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ENVIRONMENTAL INFLUENCES ON THE ADOPTION OF OPEN INNOVATION: ANALYSIS OF STRUCTURAL, INSTITUTIONAL AND CULTURAL IMPACTS

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ABSTRACT

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The concept of open innovation has recently gained widespread attention, and is particularly relevant now as many firms endeavouring to implement open innovation, face different sets of challenges associated with managing it. Prior research on open innovation has focused on the internal processes dealing with open innovation implementation and the organisational changes, already taking place or yet required in companies order to succeed in the global open innovation market.

Despite the intensive research on open innovation, the question of what influences its adoption by companies in different contexts has not received much attention in studies. To fill this gap, this thesis contribute to the discussion on open innovation influencing factors by bringing in the perspective of environmental impacts, i.e. gathering data on possible sources of external influences, classifying them and testing their systemic impact through conceptual system dynamics simulation model. The insights from data collection and conceptualisation in modelling are used to answer the question of how the external environment affects the adoption of open innovation.

The thesis research is presented through five research papers reflecting the method triangulation based study (conducted at initial stage as case study, later as quantitative analysis and finally as system dynamics simulation). This multitude of methods was used to collect the possible external influence factors and to assess their impact (on positive/negative scale rather than numerical).

The results obtained throughout the thesis research bring valuable insights into understanding of open innovation influencing factors inside a firm's operating environment, point out the balance required in the system for successful open innovation performance and discover the existence of tipping point of open innovation success when driven by market dynamics and structures. The practical implications on how firms and policy-makers can leverage environment for their potential benefits are offered in the conclusions.

Keywords: Innovation, Open Innovation, Innovation System, Institutions, Culture, Environment

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And time for reflection with colleagues is for me a lifesaver; it is not just a nice thing to do if you have the time. It is the only way you can survive (Margaret J. Wheatley)

Writing this thesis has been a continuous learning not only academically and professionally, but also socially. Now it is time to thank those, who have been the source of this diverse experience throughout past two years. First, I would like to thank my supervisor Marko Torkkeli for the opportunity and circumstances to carry out this thesis work and in the first place – for luring me into starting it. His expertise on the topic of this dissertation and continuous encouragement, enthusiasm and optimism were invaluable.

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Lappeenranta, 30.06.2011

Irina Savitskaya

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LIST OF ABBREVIATIONS

ETC	External Technology Commercialisation
FDI	Foreign Direct Investments
IDV	Individualism
IPR	Intellectual Property Rights
IS	Innovation System
LTOWVS	Long-term vs. short-term orientation
MAS	Masculinity
MNC	Multinational Corporation
NIH	Not Invented Here
NIS	National Innovation System
NPD	New Product Development
NSH	Not Sold Here
OI	Open Innovation
PDI	Power Distance
R&D	Research and Development
RIS	Regional Innovation System
ROIS	Regional Open Innovation System
RQ	Research Question
SME	Small and Middle-Sized Enterprise
UAI	Uncertainty Avoidance

PUBLICATIONS

The thesis consists of the introductory part (Part I) and the following publications (Part II). The publications comprising the second part of the thesis are listed below, summarizing the contribution of the author of this thesis and the acceptance procedure of each paper.

Publication 1

Savitskaya, I. and Torkkeli, M. 2010. Markets for Technology in an Emerging Economy: Case of St. Petersburg Russia, *Innovation (Инновации), Special Issue on Open Innovation,* 6 (140), pp. 6-10.

The author was responsible for the literature review study design and implementation in collaboration with second author. The paper was accepted to the Special Issue of the Journal based on a double blind review.

Publication 2

Savitskaya, I and Torkkeli, M. 2011. A Framework for Comparing Regional Open Innovation Systems in Russia, *International Journal of Business Innovation and Research*, 5/3. *Forthcoming*

The author was responsible for designing the framework for analysis and data collection and interpretation. The original working paper was presented at the doctoral tutorial and was invited to the journal, where the full paper was double blind reviewed.

Publication 3

Savitskaya, I., Salmi, P., Torkkeli, M. (2010) Barriers to Open Innovation: case China, *Journal of Technology Management and Innovation,* 5, 4, pp. 10-21.

The author was responsible for literature review and hypotheses introduction as well as for designing the research. The paper was submitted to the regular issue of JOTMI and accepted after the blind review.

Publication 4

Savitskaya, I., Salmi, P., Torkkeli, M. (2010) National Innovation System for Open Innovation: facilitator or impediment, *Proceedings of III ISPIM Symposium*, 12-15 December 2010, Quebec, Canada.

The author was responsible for the literature review and hypotheses building as well as for designing the research. The paper was accepted to the conference after the double blind review of an extended abstract and presented at the conference session.

Publication 5

Savitskaya, I. and Kortelainen, S. (2011) Innovating within the system: the simulation model of external influences on open innovation process, *Proceedings of XXII ISPIM Conference*, 12-15 June 2011, Hamburg, Germany.

The author was responsible for the literature review and causal model creation as well as for designing the research outline. The paper was accepted to the conference after the double blind review of an extended abstract.

PART I: OVERVIEW OF THE THESIS

1. INTRODUCTION

"It is change, continuing change, inevitable change that is the dominant factor in society today. No sensible decision can be made any longer without taking into account not only the world as it is, but the world as it will be" - Isaac Asimov

1.1. Background

Innovation is widely considered a crucial source of competitive advantage and survival in the dynamic environment (Dess and Picken, 2000; Tushman and O'Reilly, 1996) and a focal point of an organisation's strategy (Milling and Stumpfe, 2000). Organisations innovate to adapt to their external environment and to respond to perceived external and organisational changes (Damanpour and Aravind; Gopalakrishnan and Damanpour, 1997). Many industries traditionally focus on internal innovation (Grönlund et al., 2010) whereas others have been in continuous co-innovation processes over the decades (Mowery, 2009). During the last decade, the intensification of global competition has resulted in the emergence of new approaches to cooperation for innovation. The rapid development of information and communication technologies has enabled integration of customers and suppliers into innovation process despite the physical distances between them. The propensity to cooperate and open up the company borders intensified in the 1990s (Gassmann, 2006) and the shift towards open innovation began, reaching its peak at the time when Chesbrough (2003a) raised the issue of whether open innovation is "the new imperative for creating and profiting from technology".

The notion of "open innovation" was coined by Chesbrough (2003 a,b) and has quickly gained the interest of both researchers and practitioners. The concept refers to a way of innovation management where a company provides internally produced knowledge for the market and lets external knowledge flow in, in order to maxime the value for the company. It can also be described as "both a set of practices for profiting from innovation and a cognitive model for creating, interpreting and researching those practices" (West et al, 2006, p. 286).

According to the open innovation model, innovations emerge increasingly as a result of inter-organisational cooperation; hence, the environment of this cooperation attracts attention to the systems of innovation. The national system of innovation (NIS) refers to a framework that aims at explaining the differences in innovation performance of nations through the differences in their institutional support for such innovation (Lundvall, 1992; Nelson, 1993). The NIS framework stresses the idea that the flow of knowledge (and technologies) between individuals and organisational actors is the key to the innovation-creating process. While numerous factors affect these knowledge flows, among the most important is the existence of various "institutions". These include, for instance, a nation's intellectual property (IP) policy, which by determining the formal appropriability of innovations (through patenting and other laws) has a significant effect on the development and diffusion of knowledge. This set of institutions also provides the framework within which innovation policies (concerning e.g., public funding of research and development) are formed and implemented.

While formal institutions to a considerable degree, shape the external relationships among key actors (firms, universities, public research institutes, etc.) in the NIS, there are also structural factors that affect the flows of knowledge between firms. In particular, the industry/market structure affects, and is dependent upon, firms' rent appropriation strategies (e.g., the use of patents and technology licensing; Arora, 1997) and, therefore, also the knowledge flows between them. Indeed, diverse industries may represent distinct "systems" of innovation even within a nation (Nelson and Rosenberg, 1993). In the cross-country comparisons of NISs, it is therefore important to take industry specific factors into account as well.

Companies that operate in an open innovation environment do not have to rely only on internal funding for R&D, and since firms do exist in regional systems the open innovation benefits are best achieved in regional clusters. This fact was explained by economists (Romer 1987; Krugman 1991) who pointed out the benefits of geographical proximity and regional concentration of network partners due to reduced production and transport costs and lower costs of accessing information locally. Hence, the role of regional systems for fostering innovation activation and open innovation interactions of the firms is increasingly high, especially for small and middle-sized companies. The regional innovation system is enabled by knowledge exchanges among different actors of regional networks, including governmental institutions. The nature of such knowledge exchange is on a large scale defined by national policies enabling the creation and incorporation of innovation within a national economy.

