800]***	0.16300
RDGDP	-86.1173 (15.3792) [-5.59957]***	-0.00004 (0.00003) [-1.58445]	0.05876

The fourth step in our analysis is to investigate the direction of causality and determine whether one-way ($Y \rightarrow X$) or two-way ($Y \leftrightarrow X$) relationships exist between the four innovation variables and R&D investments for all 93 countries. The Granger causality test results with the 10 lag specification based on the VECM model are presented in Table 7. Results indicate five possible two-way long-run relationships between inventions (patents) and product innovations (high-tech exports), inventions and process innovations (labour productivity), inventions and research innovations (scientific publications), process innovations and research innovations as well as inventions and R&D input.

These results confirm coevolution between innovation diffusion and innovation generation, because they indicate feedback effects amongst different types of innovation while going through cycles of diffusion and reinvention within the system. These results support our conceptual model presented in Graph 1 (Part 3 of the Chapter) by empirically showing that inventions depend not only on R&D investments, but also on research, product and process innovations. Also, two one-way relationships may indicate that product innovations could influence process innovations as well as R&D input.

The final step in our first hypothesis analysis is to explore the Granger causality results for the five different country groups with the 10 lag specification. The summary of results is presented by Table 8. The results reveal many differences amongst groups of countries with different development levels (please see illustration of the differences between the groups in the Appendix, Figures 1A-5A on p. 80-84). High-income advanced OECD countries have six long-run two-way relationships which confirm the presence of strong innovation generation and diffusion relationship within these NISs. These results may indicate that different types of innovations draw on each other. These relationships generate more re-inventions and innovation spillovers to different industries in the OECD countries.

The results also show that the OECD group is the only one with R&D led high-tech exports (Figure 1A). This may indicate that product innovations in other countries are brought in by multinational corporations originating from the OECD countries. The results for the East Asian group reveal four two-way long-run relationships between process innovations and inventions, research innovations and inventions, process innovations and research innovations, also R&D investments and inventions.

Two one-way relationships indicate that research and process innovations are led by R&D investments. Overall, these results indicate that East Asian countries have a medium-strength relationship between innovation diffusion and generation.

The results for the Eurasian countries show three two-way relationships between the following: product innovations and inventions, process and research innovations as well as research innovations and R&D input (Figure 2A). These results indicate a weaker coevolution between innovation diffusion and generation within the system compared to the OECD or the East Asian group. The results for the Latin American countries indicate weak innovation diffusion and low internal dynamics of NISs (Figure 4A). A two-way relationship is confirmed between R&D and research innovation which may lead to inventions, however, the scientific research is not further related to process or product innovations directly.

The results for low income African and South Asian countries show only one two-way relationship between process innovations and inventions (Figure 5A). This may indicate that innovation is only led by increases in labour productivity. The lack of any other significant relationships may indicate very weak and static NISs. The overall results for the African and South Asian countries do not indicate coevolution between innovation generation and diffusion that may lead to re-inventions or further spillovers of process innovations and inventions to other industries.

Table 7: Granger causality test results based on VECM model for 93 countries with 10 lag specification. Note: *** indicate 1% significance levels. A more detailed explanation of variables is provided in the Appendix on p. 76-78.

Causal relationship	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5	Lag 6	Lag 7	Lag 8	Lag 9	Lag 10	Granger causality
htexports ---> patents	19.4341***	12.359***	8.4494***	5.4806***	4.6667***	3.7294***	3.4361***	3.7496***	2.8547***	2.5458***	Yes
patents ---> htexports	3.7512*	0.8518	3.1156**	2.5743**	3.9529***	3.2076***	2.8391**	2.4095**	1.9815**	1.8960**	Yes
lproductivity ---> patents	0.1115	1.0773	1.9516	2.5073**	2.7937**	2.473**	2.7464**	3.2791***	2.7199***	2.4488***	Yes
patents ---> lproductivity	39.4662***	20.2473***	12.9998***	10.8031**	8.5820***	6.656***	5.2857***	4.6131***	3.8498***	3.5324***	Yes
spublications ---> patents	22.3041***	9.5924***	7.0951***	15.4992***	15.9644***	10.9129***	9.7662***	6.0074***	4.7075***	4.4844***	Yes
patents ---> spublications	0.0387	5.6634***	3.8533***	2.8845**	10.7566***	9.7016***	7.0536***	5.8051***	7.1352***	7.9169***	Yes
lproductivity ---> htexports	1.7698	1.7285	1.3072	0.979438	1.0926	0.792	0.661	0.5895	0.5366	0.6068	No
htexports ---> lproductivity	21.212***	11.3741***	7.0321***	4.6292***	3.8687***	3.2562***	2.6835*	2.1207*	1.5735	1.2138	Yes
spublications ---> htexports	7.7169***	2.8991*	1.6649	1.1064	1.8992*	1.484	1.168	1.3317	1.3926	1.3931	No
htexports ---> spublications	3.7730*	2.5031*	2.6977**	2.1927*	1.1956	0.935	0.843	0.6869	0.6201	0.5461	No
lproductivity ---> spublications	86.4786***	42.7379***	27.3257***	19.9103***	14.1431***	10.824***	9.6999***	8.7184***	7.7549***	8.4113***	Yes
spublications ---> lproductivity	2.8077*	3.0248***	2.3404*	2.3442**	6.0183***	9.1031***	9.5191***	7.6838***	6.5655***	6.1890***	Yes
patents ---> rdgdp	3.3203*	8.7874***	8.0736***	6.1894***	6.1262***	5.1893***	4.5576***	4.6738***	4.9122***	4.7595***	Yes
rdgdp --> patents	45.7103***	31.2106***	21.1088***	14.6563***	12.3006***	8.5880***	8.2294***	7.2477***	6.3909***	5.5721***	Yes
htexports ---> rdgdp	5.2121**	7.2842***	5.1628***	4.3898***	3.4872***	2.8086**	2.2834**	2.2273**	1.8538*	1.9206**	Yes
rdgdp --> htexports	5.2468**	2.2898	2.1905*	1.4154	1.2933	1.0496	0.6949	0.9303	1.0341	0.8352	No
lproductivity ---> rdgdp	3.7822*	14.3933***	10.7951***	8.1252***	7.0595***	5.3798***	4.8513***	4.3507***	3.7373***	3.6365***	Yes
rdgdp --> lproductivity	68.0231***	33.6474***	20.1807***	13.3866***	10.4177***	7.6537***	6.6158***	5.5168***	4.5518***	3.6148***	Yes
spublications ---> rdgdp	78.9564***	34.9795***	21.5502***	15.7983***	11.8283***	9.5668***	7.7002***	6.9305***	6.6363***	5.5332***	Yes
rdgdp--> spublications	24.0732***	10.0902***	8.9963***	8.7962***	8.4604***	6.9977***	8.6422***	7.9075***	6.8380***	5.5138***	Yes

Table 8: Granger causality test results for five country groups based on VECM model with 10 lag specification. A more detailed explanation of variables is provided in the Appendix on p. 76-78.

Causal relationship	OECD 6 two way	East Asia 4 two way	Eurasia 3 two way	Latin America 1 two way	Africa and S. Asia 1 two way
htexports ---> patents	Yes	No	Yes	Yes	No
patents ---> htexports	Yes	No	Yes	No	No
lproductivity ---> patents	Yes	Yes	No	No	Yes
patents ---> lproductivity	Yes	Yes	No	Yes	Yes
spublications ---> patents	Yes	Yes	Yes	Yes	No
patents ---> spublications	Yes	Yes	No	No	No
lproductivity ---> htexports	Yes	No	No	No	No
htexports ---> lproductivity	Yes	No	No	No	No
spublications ---> htexports	Yes	No	No	No	No
htexports ---> spublications	Yes	No	No	Yes	No
lproductivity ---> spublications	No	Yes	Yes	Yes	No
spublications ---> lproductivity	No	Yes	Yes	No	No
patents ---> rdgdp	Yes	Yes	No	No	Yes
rdgdp --> patents	Yes	Yes	No	No	No
htexports ---> rdgdp	No	No	No	No	No
rdgdp --> htexports	Yes	No	No	No	No
lproductivity ---> rdgdp	No	No	Yes	No	No
rdgdp --> lproductivity	No	Yes	No	No	No
spublications ---> rdgdp	No	No	Yes	Yes	No
rdgdp--> spublications	No	Yes	Yes	Yes	No

3.6.2. Results of the second hypothesis testing

(H2: Social, institutional and economic factors have long-run causal relationships with inventions)

Further analysis presents the results of the second hypothesis testing for the five country groups (presented in Table 9). We want to determine whether one-way ($Y \rightarrow X$) or two-way ($Y \leftrightarrow X$) relationships exist amongst social, institutional and economic factors and inventions for the five different types of NISs. We follow the same four step methodology: panel unit root tests confirm that panels are stationary, Pedroni cointegration indicates existing long-run coevolution; therefore, we examine relationships with VECM cointegration tests and confirm them with Granger causality analysis.

The results show that the second hypothesis is confirmed for three out of five groups. Different social, institutional and economic factors have direct or indirect long-run relationships with inventions for the OECD, Eurasian and Latin American group. The results for the African and South Asian group confirm that institutional and economic factors, but not social factors have long-run relationships with inventions. While the results for the East Asian group show that social and institutional factors have a direct impact on inventions while economic factors do not. Let us review the significant relationships amongst specific factors for all of the groups.

As presented in Table 9, the results show five two-way and six one-way significant long-run relationships for the OECD group. Two social, four institutional and one economic variable have a direct impact on inventions. Secondary school skills, R&D capabilities of higher education, infrastructure improvements, press freedom, strong state involvement in the banking sector and strong trading position have a direct impact on inventions for the OECD group. The long-run two-way relationship is also confirmed between R&D performed by the education and by government sectors, which may indicate joint research projects leading to inventions. Total public expenditure on education is also significant for the R&D capabilities of the higher education sector. This group is also the only one with the significant relationship from R&D investments to high-tech exports, which may indicate that product innovations are transferred to other groups of countries through multinational corporations originating from the OECD countries.

Table 9: Granger long-run causality analysis of significant social, institutional and economic factors (with 10 lag specification), directly (highlighted) or indirectly leading to inventions (measured by patents).

	OECD	Eurasia	East Asia	Latin America	Africa and S. Asia
Social	<p>2enroll <--> patents</p> <p>gerdeduce --> patents</p> <p>gerdgov <--> geredduce</p> <p>pubexpeduc --> geredduce</p>	<p>primpltch --> patents</p> <p>happiness --> patents</p> <p>trust --> patents</p> <p>GINI --> happiness</p> <p>GINI --> primpltch</p> <p>GINI <--> trust</p>	<p>myschool --> patents</p> <p>3enroll --> patents</p> <p>happiness --> 3enroll</p> <p>trust --> 3enroll</p> <p>GINI --> trust</p>	<p>primpltch ---> patents</p> <p>2enroll --> patents</p> <p>myschool --> patents</p> <p>GINI --> patents</p> <p>gerdbus <--> patents</p> <p>gerdgov <--> patents</p> <p>gerdgov <--> geredduce</p> <p>gerdeduce <--> gerdbus</p>	
Institutional	<p>pressfreedom <--> patents</p> <p>internet <--> patents</p> <p>finfreedom --> patents</p> <p>grossfixedcf --> patents</p> <p>grossfixedcf <--> finfreedom</p> <p>corruptpercp --> finfreedom</p>	<p>contrenforce --> patents</p> <p>corruptpercp --> patents</p> <p>finfreedom --> contrenforce</p> <p>contrenforce --> corruptpercp</p> <p>finfreedom --> corruptpercp</p>	<p>finfreedom <--> patents</p> <p>grossfixedcf --> patents</p> <p>grossfixedcf <--> domcredit</p>	<p>grossfixedcf <--> patents</p> <p>finfreedom --> grossfixedcf</p> <p>corruptpercp --> patents</p> <p>contrenforce --> corruptpercp</p> <p>pressfreedom --> contrenforce</p> <p>opentrade <--> grossfixedcf</p>	<p>grossfixedcf <--> patents</p> <p>pressfreedom --> grossfixedcf</p> <p>internet --> patents</p> <p>internet --> grossfixedcf</p> <p>finfreedom --> internet</p> <p>pressfreedom --> internet</p> <p>corruptpercp --> patents</p> <p>finfreedom --> corruptpercp</p>
Economic	<p>opentrade --> patents</p>	<p>opentrade --> patents</p> <p>domcredit <--> opentrade</p> <p>domcredit --> patents</p>		<p>opentrade --> patents</p> <p>GINI <--> opentrade</p>	<p>opentrade --> patents</p> <p>pubexpeduc --> opentrade</p> <p>pubexpeduc --> geredduce</p> <p>gerdeduce --> opentrade</p> <p>gerdgov --> opentrade</p>

The results for the Eurasian group (Table 9) reveal two two-way and 12 one-way, significant, long-run relationships. Three social, three institutional and one economic variable has a direct impact on inventions. Two two-way relationships are revealed between GINI and trust, domestic credit from local banks and trading position. One-way, significant, long-run relationships are confirmed between skill formation in primary school, institutional efficiency, strong trading position, corruption perception, trust, happiness and inventions. The analysis also shows that trust and happiness have a long-term impact coming from the social cohesion indicator, which may confirm that inequality has an indirect effect on the innovation outcome for the Eurasian group. Overall, we may summarise, that primary education quality, social values, institutional efficiency, infrastructure and domestic credit all have a direct impact towards inventions, while social cohesion has an indirect impact.

The second hypothesis is not confirmed for the East Asian group since the results show that social and institutional factors have a direct impact on inventions, while economic factors do not. These results may indicate that informal investments in inventions are made through multinational corporations. Nevertheless, the results reveal three significant two-way relationships and six one-way relationships. The total years of schooling, tertiary education skills, financial efficiency and quality of infrastructure all have a direct impact on inventions. Social cohesion indicators have an indirect impact on inventions. It is the only group that has the opposite of the expected causal relationship between patents and trading position. The causality analysis indicates that inventions lead to trade, but not the other way around.

The overall results for the Latin American countries confirm the second hypothesis. Seven significant, two-way and ten one-way relationships are revealed. Primary and secondary school skills, years of schooling, social cohesion, R&D skills of businesses and government, quality of infrastructure, corruption perception and trading position have a direct effect on inventions. The results also show that the R&D skills of the education sector, the financial sector and institutional efficiency, press freedom and social cohesion have an indirect effect on inventions. The two-way relationships amongst R&D performed by business, government, education sectors and inventions may indicate on-going, long-term joint research projects leading to innovations. However, these collaborations may not lead to strong innovation diffusion and strong internal dynamics of NISs (as confirmed by the first hypothesis),

because corruption perception, quality of infrastructure, freedom of press and social cohesion may act as limiting factors.

We cannot confirm the second hypothesis for the African and South Asian countries, because only institutional and economic factors, but not social factors have a long-run relationship with inventions. It is the only group where the results do not reveal any education quality or skills indicators leading to innovation which may indicate that these countries lack both basic absorptive and advanced innovative skills. However, one two-way cointegrating relationship is revealed between quality of infrastructure and inventions. Additionally, three one-way relationships indicating a direct impact on inventions are revealed between the following: internet and inventions, corruption and invention, trade and inventions. Freedom of press, financial efficiency, public expenditure on education and R&D skills by education and government sectors have an indirect effect on inventions.

3.6.3. The overall significance of results

It is important to address the overall significance of the results for the five country groups. After combining supporting results from the first and second hypothesis, we may confirm that the internal dynamics of NISs are driven by the coevolution of innovation generation and innovation diffusion for high-income advanced and mid-income groups of countries (Table 10). Different social, institutional and economic factors stimulate or limit the innovation generation and diffusion processes within different groups depending on their development level and the specifications of national systems. Our results indicate that the more advanced countries have stronger relationships between innovation generation and innovation diffusion within their NISs in comparison to mid and low-income countries.

Based on these results we may conclude that the countries in the OECD group have strong and dynamic NISs supported by secondary school skills, R&D capabilities of the higher education sector, quality of infrastructure, freedom of press, strong state involvement in the banking sector and a strong trading position. The overall results for the East Asian group indicate fair NISs supported by total years of schooling and advanced tertiary education skills, quality of infrastructure and financial efficiency. Our results may also indicate that an informal R&D support comes from foreign multinational organisations for Eastern Asian countries (Lee and Narjako, 2015).

Moving further, we may conclude that Eurasian countries have weak NISs due to a lack of stimulating social and institutional factors (as noted also by Radosevic and Kaderabkova, 2011). The lack of advanced research skills, institutional quality, domestic credit availability, corruption control and social cohesion may limit absorptive and innovative capabilities. The results for the Latin American group reveal weak NISs due to low innovation diffusion. The two-way relationships amongst R&D performed by businesses, government, education sectors and inventions may indicate on-going long-term joint research projects. However, these collaborations do not lead to strong innovation diffusion and internal dynamics of NISs, because corruption perception, quality of infrastructure, freedom of press and social cohesion may act as limiting factors (Dutrenit and Sutz, 2014).

The overall result for the African and S. Asian group indicate very weak and static NISs, because tests do not reveal a strong network of causal relationships and coevolution patterns. One cointegrating relationship is revealed between process innovations and inventions, which may indicate that innovation is led only by increases in labour productivity. The lack of any relationships amongst any other innovation proxies may indicate the lack of innovation diffusion within innovation systems.

Overall, we may summarise that three areas are the most common for our country groups with the direct impact on inventions: various education skills (for 4 groups out of 5), infrastructure improvements (4 out of 5) and strong trading position (4 out of 5). Our results also reveal that the quality of institutions (significant for 3 out of 5 groups) and social cohesion (significant for 2 out of 5 groups) may have direct impact on inventions for mid and low income countries, which may be explained by income and opportunity inequalities as well as a lack of institutional capabilities in developing countries (as discussed by Lundvall et al., 2009; Dutrenit and Sutz, 2014).

Table 10: The summary of results for the five country groups.

Groups of countries	1st hypothesis confirmation	2nd hypothesis confirmation and significant input factors
Advanced OECD	Yes, strong NIS dynamics	Yes <ul style="list-style-type: none"> • secondary school capabilities and advanced R&D skills by higher education sector • democracy level and quality of infrastructure • strong trading position
Mid-income Eurasian	Yes, weak NIS dynamics	Yes <ul style="list-style-type: none"> • quality of basic education and social cohesion • quality of institutions • strong trading position and domestic credit availability
Mid-income East Asian	Yes, fair NIS dynamics	No <ul style="list-style-type: none"> • tertiary education capabilities • quality of infrastructure • no significant economic input factors
Mid-income Latin American	Yes, weak NIS dynamics	Yes <ul style="list-style-type: none"> • quality of basic education, secondary school capabilities and social cohesion • quality of infrastructure and institutions • strong trading position
Low-income African and S. Asian	No, very weak/static NIS	No <ul style="list-style-type: none"> • no significant social input factors • quality of infrastructure and institutions • strong trading position

3.7. Conclusion

In this chapter we have argued that the dynamics of NISs are driven by the cointegrating relationship of four different innovation outcomes and investments in R&D. We have also argued that various social, institutional and economic factors may enhance or limit innovation generation process. The NIS approach, together with the innovation diffusion conceptual model was used to analyse these two hypotheses. A set of indicators for the period of 1980-2008 from the existing CANA database for 93 countries (grouped into five clusters) was used to explore these arguments.

The empirical methodology was based on the panel cointegration approach. The empirical operationalisation of the cointegration concept was analysed by investigating the existence of the long-run relationships amongst the variables and by analysing the direction of causality for each pair of variables. The significant relationships, indicating differences in dynamics of NISs' amongst the five groups, (based on the findings from the first hypothesis testing) were illustrated in Figures 1A-5A in the Appendix. Both hypotheses were confirmed for the OECD, Eurasian and Latin American groups (Table 10). We did confirm the first, but not the second hypothesis for the East Asian countries. We could not confirm the two hypotheses for the African and S. Asian group due to the lack of relationships amongst the variables.

This chapter contributes to the NIS literature by proposing a conceptual and empirical model which may be used by scholars and governments to analyse the internal dynamics of national innovation systems. The model reveals the level of dynamics as well as specific social, institutional and economic factors that may influence innovation generation within the NISs. These results may be used to analyse impact of relevant policies to innovation outcomes. For example, we may argue that our results reveal a possibly strong and direct involvement of the state in innovation creation in the OECD group. The OECD NISs could have been supported by strong interactions amongst innovation, trade, education and labour/industrial policies resulting in better innovation outcomes:

$$\text{Innovation Policy} = F(\text{Education Policy, Labour Policy, Trade/Industrial Policy, R\&D Investments})$$

Why is the coordination of policies so important? It is important since a mix of many different social, institutional and economic factors like public spending on education, school enrolment ratio, corruption perception, time and cost of enforcing contracts, trade openness, credit availability for research and development etc. may limit or enhance innovation generation and diffusion within NIS. Therefore, countries seeking to maximise innovation potential may want to coordinate their innovation policy with education, labour, trade/ industrial policies and investments in R&D. For example, a number of scholarships available for engineers or medical doctors at universities (education policy) may depend on specific industry needs (trade / industrial policy). Also, specific R&D funds allocated by national innovation policy may be directed to these universities (and linked with education policy) to enhance research, product and process innovation potential.