The other set of impacts on open innovation comes from national and organisational cultures. Some researchers (e.g. Takada and Jain, 1991; Straub, 1994; Dwyer et al, 2005) suggest that culture has an influence on the diffusion of innovations. The five dimension index scores of culture offered by Hofstede (1991, 2001) explains the behaviour of individuals and organisations by their national culture peculiarities, measured through collectivism versus individualism, the level of power distance, uncertainty avoidance, masculinity or femininity and long- or short-term orientation. For instance, collectivism ranking higher with regard to individualism might have a positive influence on open innovation since a collectivistic culture is more prone to form cooperative ventures (Michailova and Hutchings, 2006). The first attempts to discover the cultural aspects of open innovation were undertaken based on Hofstede's (1980) cultural comparison research and project GLOBE (Javidan et al. 2006; House et al. 2004) in line with research of cultural influence on innovation capability (Sun 2009) and cultural background for innovation (Pohlmann, 2005).

Despite the intensive research in the field of open innovation over the past few years, there are many questions still left unanswered (Chesbrough et al. 2006), among which is the influence of national cultures on adoption of open innovation practices and the barriers towards openness imposed by the institutions in the environment. This study aims to address these questions and to contribute to understanding of uneven open innovation practices dissemination. The importance of environment has been acknowledged by previous research in business fields, with highest concentration of studies on the field of international business and cross-cultural management. On the other hand, innovation management research consider environmental factors primarily inside innovation systems theories, which do not cover all aspects of innovation processes and interactions. Hence, to understand what drives the decisions of business (apart from their own strategy and goodwill), the study taking into account the environment is needed.

The purpose of the thesis is to contribute to the discussion of open innovation and the factors influencing the adoption of this approach to innovation management by many firms. Though the adoption rates have been different in many countries, the question of why this is so is hardly addressed. A literature review is done to distinguish the factors which will hinder open innovation adoption, and empirical research was carried out to test these influences and to find out other possible factors.

1.2. Theories on environmental influences to innovation

The influence of the environment on the strategies and operations of companies has previously been studied mainly from the perspective of MNCs entering new markets (Cui et al 2006; Luo and Park, 2001). The newer trend has been to study technology transfer influencing environments; however the focus of these studies remained at the level of intrafirm transfer (Cui et al 2006).

Classic business theories acknowledge the influence of such country-specific environments as institutional and economic, to the nature and intensity of competition and dynamics of local industries (Root, 1988; Ghoshal and Nohria, 1993). However, the shortcoming here lies in the fact that most prior research has focused on institutional or economic factors (Contractor and Sagafi-Nejad, 1981; Marton 1986) and overlooked the importance of e.g. cultural environment (Cui et al. 2006).

Ghoshal and Nohria (1993) emphasise the critical role of environmental demands on the requirements of capabilities that organisations need in one or other settings. Shenkar (1990) stresses, that in emerging markets especially these influences will be strong due to the ambiguous property rights, imperfect markets and asymmetric information, and uncertainty in government actions.

Dess and Beard (1984) determine environments through dynamism, complexity, and hostility. The high dynamism of the environment is often associated with uncertainty in decision-making and fast changing demand, which is related to hostility (competition, entry barriers).

The importance of the environment as an influencing factor in classic managerial theories is reflected through multiple paradigms of global competitive advantage, such as firm- and location specificity (Kogut, 1985), configuration-coordination framework by Porter (1986), globalisation-localisation approach by Ghoshal (1987) and market context studies of subsidiaries of MNC by Birkinshaw (1997). Henderson and Mitchell (1997) proved the dependence of firm behaviour and industry structure and other environmental context.

Certain factors concerning the environment have been empirically studied by previous research and proved to have a substantial impact on a firm's strategies and behaviour. As such, work of Luo and Park (2001) demonstrates, the market environment directly influences a firm's selection of strategy, where initiatives directly come from the environmental context in which the firm operates.

While different viewpoints were presented as to the matter of environmental influences (Figure 1), their relative influence and especially their simultaneous influence have not been much studied. For example, while analysing the market environment, researchers have identified two factors – competitive intensity and market dynamism (Grewal and Tansihaj, 2001; Jap, 1999) and later a comparison was made between them (Cui et al., 2006), however, it did not take into account the simultaneous influence of other factors. The cultural environment is one more environmental factor, which has not been deeply researched (Cui et al.2006).

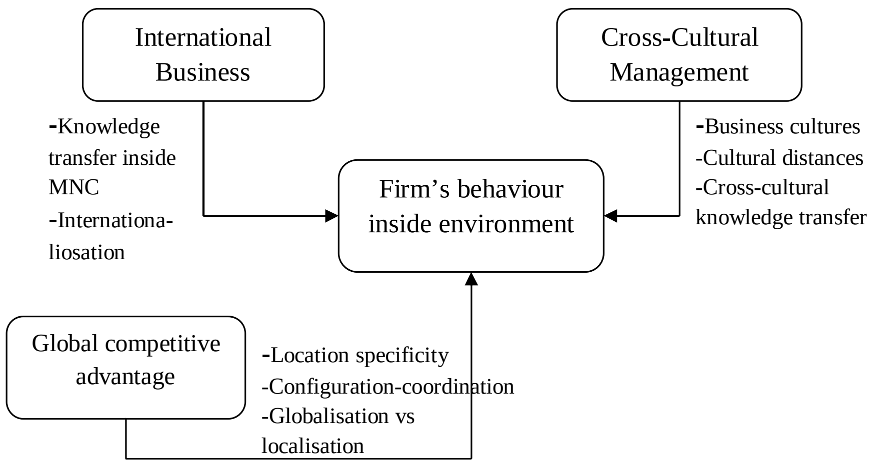

Figure 1. Prior studies on environmental influences on behaviour of the firm

Regarding the role of the environment in open innovation, the work by Lichtenthaler (2009) concerns the outbound side, and proves the impact of outbound innovation to a firm's performance to be higher in an environment characterised by high degrees of technological turbulence (Gambardella et al., 2007), transaction rate (Teece, 1998), and competitive intensity (Cui et al, 2006; Lichtenthaler 2009; Fosfuri, 2006).

Among the other factors of environment influencing open innovation can be mentioned development of technology markets (Gambardella et al., 2007; Arora and Ceccagnoli, 2006; Savitskaya et al, 2010), as well as appropriability regime (Teece 1986) and IPR (regulatory institutions) (Andersen and Konzelmann, 2008; Yang and Kuo, 2008), industry structure (Savitskaya et al, 2010) and national culture (Ciu et al., 2006; Michailova and Hutchings, 2006). The main cultural aspect emerging in knowledge sharing (which underlies open innovation) is the dimension of individualism vs. collectivism (Hofstede, 2001) and universalism vs particularism (Michailova and Hutchings, 2006). These dimensions of culture are the explanations of the emergence of Not Invented Here (NIH) and Not Sold Here (NSH) syndromes.

In the market, where the product development often happens as a collaborative effort, concern does exist as regards how to utilise the results of a combination of external and internal research inputs and who should claim the ownership of the results (Braczyk et al., 1998). The concept of an appropriability regime developed by Teece (1986) describes how the strength of intellectual property rights (IPR) affects the distribution of profits from innovation, as well as trade in technology markets. These factors do interfere with NPD process at different stages; however, their impact at every stage is not widely studied, providing the research gap to be addressed by the thesis.

Methodologically, open innovation has been mainly studied at the level of company or industry with either case studies, or industry-focused surveys. However, the country and culture aspects were neglected. Moreover, system dynamics research has not yet become widely used in innovation management, and especially open innovation process modelling. In this regard, the research in question presents an invaluable contribution to open innovation understanding and methodology.

1.3. Scope and Objective

The open innovation paradigm belongs to the innovation management field of study, which is a part of a technology management doctrine. The explanation and analysis of environmental influences on innovation management practice brings in the aspect of theory of systems, which partly encompasses institutional theory. Separate emphasis is made in this thesis on the cultural aspect of the environment, acknowledging the role of culture at all levels in the system – at individual, firm, and governmental (Figure 2). The focus of this thesis lies in the intersection of these perspectives and arising from them external factors, which influence a company's behaviour inside its business environment. The internal company processes are acknowledged but not viewed separately in this context.

The main assumption behind the research conducted for this thesis is that the firms striving to implement open innovation face the need to alter not only their internal processes, but to adjust to the impacts of external factors coming from the operational environment. Acknowledgement of these factors would influence internal measures implemented to foster a shift towards open innovation way of thinking in organisations, and the strategy developed to support it.

To support this claim the framework of external influences is created based on a few streams of research dealing with the problem of organisational co-innovation from different aspects.

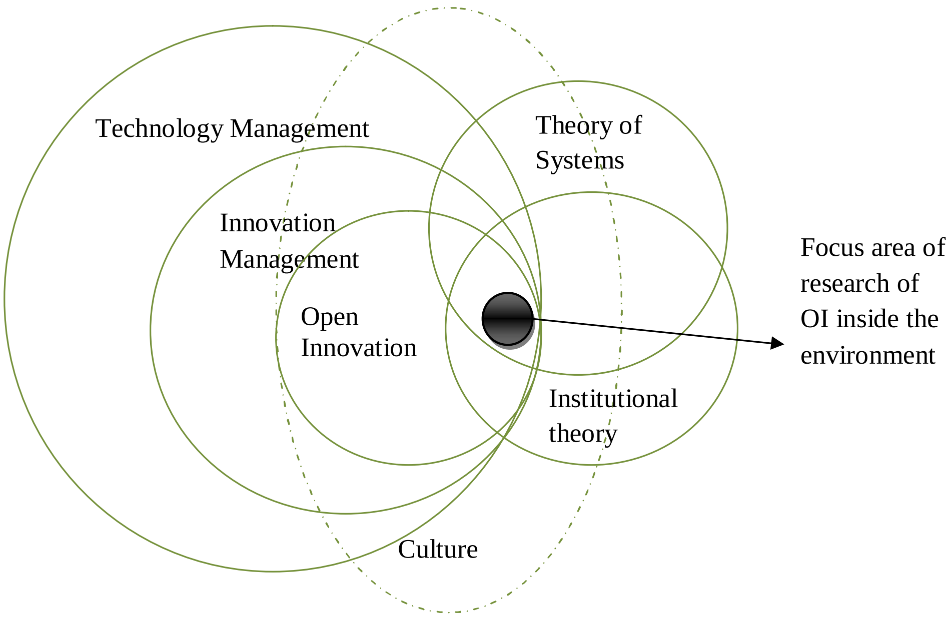

Figure 2. Focus area of current research on OI inside the environment

The **main objective** of this study is to identify the potential sources of external influences on open innovation practice adoption by firms, and to analyse their impact and distinguish potential ways they can be leveraged.

Hence, the external influences on the adoption of open innovation practices are divided firstly into the innovation system level (including institutional), as for instance, the influence of innovation policies and public funding on a firm's involvement with open innovation processes. Then, secondly, the cultural level, i.e. certain features of national and mental models of employees creating an attitude towards the use of open innovation practices within the company.

The main research question (RQ) is *How does the environment affect the adoption of open innovation by companies?*

For the convenience of carrying out the research in few steps, the following sub-questions are introduced:

RQ1 *What are the factors influencing open innovation adoption?*

RQ2 *How do external factors influence the tendency to open innovation in the companies?*

RQ3 *How do environmental factors influence open innovation performance in companies?*

To combine these different aspects in addressing the problem set in this thesis, methodological triangulation is applied as a method, combining the qualitative and quantitative approach to studying the phenomena, and adding a system dynamics simulation viewpoint to analyse the findings.

As the result of the literature review the first framework is formed, and as the research continues, the framework is supplemented with the findings from the interviews and case studies. Finally, after empirical testing with quantitative data, the causalities and effects are distinguished and the system dynamics model is built. The role of the attached publications is to demonstrate the path the research took, starting from the initial case analysis and research on their position within the system to collecting the missing elements for the final framework and building a model which is able to forecast possible scenarios. Each publication presents a search for the answer to one of sub-questions imposed in the thesis and the interconnection and contribution of publications is elaborated in Chapter 4.

1.4. Limitations

The focus of the thesis is on the influences of external factors to open innovation adoption, based on the theory of innovation systems (including institutional theory) and explained further through the study of national culture. The restriction to these theories only limits the study in terms of including other possible influencing factors. However, the case study approach for primary data collection is targeted towards counterbalancing this aspect by maintaining open questions, in case new items should be mentioned.

Since the study focuses on external impacts, the internal company processes are acknowledged but not viewed separately in this context. Hence, the influence of the external environment is viewed in absolute terms, disregarding the internal company processes. Simultaneous influence of internal and external environments might provide somewhat different results, however this is the next step in such kind of research and provides the agenda for further studies.

One more limitation concerns the data collection: 1) purposive sampling in the case selection allowed for analysing only the companies which are involved in open innovation to some extent, whereas studying completely closed companies and their barriers could bring additional insights into the companies' reluctance to embrace open innovation. 2) Misbalanced countries samples for Finland, China and Russia may be regarded as not representative enough and decrease the generalisability and reliability of the findings, however, taking into account the total number of businesses operating in theses countries, the misbalance does not seem to lead to an unrepresentative and incomparable sample. 3) The use of system dynamics as a method has some identified limitations which need to be acknowledged. The greatest concern here is in the trade-off between the generality, realism and level of detail in the model (Axelrod 1997). These aspects counterbalance one another, as e.g. higher realism in the model will lead to an accurate case description with quantitative predictions, but simultaneously to less generalisable results (Kortelainen, 2011). Additional limitation related to simulation model building comes from simplification of underlying processes, this is justified by keeping the lower level of complexity of the model (Repenning 2001) to keep it lighter, but on the other hand brings some limitations in terms of including more of factors, potentially defining system behaviour.

1.5. Definitions of key terms

1.5.1. Innovation

The term "innovation" does not have a single widespread definition. The term innovation was defined in 1934 by Schumpeter as respectively, new products, new processes, new raw materials, new forms of organisation and new markets (Lundvall, 2007). According to Webster's dictionary, innovation is *"the making of a change in something established"*. Tidd et al. (2005) cites the definition of innovation made by Drucker: "Innovation is the specific tool of entrepreneurs, the means by which they exploit change as opportunity for a different business or service. It is capable of being presented as a discipline, capable of being learned, capable of being practiced". According to Schilling (2006), innovation starts from generating new ideas, which later acquire value by being converted into new products, services, processes; as soon as idea is practically implemented it can be called an innovation.

The definition by Schilling already includes the commercialisation of innovation – bringing it to market; hence, innovation should be differentiated from invention. Fagerberg (2003, p.3) states this difference by saying that *invention* is the "first occurrence of idea for a new product or process", while *innovation* is "the first commercialization of the idea". In some research industries, innovation and invention appear at the same time (e.g. biotechnology), on the other hand there are known cases, when the time lag between innovation and invention could be several decades (Rogers, 1983). Inventions may take place in universities or other research institutions, however innovations occur mostly in more commercial environment; transformation of former into latter requires certain types of knowledge, skills and facilities, market knowledge, financial resources etc. (Fagerberg, 2003, p.3).

In this thesis, innovation is understood both as a process, leading from ideation to commercialisation and as a final applied result of this process – successful introduction of a thing, a method, or a practice.

1.5.2. Open Innovation

There is still no common definition of open innovation, however, the starting point of the discussion was set by Chesbrough (2003) describing open innovation as *"paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology"*. Later on, in the book devoted to researching new paradigms for open innovation, the definition extended into describing OI as "*... the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively.* [OI] *assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to markets, as the firms look to advance their technology. Open innovation combines internal and external ideas into architectures and systems whose requirements are defined by a business model"* (Chesbrough, 2006, p. 1).

Based on cumulative knowledge of open innovation research in past years, Lichtenthaler (2011, p. 77) introduces his own definition of open innovation as "*systemically performing* *knowledge exploration, retention, and exploitation inside and outside an organization's boundaries throughout the innovation process"*.

1.5.3. Innovation System

The concept of the innovation system stresses that the cooperation and transfer of technology and information among people, enterprises, and institutions is key to an innovative process. It describes the linkages between the actors, who are required in order to turn an idea into a process, a product, or a service on the market. Innovation systems have been categorised into national innovation systems, regional innovation systems, local innovation systems, technological innovation systems and sectoral innovation systems. This thesis mainly discusses national innovation systems (NIS) and innovation systems in general (IS).

NIS can be viewed as a historically formed subsystem of national economy where various organisations and institutions interact and influence each other in the undertaking of innovative activities (Balzat and Hannush 2004). Among the elements of NIS can be listed industry, science and research, education and government, etc.

A national system of innovation has been defined as follows (the definition by Metcalfe (1995) is the description of NIS underlying the concept understanding in the thesis):

Freeman, 1995	.. the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies
Lundvall, 1992	..the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge ... and are either located within or rooted inside the borders of a nation state
Nelson, 1993	... a set of institutions whose interactions determine the innovative performance ... of national firms.
Patel and Pavitt, 1994	..the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country
Metcalfe, 1995	..that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies.

1.5.4. Institutions

"Institutions are systems of established and prevalent social rules that structure social interactions" (Hodson, 2006, p.2). This approach encompasses that introduced by Douglass North (1991) who made a distinction between institutions and organisations. Hence, institutions are the "rules of the game", consisting of both the formal rules (regulatory institutions) and the informal social norms that govern individual behaviour and structure social interactions (institutional frameworks). Language, money, laws, metric systems, firms (and other organisations) and even table manners are all institutions.