It is important to note that the econometric results for Eurasian countries may have strong policy implications and should lead to further discussions about coordination of the EU policies. The findings from the first hypothesis testing show, that one half of the EU countries (from the OECD group) have very strong NISs, while the other half (from the Eurasian group) does not. The findings indicate that Eurasian countries may not have strong NISs possibly due to low coordination between different types of innovations and a lack of stimulating social and institutional factors. Based on these results we may argue that the EU countries have significantly different innovation generation and diffusion patterns.

As a result, following the same EU innovation policy might not lead to the same outcomes in all EU countries. The post-socialist Eurasian countries may not have research capabilities, institutional quality and domestic credit availability to support innovation generation. A high corruption level, institutional inefficiency and high-income inequality may limit absorptive and innovative capabilities. The lack of innovation policy coordination with education, labour and trade policies may limit innovation diffusion within these countries. These conclusions support the arguments of the “European periphery paradox” (discussed in Chapter 1) and could be investigated further.

We may also conclude that the dynamics of the East Asian NISs is only partially driven by the coevolution of different policies. The results may indicate that the high-tech manufacturing sector is owned by foreign companies and it does not

originate from local scientific research or process innovation. Overall, we may conclude that the East Asian countries may want to focus on developing national trade/industrial policies and coordinating them with local education, labour and innovation policies in order to enhance innovation diffusion and the overall dynamics of their systems. Weak and static NISs in Latin American, African and S. Asian countries may be explained by the lack of coordination amongst relevant policies. Both groups may want to focus on improving the overall quality of education and social cohesion. Structural and institutional factors may also be addressed in order to stimulate innovation adoption and diffusion within their NISs.

The econometric exercise presented in this chapter reveals some limitations and outlines some possibilities for further research. It is important to understand limitations of the panel cointegration approach in order to avoid misleading interpretation of the results. The two-way causal relationship may be criticised for testing the causality by pairs, one-way at the time (first from A1 to B1, then from B1 to A1), however, this test is part of a system. The Wald test is used (over the coefficients from the system) to make sure that effects from the other variables are also included in the analysis, as advocated by Castellacci and Natera (2013). Granger-causality tests are also used as part of the four steps of a panel cointegration approach to confirm long-run two-way relationships. However, it is important to note that Granger-causality tests may have misleading results when the true long-run relationship involves three or more variables.

We group our 93 countries into five clusters based on their development level and geographical location, however, we acknowledge that the individual countries within these groups have many differences. Therefore, further analysis of a national data may lead to more reliable and robust results. Also, it would be interesting to test the cointegration amongst different social, institutional and economic factors and the three other innovation outcomes used in our first hypothesis testing: research innovation measured by scientific publications, product innovation measured by high-tech exports and process innovation measured by labour productivity. These three additional panel cointegration models might reveal an even deeper and wider understanding or internal relationships amongst determinants of the internal dynamics of NISs.

Appendix

Table 1A: Description, scope and codes of innovation variables used for the first hypothesis testing.

Indicator and Definition	Scope	Code
Ratio of UPSTO patents per capita: number of utility, design and plant patents granted by UPSTO by year and inventor's country of residence.	Proxy for inventions	PATENTS
High-tech exports as % of manufacturing exports: exports of products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.	Proxy for product innovation	HTEXPORTS
Ratio of scientific and technical publications per capita: articles published in physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.	Proxy for research innovation	SPUBLICATIONS
Labour productivity per hour worked: average output produced by unit of labour. Estimated by dividing GDP by labour input.	Proxy for process innovation	LPRODUCTIVITY
Research and development funds as % of GDP spend. Represents investments in R&D carried out by each country.	Proxy for innovative input	RDGDP

Table 2A: Description of independent variables with definition, scope and code used for the second hypothesis testing.

Indicator and Definition	Scope	Code
Most people can be trusted. Percentage of people that answered, "Most people can be trusted". May influence entrepreneurial, creative and innovative abilities.	Proxy for social cohesion	TRUST
Feeling of happiness. Index constructed using scales for each happiness level. Index from 3 (Very happy) to 0 (Not happy). May influence entrepreneurial, creative and innovative abilities.	Proxy for social cohesion	HAPPINESS

Enforcing contracts: time. Number of days needed to enforce a contract. Days are counted from the moment the plaintiff files the lawsuit in court until payment. Could be used as a measure of policy and institutional efficiency and quality.	Proxy for institutional efficiency	CONTRENFORCE
Finance freedom indicator, scored on a 100-point scale (100 - no interference, 0 - repressive government interference). Measures banking efficiency as well as independence from government control and interference in the financial sector. State ownership of banks leads to lower index. May be innovation limiting or enhancing factor based on type of finance available.	Proxy for banking sector efficiency	FINFREEDOM
Gross fixed capital formation (% of GDP). Includes land improvements, plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings.	Proxy for infrastructure improvements	GROSSFIXEDCF
Internet users per 1000 people. People with access to the worldwide network divided by the total amount of population for the correspondent year. May improve business infrastructure and benefit overall national creativity and capabilities.	Proxy for infrastructure improvements	INTERNET
Primary school pupil-teacher ratio. Number of pupils enrolled in primary school divided by the number of primary school teachers. May enhance overall national capabilities.	Proxy for basic skills and education quality	PRIMPPLTCH
Mean years of schooling. Average number of years if school completed in total population over 14 years old.	Proxy for capabilities	MYSCHOOL
Gross enrolment ratio secondary. Ratio of total enrolment, regardless of age, to the population of the age group that officially corresponds to secondary level.	Proxy for capabilities	2ENROLL
Gross enrolment ratio tertiary. Ratio of total enrolment, regardless of age, to the population of the age group that officially corresponds to tertiary level.	Proxy for advanced capabilities	3ENROLL

Public expenditure on education as % of GDP. Total public (current and capital) expenditure on education as % of GDP. May enhance overall national capabilities.	Proxy for education support	PUBEXPEDUC
Corruption perception index. Transparency International Index. Index from 0 (High Corruption) to 10 (Low or None Corruption). May limit or enhance entrepreneurial and innovation potential.	Proxy for institutional efficiency	CORRUPTPERCP
Domestic credit by banking sector as % GDP. Includes all credit to various sectors on a gross basis, with the exception of credit to the central government, which is net.	Proxy for domestic credit availability	DOMCREDIT
Gini index represents income distribution and measures level of inequality. 0 represents perfect equality and 100 perfect inequality. May impact opportunities for education and skill formation.	Proxy for social cohesion	GINI
Trade openness indicator. Ratio of (Import+ Export)/GDP. Measures integration into the world economy. May open external sources of knowledge and enhance capabilities of local firms and institutions.	Proxy for strong trading position	OPENTRADE
GERD - performed by government %. Total domestic intramural expenditure on R&D during the reference year, of institutions corresponding to government, independent of the source of funds and expressed as a percentage of GDP. Could be an indicator of advanced R&D capabilities at national level.	Proxy for R&D skills by government sector	GERDGOV
GERD - performed by higher education %. Total domestic intramural expenditure on R&D during the reference year, of institutions corresponding to higher education, independent of the source of funds and expressed as a percentage of GDP. Could be an indicator of advanced R&D capabilities at institutional level.	Proxy for R&D skills by higher education sector	GERDEDUCE
GERD - performed by business enterprise %. Total domestic intramural expenditure on R&D during the reference year, of institutions corresponding to business enterprise, independent of the source of funds and expressed as a percentage of GDP. Could be an indicator of advanced capabilities at a firm level.	Proxy for R&D skills by private firms	GERDBUS

Figures 1A-5A: Illustration of the results from the first hypothesis testing.

Figure 1A: OECD group (6 two-way and 1 one-way relationship).

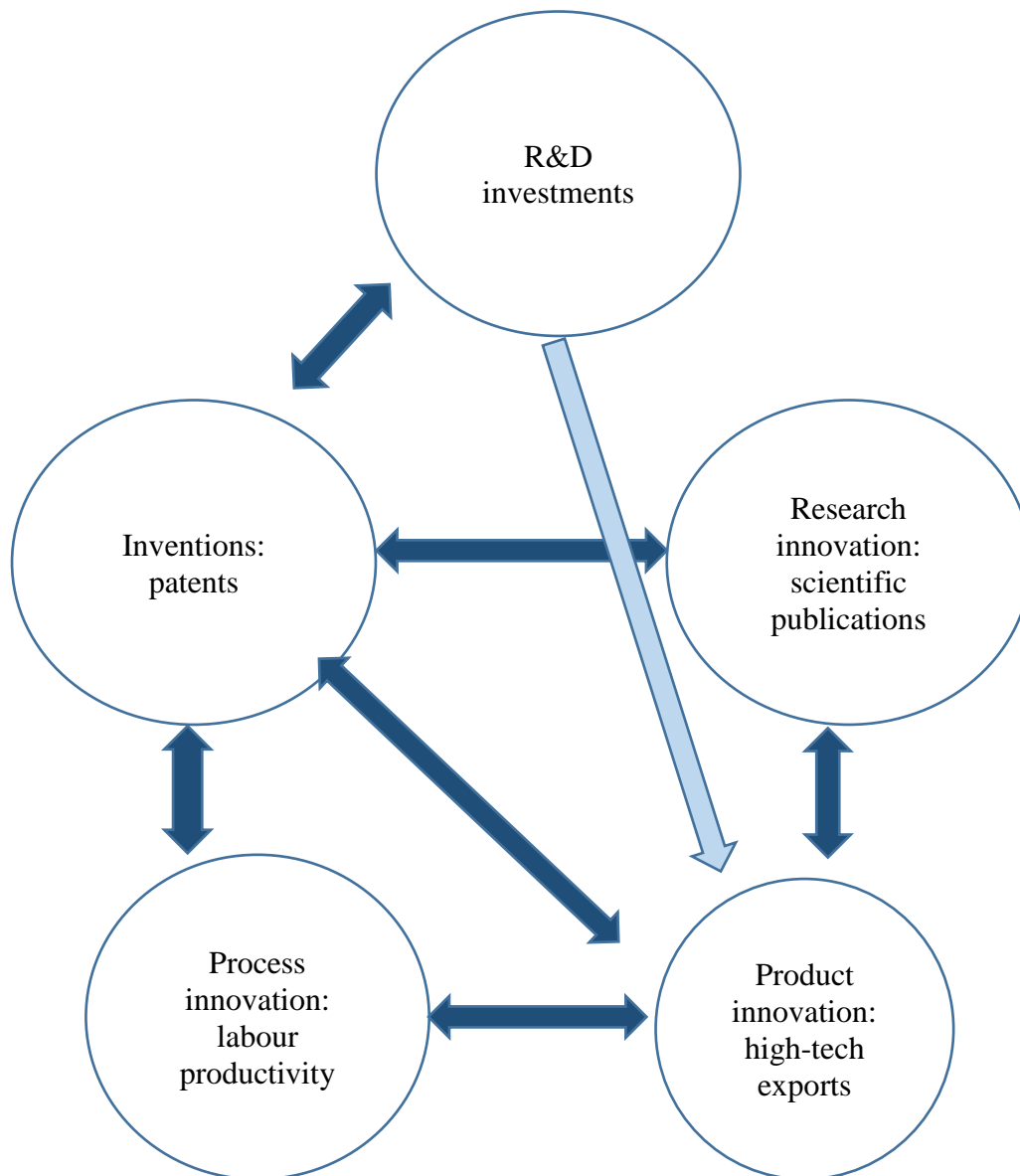


Figure 2A: Eurasian group (3 two-way and 2 one-way relationships).

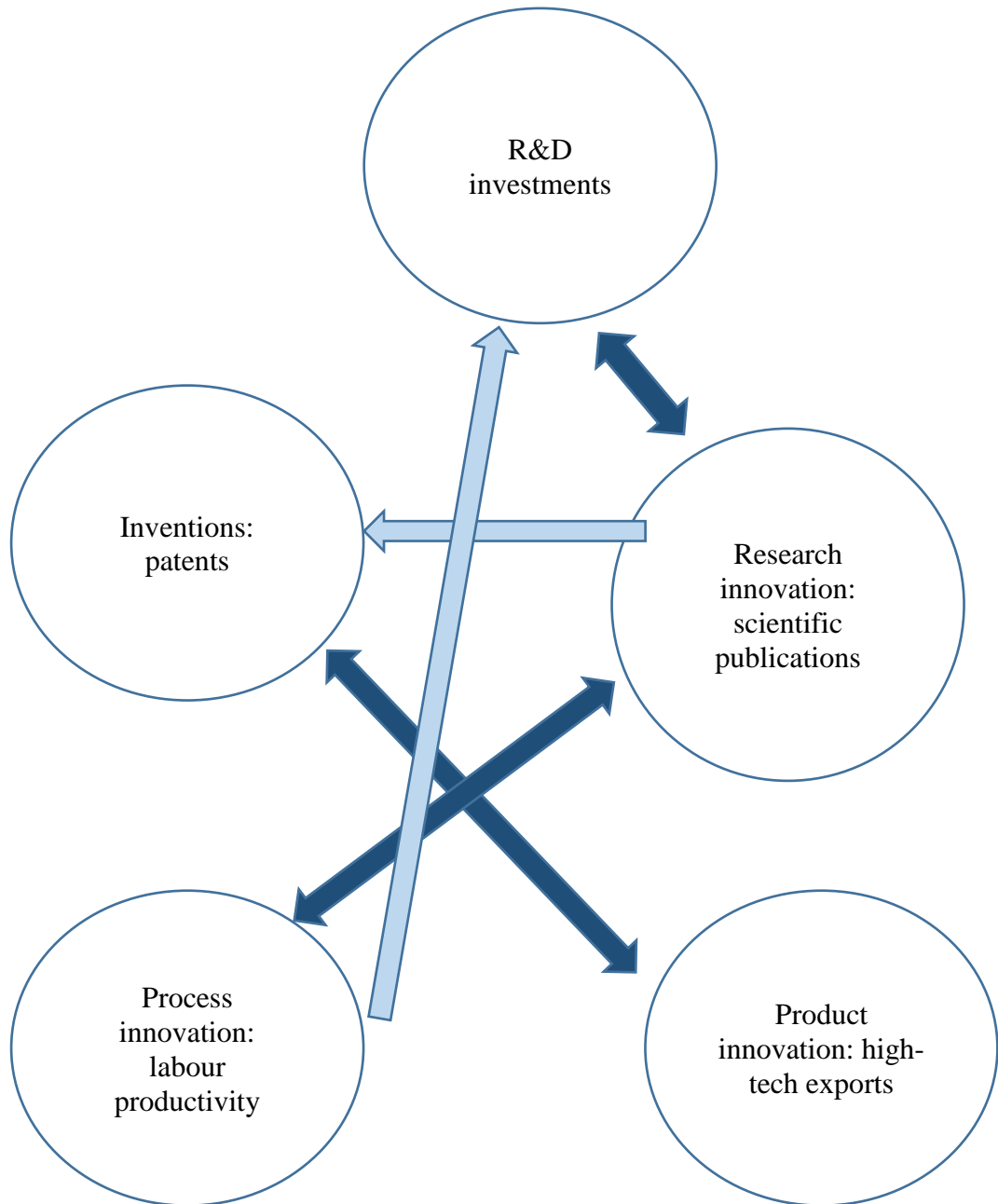


Figure 3A: East Asian group (4 two-way and 2 one-way relationships).

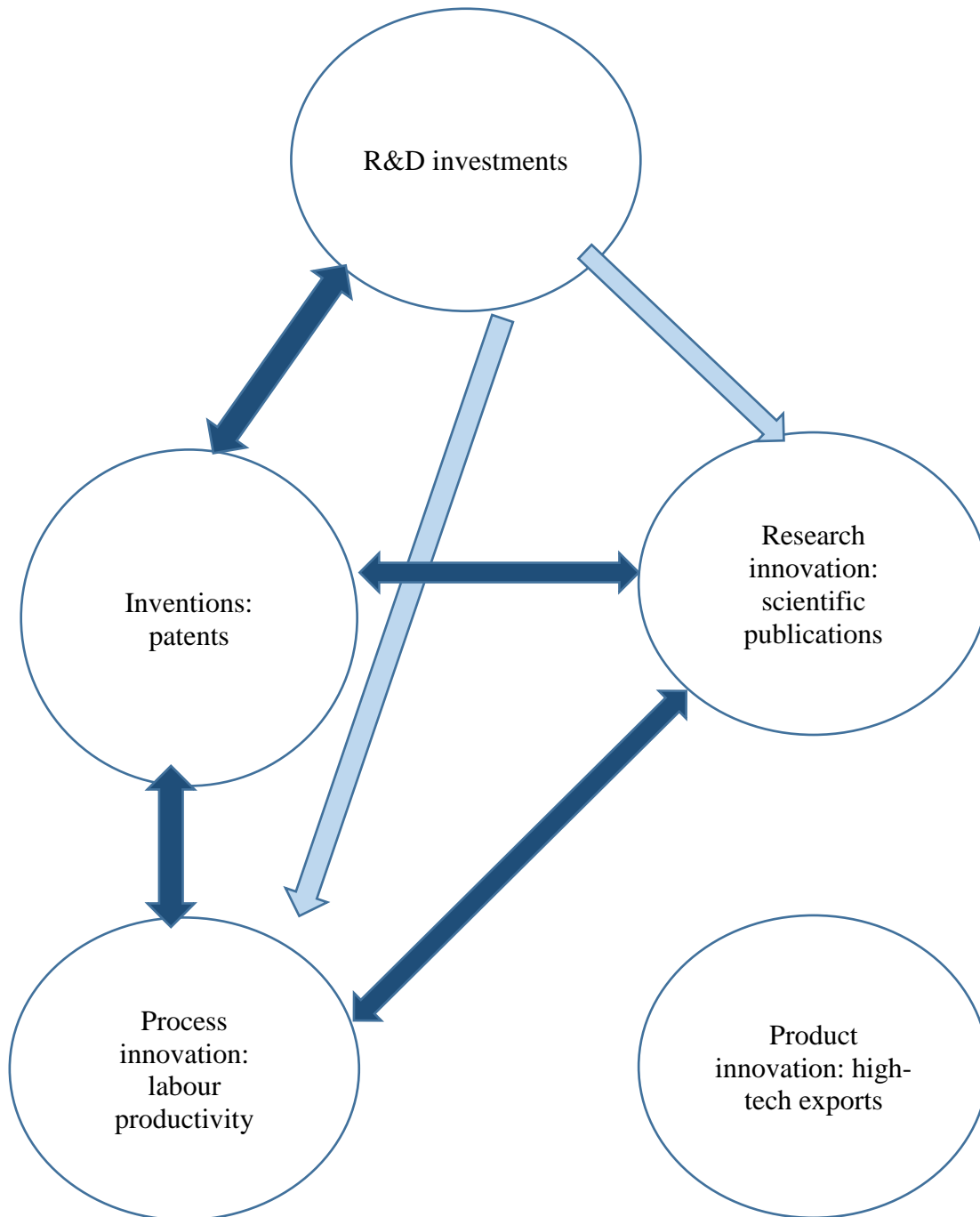


Figure 4A: Latin American group (1 two-way and 5 one-way relationships).