Scott (1995) distinguishes between regulatory, normative, and cognitive institutions. Regulative institutions consist of *"explicit regulative processes: rule setting, monitoring, and sanctioning activities"* (Scott 1995, p. 35). Regulatory bodies and existing laws influence a firm's behaviour from the perspective of regulatory institutions. The normative aspect introduces *"a prescriptive, evaluative, and obligatory dimension into social life"* (Scott 1995, p. 37) and influence how values and normative frameworks define choices and behaviour. Scott (1995, p.40) states that: *"cognitive elements constitute the nature of reality and the frames through which meaning is made"*. Cognitive institutions are often closely linked with culture (Jepperson, 1991).

1.5.5. Culture

Culture has been also defined and interpreted in many ways. One of very common definitions belong to Kluckholn (1951), suggesting that *"culture consists in patterned ways of thinking, feeling, and reacting, acquired and transmitted mainly by symbols, constituting the distinctive achievements of human groups, including their embodiments in artifacts; the essential core of culture consists of traditional ideas and especially their attached values"*.

The other definition was offered by Hall (1981), who sees culture primarily as a communication system that can be used to create, transmit, and store information. Only people with similar cultural background could understand each other's message. On the other hand Mårtensson (1998) sees culture as *"the total amount of knowledge, experience, conceptions, values, attitudes, meanings, hierarchies, religions, relations to time, roles, relations to space, concepts of universe, material objects and possessions acquired by a large group of people during many generations through the efforts made of both individuals and groups"*

The definition that is central to this thesis was offered by Hofstede (1991), who defines culture as *"collective programming of the mind that distinguishes members of one group or category of people from another"*. The sources of one's mental programmes lie within the environment in which one grew up and collected experiences. Mental programmes vary as much as the social environments in which they were acquired. (Hofstede, 1991).

1.6. Structure of the thesis

The structure of the thesis can be described through an input-output scheme (Figure 3). The first chapter is devoted to the introduction of the background and reasoning of the study, with the research gap coming from the literature on the topic. It also includes a definition of the scope, delimitation as well as an introduction to the concepts to be used later in the thesis.

The following, the second chapter, concerns the literature review of the main theories included in the constructed framework – it discusses open innovation as a theory and the composites of the model, which interact with external elements within system of innovation. Hence, it is followed by a review of innovation systems (IS) research, and the institutional view inside it (in this thesis Institutional view is treated as a component of NIS, the reasoning for which is presented in Chapter 2). The literature review ends in identification of common elements of reviewed theories and introduction of the framework and classification of environmental factors influencing open innovation adoption in the companies.

The third chapter discusses the methodological approach and the research design and implementation. The chapter deals with the question of benefits of the method triangulation approach as well as discussing all of the three applied methods in particular (qualitative, quantitative and system dynamics approaches).

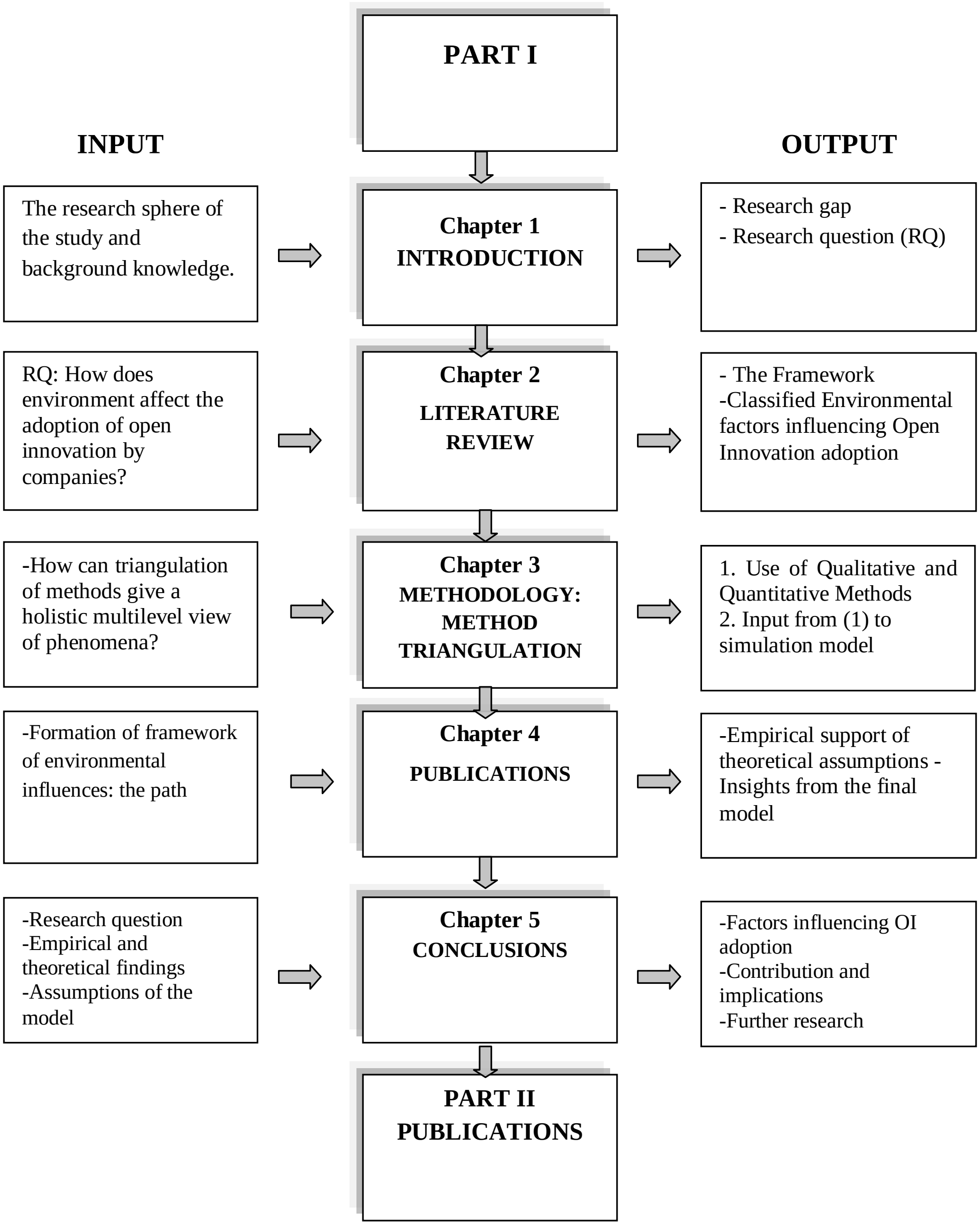

Figure 3. Structure of the thesis

The forth chapter gives an overview of the publications comprising Part II of the thesis. The role of each publication is to advance the understanding of the phenomena addressed by the main research question of the thesis. Hence, the publications depict the path from the initial investigation of the phenomena through the case study approach (publication 1) to a model allowing for testing innovation behaviour under different market conditions (publication 5). The publications in between (publications 2,3,4) add to the final framework by researching the different environments where open innovation is taking place and contributing to the model by the achieved results.

The fifth chapter concludes the thesis. It is divided into sections representing summaries of the findings, contribution to the theory of open innovation and implications to practice, discussion of limitations and further research opportunities, which are indicated by this research.

2. LITERATURE REVIEW

The aim of this part of the thesis is to provide an overview of the main theories building the framework of the thesis, and to particularly give insights into the concept of open innovation itself. In addition, it illustrates different approaches to studying external-to-firm factors as an innovation system, as well as regulations and national culture, and also offers a means of classification and structuring for them. The chapter concludes with integrated theoretical framework implemented in the resulting system dynamics simulation model. The overview of open innovation literature is followed by an operating environment description divided into structural and institutional influences. Cultural impacts receive special attention since this topic is underrepresented in open innovation research. The division of literature overview into these sections comes from the background knowledge presented in Chapter 1.2 on the theories behind environmental influences. The main selection criteria for the theories were a metasearch of literature by different combinations of keywords *environment*, *performance*, *innovation*, and then separate search for *culture and innovation*. The search and analysis was conducted in many stages, and in the end, the papers mentioning any kind of factors in the environment which will have a connection to innovation performance were selected, analysed and classified. The classification of literature and factors, as well as proxy for the concluding model, is presented in Table 1. The most often mentioned factors with most explicit causal relationship are selected to be included to this final literature overview reporting table.

The classification of factors into institutional, structural and cultural is based on the nature of the theories including the Proxies as objects of studies. These theories are institutional theory and regulatory factors within it, forming the *institutional* factor; national system comprising the markets for knowledge and technology and its characteristics stands for *structural* factor and beliefs, values and dimensions labelled as *cultural* factor. The following chapter is devoted to opening up each of the factors and connecting them to open innovation.