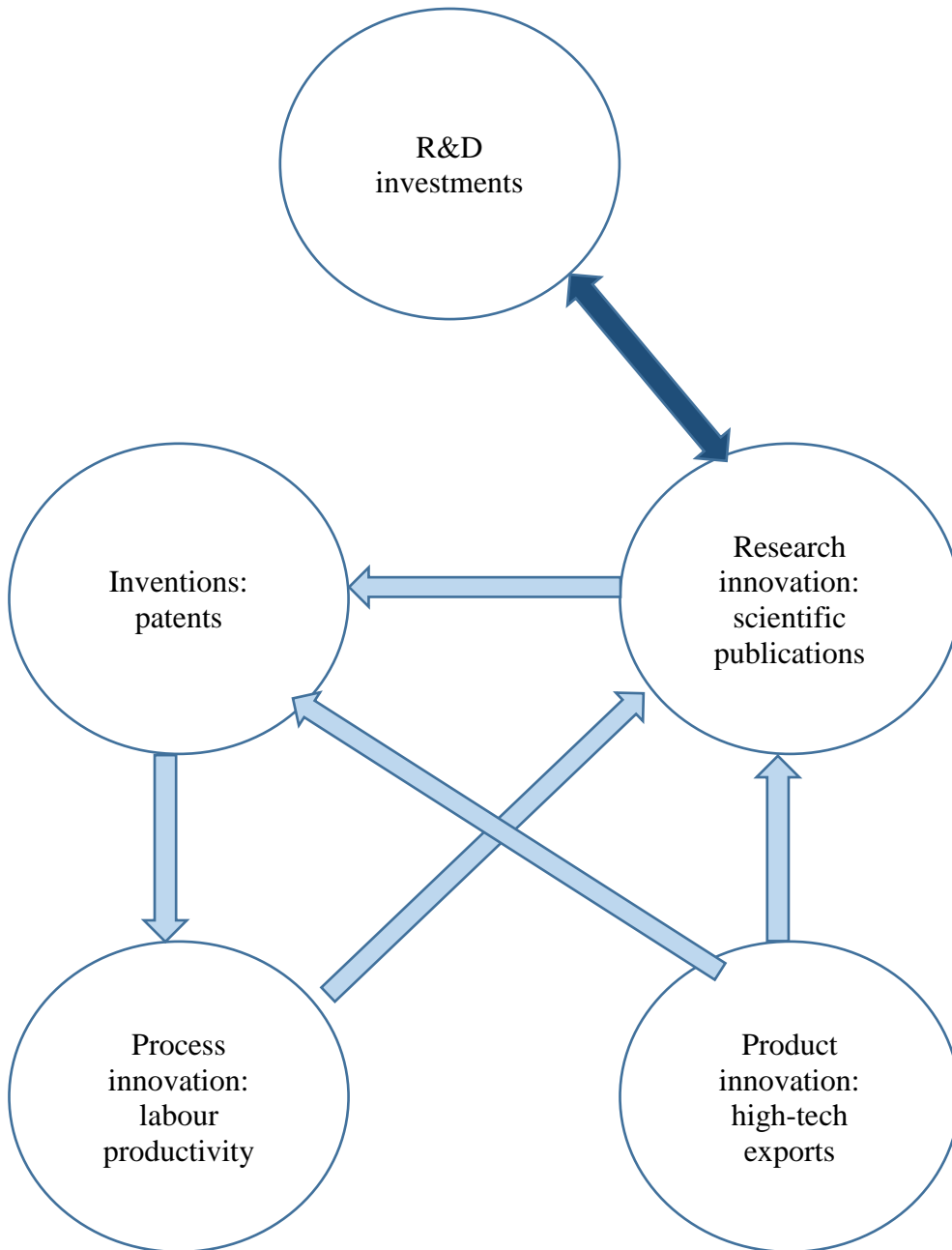
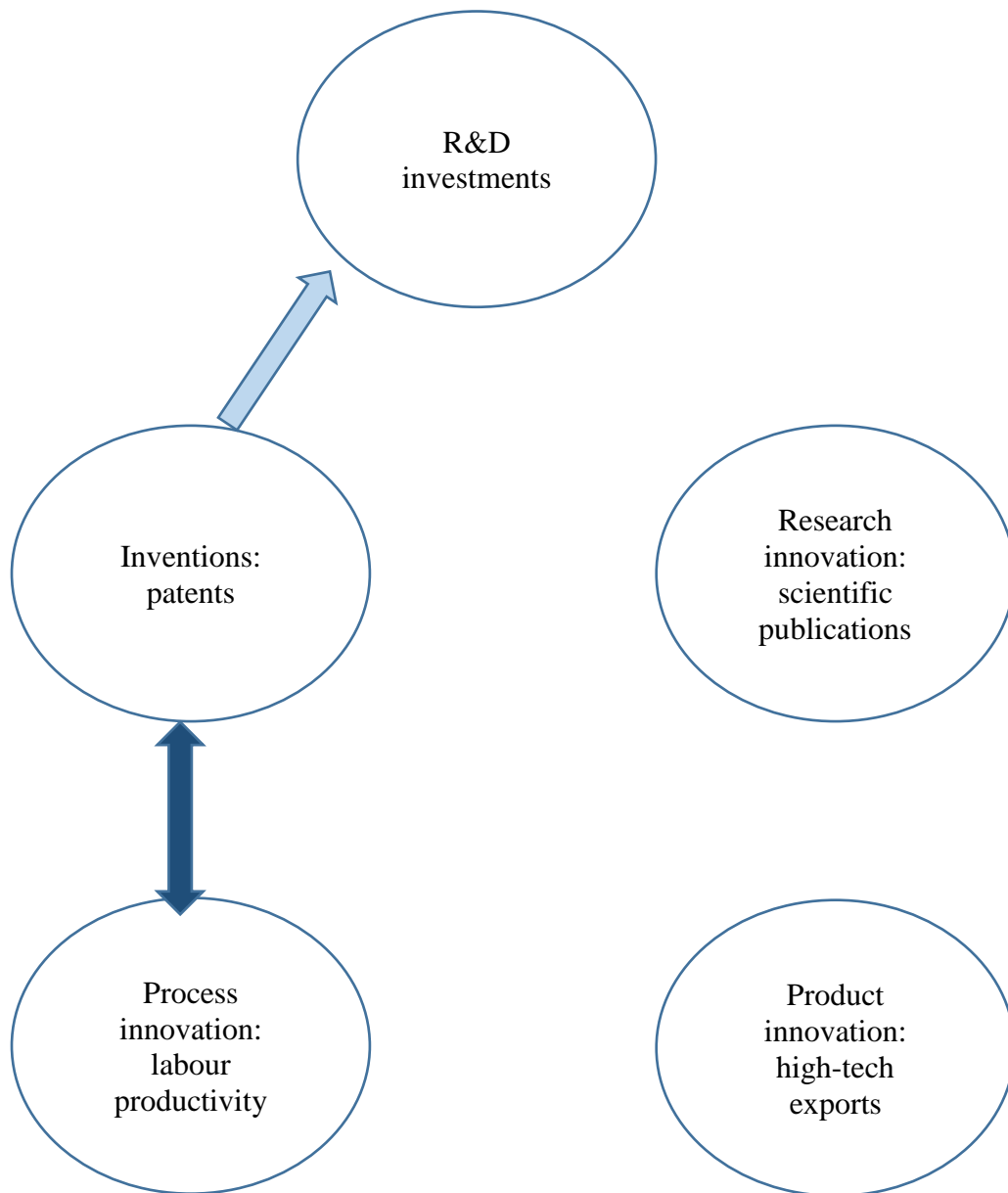


Figure 5A: African and South Asian group (1 two-way and 1 one-way relationship).



Chapter 4: The role of institutional entrepreneurship in transformation of the national innovation system of a transition economy: the case study of Lithuania

4.1. Introduction

The motivation behind this study is to understand why European post-Soviet countries still lag behind the top European innovators despite having full access to free markets, top scientific knowledge and the European Union (EU) funds. These countries were recognised and analysed by economists as transition states 20-30 years ago, but based on the recent literature, one may assume that the transition period has ended a long time ago.

The current literature explains the lagging behind as a catch-up process and suggests focusing on growth-enhancing policies (e.g. competition and education) as well as on innovation policies (Borras and Edquist, 2013, Radošević and Kaderabkova, 2011), on changes in education sector to update capabilities (Karaulova et al. 2016, Urbanović and Wilkins, 2013) and on more active relationships between businesses and universities (Binkauskas, 2014, Watkins et al. 2015) to stimulate innovation. The current approaches examine key components of NISs at macro and micro levels, and their interconnections. However, the role of human agency and, in particular, the role of institutional entrepreneurship within public organisations remains understudied.

Based on the initial research question (What factors affect transformation of the transition NIS?), this chapter argues that NISs of post-socialist countries are still in transition due to various institutional inefficiencies (such as a lack of relevant organisational, managerial and entrepreneurial capabilities), institutional stickiness and rigidity. Transition is a long-term systemic change and government institutions should be the key moderators of this change. However, the initial findings from data show that various institutional inefficiencies of the public sector act as barriers to transformation. Such findings encourage a narrowing down to questions of what (who) and how reinforce institutional change. The deeper analysis of data from interviews reveals that institutional entrepreneurship reinforces institutional change through various internal (within an organisation) and external pressures (better policy-making

and implementation). For the purpose of the chapter, we define institutional entrepreneurship as an initiative to shape and change institutions (DiMaggio, 1988).

The theoretical contribution of the study to the NIS literature of transition economies is twofold. Firstly, it reveals that public institutions need to change in order to transform innovation systems faster and more effectively. Secondly, it points to the importance of the human agency role in the process of institutional change. The study shows that institutional entrepreneurship might be the key mechanism to stimulate institutional change, to improve system-wide capabilities and to enhance the overall transformation of the transition NIS. The problem of institutional inefficiency has been acknowledged in innovation literature of transition countries for many years. However, institutional entrepreneurship has never been analysed as a solution.

The findings have important implications for academics, managers and policy makers of transition and developing countries. It is important to understand the mechanisms behind the transformation of NISs of transition economies because 15 post-soviet countries in Europe and Asia have a total population of 292.6 million. These countries vary in size from 1.3 million in Estonia to 143.9 million in Russia, but all together they have a very significant contribution to the overall economic growth patterns of both regions. The case study focuses on small states that could be distinguished from others by their population size. Following a definition from the Forum of Small States by the United Nations we conclude that 11 out of the 15 post-soviet states could be defined as small states with a population of under ten million. All small states face similar challenges in pursuit of innovation-based growth such as the lack of scale for investments in scientific research, innovative infrastructure and high-tech manufacturing.

The chapter is organised in the following order. Firstly, we review literature on the NIS of transition economies. Secondly, we review the methodological approach used to design the case study. Following this is the analysis of findings from the qualitative study of interviews in Lithuania. We conclude by discussing the implications of the study, its limitations and possible directions for future research.

4.2. Literature review

4.2.1. The NIS approach within the context of transition economies

In this study we use a broad definition of NIS as proposed by Lundvall et al. (2009). We define NIS as an interaction between formal (laws) and informal (cultural norms and values), public (institutions) and private (firms) national components in new knowledge production. Early studies of highly developed NISs focused on macro level components. However, the rapid growth of developing countries expanded the definition of NIS and shifted the focus towards local capabilities (Kim, 1993; Lundvall et al., 2009). The NIS approach for the analysis of developing countries incorporated new aspects such as macro and micro interactions (Lefwitch, 2009), the active role of the government and policies (Gu and Lundvall, 2006a and 2006b; Kathura et al., 2013), networks, industry associations and other intermediaries (Dalziel, 2006; Dutrenit et al., 2012) as well as internationalisation (Carlsson, 2007).

The NIS framework is very useful for analysing developing and transition countries due to its focus on the 'local' capabilities to change, adopt and develop new skills (Lundvall et al., 2009; Metcalfe and Ramlogan, 2008; Hogselius, 2005; Kitanovic, 2007). A transition economy may be highly developed, however, it may still face similar issues to a developing economy. Economists raise certain issues for developing countries. For example, Abramovitz (1994) argues that various capabilities are more important than resource endowments and means to enhance the potential of social capital. New knowledge and learning (Arocena and Sutz, 2005) are important in order to catch-up and advance (Abramovitz, 1986). Public institutions and new policies (Acemoglu et al., 2003) act as the main causes of economic development and may even be related to major structural changes (Kaldor, 1967).

It is important to understand that socialist countries had a specific industrial and institutional structure for over 50 years which restricted their knowledge creation patterns. Therefore, skills of knowledge building at individual, firm and institutional levels were very limited. Socialist economies were controlled by a single political party. All production was state-owned and there was always one main coordinating mechanism for all countries (Hogselius, 2005). As a result, there were no small and medium enterprises and there was no market since the political authorities planned all

steps of production and distribution. Large state-owned companies performed not only production, but also social and political functions.

Based on these historical facts, we may argue that socialist countries were not dynamic learning economies, but very static and stable implementation mechanisms of the USSR planning system. Learning and change within states was very slow and it was implemented only if ordered by the main ruling party. For example, students did not have to look for a job after the graduation. Instead, they received a relevant position after graduation according to the law. Firms did not have to look for new markets to sell their production. Instead, they just had to ship products according to the 'five-year plans' crafted by the political party. Product or process changes were made if requested from 'the above' - companies themselves did not analyse or follow changes in the market (Hogselius, 2005). Universities were guaranteed with a funding stability and a certainty of supply and demand of students (Kitanovic, 2007). All institutions had very limited autonomy, but they all had stability because of this so called 'five-year' planning.

The term 'transition' could be defined as a transformation from planned socialist economy to market oriented economy. It also includes a change from being integrated with other socialist states to being integrated into the global economy. During this transition period, a country develops new capitalist skills. Private firms become very important players, but due to their relatively low experience and maturity level, new policies and government institutions with clear strategic vision act as important facilitators to support the reorientation and transformation of a transition economy. The effectiveness of macro and micro interactions, and the active role of public institutions, universities and industry networks, as well as internationalisation become the prerequisites for economic change, much in the same way as with developing countries.

Drawing from the most current empirical qualitative case studies of transition NISs, we may argue that the success of transformation and reorientation depends on the national abilities (at individual, firm and institutional level) to become a learning economy. Such abilities include a capacity to build on the existing knowledge and to catch-up with the current global market needs. Three major themes emerge in the current literature to address transformation problems: the education sector (Grimes and Millea, 2011; Urbanovic and Wilkins, 2013; Karaulova et al. 2016), relationships

between businesses and universities (Inzelt, 2004; Binkauskas, 2014), innovation and other related policies (Radosevic and Kaderabkova, 2011; Smallbone and Welter, 2012; Kattel and Primi, 2012; Paliokaite et al. 2016).

Grimes and Millea (2011) and Urbanovic and Wilkins (2013) argue that internationalisation as well as having new training, new evaluation criteria and new teaching methods, would benefit education systems. Grimes and Millea (2011) look at the effectiveness of secondary school teacher training in Kazakhstan, while Urbanovic and Wilkins (2013) analyse the quality of higher education in Lithuania through the internationalisation strategy perspective. Grimes and Millea argue for the importance of retraining teachers in post-soviet countries. They show that the results of students taught by trained teachers achieve higher scores on standardised tests. Urbanovic and Wilkins (2013) analyse internationalisation as a strategy to improve the quality of higher education in Lithuania. They conclude that the benefits of internationalisation outweigh disadvantages in the higher education systems of small states. Urbanovic and Wilkins advocate for institutional mergers, for the recruitment of best international professors and for setting internationalisation targets for universities.

Inzelt (2004) and Binkauskas (2014) argue in favour of the active role of government to address the transformation of NIS through policies. Inzelt (2004) analyses university, industry and government relationships in Hungary. He argues that the internationalisation of business R&D and innovation processes has been very important in the development of the Hungarian innovation system. Inzelt suggests that more interactions between businesses and universities could be facilitated by an innovation policy and active government programs that would support knowledge-based growth in transition economies. Binkauskas (2014) examines reasons behind the successful cooperation between universities and businesses in Lithuanian NIS and looks at the knowledge transfer channels throughout the course of the last ten years. Binkauskas concludes that the characteristics of the Lithuanian NIS are the same as those of a developing country. He lists the absence of innovation culture, ineffective funding of universities, lack of mediators and intermediaries between businesses and science and the absence of tax incentives for businesses as the main barriers behind the long delay in development of NIS.

Many economists argue that innovation policy together with other policies play a major role in the transformation of transition NISs in Europe. Radosevic and Kaderabkova (2011) propose to focus on growth enhancing policies (like competition and education) as well as focusing on demand side policies that could stimulate local innovation culture and improve systemic responsiveness to new emerging challenges and market needs. Kattel and Primi (2012) propose focusing on two major problems: the long-term strong mismatch amongst R&D, education system outcomes and local industry needs; as well as the double fragmentation of innovation policies. They argue for specific policy goals and instruments, incremental efforts to enhance capabilities fitting a specific context and time, as well as, for policy continuity as a major solution for the “European periphery paradox” (ibid, 2013).

While most papers focus on opportunities to enhance NISs of transition economies through policies, the impact of the human factor in policy creation, implementation and the whole process of institutional change remains overlooked. Paliokaite et al. (2016) argue that actors, representing different groups of the NIS, do not behave “according to the logic of appropriateness” (ibid, p.149). Many actors during the process of policy creation and implementation do not rise above their own interests, instead, they just make decisions based on a potential benefit for themselves. The authors suggest that better monitoring and post-evaluation of the policy creation could be better implemented through triple-quadruple-quintuple partnerships within the NIS and beyond.

The problem of institutional inefficiency in transition economies is recognised by scholars (Archa and Balazs, 1999; Hogselius 2005; Kitanovic 2007; Alesina and Fuchs-Schündeln, 2007; Binkauskas, 2014; Paliokaite et al. 2016), however, the role of institutional entrepreneurship within the process of institutional change is understudied. The concept of institutional entrepreneurship is widely discussed in management and organisational studies and is defined as an initiative to shape and change institutions (DiMaggio, 1988). The institutional entrepreneurship concept is often contrasted with the institutional embeddedness paradox which argues that an individual might be restricted by existing organisational limitations (Archer, 1995).

Institutional theorists emphasise that organizational behaviours are defined as stable, repetitive and very resistant to change. Force of habit or path dependency, history and tradition as well as social conformity to various norms and expectations

may be listed as main causes for such resistance and ongoing institutional embeddedness (Meyer and Rowan, 1977; Zucker, 1977; DiMaggio and Powell, 1983). However, the social conformity to static institutional rules contradicts with the role of rational agency (strategic management behavior by institutional entrepreneurs).

Beckert notes that these two “mechanisms...contradict each other, but, nevertheless, remain interdependent” (1999, p. 777). Beckert argues that the necessity to reduce uncertainty holds institutional rules and strategic agency (institutional entrepreneur) together as two coordinating mechanisms. This tension between the ‘new’ and ‘old’ institutionalism opens new possibilities to expand our knowledge in organizational analysis. Furthermore, the concept of institutional entrepreneurship sheds new light on the process of institutional change by reintroducing the agency, power and interests into analyses of institutions.

The key issues in institutional entrepreneurship theory are related to understanding which actors and how are able to see, initiate and impose alternative institutional arrangements (Greenwood and Suddaby, 2006; Boxenbaum and Battilana, 2004; Seo and Creed, 2002; Holm, 1995). The concept of institutional entrepreneurship draws on Schumpeterian understanding of entrepreneurship as an interest driven strategic behaviour. This behaviour is not focused on routines, it is oriented towards change in the economy, organisation and society. The change is led by individual agents and is targeted towards doing something new, different and better.

Schumpeter (1943) defined entrepreneurship as ‘creative destruction’. However, it is important to recognise both, possible destructive and constructive aspects of innovative entrepreneurial actions. Institutional entrepreneurs might destroy established practices and routines by providing new and better alternative models to fulfil goals. Following Schumpeter’s (1943) arguments, we may view institutional entrepreneurs as open, motivated to change and aware of various new alternatives.

The academic literature touches upon various important aspects of institutional entrepreneurs. Beckert (1999) stresses abilities of institutional entrepreneurs to dis-embed themselves from existing institutional constraints in order to change existing institutions or to create new ones. DiMaggio (1988) notes that institutional change is possible if individual actors are organised, motivated, entrepreneurial and are able to see opportunities in institutions that they highly value. Garud et al. (2002) proposes to

look at institutional entrepreneurs as champions that lead and strategise collective actions that change innovative technology fields.

The role of power is an important aspect of institutional entrepreneurship practices and possibilities to legitimate institutional change. Power may be established by resources, knowledge and important social position within a network. Battilana (2006) argues for the importance of social position and power in relation to individual abilities to resist institutional embeddedness and challenge existing rules. She notes that the social position might empower institutional entrepreneurs to initiate changes and gather other actors and resources that are necessary for changes.

The institutional 'work' performed by institutional entrepreneurs could be summarised as purposive actions aimed at creating, maintaining or disrupting institutions (Lawrence and Suddaby, 2006). Maguire et al. (2004, p. 657) argue that entrepreneurial initiatives are "activities of actors who have an interest in particular institutional arrangements and who leverage resources to create new institutions or to transform existing ones". Institutional entrepreneurship is also about "entrepreneurs who seek to change institutionalised rules" (Beckert 1999, p. 791), to "organize actors with sufficient resources" (DiMaggio, 1988, p. 4), to expand boundaries and reconfigure existing belief systems (Lawrence and Suddaby, 2006).

By legitimising the change, institutional entrepreneurs initiate "corrective" and "purposive" internal actions (DiMaggio 1988, p. 5) in order to disrupt institutions (Oliver, 1992). Such institutional 'work' could be related to deinstitutionalisation (Oliver, 1992) or the lowering of institutional embeddedness (Greenwood and Suddaby, 2006) through bridging boundaries (Lawrence and Suddaby, 2006). Greenwood and Suddaby argue that "a network position that bridges fields lessens institutional embeddedness by exposing actors to inter-institutional incompatibilities, increasing their awareness of alternatives" (ibid, p. 38). Oliver (1992) notes that pressures for deinstitutionalization may be political, functional or social.

There are many examples of institutional entrepreneurship in public organisations in the recent academic literature. The introduction of business planning in museums in one of the provinces in Canada (Oakes et al. 1998). Professional associations initiating new standards of procedures for accounting firms in Canada (Greenwood et al. 2002). Professional associations developing and coordinating policy work to get funding for innovative diabetes treatments in Austrian hospitals

(Windrum et al. 2018). An IT firm leading and sponsoring the creation of new technological standards in the USA (Garud et al., 2002). A grass roots initiated radical change of the overall education system in Estonia (Loogma et al. 2013). Entrepreneurial universities and academic entrepreneurship as an effort to promote technology and knowledge transfer (Clark, 1998; Etzkowitz, 2003; Etzkowitz et al. 2008; Pinheiro and Stensaker, 2014; Benneworth et al. 2016; Guerrero et al., 2016). An entrepreneurial university in a civic society acting as a civic entrepreneur in the state of Oregon, USA (Etzkowitz, 2013) and institutional entrepreneurship in public sector agencies in order to provide policy guidance (Leyden, 2016).

Despite the rich literature, there is no clear direction concerning the ways to analyse the process of institutional change. Therefore, we chose to follow an activities-based analysis of NIS (proposed by Edquist, 2005) in order to understand how the process of institutional change unfolds and what factors influence the whole transformation of the NIS. Edquist (2005) argues that the two main functions of NISs are to develop and diffuse innovations. He proposes to follow the activities-based approach in order to understand how different activities fulfil the two main functions of an innovation system. Edquist (2005) lists ten main activities grouped into four areas: provision of knowledge inputs, demand side activities, creation and change of organisations needed for developing new fields of innovation, support services for innovating firms.

Hogselius (2005) and Kitanovic (2007) also favour the activities-based approach for the analysis of transition NISs. Hogselius (2005) argues that the activities proposed by Edquist (2005) may be defined as actual processes within a system. These processes are serving in the creation, diffusion and utilisation of innovations. Kitanovic (2007) notes that innovations could be defined as combinations of existing and/or new knowledge for transition economies. This change in knowledge depends on learning processes, therefore, we may look at NIS activities as determinants of knowledge building. Lundvall and Johnson (2006) propose to acknowledge four broad categories of knowledge: *know what*, *know why*, *know who (when and where)* and *know how*. They argue that *know how* and *know who* are especially relevant to transition economies, since firms, government agencies and universities need to learn how to develop relationships amongst different groups at the national and international level.

4.3. Methods and data analysis

The rationale for using a single case study method could be supported by Yin's (2014) definition. He argues that a single case study is a unique way of observing any natural phenomenon in a real life context. By unique he means that only a small geographical area and a small number of subjects of interest within that area are examined in detail. Yin argues that a single case study method may be effectively applied for theory testing as well as theory building. Yin (2014) also notes that a single case study does not represent a sample, therefore, the researcher's goal is not to generalise results, but to expand and generalise theories.

4.3.1. Research setting

The context of Lithuania for the case study was chosen due to a few reasons: due to the relatively low innovative performance (OECD, 2016; Paliokaite et al. 2016; Binkauskas, 2014); the lack of studies analysing factors of transition NISs; and the familiarity with the local culture, language and institutions. Lithuania is a small Eastern European country with the population of 2.7 million according to 2015 statistics. Lithuania went through many structural changes and experienced high growth rates since gaining independence from the USSR in 1990. In 2004, the country joined the European Union and in 2015 it adopted the euro. Lithuania is considered as a highly developed country with one of the highest Human Development Index's. It has been called the Baltic Tiger by the Economist in 2003 and was seen as a success story after the collapse of the USSR, but currently Lithuania is at the bottom of the EU innovation performance rankings⁹.

The use of the qualitative research method was appropriate due to a number of reasons. Based on the theoretical insights from the literature of transition economies, we already know that the success of transformation of NIS depends on its capabilities to change, adopt and develop new skills. Therefore, we decide to use semi-structured interviews. We interview actors of the NIS in order to learn how they participate in the innovation system, what activities they perform, and whether they perform them

⁹ As reported by a multi-dimensional innovative performance index Innovation Scoreboard by the European Commission (2017):

https://www.rvo.nl/sites/default/files/2017/06/European_Innovation_Scoreboard_2017.pdf

well or not. The activities approach is useful because it allows participants to evaluate their own activities and reveal their capabilities to participate in various innovative projects. While discussing activities, actors analyse interactions with other actors and their capabilities as well. It also helps to reveal positive factors that influence positive change as well as barriers that restrict change in capabilities, innovative activities, innovative outcomes and the overall transformation of the NIS.

4.3.2. Data collection

The scope of the analysis includes 30 in-depth, semi-structured interviews with representatives from government agencies, universities, science research centres and private non-profit associations representing local innovative firms. The selected organisations represent major stakeholders of the Lithuanian innovation system. The organisations were selected based on their active participation in various activities of the NIS. All participants had a deep and wide understanding of the local innovation system since they were members of the strategic science, research and innovation policy advisory group, organized and led by the Office of Prime Minister. This working group was created in 2014 and was involved in the current 2014-2020 innovation policy creation and implementation.

Table 1 lists four groups amongst 30 participating organisations which are major stakeholders of the Lithuanian innovation system. The sample covers all major institutions in Lithuania. Two Ministries (Education /Science and Economy) in Lithuania are directly related to innovation policy creation and implementation. We interviewed eight representatives from government agencies under the two Ministries. These agencies are responsible for implementing various innovation policy instruments, providing R&D funding for businesses and consulting services during the R&D process, providing support during the commercialisation process and other legal advice.

We chose eight representatives from science and research-based universities. We also invited representatives from five public research centers that are active players in the innovation system, as well as representatives from nine non-profit business associations (representing views of local innovative companies) to participate in our study. Additional sources of evidence include policies and publicly available statistical data from Eurostat and the Lithuanian Department of Statistics.

Table 1: Four groups of participating organisations.

Government agencies	8
Universities	8
Non-profit business associations	9
Science and research centers	5
Total	30

4.3.3. Development of questionnaire

The main goal of the study was to understand factors that drive transformation of an innovation system. The unit of analysis: activities and interactions of public and private non-profit institutions. These institutions represent major stakeholders of the NIS. In the development of the questionnaire, we started with the activities-based approach (Edquist, 2005). We expected that it would allow us to uncover possible gaps in activities, evaluate activities and capabilities, as well as to reveal underlying mechanisms that affect innovation generation and diffusion within the innovation system. We chose to conduct semi-structured interviews because we wanted to get the maximum breadth and width of the reality of the Lithuanian NIS. We based our questions on the prior knowledge of the NISs of transition economies, as advocated by Sobh and Perry (2006).

We started interviews with six broad, semi-structured WHAT, HOW and WHY questions (please see a sample questionnaire in the Appendix on p. 118). We wanted to understand how an organisation participates in the NIS, how it relates to other players, and what factors have a positive and negative effect on their innovative activities etc. In addition to the six broad questions, we explored five to six more specific questions related to factors that influence their innovative activities, relationships with other players and the overall transformation of the NIS.

These additional questions depended on the flow of conversation, specific innovative activities that an organisation performs, and the type of an organisation etc. With the more specific questions, we wanted to understand how these factors change, and who changes them. During the interviews, we encouraged our participants to raise additional questions, to develop their own hypothesis and to uncover hidden,

underlying mechanisms and/or causal explanations of positive and negative factors behind the transformation of the NIS.

4.3.4. Interviewees

The selected representatives from government agencies and business associations were mid or senior level managers directly related to innovation policy through one of these functions: policy-making, policy advising or policy implementation. The representatives from universities and research centers were selected based on their positions related to the direct management of innovative research projects and /or the management of innovation departments. The participants had 6-15 years of experience in their positions and/or fields. All potential participants were initially contacted by email. The content of the email included an overview of the study and an invitation to participate in the interviews. The second email included information about the proposed day and time for the interview at the participant's place of work.

4.3.5. Interviews

All interviews were conducted from July of 2016 to February of 2017. Interviews lasted an average of 90 minutes and were conducted in person at the participant's place of work. All conversations were audio recorded and transcribed. Throughout each meeting the interviewer also took notes of relevant points which later led to further questions. As interviews proceeded, the interviewer added or changed certain questions influenced by previous interviews and an increased knowledge about critical issues concerning the local innovation system.

Therefore, the research design consisted of two stages: prior theory and triangulation. Firstly, the interviewer asked questions based on prior knowledge but then later on in the process, questions were changed based on new information. Some interviewees were asked to further explain specific questions by email and telephone after all interviews were conducted. The purpose of this triangulation was to capture the actual multi-level complexity while using prior knowledge as additional evidence at the end of the process, as advised by Sobh and Perry (2006).

4.3.6. Data analysis (first phase)

Given the context of transition NIS, we first aimed to understand factors that influence the process of transformation. The interviews revealed that Lithuania has a functioning innovation system, however, “the system is static and slow in responding to a changing environment” (Business representative 6). Interviewees argued that the lack of interactions amongst the major actors of the NIS (institutions, universities and firms) as well as the lack of relevant organisational, managerial and entrepreneurial capabilities cause the system to be static and slow. Following these findings, as well as prior knowledge from the NIS literature, we may argue that policies created by government institutions, new knowledge created by universities, and innovations produced by local firms shape the transformation of the Lithuanian NIS. All these factors are path dependent from historically established cultural norms and organisational behaviours.

From the interviews we learned that domestic high-tech firms in laser, bio technologies and information technology services are the most active players in the NIS. These sectors were developed by the state 30-40 years ago. Having been privatised after the 1990s, these sectors were able to continue established international business relationships after adjusting to market needs, while many other mature industries collapsed completely. High-tech sectors experienced 18-20% annual growth over the last five years (The Statistics Department of Lithuania, 2016) and have good growth potential for the future. As a result, business associations within these sectors take initiatives to launch research projects, policy changes, networking with local universities and other institutions.

However, high-tech manufacturing firms are too small (they generate only 1% of the GDP value) to generate significant growth in breakthrough innovations in the economy. Knowledge intensive service firms generate 13% of GDP value (please see Graph 1A and Table 1A in the Appendix on p. 119 for more details), but all together these two groups employ only 2% of the working population. From the interviews we also learned that “local high-tech firms updated skills very fast due to export based growth” (Business representative 2). They had no other choice, but to catch-up with technological change and develop more innovative skills in order to be able to compete internationally.

Due to the relatively small share of high-tech industries in the economy, the interviewees do not expect local businesses to lead the breakthrough in innovations. The innovation diffusion of local high-tech products and services is low, because the majority of local businesses are not mature enough to adopt them. However, one respondent argues that the “breakthrough in innovations could come from local scientists if it is supported by institutions and policies” (Research centre representative 2). “Lithuania has great R&D infrastructure” (Business representative 1), but not enough researchers or enough innovative research projects. Another respondent notes: “if we focus our R&D funds and policies to making a career of researcher popular in Lithuania we could be very successful innovators” (University representative 3).

All respondents agree that universities are at the center of knowledge creation. However, “universities still remain relatively closed organisations and act as the most misbalancing components within the current NIS structure of Lithuania” (Government representative 1). Universities are responsible not only for innovation, but also for the overall capabilities produced by the whole education system, since they prepare teachers for primary and secondary education. One representative defined the current education system as “... too standardised and unable to enhance creativity, entrepreneurship and innovative skills.” (Business representative 3). All respondents argue for higher level of openness and internationalisation of local universities, however, Lithuanian universities currently have only 4.3 % of international students in the pool of total tertiary level students and only 1.2 % of international PhD students (based on the 2015 data from the Department of Statistics of Lithuania).

The overall legal framework produced by public institutions is very important in the process of transformation of the NIS; and public institutions are expected to be the key moderators of the change. Innovation policy is especially important for the transformation of the NIS because it guides the overall distribution of R&D funds through various implementation tools. The R&D funds are provided by the local government and the EU structural funds based on the six priority (smart specialisation¹⁰) areas. However, some respondents argue that the current 2014-2020

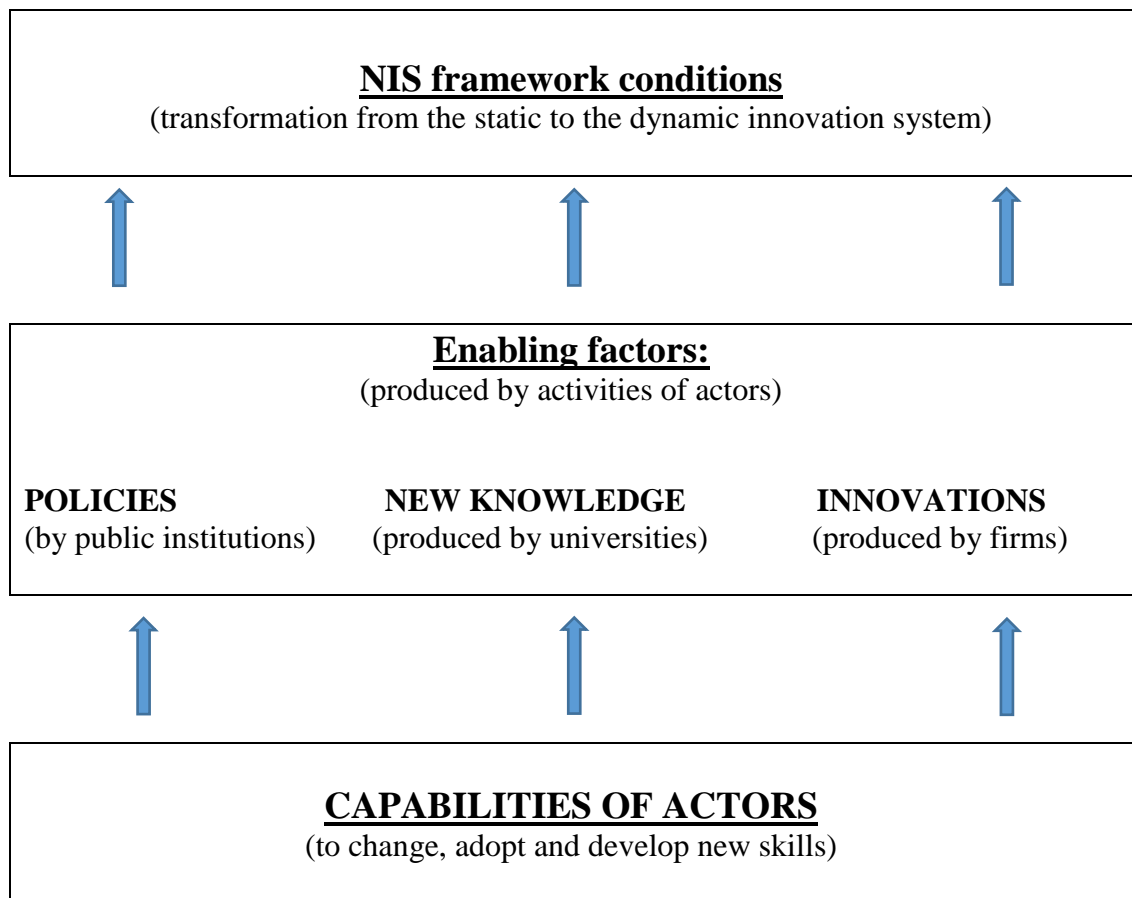
¹⁰ The smart specialisation areas include: energy and sustainable development; health technologies and biotechnology; agro-innovation and food technologies; new processes, materials and technologies for industry; transport, logistics and ICT; inclusive and creative society (The Lithuanian Innovation Development Program 2014–2020).

national innovation policy is disappointing for innovative businesses, because "... it does not attempt to be a strategy to increase future innovation potential" (Business representative 4). "It does not provide instruments to stimulate production of higher added value products and services" (Business representative 9).

The internal capabilities of employees at local public institutions were mentioned in interviews as very important factors in the process of policy creation and implementation. However, many respondents note that "employees of public institutions and especially universities are still afraid of a change, even though innovation is a change" (Business representative 2). All respondents agreed that most of the public institutions in Lithuania still lack relevant organisational, managerial and entrepreneurial capabilities. "Most government officials still think that innovation will happen on its own and that there is no need to stimulate it. In fact, there are only about 20 people in government agencies who really understand the meaning of the NIS and how it could become more efficient" (Government representative 5).

Following the initial analysis of the data, a conceptual framework (Figure 1) illustrating the transformation of the NIS was developed. Figure 1 shows that the individual and organisational capabilities of public institutions influence the effectiveness of policy creation and implementation. The capabilities of professors at universities allow them to create new knowledge, as well as to increase the capabilities of graduate students. The capabilities of local firms allow them to adopt, generate and diffuse innovations. The interaction (or lack thereof) between these factors leads to the overall framework conditions of the NIS. All respondents agreed that public institutions need to change because the old Soviet mindset - when people simply want to follow orders and do not want to initiate or lead any changes - remains an outstanding issue in the transformation of institutions into modern and effective organisations that meet local industry needs, and respond to a changing environment.

Figure 1: Factors that influence transformation of the NIS. Source: interviews.



4.3.7. Data analysis (second phase)

Following the first conclusion from the analysis (that institutions need to change), we decided to refine the focus and performed a second phase of data analysis in search for underlying mechanisms that stimulate institutional change. During the second phase, we followed the data reduction process (Easton, 2010). We listened to all of the recordings and reviewed the transcripts and notes of all of the interviews again. During the process we discovered a reoccurring theme of strategic entrepreneurial leadership in discussions concerning changes in public institutions. The existing literature confirmed that various forms of institutional entrepreneurship ‘work’ acted as mechanisms that stimulated institutional change (Table 2).

Table 2: Definitions of institutional entrepreneurship/entrepreneurs from the existing literature.

Institutional entrepreneurship is “purposive, interest-driven behaviour” (DiMaggio, 1988, p. 4). “New institutions arise when organized actors with sufficient resources see in them an opportunity to realize interests that they value highly. Institutional entrepreneurs “create a whole new system of meaning that ties the functioning of disparate sets of institutions together” (ibid, p. 14).

(Beckert, 1999, p. 791-793) notes that institutional entrepreneurship is an “active persuasion of new opportunities.” It is about “entrepreneurs who seek to change institutionalized rules to enhance their interests.” Institutional actors use legitimized power as “stabilizing factor in processes of institutional change”.

Garud, Jain and Kumaraswamy (2002, p. 196) note that institutional entrepreneurs “create a whole new system of meaning that ties the functioning of disparate sets of institutions together”. They act like “champions who lead and strategize collective actions”.

Maguire, Hardy and Lawrence (2004, p. 657) argue that institutional entrepreneurship could be defined as “activities of actors who have an interest in particular institutional arrangements and who leverage resources to create new institutions or to transform existing ones”.

Lawrence and Suddaby (2006, p. 215) “refer to ‘institutional work’ – the purposive action of individuals... aimed at creating, maintaining or disrupting institutions.”

Greenwood et al. (2008, p. 19) argues that institutional entrepreneurship is “almost synonymous with institutional change”.

During the second phase of the analysis, we identified 18 first order categories that correspond with theoretical statements about the role of institutional entrepreneurship during the process of institutional change (Table 3). We then collapsed these categories of institutional work into six second order categories. During the process of data analysis, we looked for links amongst the first and second order categories. We went back and forth from the emerging themes and the existing literature iteratively and identified two aggregate theoretical dimensions that justify the role of institutional entrepreneurship in the process of institutional change (Table 3). The following section of findings analyses these theoretical dimensions in more detail. Table 4 provides representative quotes (linked to 1st and 2nd order categories that correspond with theoretical statements) about institutional entrepreneurship work undertaken during the transformation of Lithuanian NIS.

Table 3: The data structure from interviews.

1st order category (specific examples of institutional entrepreneurship work undertaken during the process of transformation)	2nd order category (sub-categories of institutional entrepreneurship work)	Aggregate broad theoretical categories of institutional entrepreneurship work
<p>1. Review internal processes and evaluate effectiveness.</p> <p>2. Motivate existing staff to be creative and propose internal bottom-up changes.</p> <p>3. Encourage internal knowledge exchange between departments.</p> <p>4. Hire new entrepreneurial managers if needed.</p> <p>5. Secure funding to update old methodologies, processes.</p> <p>6. Increase salaries to attract young, motivated and creative staff.</p> <p>7. Initiate on the job training for staff.</p> <p>8. Encourage joint projects, networking and learning from other institutions.</p> <p>9. Change hiring systems to encourage applications from professionals within private sector and with international experience.</p> <p>10. Initiate and motivate participation in international projects.</p>	<p>1. Initiate optimisation of internal processes.</p> <p>2. Mobilise resources and competences for transformation.</p> <p>3. Open-up closed systems to encourage knowledge exchange with external institutions.</p>	<p>1. Initiate and lead internal transformation of public institutions.</p>
<p>11. Analyse causes of innovation policy failures with other stakeholders.</p> <p>12. Learn from best international innovation policy and R&D practices.</p> <p>13. Network with all stakeholders of the NIS to develop evidence-based policy changes enhanced by relevant policy instruments.</p> <p>14. Network with ministries and other government agencies to mobilize political support for policy changes.</p> <p>15. Initiate and lead collective action for bottom-up policy approach.</p> <p>16. Leverage political support to ensure that innovation policy corresponds with (or relates to) education, labour and social welfare policies.</p> <p>17. Leverage political support to ensure continuity of the long-term strategy of innovation policy.</p> <p>18. Network with managers of ministries and other government agencies to ensure relevant policy implementation.</p>	<p>4. Learn from policy failures.</p> <p>5. Challenge the existing rules, practices and institutionalise the alternative.</p> <p>6. Mobilise political support to ensure policy coordination and continuity.</p>	<p>2. Initiate and strategise collective action for better policy making and implementation.</p>

Table 4: First and second order categories with representative quotes about institutional entrepreneurship work undertaken during the transformation of Lithuanian NIS.