Table 1. Overview of background theories and environmental factors influencing innovation

THEORY/ FRAMEWORK	OBJECTS and AUTHORS	FACTORS	CATE-GORY[1]	PROXY
International business (internationalisation of MNC)	Market environment (Grewal and Tansihaj, 2001; Jap, 1999; Cui et al, 2006)	Competitive intensity Market dynamism	2	Market Dynamics
	Dess and Beard 1984	Dynamism (uncertainty), complexity and hostility	2	Market Dynamics
	Cultural environment Cui et al., 2006	National culture Organisational culture	3	Culture
	Nature and intensity of competition and dynamics of local industries (Contractor and Segafi-Nejad, 1981;	Institutions	1	IPR/Regulations Culture

[1] 1. Institutional factor. 2. Structural factor. 3. Cultural factor (suggested classification)

	Marton 1986)			
	Environmental demand to capabilities (Ghostal and Nohria, 1993; Shenkar 1990)	Property rights Imperfect Markets Asymmetric Information Government actions ((un)certainty)	1 2 1	IPR Market for technology Regulations
Knowledge based view	Knowledge transfer and sharing (Michailova andHutchings, 2006)	National culture (mindset, beliefs, hostility) Technological distance	3 2	Culture Market for technology
Transaction cost	Coase 1937	Imperfect markets (asymmetric information and asset specificity) Coordinating role of institutions	2 1	Market for technology Regulatory
	Klein 1983	Cost of transactions	2	Market for technology
Managerial Theory of the firm	Williamson 1966	Asset specificity of production	2	Market for technology
Cross-Cultural Management	Hofstede, 1984, 2001 Trompenaars, 1997 Michailova and Hutchings, 2006 Ethnocentrism, (Benett 1993)	Five cultural dimensions Seven dimensions Filter for external information	3 3	Individualism vs. collectivism (Culture) Culture
Open Innovation	Lichtenthaler 2009	Technological turbulence Transaction rate Competitive intensity	2	Market Dynamics
	Gambardella et al. 2007, Arora and Ceccagnoli, 2006)	Technology markets	2	Markets for Technology
	Regulatory institutions (Anderson and Konzelmann, 2008)	IPR	1	IPR
	NIH and NSH (Katz and Allen, 1982; Chesbrough 2003)	Mindset, attitudes	3	Culture
National innovation system	Knowledge flow (Lundvall, 1992; Nelson, 1993) Institutions (Scott, 2001)	Existence of institutions as: IPR, Innovation policies (incl. public funding of R&D)	1 1	IPR

The Proxies build from the factors are the ones, applied for analysis at the later stages of research. They are approximation of the meaning and essence of factors as mentioned in literature, since authors tend to give their own specific names to concepts which are rather close in their impacts. The grouping is made on the basis of logical causal relationship; the factors having similar 'sign' (positive vs. negative) of influence and common components are grouped in one category. The factors are later simulated in their impacts to innovation performance (Publication 5).

2.1. Open Innovation

2.1.1. The roots of the concept

Traditionally, most industrial firms have focused on internal development of new technologies and holding them within the company through either integrating them into their own new products or keeping them "shelved" for better times. However, since the 1990s, the frequency of various technology transactions has increased significantly due to the development of markets for technologies (Arora et al., 2001). This has led to the fact that companies have started to use external technologies and knowledge in their R&D processes to an increased extent (Granstrand et al., 1992).

The open innovation paradigm can be viewed as a diffusion of antecedent trends such as: the globalisation of innovation, occuring due to modern ICT providing virtual work opportunities; access to new markets and resources (Gassman and von Zedtwitz 1998, 2003); the outsourcing of R&D applied due to cost saving; the speeding up the innovation process and limited proprietary resources (Katz and Allen 1982; Pisano 1990); the vertical and horizontal integrations with suppliers (Hagerdoorn 1993; Tidd et al. 2005); and users (von Hippel 1986, 2005), to name just a few. Even the resource based view of the firm can advocate the appearance of an open innovation paradigm, e.g. absorbed external knowledge while integrated with valuable and rare proprietary resources may generate the unique product that is difficult to imitate or substitute (Kock and Torkkeli 2008). Due to relations to such a vast set of theories, open innovation has often been viewed critically in the literature: e.g. Groen and Linton (2010) have initiated a special issue on open innovation in *Technovation* to answer the question if open innovation is a true field of study. In respect to the critical view on open innovation, should be mentioned the important conceptual work by Dahlander and Gann (2010) systematising different types of openness and Trott and Hartmann (2009), arguing the novelty of the open innovation concept, and questioning if it is "old wine in new bottles".

However, the main distinctions in the open innovation framework from the earlier managerial theories as highlighted by Lichtenthaler (2011) are:

- Open innovation integrates inbound and outbound knowledge flows, whereas most of earlier works addressed exclusively one or another direction.
- OI emphasises the additionality effect of internal and external innovation processes in the companies, when most of previous research raised them as an either-or question.
- OI contributes to commodification of technology and innovation management research, while much of the prior research tended to separate technology issues and innovation processes.

A key idea of open innovation is the assumption that "not all the smart people work for you". Instead, beneficial technologies can be found at any location worldwide and within companies of any size. Increasing cost and speed of R&D lead to a situation, where the effect of economies of scale for R&D decreased substantially (Chesbrough, 2006). In the distributed and dynamic environment, where every organisation has valuable technologies, firms benefit more from trade in technology, earning monetary or strategic benefits by selling their own, and saving resources by gaining access to external ones. Despite the vast amount of successful cases and benchmarks of open innovation, challenges to its implementation still exist. Prior research has mainly focused on the internal firm related barriers and these matters were raised by rather extensive research (e.g. Chesbrough, 2003, 2004, 2006; Laursen and Salter 2006; Gassman and Enkel 2004; Huston and Sakkab, 2006; Rivette and Kline 2000).

2.1.2. Open Innovation processes

As was already mentioned above, open innovation can be described in terms of a combination of two differently directed processes: inbound and outbound. The model depicting the open innovation approach to external technology commercialisation has been introduced and elaborated on by Gassmann and Enkel (2004), and it describes the open innovation approach in terms of three innovation processes. The outside-in process or more specifically knowledge acquisition (as the outside-in process as a term was introduced in the early 2000s) has been widely studied in academia (Granstrand et al. 1992; Kurokawa 1997; Veuglers and Cassiman 1999), as well as practiced by the business (Huston abd Sakkab, 2006). The outside-in process stands for acquisition of external knowledge and integration of it into a company’s own new product development in order to save costs, speed up the development and shorten the time to market. This term often refers to in-sourcing of external knowledge through spinning in, licensing in, acquisitions (in order to get valuable technology, personnel etc.) and collaboration along the value chain. The latter can be illustrated by the example of Procter and Gamble, who cooperate with customers, suppliers, competitors and other institutions to pursue ideas, which can be utilised in the process of new product development (Huston and Sakkab 2006). Inbound OI is usually associated with R&D intensity and emerging from it absorptive capacity of the company (i.e. the ability to identify and utilise valuable external knowledge (Cohen and Levinthal, 1990)) as prerequisite for knowledge sharing. Moreover, various governance modes for internalising external knowledge have been studied in past years. This includes e.g. strategic alliances, joint R&D, acquisitions and inward technology licensing (Hagedoorn and Duysters, 2002; Tsai and Wang, 2007; Vanhaverbeke et al., 2002). Additionally, matters of the “make-or-buy” decision have been examined from various perspectives (e.g. Ferretti and Romano, 2006; Granstrand et al., 1992; Veugelers and Cassiman, 1999).

One more theoretical framework adding to an understanding of the factors underlying open innovation is the transaction cost economics (Williamson, 1985). The decline in transaction costs in the market (i.e., caused by more efficient markets for technology) is commonly considered as one of the important factors in the shift to higher openness of innovation (e.g. Arora et al., 2001; Narula and Hagerdoorn, 1999). On the other hand, various strategic factors often influence the decision to use in-sourced external knowledge. For example, in the case of alliances, accessing complementary assets and capabilities (Rothaermel, 2001; Teece, 1986) may be an important motive for cooperation and hence the availability of the potential partners in the market is important.

The second, inside-out process (or outbound open innovation by Chesbrough 2003) represents external knowledge exploitation, where additional profits are earned by selling IP, transferring ideas to the outside environment, etc. This process has been thoroughly studied by Lichthenthaler both at operational and strategic levels (2005, 2007, 2008a, 2008b). The inside-out process is associated with outbound technology transfer capabilities, and hence often studied within the knowledge transfer framework (e.g. Granstrand et al 1992). Outbound open innovation has been successfully deployed by such companies as IBM, Novartis etc, aiming at decreasing the fixed costs of their R&D, sharing the risks, or gaining access to distribution channels and brands, as done by Ascom (Gassmann and Enkel 2004). The ‘surplus’ of research, not matching the current business model, had to be shelved within the closed innovation model (Chesbrough 2003). This means that the company had to fiercely protect this surplus by intellectual property rights in order not to lose control of it (as even the employees of the company could utilise the surplus to establish their own business with venture money). The open innovation approach states that the surplus can be used for realising some potential value through selling it to the other company, which could utilise it better within the company’s resource base and business model.