Specific examples of 1st order categories and 2nd order sub-categories of the institutional entrepreneurship work undertaken	Representative quotes
<p>Initiate optimisation of internal processes:</p> <ul style="list-style-type: none"> • Review internal processes and evaluate effectiveness. • Motivate existing staff to be creative and propose internal bottom-up changes. • Encourage internal knowledge exchange between departments. 	<p>“Stakeholders of the NIS feel positive about the currently ongoing strong entrepreneurial leadership to transform and optimise universities, initiated and led by the new Minister of Education” (Business representative 1).</p> <p>“Representatives from all universities participated in discussions with government representatives and exchanged various ideas regarding the optimization process of the higher education system” (University representative 2).</p> <p>“The administrative processes in the public agency were reviewed, evaluated and changed based on suggestions from staff in various departments”. (Government representative 8).</p>
<p>Mobilise resources and competences for transformation:</p> <ul style="list-style-type: none"> • Hire new entrepreneurial managers if needed. • Secure funding to update old methodologies, processes. • Increase salaries to attract young, motivated and creative staff. • Initiate on the job training for staff. 	<p>Most cases of internal transformation and optimisation of public institutions “were initiated and led by new, motivated and entrepreneurial managers” (Government representative 2).</p> <p>“The new leader of the agency put a lot of effort in securing the funding for updates of old methodologies, old processes and IT systems. He also initiated on-the-job training for the existing staff and hired new department managers” (Government representative 7).</p> <p>“The new rules to calculate salaries in public institutions is usually the only way to attract staff with relevant innovative skills” (Government representative 3).</p> <p>“Initiation of the on-the-job training programs for all university and high school staff is led by the Minister of Education as part of the internal optimization and transformation processes” (Government representative 6).</p>
<p>Open-up closed systems to encourage knowledge exchange with external institutions:</p> <ul style="list-style-type: none"> • Encourage joint projects, networking and learning from other institutions. • Change hiring systems to encourage applications from professionals within private sector and with international experience. • Initiate and motivate participation in international projects. 	<p>The current institutional entrepreneurs “look for new opportunities of knowledge exchange not only within their own organisations, but also outside of public organisations. Business representatives are encouraged to contribute to various policy debates”. (Business representative 6).</p> <p>Our manager “initiates networking and encourages joint projects with other public and private organizations” (Research centre representative 1).</p> <p>The hiring system of public institutions “has been impossible to navigate for candidates with work experience in foreign countries or public sectors. We are changing the system. It will recognise foreign education</p>

	<p>and work experience outside the public sector” (Government representative 6).</p> <p>“It is not enough for a researcher to be great in his/her own research” (Business representative 5). Innovation is a very interactive process, therefore, “research centres try to have many international working-relationships which would help to enhance possibilities for innovative outputs” (Research centre representative 3).</p>
<p>Learn from policy failures:</p> <ul style="list-style-type: none"> Analyse causes of innovation policy failures with other stakeholders. Learn from best international innovation policy and R&D practices. Network with all stakeholders of the NIS to develop evidence-based policy changes enhanced by relevant policy instruments. 	<p>“The idea to create science valleys came up from analysing international R&D practices and learning from our closest neighbours” (Government representative 2).</p> <p>“After discussing alternatives with all stakeholders (associations of local firms, universities and other ministries) we decided to reduce the number of science valleys from 13-5, to redefine goals and coordination with universities. We also simplified the management system, because we recognized that the initial one was not effective at all” (Government representative 8).</p> <p>The creation process of the current 2014-2020 innovation policy “was the first ever attempt to discuss and analyse the overall innovation system of Lithuania from the perspective of all stakeholders” (Business representative 8).</p> <p>“We finally have couple Ministers who recognise that certain policies do not work for innovative businesses, therefore, we are invited to analyse causes and discuss various possibilities for changes together” (Business representative 4).</p>
<p>Challenge the existing rules, practices and institutionalise the alternative:</p> <ul style="list-style-type: none"> Network with ministries and other government agencies to mobilise political support for policy changes. Initiate and lead collective action for bottom-up policy approach 	<p>“After one year of discussions with the stakeholders (associations of local firms, universities and other Ministries), the current Minister of Education proposed to bridge boundaries by consolidating universities into networks” (Business representative 5).</p> <p>“The current reform of higher education is different from others performed in the past because it encouraged the bottom-up changes proposed by universities and their faculties” (University representative 5).</p>
<p>Mobilise political support to ensure policy coordination and continuity:</p> <ul style="list-style-type: none"> Leverage political support to ensure that innovation policy corresponds with (or relates to) education, labour and social welfare policies. 	<p>“The highest officials of Lithuania have been very active supporters of changes in the innovation policy as well as in the current changes of the education policy. They have initiated and led multiple meetings with Ministries in attempts to mobilise political support for the strategic changes” (Government representative 1).</p> <p>“Coordination amongst Ministries is the key for policy continuity. These days, coordination is better compared to what it was ten years ago. But still, we have a long way to go” (Government representative 9).</p> <p>All respondents agree that the implementation of the innovation policy should not depend on changes in political views (elections etc.), however, in reality “it is all about leveraging long-standing relationships” (Government representative 1).</p>

4.4. Findings: the role of institutional entrepreneurship in the process of change.

Based on the theoretical insights, the institutional work performed by institutional entrepreneurs could be defined as purposive actions aimed at creating, maintaining or disrupting institutions (Lawrence and Suddaby, 2006). The first theoretical dimension from the analysis of data, initiating and leading internal transformation, falls into the categories of maintaining existing or creating new institutions through change. Meanwhile, the second theoretical dimension from the analysis of data, initiating, leading and strategizing collective action for better policy making and implementation, falls under the category of disrupting institutions or deinstitutionalisation through change.

Initiate and lead the internal transformation of public institutions (maintaining existing institutions or creating new institutions through change).

Based on the interviews, the aggregate category of internal transformation *includes three themes: initiation of optimisation, mobilisation of resources and competences, and the opening-up of closed systems* to encourage knowledge exchange. These findings relate to the following theoretical insights. For example, Greenwood (2008, p. 19) notes that institutional entrepreneurship is “synonymous with institutional change”. The existing literature acknowledges “corrective” and “purposive” internal actions of institutional entrepreneurs (DiMaggio 1988, p. 5) in order to disrupt institutions (Oliver, 1992). The entrepreneurial initiatives could be defined as “activities of actors who have an interest in particular institutional arrangements and who leverage resources to create new institutions or to transform existing ones” (Maguire et al. 2004, p. 657). It is about “entrepreneurs who seek to change institutionalised rules” (Beckert 1999, p. 791), “organize actors with sufficient resources” (DiMaggio, 1988, p. 4), expand boundaries and reconfigure existing belief systems (Lawrence and Suddaby, 2006).

Initiate optimisation of internal processes. How did institutional entrepreneurs initiate and lead the internal transformation of public institutions in the Lithuanian NIS? Optimisation of processes was started by initiating reviews and evaluations of the effectiveness of internal processes and by motivating existing staff to participate in these processes and propose changes. This was also achieved by

encouraging the exchange of ideas amongst all internal departments. Examples of such institutional entrepreneurship work came up in discussions about changes in a few Ministries, in the Office of Prime Minister, in town halls, in universities, in a government agency responsible for collecting taxes, in an agency distributing R&D funds and, in an agency, responsible for attracting foreign investors for R&D projects etc.

The topic of changes within the education system came up as especially important, since the education system is responsible for producing people with relevant capabilities. The overall education system in Lithuania was defined as "... too standardised and unable to enhance creativity, entrepreneurship and innovative skills." (Business representative 3). During the discussions of the possible causes of these problems, business and government respondents pointed to old teaching methodologies, to the lack of young and motivated teachers and to the lack of "a long-term strategic vision and leadership to initiate and effectively manage changes within education sector" (Government representative 1).

Despite the long-standing problems within the education sector, many respondents felt positive about the currently ongoing "strong entrepreneurial leadership to transform and optimise universities, initiated and led by a new Minister of Education" (Business representative 1). During the interviews, government officials noted that five high quality universities would be enough to fulfil local needs, however, Lithuania currently has 22 universities (14 public and 8 private) and 20 colleges. It is not surprising that "this wide range of universities leads to the low overall quality of graduates" (Research centre representative 1). Only one Lithuanian university is ranked in the 501-550 bracket by the 2015 World University Rankings, four universities were ranked in the 701 + bracket and "in general, these ratings became worse during the last five years" (University representative 3).

Some respondents argued that the current reform of higher education is different from others performed in the past because it "encourages bottom-up changes proposed by universities and their faculties" (University representative 5). The problems of low funding for researchers, low R&D funds, and the lack of networking amongst universities are also acknowledged and taken into consideration within the optimisation process. These findings correspond with a very recent NIS literature

discussing institutional entrepreneurship as an effective instrument towards the transformation of universities (Karaulova et al. 2016; Benneworth et al. 2017).

Mobilise resources and competences for internal transformation. Under the broad category of mobilising resources and competences, institutional entrepreneurs secured funding to update old methodologies, old processes and systems, initiated on-the-job training for existing staff, hired new managers, and increased salaries to attract young, motivated and entrepreneurial staff. Most cases of internal transformation and optimisation of public institutions “were initiated and led by new, motivated and entrepreneurial managers” (Government representative 2).

Many respondents noted that entrepreneurial, organisational and managerial skills are equally as essential in transforming inefficient government institutions as they were essential in transforming local private firms. Therefore, in the case of Lithuania, many institutional entrepreneurs came from private sectors or/and they had international experience. Many government representatives noted that in many cases, hiring a new manager was the only solution since the old ones did not have relevant entrepreneurial skills.

Initiation of the on-the-job training programs for all university and high school staff is led by the Minister of Education as part of internal optimisation and transformation processes¹¹. Business representatives argue that such a program should be mandatory for all employees of government agencies. “Lithuania has one of the lowest participation rates in lifelong learning activities” (Business representative 2). It is under 10 % for 25-64 year-olds based on the 2014 data from Eurostat, which is four times lower compared to the most innovative European countries. Associations of local firms try to fill in some of these gaps by offering training to members, however, all our respondents agreed that these efforts are not enough to enhance the overall national innovative skills. Based on the 2013 Business Environment and Enterprise Performance Survey¹², 34 % of firms in the Lithuanian industry find the education of labour force inadequate. This share is very high when compared to the 5% average in the most innovative European countries.

¹¹ Currently the official plan is to change from the Ministry of Education to the Learning for Life Ministry.

¹² The survey is conducted by the European Bank of Reconstruction and Development and the World Bank: <http://ebrd-beeps.com/>.

A strong push for increase in salaries for staff of public institutions through new institutionalised rules was also part of the processes of institutional change led by new managers in public institutions. The interviewees noted that there is a big mismatch between salaries in public and private sectors in Lithuania. “New rules to calculate salaries in public institutions is usually the only way to attract staff with relevant innovative skills” (Government representative 3). Such entrepreneurial practice of changing institutionalised rules as part of internal transformation were used by the Office of Prime Minister, the government agency responsible for collecting taxes, and the government agency responsible for distributing R&D funds etc.

The opening-up of closed systems to encourage knowledge exchange. Institutional entrepreneurs “look for new opportunities of knowledge exchange” within organisations as well as outside of public organisations” (Business representative 6). They do so by “initiating networking and encouraging joint projects with other organisations” (Research center representative 1). Initiating openness, cooperation and internationalisation amongst universities and research center is especially important, as argued by many respondents during the interviews. “It is not enough for a researcher to be great in his/her own research” (Business representative 5). Many respondents argued that researchers need to work with industries and firms in order to realise the applicability of their science to the society. They also need to know when and where to introduce their novelty in order to convert it to a successful innovation. Innovation is a very interactive process, therefore, “research centers try to have many international working-relationships which would help to enhance possibilities for innovative outputs” (Research center representative 3).

The interviews reveal that institutional entrepreneurs have also initiated major changes in the hiring system of some government agencies, because the current system acts as a barrier for the process of institutional change by limiting knowledge exchange possibilities. The current hiring system ‘holds’ open positions for current employees and only advertises them openly if an internal candidate is not available. Also, many participants acknowledged that “sometimes positions are still tailored to fit specific candidate” (Government representative 8). Such hiring practices reduce the chances of candidates from other sectors to participate and to bring in new knowledge to ‘closed style’ public organisations. The public hiring system “is impossible to navigate for candidate with work experience in foreign country” (Business representative 1),

because it does not recognise foreign education or work experience, therefore, the candidate is not even able to go through the system and submit an application.

Initiate, lead and strategise collective action for better policy making and implementation (deinstitutionalisation through policy failure and policy learning and system-wide change). Based on the interviews, this aggregate category could be composed of three themes: learning from policy failures, challenging existing rules and practices by institutionalising alternatives (lowering institutional boundaries), and by mobilising political support for policy coordination and continuity (boundary bridging). Elmore (1987) argues that policy failures can be confirmed by experts, and that these recognised failures can create system-wide opportunities for policy learning after institutions are exhausted by repeated failures. Policy learning could be defined as a process of updating beliefs concerning policies, based on various experiences (Dunlop and Radaelli, 2013).

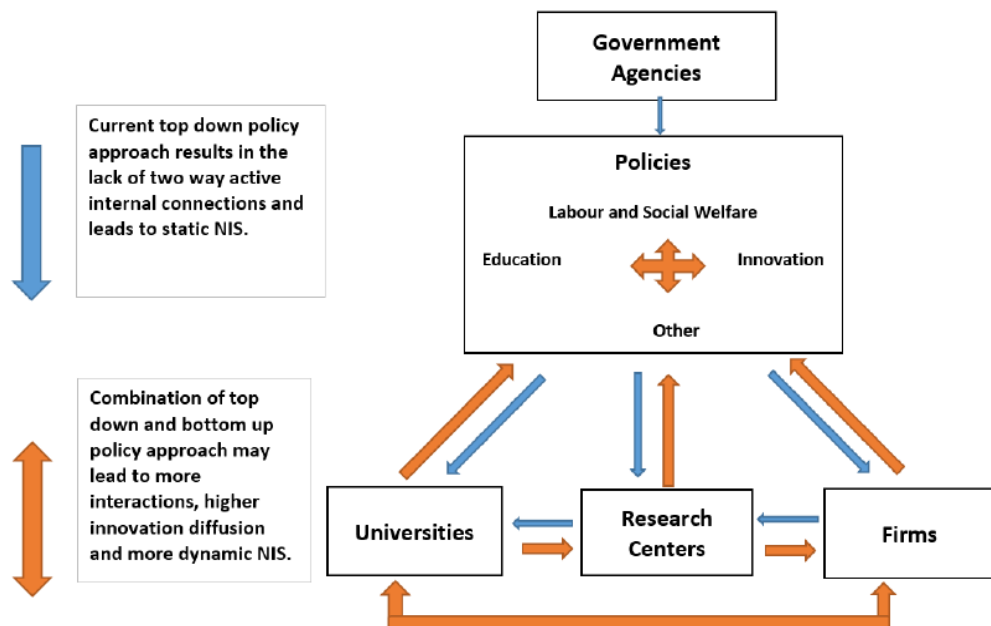
The existing literature recognises the role of institutional entrepreneurship for initiation, leadership and lobbying for changes in policy making regulations and implementation (Suchman, 1995; Fligstein, 1997; Hoffman, 1999; Garud et al. 2002). Such institutional ‘work’ could be related to deinstitutionalisation (Oliver, 1992) or the lowering of institutional embeddedness (Greenwood and Suddaby, 2006) through bridging boundaries (Lawrence and Suddaby, 2006). Greenwood and Suddaby argue that “a network position that bridges fields lessens institutional embeddedness by exposing actors to inter-institutional incompatibilities, increasing their awareness of alternatives” (ibid, p. 38). These arguments are based on policy learning theories which focus on human agency and how individuals learn, solve problems and trigger changes in institutions (Sabatier, 1988; Radaelli, 2009; Bennett and Howlett, 1992; Borrás, 2011). Lewis and Triantafyllou (2012) note that policy learning could also be characterised by bottom-up rule making.

Learning from policy failures. The findings from the case study provide evidence that link institutional entrepreneurship activities to deinstitutionalisation through policy failures, policy learning and small, slow steps towards system-wide changes. During the interviews, many respondents argued that the current top-down policy approach is not effective at the current stage of the Lithuanian NIS. Universities, firms and government agencies need to cooperate in setting policy goals

and specific policy instruments to reach the overall national strategic goals of the NIS (Figure 2).

Business representatives noted that evidence-based (local industry and education system needs based) policy approach may be more effective in stimulating networking and leading to more joint projects between firms, government institutions and universities. “Policies need to reflect local industry and university needs. We finally have couple Ministers who recognise that certain policies do not work for innovative businesses, therefore, we are invited to analyse causes and discuss various possibilities for changes together” (Business representative 4).”

Figure 2: Policy making: the traditional top-down policy approach resulting in the lack of two-way internal connections amongst policies and members of the NIS as well as attempts to institutionalize the bottom-up policy approach. Please note: Blue colored arrows indicate the traditional top-down policy approach. Orange colored arrows represent attempts to incorporate the bottom-up policy making approach. Source: interviews.



The actual attempts to incorporate the bottom-up rule making, improved the whole structure of the Lithuanian NIS. These attempts resulted from repeated policy failures that have been recognised not only by the local innovative firms, but also by representatives of various government agencies and institutional entrepreneurs. For

example, the concept of the innovation system, together with the concept of science and technology parks (or the so-called science valleys) has been introduced by the Office of Prime Minister back in 2003. However, there was no political consensus on how to link the two together, since many Ministers still thought that “innovation will happen on its own” (Research center representative 5). The creation of science valleys took off in 2007, and in 2010 Lithuania already had 13 of them. However, many respondents noted that during this period, the valleys “were just expensive R&D infrastructure without a long-term strategy” (University representative 1).

The official evaluation process for the effectiveness of valleys in 2011, initiated by the Minister of Economics at the time, suggested reducing the number of valleys, coordinating goals with the innovation policy and changing the complicated institutional management system. The same Minister initiated and strategised collective action and support from other Ministers to launch the Lithuanian Innovation Development Program¹³ 2014-2020 to support competitiveness and economic growth through innovation. The creation process of the current 2014-2020 innovation policy “was the first ever attempt to discuss and analyse the overall innovation system of Lithuania from the perspective of all stakeholders” (Government representative 8).

Acknowledging previous policy failures and discussing alternatives with all stakeholders (associations of local firms, universities and other ministries) resulted in a reduction in the number of science valleys (from 13 to 5), redefinition of goals, better coordination with universities, simplification of management system and coordination with the innovation policy. The goals of research centers were directly related to the priority specialisation areas (as part of innovation policy) and were enhanced by the R&D funds. Even though the policy making of the Lithuanian Innovation Development Program 2014-2020 and selection of the priority specialisation areas was criticized by many (Paliokaite et al. 2016), it was the first ever ‘entrepreneurial’ and systemic attempt to bridge boundaries and lower institutional embeddedness, acknowledge various alternatives, discuss them and improve the policy making process.

¹³ The Lithuanian Innovation Development Program:
http://www.mita.lt/uploads/documents/lithuanian_innovation_programme.pdf

Challenging existing rules, practices and institutionalising the alternative.

The ongoing attempt to incorporate the bottom-up rule making by the new Minister of Education continues the initiative towards lowering institutional embeddedness in Lithuanian universities. The Minister is leading and strategising for collective action to reduce the number of universities by consolidating and restructuring them. Lowering the institutional embeddedness of universities has been a long-standing priority of the Lithuanian Innovation Development Program 2014-2020, however, several previous Ministers failed to initiate any major changes.

“After one year of discussions with stakeholders (associations of local firms, universities and other ministries), the current Minister of Education proposes to bridge boundaries by consolidating universities into networks” (Business representative 1). The re-evaluation of programs within universities is also on the agenda, since innovative firms complain that they cannot fill in vacancies due to a shortage of local graduates in specific areas. Some universities have been networking already due to entrepreneurial deans, however, the current reform tries to change the rules of the game for all universities and make it a systemic institutional change.