The role of IPR is especially emphasised in connection with outbound open innovation, which has mainly been studied through technology licensing. According to Widmer (cited by Escher 2005), the licensing approach is closely related to the innovation process and in- and out-licensing activities are integrally connected: the technology is acquired following the needs of the innovation process and the same innovation process delivers the surplus which may be licensed out. Telesio (1981) treats international technology licensing as a mean to enter a foreign market without costly direct investments. Parr and Smith (1993) as well as Megantz (1996) consider IP to be an important company asset that could bring higher added value through out-licensing. Katz and Shapiro (1985) studied optimal licensing behaviour once a technology has been patented and it has been discovered that the major innovations will not be licensed but firms will tend to license minor innovations (which can be referred to widely used nowadays terms of core vs. non-core technology and theory of core competence introduced by Prahalad and Hamel (1990)). Gallini and Wright (1990) also studied licensing in terms of behaviour; they conducted a study on whether the exclusive or non-exclusive contracts are used to transfer technology.

Hence, licensing and therefore formal protection of intellectual property and ability to leverage it in the market are important factors to promote open innovation. Furthermore, licensing enhances demand (or creates a second source of supply) (Corts 1999), controls competition by decreasing the competitors ability to innovate (other firms’ R&D investments tend to decrease with licensing in) and gains technological advantage (Gallini 1984), and finally acts as an option for foreign direct investments (Mottner and Johnson 2000).

The third, coupled process, combines inbound and outbound innovation through working in alliances with multiple partners, where both input of external knowledge and output of own knowledge are crucial for success. Depending on the business model and business objective, firms usually tend to select current processes to be actively implemented within the company (Gassmann and Enkel 2004). These processes have not been divided by the authors into explicit stages, but their objectives and challenges are similar to the ones described in other literature (Escher 2001; Lichtenthaler 2005).

As described by Chesbrough (2003a,b), the opportunities for using external knowledge have increased significantly and the inbound OI, or more specifically knowledge acquisition has been widely studied by academics (Granstrand et al., 1992; Kurokawa 1997; Veuglers and Cassiman 1999). It has also been practiced by business - e.g. Procter and Gamble's Connect and Develop case (see Chesbrough et al., 2006). While the acquisition of external technologies is currently commonplace, the use of technologies and intellectual property (IP) outside the company (outbound open innovation as defined by Chesbrough (2003) and Gasmann and Enkel (2004)) is still a rather rarely observed (Athreye and Cantwell 2007; Mendi 2007).

2.2. Firm's external environment

2.2.1. Innovation System – structural influences

Since the late 1980s, the term 'National Innovation System' (NIS) (Freeman 1982a,b, 1995; Lundvall 1988, 1992; Nelson 1993) has become widely used to describe the framework for analysing technological change, which is considered to be an essential foundation for long-term economic growth (Intarakumnerd et al. 2002) and the competitiveness of a country. A stream of research has concentrated on different elements within innovation systems. These include universities (Gübeli and Doloreux 2005) and their collaboration with industry (see e.g. Philbin 2008; Bjerregaard 2009; and Dooley and Kirk 2007) as well as the role of regulations within the system (Cetindamar 2001; Delaplace and Kabouya 2001).

The concept of a National Innovation System was first mentioned by Freeman (1982a) and explained by Lundvall (Freeman, 1995). However, the idea was not brand new as its roots go back to Friedrich List's conception of 'The National System of Political Economy', which advocated the protection of industries with policies to accelerate industrialisation through learning to implement new technologies (Freeman 1995).

NIS can be viewed as a subsystem within a national economy, where various organisations and institutions interact and influence each other in undertaking innovative activities (Balzat and Hannusch 2004). NIS describes the intersection of industry and research and development undertaken by many parties. This interaction is affected by the availability of skilled labour (education and training policies), and incentive mechanisms provided by government (Intellectual Property Rights (IPR), tariffs, subsidies, taxation etc).

A distinction has been made between 'narrow' and 'broad' definitions of national systems of innovation (Lundvall 1992; Freeman 2002; Feinson 2003). The narrow version includes institutions which are directly involved in scientific and technological innovation and promote dissemination of knowledge. The broad perspective takes into account the social, cultural, and political environment embedding the narrow NIS (Freeman 2002; Feinson 2003). Additionally, Lundvall (2007) mentions two layers of NIS and therefore two ways to study it. The core and the wider settings of the innovation system can be studied from the inside-the-firm innovation creation perspective ('core') and the outside-the-firm environment (‘wider’) viewpoint. The research presented in this paper follows the second approach: the narrow interpretation of a NIS. This approach is more common in studying developing countries, where the public infrastructure is presented more openly than firms’ inner processes and the standard indicators of surveys on innovation research may not capture the reality of the innovation system (Lundvall 2007).

Most of the research on NIS has been ex-post rather than ex-ante and has tried to explain and analyse existing NIS since it was developed from studies of industrialised countries and in particular studies on northern European countries. In the case of developing countries, an ex-ante approach is required to analyse the mechanisms behind systems of innovation and to provide a comprehensive understanding of it. Such research has been undertaken on newly industrialised countries in Asia (Kim 1993; Hou and Gee 1993; Wong 1996) and also to a lesser extent on other technologically less successful countries in Asia and Latin America (Dahlman and Nelson 1995; Katz and Bercovice 1993; Arocena and Sutz 2000; Intarakumnerd 2002). Dahlman and Nelson (1995), who draw their conclusions from a study of the technological capability in 14 developing countries, state that the promotion of human resources is the largest factor for successful development. NIS works through the introduction of knowledge into an economy and require active learning. The success of learning is determined by the absorptive capacity of individuals and organisations, as well as political, social, and economic infrastructure and institutions (Lundvall et al. 2002; Intarakumnerd 2002; Kitanovic 2007). However, it should be noted that social absorptive capability alone is not enough to explain the differences in the performances of developing economies.

Developing economies have a tendency to adopt technologies from developed countries rather than create their own, due to the relatively low levels of education, productivity, and income (Kitanovic 2007). Gu (1999) suggests that NISs are country and development level-specific. This means that two countries with the same initial characteristics will demonstrate different NIS patterns. However, Gu (1999) also suggests that NIS in developing and developed countries can be distinguished as regards the following lines:

- NISs in developing countries are less developed in terms of institutional composition and links between organisational units;
- Rapid learning and innovation through imitation is a prerequisite for rapid creation of a NIS by emerging economies;
- Market mechanisms are under-developed in emerging countries;

The importance of knowledge and learning are central for the success of NIS in developed countries. Although, it is not so straightforward for developing countries, they still face the need for capital accumulation to secure the operational level of NIS. One distinctive feature of the NIS in developing countries is often a proactive role by the government as a mediator of every link within the NIS.

The importance of capital accumulation (Gu, 1999) is supported by research on Foreign Direct Investment (FDI) inflows. For example, a study on knowledge absorption in emerging economies (Torkkeli et al., 2009) shows that regions with favourable absorption climates are more likely to attract FDI and portfolio investments. FDI is considered to be the major channel by which to transfer technology into a developing country, therefore the importance of absorptive capacity improvement cannot be overemphasised.

2.2.2. Institutional theory and institutional influences

Freeman (1987) defined NIS it as "*network of institutions in the public and private sectors whose activities and interactions initiate, import, and diffuse new technologies*", and Lundvall defined "structure of production" and "the institutional set-up" as two most important dimensions that shape the system of innovation (Lundvall 1992). The original definition of NIS emerged from reviewing the set of institutions and their impact on new technologies. In this regard, the research on *Institutional theory,* seeking to examine the behaviour of organisations, individuals and other actors under institutional arrangements and settings (Ahlstrom and Bruton, 2010) cannot be neglected. Hillman and Keim (1995) state that to better understand the business-government interfaces the institutional settings should be incorporated. They stress, that apart from formal constraints (e.g. legal rules) the informal constraints (as culture and norms) should be recognised. According to North (1991), institutions together with the standard constraints of economics define the choice of a set of business operations, providing the incentive structure of the economy. Though there is a variety of approaches on how to classify various institutions (Hirsch and Lounsbury, 1997) the classification by Scott (2001) is often considered as central (Ahlstrom and Bruton, 2010). Scott (2001) differentiates between regulatory, normative, and cognitive pillars of institutional theory. Regulatory ones give incentives and a legal framework created by an authoritative body for regulating the system actor's behaviour (Ahlstrom and Bruton 2010); the normative and cognitive ones are social constructs, which strongly draw upon culture. However, the differentiation should be made as a normative pillar represents the actions the organisations ought to take, how they should behave in terms of rights and obligations (Ahlston and Bruton 2010) and cognitive ones explains the actions by rather unconscious ideation structures. Busenitz et al (2000) emphasise that organisations are embedded in country-specific institutional settings based on the legal regime and the business environment. Institutions are often viewed as stable over time (Brintand Karabe 1991), which can be argued by the assumption that e.g. the regulatory framework of the country can be changed rather rapidly by any new regulatory document issued. Table 2 summarises the main features of different approaches to innovation systems.