Mobilising political support to ensure policy coordination and continuity remains to be a very challenging task for institutional entrepreneurs in the Lithuanian NIS. All respondents agree that the implementation of the innovation policy should not depend on changes in political views (elections etc.), however, in reality “it is all about leveraging long-standing relationships” (Government representative 1). Some respondents note that an active participation of associations representing local innovative firms has been improving the process of policy making. They act as institutional entrepreneurs in strategising collective actions and mobilising political support from entrepreneurial Ministers. “The highest officials of Lithuania have also been very active supporters of changes in innovation policy as well as in current changes in education policy. They have initiated and led multiple meetings with Ministries in attempts to mobilise political support for strategic changes” within the NIS (Government representative 1).

Coordination amongst public institutions is the key for policy coordination and continuity, however, “the lack of institutional openness, and cooperation amongst institutions still leads to unbalanced policies” (Business representative 7). Various attempts by institutional entrepreneurs to initiate internal transformation and open-up

closed systems (as discussed in the previous section about internal transformation) have led to better coordination, better policy making and implementation practices. Educating government employees about the concepts and activities of the NIS, has also helped institutional entrepreneurs to mobilise political support for policy changes.

4.5. Discussion

This case study provided a framework for explaining factors that influence the transformation of the transition NIS. The initial analysis of the data revealed that various institutional inefficiencies may act as one of the major barriers to transformation. Therefore, the first conclusion from the data analysis was that institutions need to change. The deeper, second phase analysis of the data pointed to institutional entrepreneurship as a mechanism that may stimulate institutional change.

Following the theoretical insights from the literature of institutional entrepreneurship, the institutional ‘work’ was grouped into two aggregate theoretical categories: initiating and leading internal transformation (maintaining existing institutions or creating new ones), and initiating, leading and strategising collective action for better policy making and implementation (deinstitutionalisation). Therefore, the second conclusion from the data analysis is that institutional entrepreneurship acts as a mechanism that stimulates institutional change through internal and external pressures (Figure 3).

Figure 3: Two ways to enhance institutional change through institutional entrepreneurship.

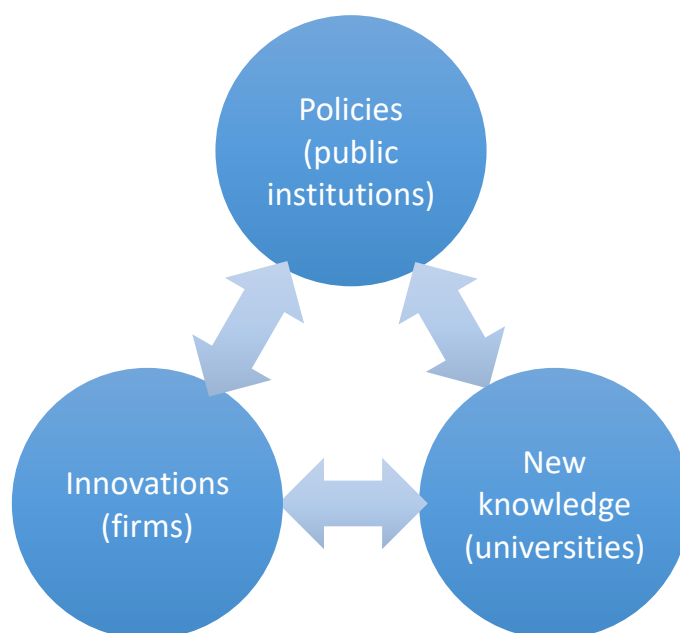
<u>Tool</u>		<u>Mechanism</u>		<u>Two ways to enhance change</u>
Institutional Change	←	Institutional Entrepreneurship	←	Internal pressures (within organisation) External pressures (policy making level)

The main contribution of the study is in revealing the importance of institutional entrepreneurs (individual agents) in the process of institutional change and the overall transformation of NIS. Public institutions play a very important facilitating role and the issue of institutional inefficiencies is recognised by scholars, however, the micro perspective (or the role of human agency) and its relation to institutional change, policy creation, implementation, and transformation of the NIS is still relatively understudied in the current NIS literature of transition economies

(Kravtsova and Radosevic, 2012; Binkauskas, 2014; Gokhberg and Roud, 2016; Dezhina and Etzkowitz, 2016; Gu et al. 2016). Many NIS studies focus on firm, industry, institutional level or macro level analysis of innovation policies. However, the micro perspective usually starts with a firm level analysis while the role of an individual agent remains overlooked.

The study contributes to a better understanding on how internal and external pressures, initiated and led by institutional entrepreneurs, enhanced the overall transformation of the NIS (Figure 4). Firstly, an institutional entrepreneur initiates and leads changes within institutions in order to improve policy making and implementation processes. Internal initiatives within public organisations may open-up public institutions to better cooperation with universities and businesses, which leads to evidence-based policies (or a combination of a top-down and a bottom-up policy approach). Secondly, if policies are relevant and represent the local needs, the local businesses, universities and other agencies participate more in various R&D projects and enhance the overall cooperation between actors which may result in more innovations. This encouragement of two-way interactions between all actors of the NIS, leads to a faster transformation of the whole system moving from relatively static to relatively dynamic.

Figure 4: Institutional entrepreneurship encourages two-way interactions between public institutions, universities and local businesses. Source: findings from interviews.



This case study also illustrates how institutional change happens as an interactive process between formal and informal elements of the system. It relates to North's (1994) definition of the institutional evolution as an interaction between institutions (as laws or 'rules of game') and organisations (as entrepreneurs). The study shows that both state and entrepreneurs can be change agents. In the case of the transition NIS, institutional entrepreneurs act as change agents by changing existing institutions, creating new institutions or by initiating and leading a deinstitutionalisation process. This helps to lower institutional embeddedness and bridges gaps in cooperation to improve policy making and implementation. Even though not all institutional entrepreneurship activities have been successful, the examples from the case study show that it could be one of the most effective ways to stimulate institutional change in the transition economy.

4.6. Conclusion

The purpose of this chapter was to reveal barriers to transformation of a transition innovation system and to point to mechanisms that stimulate transformation. The case study of the Lithuanian NIS was based on 30 semi-structured, in-depth interviews with major stakeholders of the innovation system. Participants included representatives from universities, research centres, government institutions and non-profit associations of local innovative firms. We employed the NIS approach as well as institutional theory as the theoretical base for the analysis.

The two-phase analysis of interviews revealed that the Lithuanian innovation system is still in transition. It is still on its way towards a dynamic NIS. The country caught-up with technological upgrading, but still lags behind the top European innovators in performance due to various gaps in capabilities at all levels of the system. Our respondents argued that inefficient government institutions may be one the most important barriers to the transformation of the NIS. The study revealed that the focus on the role of institutional entrepreneurship and its relation to institutional change may be the best point of departure in understanding the transformation of the transition NIS. Such findings have important implications for academics, policy makers and managers in all transition countries.

Since the study is based on a single case, it is limited in a number of ways and could be criticised for external validity or generalisability, methodological rigour and researcher subjectivity. Further research in different contexts could validate the current findings. However, it is important to acknowledge that countries with different historical contexts may have completely different results. Large-N studies may also present different results since it may be hard to capture both the breadth and depth of questions raised. Following methodological guidelines and systemic procedures is also very important for validating a case study. We believe this chapter clearly presents methodological techniques and epistemological grounding. The issue of researcher subjectivity is also important. This case study employs the triangulation technique in order to eliminate bias views of the questions discussed during interviews.

There are several possibilities to extend the research. Case studies focusing on specific fields could be very insightful and may lead to a better understanding of the dynamics between various industries within the NIS. The same study may also focus on a specific type of organisation, such as universities, in order to understand the factors that restrict or enhance the transformation from ordinary to relatively entrepreneurial universities. Analysis of the process of institutional change in specific Ministries or other government agencies may also enhance the understanding of issues in the policy making and implementation processes.

Appendix

The sample questionnaire that was used to start conversations with each participant:

1. How does the organisation define innovation?
2. How does your organisation understand NIS? How does the organisation participate in NIS? What are your major activities in NIS?
3. How does the organisation relate to other players of NIS?
4. What are the main drivers of innovative activities based on the experience of the organisation? Why and how are these drivers important?
 - Is the positive innovation driving factor present for a long time?
 - Who, how and when initiated and implemented it?
 - Was it easy to implement?
 - How long did it take to implement?
 - How does this positive factor affect your organisation?
5. What factors limit innovative activities and innovative performance based on the experience of the organisation? Why and how these factors act in limiting way?
 - Is the limiting factor still present? Or was it solved already?
 - How was the problem solved?
 - Who initiated the change?
 - How did they solve it?
 - What was the cause of the limiting factor?
 - How long did it take to solve the problem?
 - How does the solution of the problem affect your organisation?
6. Are there any other important questions that we did not discuss?

Graph 1A: Composition of Lithuanian economy. Source: Eurostat and Statistics Department of Lithuania.

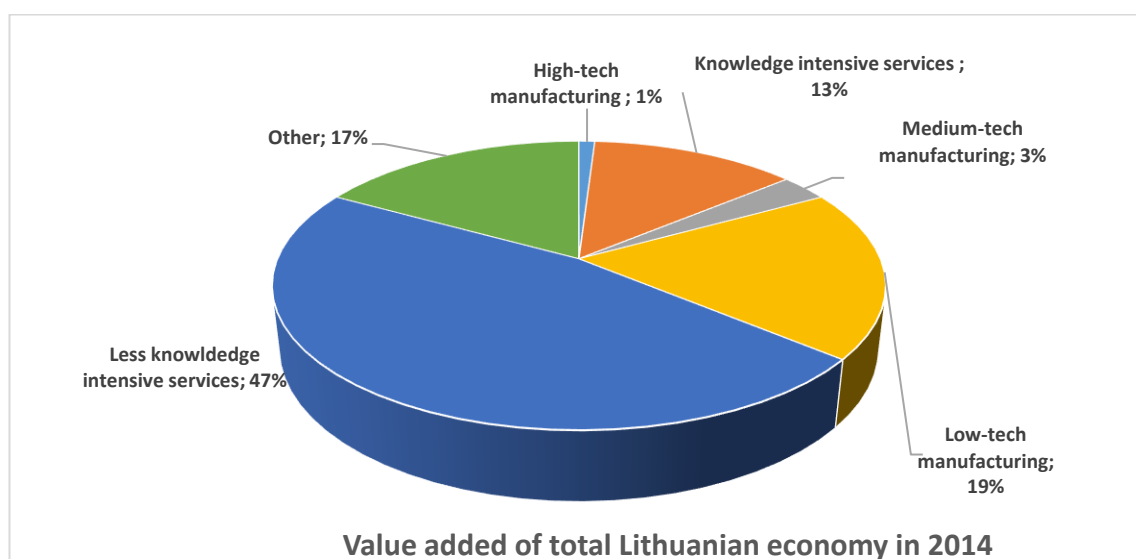


Table 1A: Aggregation of knowledge intensive manufacturing and services. Source: Eurostat.

High technology manufacturing	Manufacturing of pharmaceuticals, medicinal chemicals, botanical products; office machinery and computers; radio, television and communication equipment; medical, precision and optical instruments, watches and clocks; aircraft and spacecraft.
Medium technology manufacturing	Manufacturing of chemicals and chemical product; electrical machinery and apparatus; motor vehicles, trailers and semi-trailers; refined petroleum products and nuclear fuel; rubber and plastic products; basic metals and fabricated metal products; other non-metallic mineral products; building and repairing of ships and boats.
Low technology manufacturing	Manufacturing of food products, beverages and tobacco; textiles and textile products; leather and leather products; wood and wood products; pulp, paper and paper products; publishing and printing.
Knowledge intensive services	Financial intermediation; real estate activities; computer related activities; research and development, post and telecommunications; renting of machinery and equipment; water and air transport; other business activities.
Less knowledge intensive services	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods; hotels and restaurants; land transport; activities of travel agencies.

Table 2A: Major components of Lithuanian NIS and their activities. Source: interviews.

Major components of the NIS	Activities
Universities	Competence building through education and R&D activities.
Government institutions	Providing R&D funding, creating laws, consulting services: commercialisation of knowledge and legal advice.
Research centers	Performing R&D activities, providing consulting services on technology transfer, provide incubating activities for startups.
Associations of local innovative firms	Commercial information and legal advice, educating and encouraging change in existing firms by enhancing diversification, networking amongst firms and institutions, encouraging change in institutions.
Innovation policy	Provides theoretical overview of different ways to increase competitiveness through national innovation system. Lacks specific mechanisms or instruments and actual links to other relevant policies to implement transformation of NIS. Directs R&D funds based on smart specialisation priority areas.

Chapter 5: Towards the entrepreneurial university: the principal-agent problem

5.1. Introduction

While the NIS literature acknowledges the importance of entrepreneurial public institutions, very little attention is paid to analysing how the process of change occurs and how public institutions become entrepreneurial. Therefore, the aim of this chapter is to understand how the process of institutional change unfolds. We develop a conceptual analysis that draws on agency theory to examine incentives that may stimulate institutional change. In general, the principal-agent problem describes the difficulties involved in motivating an agent to act in the interest of a principal. In this chapter we consider the framework of a university becoming entrepreneurial, and we assume that the principal is a dean while the agent is a professor. Using this conceptual model, we explore how a balanced and an individualised incentive system could increase the professor's motivation to contribute to the university's mission of becoming entrepreneurial.

Having entrepreneurial universities has been identified as one of the most important goals for countries seeking innovation-based growth, since the university is one of the most important actors of an innovation system (Clark, 1998; Rasmussen et al. 2011; Pinheiro and Stensaker, 2014; Benneworth et al. 2016). However, the rigidity and stickiness of public institutions, and especially public universities, is still a widely recognised problem in the recent academic literature (Cummings, 2015; Karaulova et al. 2016; Korosteleva and Belitski, 2017). Public universities may be problematic actors, especially within transition and developing NISs as also indicated by the case study findings in the previous chapter.

The current studies on entrepreneurial universities investigate various inefficiency problems of universities and focus on structural institutional changes, but completely overlook potential issues at the agency level. Therefore, the main objective of this chapter is to explore how an individualised incentive system could increase the professor's motivation to contribute to the university's mission of becoming entrepreneurial. The use of incentives schemes in public and non-profit institutions is still a relatively new practice (Speckbacher, 2011) even though they have a few important purposes, such as the following: "(a) motivation for increased effort, (b)

provision of signals for self-selection in the workforce, and (c) communication of desired work outcomes and challenging of employee attention toward these outcomes.” (ibid, p.1007)

The theoretical background of the chapter draws on the NIS approach (the concept of an entrepreneurial university), the institutional theory (institutional entrepreneurship) and the agency theory (the principal-agent problem). In the principal-agent model, we assume that the principal acts as an institutional entrepreneur, following the results from the previous chapter. We define institutional entrepreneurship as the capability to shape and change institutions (DiMaggio, 1988). We define institutional change as a purposeful, systemic and organised internal change (Drucker, 1985).

We define an entrepreneurial university as a university led by entrepreneurial leaders (Drucker, 1985; Teece et al., 1997) and oriented towards innovation and entrepreneurial culture (Kirby et al., 2011). For the purpose of this chapter we distinguish between an ordinary and an entrepreneurial university by drawing on dynamic capabilities approach for organizations (Teece, 2016). Ordinary capabilities of organisations could be defined as “administrative, operational and governance-related functions” (Teece, 2016, p. 204). Therefore, we define an ordinary university as the one that focuses on administrative, operational and governance-related functions.

In contrast to the ordinary capabilities, dynamic capabilities enable organisations to learn, develop new capabilities, coordinate internal resources more effectively and respond better to changing environments. Therefore, we define an entrepreneurial university as an organisation that is able to develop new capabilities, change (Teece, 2016), is led by entrepreneurial leaders (Drucker, 1985; Teece et al., 1997) and is oriented towards innovation and entrepreneurial culture (Kirby et al., 2011).

In terms of the NIS literature, the theoretical contribution of this chapter lies in providing new insights into the process of institutional change, as well as in conceptually synthesising the three theories (agency, institutional and NIS). By incorporating institutional and agency theories, the chapter explains the relationship between meso and micro levels in the process of institutional change from an ordinary to an entrepreneurial institution. It refines the knowledge on an individualised

incentive system that serves as a motivation for professors to contribute to a university becoming entrepreneurial. The chapter challenges studies that dismiss the micro level role of human agency in institutional change. The conceptual arguments of the chapter have important managerial and policy implications for public institutions in countries seeking innovation-based growth.

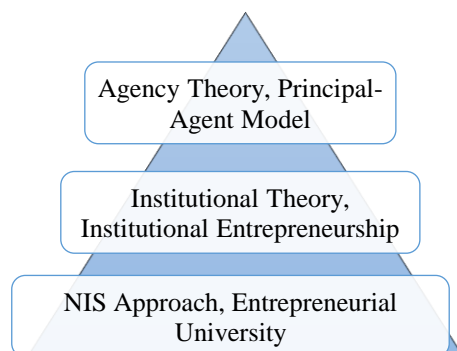
The topic of institutional change is important, because we cannot assume an easy and successful evolution of institutions in developing and transition countries, due to historical path dependencies (North, 1990). When proposing innovation-based growth, policy makers and economists assume that employees of public institutions have the relevant skills and are able to support various aspects of innovation processes successfully. This assumption might be true for highly developed Western countries, since they have a long history of relatively entrepreneurial institutional structures that are able to change and facilitate innovation-based growth. However, as the existing literature notes, the situation is different in many developing and transition countries.

This chapter is organized, by firstly reviewing the literature on entrepreneurial universities and the concept of institutional entrepreneurship as a mechanism of institutional change. Secondly, we discuss the interaction between agency and institutional theories in the context of an entrepreneurial university. We then develop five propositions using simple numerical examples to illustrate how a balanced incentive system may motivate agents to act in the interest of the principal. In the final section of the paper we conclude and discuss the implications of the chapter.

5.2. Literature review

In the literature review section, we discuss the links between the theories and concepts that we use in the chapter. The theoretical background of the analysis draws on the NIS approach and the concept of an entrepreneurial institution, more specifically an entrepreneurial university. We also draw on institutional theory, more specifically on the concept of institutional entrepreneurship as a mechanism of institutional change. We use a principal-agent model to explain how an institutional entrepreneur (the principal) leads the institutional change of a public university from ordinary to entrepreneurial. In the conceptual analysis of the principal-agent model, we focus on the incentive system designed towards motivating professors to contribute to the university's entrepreneurial mission.

Figure 1: The theoretical background of the chapter.



5.2.1. The entrepreneurial university within NIS

The current academic literature recognises three missions of universities (Clark, 1998, Etzkowitz et al., 2008; Pinheiro et al., 2017). Teaching and research are the two traditional ones, while the entrepreneurial mission oriented towards making an impact on society by engaging with outside partners is the relatively new third mission. The addition of the third mission is a result of reforms in the higher education sector due to the recognition of the lack in efficiency, decreased quality and the low relevance to global economic and social changes (Maassen and Olsen 2007; Mohrman et al., 2008; Vukasovic et al., 2012; Pinheiro and Stensaker, 2014).

The idea of an entrepreneurial university includes several new goals: improved transparency and efficiency (Stensaker and Harvey, 2011), addressing the needs of different stakeholders (Jongbloed et al., 2008), increasing regional economic development (Pinheiro et al., 2012; Karaulova et al., 2016; Benneworth et al., 2016; Pugh, 2017), and aiming for interdisciplinary collaborations and partnerships with private firms (Etzkowitz, 1984; Rasmussen and Wright, 2015) leading to global innovations (Gibbons et al., 1994; Pinheiro and Stensaker, 2014). The definition of an entrepreneurial university has evolved over the last twenty years according to the new goals as noted in Table 1.

Table 1: A selection of old and new definitions of an entrepreneurial university.

<p>A university considering new sources of funds such as patents, research under contracts and entry into partnership with private enterprises (Etzkowitz, 1984).</p>
<p>A university that undertakes entrepreneurial activities with the objective of improving regional or national economic performance as well as the university's financial advantage and that of its faculty (Etzkowitz et al., 2000)</p>
<p>A university oriented towards innovation and the development of an entrepreneurial culture which has a new managerial ethos in governance, leadership, and planning, including greater faculty responsibility for accessing external sources of funding (Kirby et al., 2011).</p>
<p>A university that involves extension from ideas to practical activity, capitalising knowledge, organising new entities and managing risks (Etzkowitz, 2013).</p>
<p>A university that tries to provide a supportive environment, in which the university community can explore, evaluate and exploit ideas that could be transformed into social and economic entrepreneurial initiatives (Guerrero et al., 2014).</p>

The entrepreneurial mission of universities is especially important within the context of the knowledge society and local NISs. The importance of close linkages between universities, governments and industries is defined as the triple helix of innovation (Etzkowitz et al., 2000). While the quadruple helix of innovation is enhanced by active civil societies together with universities, governments and industries in fostering local innovative activities and economic development (Yawson, 2009).

Many scholars argue that the addition of the entrepreneurial mission represents a fundamental change, from universities as loose organisational systems to strategic organisational actors within innovation systems. The addition of the entrepreneurial mission also represents a change of universities from closed to open systems (Whitley, 2008; Benneworth et al., 2016). The openness here is defined as new possibilities to engage actively with other actors of NISs. For example, by adding the entrepreneurial mission, universities may have enhanced legal, financial and practical possibilities to participate in various innovative R&D projects with local and international partners, develop new products and commercialise them together. As a result, many recent papers analyse the internal organisational designs that enhance a university's ability to commercialise inventions (Benneworth et al., 2016; Pinheiro and Stensaker, 2014).

However, some authors note that the focus on organizational design does not solve critical issues linked to the organisational change. The role of the individual agent and of individual leadership in the fundamental change of academic structures is more important, but still overlooked in the academic literature. For example, Pinheiro and Stensaker (2014) note that the implementation of matrix structures within public universities seeking to commercialise academic knowledge does not solve many issues associated with institutional change. Benneworth et al. (2016) argue for importance of links between place-based leadership and the concept of institutional entrepreneurship in the analysis of university organisational dynamics.

5.2.2. Institutional entrepreneurship as a mechanism of institutional change

The concept of entrepreneurship has been related to the change in the economy and society for a long time. Schumpeter (1943) defines entrepreneurship as ‘creative destruction’, and the entrepreneur as the engine that drives the process of change. Drucker (1985) argues that an entrepreneur in the education sector, in a public healthcare organisation or in any government agency has the same characteristics as in any private entrepreneurial company. Drucker defines entrepreneur and entrepreneurship as the thinking and behaviour (or characteristics) of an individual or of any organisation that responds to a changing environment, searches for change and exploits change as an opportunity. Society receives new products and services through various types of entrepreneurship (Shane and Venkataraman, 2000). Entrepreneurship may also be analysed as a mechanism which discovers and mitigates inefficiencies (Kirzner, 1997).

The concept of institutional entrepreneurship developed in the institutional theory literature in contrast to the traditional institutional embeddedness argument (Meyer and Rowan, 1977; Jepperson, 1991; Scott, 1995; Hoffman, 1999) and has already been acknowledged as a change mechanism (Greenwood et al., 2008), however, very little attention is given to understanding the process of institutional change. Traditional institutional theorists argue that an existing institutional environment restricts the structure, the organisational behaviour and the evolution of institutions (Meyer and Rowan, 1977; Jepperson, 1991; Scott, 1995; Hoffman, 1999), while new institutional scholars propose that new institutions could be created and old

institutions could be changed (DiMaggio, 1988; Beckert, 1999; Garud et al., 2002; Garud et al., 2007).

However, the social conformity to static institutional rules contradicts with the role of rational agency or strategic management behaviour performed by institutional entrepreneurs. As Beckert notes, these two “mechanisms...contradict each other, but, nevertheless, remain interdependent” (1999, p. 777). He argues that the necessity to reduce uncertainty holds institutional rules and strategic agency (institutional entrepreneur) together as two coordinating mechanisms. Beckert argues that the tension between the ‘new’ and ‘old’ institutionalism opens possibilities to expand our knowledge in organizational analysis. Furthermore, introduction of the concept of institutional entrepreneurship sheds new light on the process of institutional change. It reintroduces agency, power and interests into analyses of institutions.

DiMaggio (1988) defines the concept of institutional entrepreneurship as an initiative to shape and change institutions. DiMaggio states that institutional change is possible if individual actors are organised, motivated, and entrepreneurial and are able to see opportunities in institutions that they highly value. Beckert (1999) argues that institutional entrepreneurs are able to dis-embed themselves from existing institutional constraints in order to change existing institutions or to create new ones. Garud et al. (2002) propose looking at institutional entrepreneurs as champions that lead and strategise collective actions that change innovative technology fields.

The concept of institutional entrepreneurship has already been recognised in the literature of entrepreneurial universities as an effort to promote regional development, technology and knowledge transfer (Clark, 1998; Etzkowitz, 2004; Etzkowitz et al., 2008; Etzkowitz, 2014; Pinheiro and Stensaker, 2014; Benneworth et al., 2016; Guerrero et al., 2016). It has also been acknowledged in very recent NIS literature as an effective instrument towards the transformation of universities (Karaulova et al. 2016; Benneworth et al. 2017).

The role of institutional entrepreneurs (managers) and entrepreneurial management techniques are important throughout the process of institutional change (Drucker, 1985). Drucker notes that only an outsider or a catastrophe can impose major innovative changes in public organisations. Teece (2016) argues that entrepreneurial and leadership roles are very hard to teach or even absorb, they must develop naturally otherwise organisational performance and change will suffer. Augier and Teece

(2009) distinguish three managerial roles (skills) in all organisations: operational, entrepreneurial and leadership (Table 2). Authors note that the operational role is mostly concerned with the efficient management of current plans. The entrepreneurial role of a manager is oriented towards abilities to see and capture new opportunities (innovations). The leadership role is necessary for the management of organisational change so that the organisation is able to produce new innovations.

Table 2: Three roles (skills) of managers (following Augier and Teece, 2009).

	Operational role	Entrepreneurial role	Leadership role
Responsibilities	Planning and budgeting	Sensing and seizing	Propagating vision and value
Activities	Organizing and staffing	Orchestrating resources	Aligning people with strategy
Lever	Control and problem solving	Investing in R&D, developing new business models	Motivating people
Goals	Technical efficiency and predictable results	Competitive strategy	Unity of purpose

The concept of dynamic capabilities (Teece et al., 1997) is also relevant in the analysis of the strategic change from an ordinary to an entrepreneurial university¹⁴. The dynamic capabilities framework focuses on the role of managers in the process of changing organisational capabilities from ordinary to dynamic (Teece, 2016). The ordinary capabilities of organisations could be defined as ‘administrative, operational and governance-related functions’ (Teece, 2016, p. 204). The dynamic capabilities enable organisations to learn, develop new capabilities, coordinate internal resources more effectively and better respond to changing environments. Drucker (1985) argues that the change from the existing competences to the more entrepreneurial (dynamic) competences at the organisational level requires the change to be systemic, organised and purposeful.

¹⁴ The perspective of dynamic capabilities has already been applied in a few academic papers analysing the institutional change of public institutions. It was used in the analysis of legitimacy management and change process management within the United Nations Development Program (McKague, 2011), in the analysis of differences in leadership and strategic management at UC Berkeley and Stanford University (Leih and Teece, 2016) and in the analysis of the process of university technology transfer in China (Yuan et al., 2016).

5. 3. Principal – agent problem: towards the mission of an entrepreneurial university

Agency theory was developed in information economics literature in order to analyse the relationship (or contract) between two parties: the principal who delegates and the agent who performs the work (Arrow, 1971; Ross, 1983; Fama and Jensen, 1983; Jensen, 1983). Agency theory emphasises the need to measure performance and is usually described in cases (Demski and Feltham, 1978). The agency theory tries to resolve two problems that may occur in the principal-agent relationship. The agency problem may arise when the principal and the agent have different goals; and when it is difficult for the principal to verify what the agent is doing. This difficulty for the principal is caused by the asymmetric information in the relationship and may encourage moral hazard (Arrow, 1968; Prendergast, 1999; Perrow, 1986). The principal may resolve the problem of asymmetric information by providing incentives that would encourage the agent to reveal unknown information, such as revealing the performance in the case of the dean and the professor.

In our scenario, we assume that a new dean (principal) wants to change a university from an ordinary to an entrepreneurial institution. He initiates and leads change, and acts as an institutional entrepreneur. We draw on the leadership role of a dean within a public university, since it is mostly related with organisational change, and motivating staff to follow the new mission, vision and specific objectives of an organisation (Table 2, following Augier and Teece, 2009).

The first job of a new dean should be to create a clear mission, vision, and establish the objectives of the university. In the case of an entrepreneurial university, the entrepreneurial mission may include having a transformative impact on society and business through innovation in education and research. By setting the specific objectives, in the principal-agent setting, the dean (the principal) can motivate the professors (agents) to engage in relationships between the university and high-tech industries. As a result, such relationships may lead to various innovative R&D projects, co-patenting, commercialisation etc., and may contribute to the entrepreneurial mission of the university.

Proposition # 1: *Having a clear mission and specific objectives may help the principal to motivate agents to act in the interest of the principal – to change from an ordinary to an entrepreneurial university.*

Motivating employees to change could be especially hard in public institutions due to various bureaucratic constraints¹⁵ (Drucker, 1985). Drucker argues that seeing the mission of a public institution as a moral absolute and not as an economic cost/benefits analysis could be one of the most harmful obstacles. Therefore, institutions need to have a clear definition of their mission and realistic goals. Furthermore, failure in achieving goals should be understood as having the wrong objectives. In the case of an entrepreneurial university, having a clear mission and specific objectives may help the dean to motivate the professors to act in the interest of the entrepreneurial university if the professors can relate to the mission.

However, even with specific proposed actions to fulfil the entrepreneurial mission, the principal-agent problem may occur, because the principal and the agent may have different perceptions of risk. The dean might favour projects with higher uncertainty, because he diversifies his risk at the level of the whole organisation. However, the agent (professor) will most likely choose a project with lower uncertainty, because he or she has very limited time and resources (e.g. small number of research assistants and/or limited amount of funding) for potential research projects. The principal and the agent may have different goals due to different positions that they hold within the organisation.

Proposition # 2: *Entrepreneurial motivation (measured by specific preferred activities and projects) within the entrepreneurial university should be rewarded with an additional within-job reward system (monetary and non-monetary) besides the traditional promotion-based rewards.*

Entrepreneurial motivation, in the scenario of the entrepreneurial university, could be defined as an initiative to work with outside and/or international research groups, contributing towards the university's preferred R&D goals and publishing

¹⁵ Drucker (1985) notes three such obstacles: public budget which is awarded based on needs and not on performance; public service agency has to satisfy everyone (compared to consumer who overrides everyone in private firm); seeing the mission as a moral absolute and not as an economic cost/benefits analysis (there is no higher yield).

research only in highly ranked journals etc. Traditionally, research surrounding incentive systems is based only on agency theory, however, more recent insights from behavioural sciences expand the viewpoint (Merchant et al., 2003; Speckbacher, 2011) by arguing in favour of various incentive schemes to motivate employees. Speckbacher (2011) notes that having non-traditional rewards motivates employees to increase their effort, captivates the attention of the employees, challenges them and communicates the desired work outcomes more effectively. Such reward systems could include promotions, cash and non-cash rewards, recognition from managers and peers etc.

In general, economic models of incentives assume that a reward system increases the utility of an agent due to observable higher productivity. However, a high level of uncertainty regarding the success of research projects might influence professors to perform other preferred tasks and neglect innovative projects. Prendergast (2008) refers to such situations as a low contractibility of outputs. In such a case, project specific, non-traditional rewards might stimulate professors' entrepreneurial motivation to undertake specific, innovative, high-risk projects.

***Proposition # 3:** The dean (principal) of the entrepreneurial university should implement a balanced incentive system which includes promotion-based and within-job incentives.*

All academic institutions already have a built-in incentive system (promotion-based), however, we argue that entrepreneurial motivation (motivation for innovative, high risk, high impact and potentially high profit projects) should be awarded with additional within-job rewards. This proposition could be supported with Gibbs's (1995) arguments that he developed when modelling a manager-employee motivation problem in large private firms¹⁶. "The optimal incentive scheme must balance promotion-based and within-job incentives." (Gibbs, 1995, p. 251).

Ideally, a university could address objectives of promotion-based and within-job incentives separately, since it is difficult to differentiate between the effort on performance and the effects of abilities. If promotions have rewards, these rewards will carry incentive effects since higher effort increases the chance of being promoted.

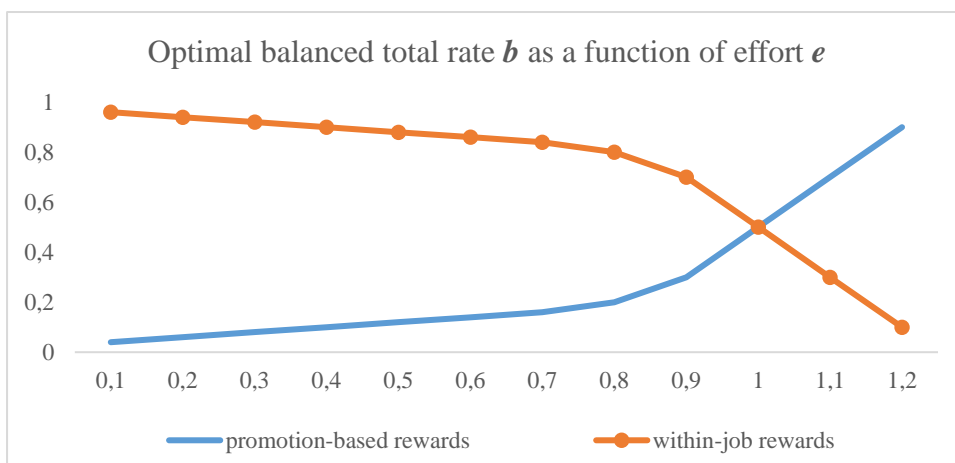
¹⁶ Gibbs (1995) analyses how middle managers are motivated in large corporations. He is also concerned with the adaptability of the incentive system to changing circumstances. Gibbs's principal-agent model was also used by Garcia et al. (2014) to analyse an editor – reviewer motivation problem in peer review.

Therefore, a university might choose to have a specific hierarchical structure which might affect productivity and increase control (Rosen, 1982), since wages generated by promotions might be influenced by wages offered at other academic institutions. Promotion-based incentives may not be available to junior professors, however, within-job incentives may increase motivation and balance the overall reward system so that junior professors are able to earn a relatively good salary based on their current performance (vs. life-long achievements-based promotion rewards).

So what is an optimal balanced incentive system? The dean (the principal) could alternate between the two forms of rewards based on observable differences in individuals (agents). Let us suppose that the optimal rate b is the sum of promotion-based rewards $b1$ and within-job-based rewards $b2$, and that b is equal to one for a balanced reward system (1). Graph 1 illustrates the optimal balanced total rate b as the function of effort e . The combination of $b1$ and $b2$ depends on the motivation that the principal is trying to stimulate by offering specific incentive systems for different agents.

$$b = b1 + b2 \quad (1) \text{ optimal balanced compensation rate}$$

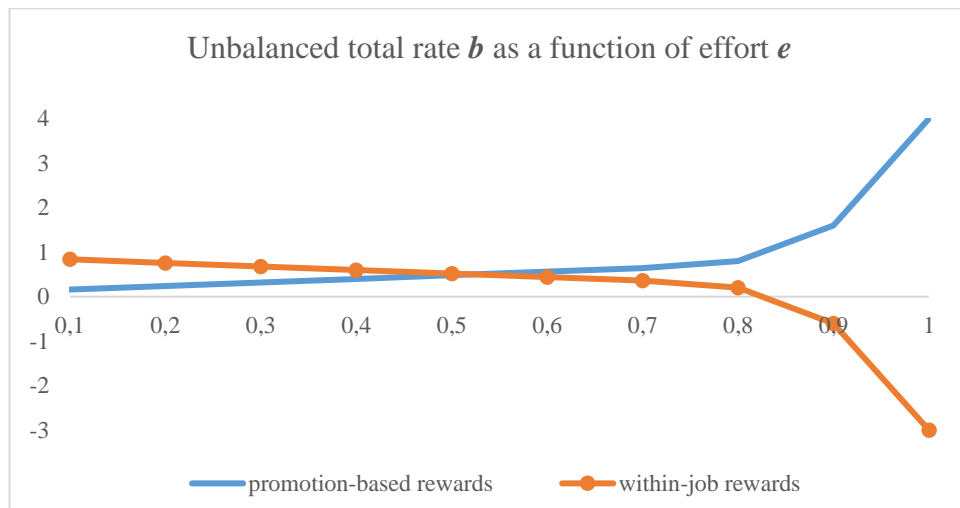
Graph 1: Optimal balanced rate b as a function of effort e . Source: author's calculations.



For example, a higher share of within-job incentives might motivate junior professors since they cannot get promotion-based incentives due to the lack of experience (and relatively lower ability). It is important for the optimal rate to be motivating (Graph 1). A high share of rewards from within-job incentives (for

preferred current on-going projects) most likely will increase the motivation and effort, while high rewards offered only for future promotion-based incentives might decrease motivation and effort of the professor that has relatively less experience and a possibly lower ability. Extra effort should always generate additional rewards for the professor, otherwise the incentive system is not balanced and may get negative (Graph 2). Graph 2 illustrates an unbalanced total rate b . In such a scenario, promotion-based incentives might increase too quickly for a junior professor. This may cause a loss of motivation, resulting in low effort when participating in current on-going research projects.

Graph 2: Unbalanced total rate b as a function of effort e . Source: author's calculations.



Proposition # 4: *The within-job incentive system should identify, reward and motivate higher effort towards the preferred objectives of the entrepreneurial university.*

The principal could focus on the within-job incentive system in order to resolve the problem of asymmetric information. It is clear that the overall performance q of the agent depends on the ability α and effort e (2). However, the principal cannot influence the ability directly, unless he/she hires the people with the best possible ability. The principal can only observe, identify effort, reward it and motivate agents to act towards the preferred objectives of the organisation. Therefore, the effective within-job incentive system may motivate high and low ability professors to apply the maximum effort and to achieve a higher overall performance on the preferred projects.

We assume that performance¹⁷ q of professors may be viewed as a combination of abilities α (specific skills and knowledge), and efforts e for new research projects (applying for high impact and high value research grants, publishing in top rated journals, participating in university-industry R&D projects potentially leading to co-patenting etc.). We also assume that the overall performance measurement has an error ε . We assume that the professor's ability α and error ε are distributed normally (2).

$$q = \alpha \cdot e + \varepsilon \quad (2) \quad \text{performance}$$

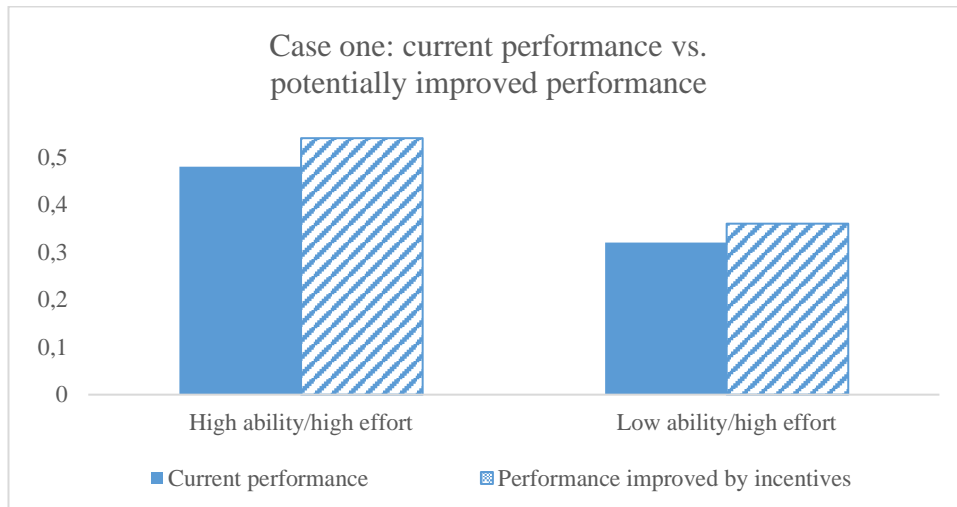
The solution to the principal's problem may be illustrated by using two cases in a simple numerical example. For **the first case**, let us suppose that professors with a high ability have a 0.6 success rate (0.4 failure rate), while professors with a low ability have a 0.4 success rate (0.6 failure rate). Another assumption may explain how high effort professors spend their time compared to low effort professors. Suppose that professors with a high effort spend 80% of their time working on preferred projects (preferred by the dean), and low effort professors spend only 20% of their time working on the valued projects. In this case, we have performance outcomes presented in the left side of Table 3. However, a new within-job incentive system may help change these numbers by motivating professors to increase their effort (as illustrated in the right side of Table 3). For example, all professors may spend more time on preferred projects (90% of their time). In such cases, incentives will raise the performance of professors with a high ability by 6% and raise the performance of professors with a low ability by 4% (Graph 3).

Table 3: Case one: current performance of professors compared to a potentially improved performance caused by the new within-job incentive system that increases the effort of all professors. Source: author's calculations.