Therefore, the institutions and the actors within the system should be viewed with the more dynamic perspective offered by the Triple-Helix model (Leydesdorff and Etzkowitz 1996). In addition, this model introduces academic institutions and governmental agencies as the units of analysis for the industrial firms, formerly kept central in Nelson and Winter's evolutionary view (Leydesdorff and Etzkowitz 1996). Howells (2002), among others, sees the role of universities to be central inside the system, as they are active players in knowledge creation and transfer. The Triple Helix model emphasises the linkages between the actors in the system.

Table 2 Theoretical views on Innovation Systems

APPROACHES TO ENVIRONMENT FOR INNOVATION CREATION	**CENTRAL ACTORS**	**MECHANISMS**	**UNIT OF ANALYSIS**
Traditional NIS	Industrial firms and institutions (Lundval 1992) and R&D support (Nelson, 1993)	Production of knowledge, regulating innovation environment, promoting creation and dissemination of knowledge	"structure of production" and "the institutional set-up" and organisations supporting R&D as the main innovation sources.
Triple-Helix	Government, University; Industry (Etzkowitz and Leydesdorff 2000)	Linkages between the actors operating in a helix mode	Academic institutions, governmental agencies, industrial firms
Quadruple Helix	Government, University; Industry and Civil society (Jensen and Tragardh 2004; Carayannis and Campbell 2009ab)	Innovation ecosystem meets financial and regulatory support by government to satisfy the ever-growing demand of civil society.	Academic institutions, governmental agencies, industrial firms, users
Institutional theorists	Organisations and individuals (Busenitz et al. 2000; Child, 2000),	Institutional arrangements influence the behaviour of central actors (Scott 1995, 2002) which impact firm decision making (Hitt et al, 2004 and strategies Peng and Wang, 2008)	Regulatory, Normative and Cognitive institutions (Scott 2001)

The recently emerged Quadruple Helix model (Jensen and Tragardh 2004) adds the perspective of civil society (Carayannis and Campbell 2009b). In the Quadruple Helix model academia and industry, together with a support infrastructure provide the integrated innovation ecosystem; governments provide the financial support and the regulation system for the definition and implementation of innovation activities. Civil Society demands the perpetual innovation of goods and services. Carayannis and Campbell (2009a) add that the participating elements in the Quadruple Helix Model are the government, research and development (R&D) facilities, industrial R&D facilities, university laboratories, and civil-society based sources of innovation and knowledge.

2.3. Cultural impacts

As discussed in the previous subchapter, institutional theory emphasises the role of culture inside the system of innovation, designating to it the cognitive institutional pillar and acknowledging the cultural impact to be also present in the other two institutional pillars (Scott, 2001; Cui et al., 2006). Apart from regulating societal norms outside the company, national culture, as one of external factors, penetrates the deepest into the internal company practices. The values and attitudes of employees are often the sequence of strong mental models imposed by national culture. In the open innovation settings, these cultural attitudes emerge in forms of Not Invented Here (NIH) and Not Sold Here (NSH) syndromes (Chesbrough 2006), which might be the result of both deep cultural believe or a technological gap and low absorptive capacity of the firm (Cohen and Levinthal, 1990).

In the cultural dimension literature, “cultural values” are considered to be the most important explanatory variables of behaviour (Kluckhohn 1951). In this context, the work by Hofstede (1980, 2001), based on responses by IBM staff across the world, derives four value dimensions: power distance, individualism and collectivism, masculinity and femininity and uncertainty avoidance. More dimensions were added in later research. George and Zahra (2002) refer to culture as to a determinant of entrepreneurial behaviour. Here it is important to distinguish between general national culture or universal values, such as measured by Hofstede (1980), Schwartz (1992), Inglehart (1997) and House (1998) and context-specific attitudes. A number of scholars point out that there is a statistical association between Hofstede’s scales of culture and e.g. entrepreneurial activity (Hayton et al. 2002; Uhlaner and Thurik 2007; Hofstede 1980). This reflects recent findings on relationships between national cultural values and practices generally (Javidan et al. 2006).

2.3.1. National and organisational culture

As almost every human being belongs to a set of different groups at the same time, people carry several layers of mental programming within themselves, corresponding to different levels of culture (Hofstede, 1991):

- national level according to one’s country;
- regional and/or ethnic and/or linguistic affiliation level, as most nations are composed of culturally different peoples;
- gender level;
- generation level, which separates grandparents from children;
- social class level, depending on educational opportunities, profession and occupation;
- organisational or corporate level, according to the way of socialisation inside organisation.

The organisational culture was studied from many aspects. Among the studies, there has been wide research by management into the psychology of leadership, teambuilding, innovativeness and creativity, and personal human traits that arise from culture (Ahmed, 1998; Martell, 1989; Robbins, 1996; and Schuster, 1986). However, these studies are out of the scope of the thesis, as is culture for producing innovations. Motivation for innovation creativity is different from motivation for acceptance of external innovations and releasing the own ones. Nevertheless, culture is often viewed as a determinant of innovation (Ahmed, 1998) as culture has different elements which can serve to enhance or inhibit the propensity to innovate. To this extent, if the strong innovation oriented culture is supposed to create innovations, the same strong culture and attitude towards creativity may inhibit the willingness to acquire the ready technology, instead of developing it.

National culture is a common characteristic of people within the borders of one country, and it should be differentiated from the culture of societies or ethnic groups. Within nations, which have existed for some time, there are strong tendencies towards integration: they share national language, education system, political system etc. Organisational culture is different in many aspects from national culture: an organisation is a social system of a different nature to that of a nation. (Hofstede, 1991)

2.3.2. Hofstede's dimensions of national cultures

Hofstede (and Bond 1984) indicated that societies, which score high on individualism and low on the power dimension, have a higher economic growth and a greater tendency to innovate; a finding confirmed by Shane (1992). However, the logic of open innovation and knowledge sharing contradicts this statement by suggesting that individualistic countries are less willing to share proprietary knowledge (Michailova and Hutchings, 2006). To elaborate further on these causalities, a detailed view on the dimensions of culture is required.

Hence, *Power Distance* (PDI) is the extent to which the less powerful members of societies, organisations and institutions accept and expect that power is distributed unequally. It suggests that a society's level of inequality is endorsed by the followers as much as by the leaders. In small power distance, there is limited dependence of subordinates on bosses and consequently the dependence is stronger in high power distance countries (Hofstede, 1991). High-power distance cultures prefer centralised hierarchical structures whereas low-power distance cultures prefer decentralised hierarchical structures. It can also lead to formality of relationships within collaborative an innovation framework.

Uncertainty Avoidance (uai) deals with a society's tolerance for uncertainty and ambiguity. Hofstede defines uncertainty avoidance as the degree to which a member of a given culture perceives and reacts to an undefined threat and unknown situations (Naumov and Puffer, 2000). It indicates to what extent a culture programmes its members to feel either uncomfortable or comfortable in unstructured situations. Uncertainty avoiding cultures try to minimise the possibility of such situations by strict laws and rules, safety and security measures (Hofstede, 1991) since they are more inclined to build higher institutional barriers. In countries with strong uncertainty avoidance, the need for rules is high, and the willingness to take risk – low. Hofstede found that high- uncertainty avoidance cultures seek more control over their environments (Herbig and Dunphy, 1998).

Individualism (idv) and its opposite**,** *collectivism* is the degree to which individuals are integrated into groups. Individualism pertains to *societies in which the ties between individuals are loose;* while collectivism describes *societies in which people from birth onwards are integrated into strong, cohesive in-groups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty* (Hofstede, 1991). The word collectivism in this sense has no political meaning: it refers to the group, not to the state. Again, the issue addressed by this dimension is an extremely fundamental one, regarding all societies in the world.

Masculinity (mas) versus its opposite, *femininity*, refers to the distribution of emotional roles between the genders, which is another fundamental issue for any society to which a range of solutions are found (Hofstede 1991). Masculinity as a model of behaviour of the average citizen is more prevalent in societies with strictly defined roles for men and women (Naumov and Puffer, 2000). Masculine cultures show a strong preference for outputs and emphasise performance; feminine cultures show preference for processes and aesthetics (Haiss, 1990; Schneider, 1989; Hofstede, 1980). Masculinity applies to societies where social gender roles are certainly distinct (toughness as characteristic for men and tenderness for women); and femininity applies to societies where these roles overlap (Hofstede, 1991).