Current performance	High ability	Low ability	Improved by incentives	High ability	Low ability
High effort	0.48	0.32	High effort	0.54	0.36
Low effort	0.12	0.08	Low effort	0.12	0.08

¹⁷ This definition of performance q was inspired by Gibbs's (1996) and by Garcia et al. (2014).

Graph 3: Performance changes for case one. Source: author’s calculations.

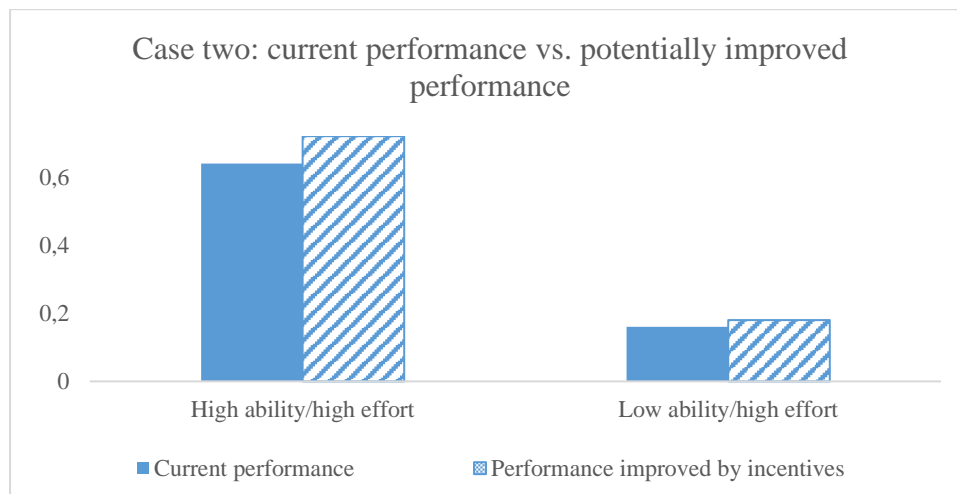


Regarding **the second case**, let us suppose that there is a big difference between the success and failure rates between high and low ability professors. Professors with a high ability have a 0.8 success rate (0.2 failure), while professors with a low ability have a 0.2 success rate (0.8 failure). We could also assume that professors with a high effort spend 90% of their time on preferred projects and only 10% of their time on other projects, while low effort professors spend 20% of their time on the valued projects and 80% on other projects. In this case, we have the current performance outcomes presented in the left side of Table 4. A new within-job incentive system may potentially change these numbers by motivating professors to increase their effort (as illustrated in the right side of Table 4). In this case, high effort/high ability professors may improve their performance by 8%, while low ability/high effort professors may improve their performance by 2% (as illustrated by Graph 4).

Table 4: Case two: current performance of professors compared to a potentially improved performance caused by the new within-job incentive system that increase the effort of all professors. Source: author’s calculations.

Current performance	High ability	Low ability	Improved by incentives	High ability	Low ability
High effort	0.64	0.16	High effort	0.72	0.18
Low effort	0.16	0.04	Low effort	0.16	0.04

Graph 4: Performance change for case two. Source: author's calculations.



Proposition 5: *The dean (principal) should link the within-job reward system with the identified motivation of professors (agents) based on age, experience, family status, personal hobbies etc. in order to increase the overall motivation and effort towards the objectives of the entrepreneurial university.*

Identified motivation has been recognised as a motivating factor within incentive systems, since it can lead employees to outperform any duties if they believe that these duties contribute to the purpose (or mission of the organisation) they value and identify with (Speckbacher, 2011). If professors identify with the entrepreneurial mission of the university, they will be motivated to contribute to it. In this case, the principal should identify what motivates the employees by collecting individual data. For example, some professors might prefer non-monetary rewards such as extra vacation days for a publication in a highly ranked journal, while others may prefer a traditional monetary reward.

In addition to the identified motivation within the incentive system, the principal could prioritise specific objectives that the organisation is trying to reach in order to motivate actors effectively. For example, if the university wants to engage in more R&D projects with the local industry, the dean might offer a different rate of pay for the participation in one or more R&D projects. If the university has a goal of increasing the number of publications in top scientific journals, the dean might offer a higher reward for each publication in higher level journals. The specific objectives

may be linked with a balanced incentive system based on the identified motivation in order to motivate actors even more effectively.

Table 5: The process of institutional change.

Institutional entrepreneurs	Institutional change	Entrepreneurial institutions
<p><u>Defined as</u> individuals who naturally have and use entrepreneurial and leadership skills (roles) to initiate and lead institutional changes that are systemic, organised and purposeful.</p>	<p><u>Defined as</u> purposeful, systemic and organised internal change of organisational capabilities from ordinary to entrepreneurial (dynamic).</p> <p><u>To implement the change, the principal should:</u></p> <ul style="list-style-type: none"> • Have a clear mission with specific objectives. • Reward entrepreneurial motivation with an additional within-job reward system besides the traditional promotion-based rewards. • Create a balanced incentive system composed of promotion-based and within-job rewards. • Build the within-job reward system that reveals, rewards and motivates higher efforts towards preferred objectives. • Link the within-job pay with the identified motivation. 	<p><u>Defined as</u> public organisations with entrepreneurial (dynamic) capabilities (abilities to change competences in order to address changing environments).</p>

5. 4. Conclusion

In this conceptual chapter we explored how institutional entrepreneurs may change institutions by utilising the framework of the principal-agent model. We adopted a general principal-agent model by Gibbs (1995) to the scenario of institutional change from an ordinary to an entrepreneurial university. In general, principal-agent models focus on micro level analysis. In our scenario, the goal was to analyse the interaction between the institutional and agency levels in the process of institutional change, since this relationship is usually overlooked and understudied in academic literature.

More specifically, in this chapter, we analysed how a balanced incentive system could motivate professors to increase their effort to a maximum in order to contribute to the mission of the university becoming entrepreneurial. In the conceptual analysis we assumed that the principal acts as an institutional entrepreneur who utilises his entrepreneurial and leadership roles in order to initiate and lead institutional change

(Table 5). The institutional change was assumed to be a purposeful, systemic and organised internal change of organisational capabilities from ordinary to entrepreneurial. By incorporating these prior assumptions and by drawing on agency theory, we created five propositions for the implementation of institutional change within the context of entrepreneurial university (Table 5) and explored the process of change.

This conceptual analysis has important implications for public organisations that are trying to change. The conceptual discussion addresses the problem of asymmetric information behind the relationship between the principal and the agent. The list of propositions in Table 5, explores how the within-job reward system may resolve the principal's problem by revealing and rewarding high effort towards the preferred objectives of the organisation.

The first proposition points to the importance of the organisation having a clear mission and specific objectives. The second proposition highlights the importance of rewarding entrepreneurial motivation. The third proposition suggests that a balanced incentive system should include promotion-based and within-job incentives. The fourth proposition emphasises the importance of the within-job incentive system. The fifth proposition suggests that the identified, individual motivation may strengthen the overall motivation and effort of the agent to act in the interest of principal.

The originality of the conceptual analysis provided by the Chapter is in synthesising the three theories: institutional, agency and NIS in the analysis of institutional change from an ordinary to an entrepreneurial institution. By synthesising the three theories, we were able to develop five conceptual propositions that link meso and micro levels in explaining the process of institutional change. We also pointed to the specific micro level tools that increase the motivation and effort of employees to contribute to the change and act in the interest of the principal. Further research may elaborate of the five propositions and examine them in various contexts, in different types of public and private organizations.

Chapter 6: General conclusion

6.1. Summary, originality and contribution to the NIS literature

This thesis has sought to contribute to the debate of the “European periphery paradox” by reflecting on the following questions: are the internal dynamics of NISs driven by the coevolution of innovation generation and diffusion; and stimulated by various social, institutional and economic factors depending on countries’ development level and geographical location? What drives the transformation of NISs in transition economies? How does the process of institutional change unfold? In the existing literature, the “European periphery paradox” is defined as a detachment from or mismatch between a general call towards innovation-based growth (and focus on innovation policy) and serious efforts to strengthen public and private actors (such as firms, institutions, universities) that are essential for knowledge creation. The evidence from this PhD thesis confirmed this definition and provided additional empirical and theoretical insights.

The quantitative Chapter 3 set the global scene by undertaking an empirical comparison of the internal dynamics of NISs of five country groups. The econometric results confirmed that there are significant differences between advanced high-income Western and mid-income Eastern European countries. These differences amongst regions were indicated by either strong or weak relationships between innovation generation and diffusion. The results also pointed to the importance of institutional factors (meso-level) and social factors (micro-level) in innovation generation.

The existing NIS literature recognises that innovation systems vary due to local framework conditions, however, it is still not clear, what the specific factors are and how they shape these internal dynamics. Some NIS studies do not fully recognise social and institutional factors in the analysis of NIS dynamics (Castellacci and Natera, 2013; Fagerberg et al. 2014). Most econometric NIS studies do not recognise innovation diffusion conceptually or empirically in the analysis of NIS dynamics. Others that do recognise the importance of innovation diffusion (such as Mahroum and Al-Saleh, 2013 and Chang, 2015), do not reveal specific relationships between factors that influence innovation generation and diffusion. Instead, they focus on the efficiency indexes of different NISs.

The originality of Chapter 3 is in addressing all these issues. The proposed innovation diffusion conceptual model defines the internal dynamics of NIS as a coevolution of innovation generation and diffusion. The model identifies systemic differences amongst different groups of NISs globally and reveals specific factors that may have influenced innovation generation and the overall internal dynamics of NISs. The originality of Chapter 3 is also in revealing the importance of the two-way interrelationships between institutional and social factors in the analysis of NISs. This interrelationship between meso and micro levels is usually overlooked and understudied in the NIS literature.

The overall results of Chapter 3 confirm the definition of the “European periphery paradox” by indicating that local history and geo-political situations may have determined specific paths of socio-economic development and shaped future opportunities for innovation-based growth. Based on the econometric insights we may argue that the dynamics of NISs and the overall innovation outcomes could have been supported by various social (e.g. social cohesion, education capabilities, research skills etc.), institutional (e.g. quality of local infrastructure and institutions etc.) and economic factors (e.g. expenditures on education, availability of credit, trade openness etc.). The presence or absence of the interrelationships amongst these factors may also indicate that strong and dynamic NISs may have been supported by the presence of strong states (through coordination of relevant policies), while weak and static NISs might not have had such support.

Building on the empirical results of Chapter 3, Chapter 4 took on the initial research question: what factors affect transformation of the NIS in a transition economy? This was done by investigating qualitatively the transition of the Lithuanian NIS. Transition is a long-term, systemic change and government institutions should be the key moderators of this change. However, the initial data findings showed that various institutional inefficiencies of the public sector (such as the lack of relevant organisational, managerial and entrepreneurial capabilities) acted as barriers to transformation. These findings facilitated a more refined question asking: what (who) reinforced institutional change and how was this done.

The NIS literature on transition and developing NISs recognises the importance of local capabilities, innovation and education policies, and the importance of relationships between businesses and universities during the catching-up processes

(Lundvall et al., 2009; Radosevic and Kaderabkova, 2011; Urbanovic and Wilkins, 2013; Watkins et al. 2015; Karaulova et al. 2016). However, while current approaches examine key components of NISs at macro and micro levels, and their interconnections, the role of public institutions during the process of transition remains understudied. More specifically, the role of human agency (the role of institutional entrepreneurship) within public institutions is not recognised in the studies of developing or transition NISs.

The originality of Chapter 4 lies in recognising the legitimisation of institutional change through institutional entrepreneurship via internal (within organisation) and external pressures (better policy making and implementation). The study also highlights the necessity of having institutional entrepreneurial capabilities as a prerequisite for adapting to a changing environment (during the process of institutional change) and for facilitating innovation generation and diffusion within NISs. Many recent studies on institutional entrepreneurship still focus only on the internal, structural aspects of the institutional embeddedness problem, but overlook the importance of leadership and staff capabilities (Battilana et al., 2009; Bruton et al., 2010; Benneworth et al., 2016).

Drawing from the qualitative results of Chapter 4, the conceptual Chapter 5, investigates the process of institutional change from an ordinary to an entrepreneurial university. The current NIS literature acknowledges the importance of entrepreneurial public institutions (Clark, 1998; Rasmussen et al. 2011; Pinheiro and Stensaker, 2014; Benneworth et al. 2016), however, very little attention is paid to analysing how the process of change occurs and how public institutions can become entrepreneurial. Most studies that investigate various inefficiency problems of universities (Cummings, 2015; Karaulova et al. 2016; Korosteleva and Belitski, 2017) focus on structural institutional (meso-level) changes, but completely overlook potential issues at the agency level (micro-level). More specifically, the current studies do not explain how to motivate employees to act in the interest of an institution that is trying to change from ordinary to entrepreneurial.

As a result, Chapter 5 employs the principal - agent model in the setting of institutional change from an ordinary to an entrepreneurial university. The originality of the conceptual model is in pointing to the specific micro-level tools that increase the motivation and effort of employees to contribute to the change and act in the

interest of the principal. The originality of Chapter 5 lies also in synthesising the three theories: institutional, agency and NIS. The NIS literature acknowledges the systemic aspect of innovation-based growth, however, the process of institutional change remains unclear. We provide clarification on the process of institutional change by applying institutional theory and investigating the role of institutional entrepreneurship as a mechanism of institutional change.

Another area that is lacking attention in the existing NIS literature is the interaction between institutional (meso-level) and agency (micro-level) factors. By applying the concept of institutional entrepreneurship to the principal-agent model, Chapter 5 is able to compensate for the area of neglect. By synthesising the three theories, we are able to develop five conceptual propositions that link meso and micro levels when explaining the process of institutional change.

6.2. Policy implications

The quantitative results of the thesis may have important policy implications for policy makers and academics. Firstly, based on the results from Chapter 3, we may argue that it is important for policy makers to acknowledge that innovation diffusion is equally important as innovation generation. Therefore, countries seeking innovation-based growth should focus on strengthening private and especially public actors (such as ministries, government agencies and universities) in order to facilitate such growth. Secondly, based on the results, we may argue, that the more advanced countries have stronger interactions between innovation, trade, education and labour/ industrial policies resulting in better innovation outcomes.

Therefore, policy makers of countries seeking innovation-based growth may want to focus on the coordination of innovation policy with other policies. The results from the econometric model also pointed to the importance of different institutional and social factors in innovation generation processes. Therefore, it could be beneficial for policy makers to acknowledge limiting factors in particular, and develop relevant policy tools to eliminate limiting institutional (such as institutional inefficiencies, corruption level etc.) and social barriers (such as quality of education, social cohesion etc).

The qualitative findings from Chapter 4 have important policy implications for academics, policy makers and managers of public institutions in transition and developing economies. Based on the findings, we may argue that policy creation and implementation processes might not be optimal if public institutions lack relevant organisational, managerial and entrepreneurial skills. These processes may also be not optimal, if public institutions lack leaders who are able to initiate and lead internal transformation to ensure that the capabilities of employees are relevant.

In such cases, institutions may be strengthened by institutional entrepreneurs who are able to initiate, lead and strategise for better policy making and implementation by learning from policy failures, by challenging existing limiting rules and practices and by mobilising political support for policy coordination and continuity. The internal capabilities of institutions might be strengthened by providing relevant training for employees, by expanding the public hiring systems to consider employees from private sectors, and by updating compensation schemes in order to be able to offer competitive salaries and to attract the staff with the best capabilities.

The conceptual arguments of Chapter 5 have important policy and managerial implications for universities seeking to become entrepreneurial. Policy makers and managers of the higher education sector should not assume an easy, fast and simple transformation from an ordinary to an entrepreneurial university. The change should be purposeful, systemic and organised. It is important for such universities to have entrepreneurial leaders who recognise that a balanced (composed of promotion-based and within-job based) and individualised incentive system is important for increasing the motivation and effort of employees to act in the interest of an organisation. Therefore, additional time, staff and funding might be needed to build a relevant within-job reward system, to link it with the identified motivation of employees, and to balance it with the existing promotion-based incentive systems.

6.3. Future research

Various innovation policy evaluations and policy suggestions from the EC and the OECD recognise the lack of cooperation between public and private institutions. However, they do not always recognise the importance of employees' entrepreneurial competences or the importance of entrepreneurial leadership in public institutions.

This link between meso (institutional) and micro (agency) level is often missing in various official policy evaluations and suggestions. It is very important for policy makers to recognise that institutional change does not happen automatically. Therefore, future academic and policy studies may focus on the analysis of specific tools that enable various internal and external initiatives led by institutional entrepreneurs. Future academic research may elaborate on the propositions from the principal-agent model in Chapter 5 and further investigate the process of institutional change qualitatively at the agency level.

This thesis has recognised that entrepreneurial public institutions are more likely to be active and strategic players in innovation-based growth. However, the entrepreneurial function of public institutions is not usually recognised by academics and policy makers as equally important as the operational function. Mazzucato (2013) is one of the few to highlight the importance of entrepreneurial state and entrepreneurial institutions in the US. Therefore, future academic research and policy analyses could be aimed at understanding more deeply the factors that enhance and stimulate the entrepreneurial function of different public organisations (ministries, universities, high schools etc.). Such studies may be beneficial in creating relevant policy and funding tools to enhance the implementation of relevant practices (e.g. incentive systems, entrepreneurial training for staff etc.) leading to relatively entrepreneurial institutions and more dynamic NISs.

Even though some of the roles of entrepreneurial institutions have already been acknowledged in the academic literature, much more qualitative research is needed to better understand, which specific practices work or do not work effectively in various contexts. Future academic work could further elaborate on the following questions: how institutions could be encouraged to create internal and external collaborations for improved policy making, to create more networking, knowledge exchange and collaborative R&D opportunities with private firms, to co-create and/or shape new market opportunities, to address better various system failures such as transition, capabilities, lock-in, networking etc.

In summary, we may argue that active interrelationships between all actors of NISs, as well as relevant competences of all actors, are essential for the internal dynamics of NISs. The entrepreneurial competences of public institutions are especially important in the current, uncertain, economic situation. Institutions are at

the centre of NISs. However, their budgets were cut during the post-crisis austerity practices and remained low due to the relatively slow growth of many national economies. Therefore, it is crucial for all government institutions: ministries, schools, hospitals, research labs, universities etc. to be entrepreneurial in order to remain competitive and sustain the quality of services that they provide. It is also important to note that the post-crisis period as well as many societal changes (like aging population or climate change) create new opportunities for social innovation in public organisations. However, entrepreneurial thinking and behaviours are essential in order to bring such opportunities to fruition and use them to provide improved and more efficient services.

6.4. Limitations of this thesis

The mixed-methods research approach of this PhD thesis could be criticised in many ways. Firstly, we cannot compare and contrast the results of qualitative and quantitative parts, because we raise questions in these two studies from different perspectives. Secondly, the quantitative study may be criticised for not using an econometric benchmarking analysis. For example, we could have calculated the amount by which low-income countries would need to increase their R&D spending in order to catch-up with high-income innovation leaders. This suggestion is often proposed in policy recommendations from the EC and the OECD.

However, based on the conclusions from this thesis, we see that higher R&D spending might not provide significant results if the lagging countries do not have entrepreneurial institutional actors to facilitate various innovation generation and diffusion processes effectively. For example, if the education sector does not provide enough scientists, and if there is no cheap way of financing the commercialisation of innovations at various stages beyond R&D etc., higher R&D funds may not lead to higher innovation outputs.

Benchmarking analysis could be helpful in comparing one high-income mature economy (with established long-term institutional structure) with another high-income economy when analysing the differences in R&D spending or levels of tertiary education in the scientific sector. However, this type of analysis is not very beneficial in comparing high and low-income countries with different innovative capabilities.

The combination of qualitative and quantitative analysis within the NIS approach is more helpful, since it focuses on non-price competitiveness and takes sociological, historical and evolutionary perspectives into account.

Thirdly, since the qualitative part of the thesis is based on a single case, it could be criticised for having a weak external validity, a lack of generalisability and the researcher's possible subjectivity. It is important to acknowledge that countries with different historical contexts may have completely different results (e.g. despite having the same geo-political situation, the three Baltic states - Latvia, Lithuania and Estonia, chose very different paths of transformation and achieved very different innovation outcomes). Large-N studies may also present different results, since it may be hard to capture both the breadth and depth of questions raised. Following methodological guidelines and systemic procedures is also very important to validate a case study. We believe that the qualitative chapter presents clear, methodological techniques and epistemological grounding. The issue of researcher subjectivity is also important. This case study employs the triangulation technique in order to eliminate biased views of the questions discussed during the interviews.

Despite the possible limitations of the study, we believe that the mixed method approach allowed for a relatively deep investigation of the "European periphery paradox" at the various levels. It also revealed important empirical and theoretical insights and opened-up new avenues for further research. The sequence of the chapters allowed for investigation at the systemic, meso and micro levels, and filled-in gaps of the current NIS literature. It also revealed a more detailed picture of the internal dynamics of NISs.

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