Long-Term Orientation (ltowvs) **-** a society's "time horizon," or the importance attached to the future versus the past and present. In long-term oriented societies, people value actions and attitudes that affect the future: persistence/perseverance, thrift, and shame. Long- term oriented societies have virtues oriented towards future rewards, in particular saving, persistence, and adapting to changing circumstances. Short-term oriented societies foster virtues related to the past and present such as immediate stability, respect for traditions, national pride, preservation of "face", and fulfilling social obligations (Hofstede et al. 2010).

The comparison of these dimensions for countries used throughout the publications comprising this thesis presented in Figure 4.

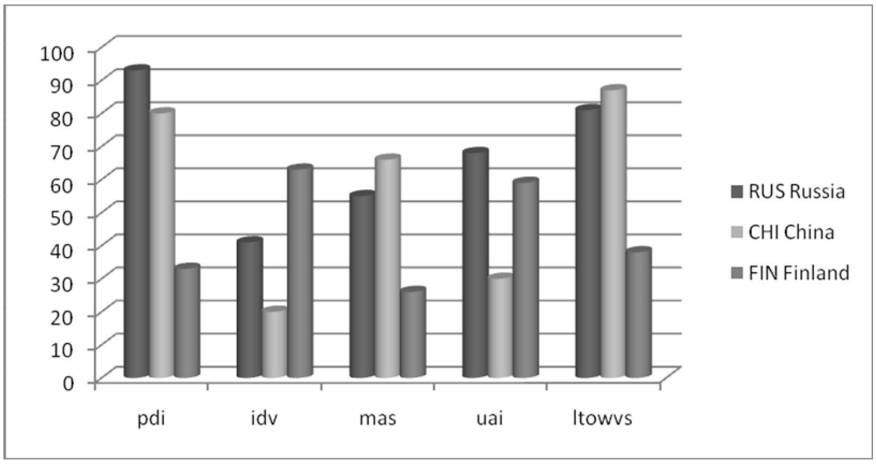

Figure 4. Cultural dimensions for China, Russia and Finland (based on Hofstede, 2008, online database)

2.3.3. Cultural Challenges to Open Innovation

Not Invented Here

As well as the challenges of finding, evaluating, negotiating, transferring and integrating the external technology into an own product, companies must face the internal resistance to external innovations, known as the Not Invented Here syndrome (Clagett, 1967; Katz and Allen, 1982; Chesbrough, 2003; van de Vrande, 2007). It refers to a negative attitude to knowledge that originates from a source outside the institution. The NIH syndrome is partly based on an attitude of xenophobia (Chesbrough, 2006) – fear and rejection of something different from us, something coming from outside. The NIH syndrome has been widely studied in the literature (for review see Lichtenthaler and Ernst, 2006) indicating the consequences that it may have in companies.

Explaining the shift to an open innovation paradigm, Chesbrough (2006) offers the following reasons for an NIH syndrome becoming prevalent: (1) fear of failing to select the right external technology, especially when the time for a project is limited and (2) fear of succeeding with integrating external technology, since it may lead in the long term to a decrease in R&D personnel in the company. The solution Chesbrough offers deals mainly with corporate reorganisation as a way of fighting employees' hostility. In the case of new enterprises, the solution will be fast growth without building unnecessary research units; not hiring extra people in the first place; for old incumbents, reassigning functions of service, development, and technology market screening for existing R&D personnel or restructuring R&D department and putting its personnel in front of the need for external technology.

The change companies have to undergo to successfully participate in knowledge transactions require not only new operating routines and dynamic capabilities (Zollo and Winter, 2002), but also involve considerable changes into company's vision, strategy and culture (Kanter, 1983). However, the resistance to external ideas may be not only be a result of the business model of the company, but of each and every employee's values and beliefs, which may be a result of their national culture. Nevertheless, why do beliefs matter? People have formed these over time, they are mentally validated, and are slow to shift substantially. Beliefs must be taken into account in order to understand the potential for conflict, hidden resistance, and improve organisational awareness and development potential. Bennett (1993) explains the tendency to filter the external information by ethnocentrism – the assumption that your own culture is central to all reality. Hence, unwillingness to accept anything created out of another culture. In the open innovation context, the situation where this could happen is the international collaboration projects of acquisition of technology from a foreign country. According to Rosinksi (1999), ethnocentrism emerges in three forms: ignoring difference (not noticing the superiority of external technology), evaluating them negatively ("we can do it better") and downplaying their importance.

Hence, certain cultural values common to an entire nation might be reflected in their attitude to using the results of somebody else's intellectual activity. Therefore, the attitude of not invented here will be higher in countries with a high level of individualism than in collectivistic countries (which contradicts the assumption by Shane (1992) and Hofstede and Bond (1984) on higher performance of individualistic countries).

Not Sold Here

Leveraging external technologies is only half of open innovation. The other important part is to let others use your ideas. Here companies encounter the Not Sold Here syndrome, the main reasoning for which is "if we are not selling it in our own sales channels, we won't let anyone else sell it, either". Hence, sales and marketing people are affected and do insist on exclusive use of their own technology for their own product (Chesbrough, 2003). NSH can be defined as a protective attitude towards external knowledge exploitation (Lichtenthaler et al. 2010). Because of it, firms may be unable to actively transfer the knowledge, even though they may be strategically intending to (Chesbrough, 2006).

The experience of external knowledge exploitation is relatively limited (Teece, 1998; Lichthenthaler et al. 2010). Among other possible barriers market failures and risks were mentioned (Silverman, 1999; Gans and Stern, 2003), as well as intellectual property protection (Davis and Harrison, 2001; Teece, 2006) and others. NSH syndrome was seldom mentioned in the literature, which mainly focused on analysing organisation and market dependent challenges. However, human factor should not remain disregarded, and even under favourable conditions, the NSH can still restrain external knowledge exploitation.

From a dynamic capabilities perspective, the competence and capability towards outward knowledge transfer was studied (Rivette and Kline, 2000; Lichthenthaler and Ernst, 2007). According to the dynamic capability view, the firms prior experience affects its capability level based on learning effects (Tripsas and Gavetti, 2000; Rothaermel and Deeds, 2006). Moreover, path dependency has been used as an explanatory factor in many employees' attitudes (Katz and Allen, 1982; Menon and Pfeffer, 2003) – a lack of prior experience may support protective attitudes.

However, attitudes towards sharing knowledge could be rooted more deeply into every employee's mindset, as defined by national culture (Michailova and Hutchings, 2006).

2.4. The Framework

The aforementioned NIS approaches view innovation from the systemic perspective, emphasising the importance of interaction of different actors in knowledge creation and dissemination processes. At the same time, the open innovation paradigm sees innovation as a result of joint collaborative efforts of many organisations (Aaboen et al. 2008; Rothwell 1992; Vanhaverbeke and Trifilova 2008). Furthermore, some researchers name such collaboration - "open system approach" (Czuchry et al. 2009), which stresses the systemic nature of co-innovation. At first glance, the players defined by the open innovation paradigm are the same as the main actors inside the Triple Helix model. However, the differentiation is made in the nature of cooperation within the models: Triple Helix explains linkages, while open innovation explains relationships (Chesbrough et al, 2006). Hence, open innovation adds to, rather than contradicts, the principles of the national innovation system and the related models. This complementarity creates an opportunity to synthesise and evaluate the interaction between open innovation implementing firms with NIS elements and to see whether open innovation can be supported or hindered by institutional and national policies.

The involvement of governments (through creation of business supporting infrastructure (Aabonen et al. 2008; Pynnönen and Kytölä 2008) and regulatory frameworks in collaborative relationships with academia and industry leads to a systemic view and a concept of joint national innovation (Aabonen et al. 2008), where an open system approach plays one of the central roles (Pynnönen and Kytölä 2008).

Both Nelson and Lundvall define NIS in terms of factors influencing innovation process. Hence, any model of an innovation process applied by firms inside NIS will be subject to external influences. According to the NIS view, the main participants of innovation process are organisations and institutions, where organisations are firms, universities, venture capital organisations, and public agencies responsible for innovation policy and support (Edquist 2006).

In a case where the government-business link within NIS is operating well and innovation support mechanism are created, there is the concern as to how to utilise the results of publicly supported research and who would claim the ownership of the results (Braczyk et al., 1998). The concept of appropriability regime developed by Teece (1986) describes how the strength of intellectual property rights affects the distribution of profits from innovation, as well as trade in technology markets. The set of norms and regulations created inside NIS on how to operate in publicly funded project are required in order to establish the suitable appropriability regime framework for such projects. Often, the reporting system for such research is too complex and the appropriability of innovative output is not that clear. The decision on whether the outcomes of publicly funded research become the property of a firm, a government or is jointly owned is made at the country level. If this situation is often regulated at the stage of obtaining the public funding, the question of who has a full right to manage the research surplus usually stays outside the considerations. Unclear regulations in this field would lead to the result that the research surplus keeps accumulating on the shelves since firms will be unsure whether they are allowed to commercialise it externally on their own. Additionally, the complexity of IPR regimes decreases motivation to start new IPR negotiations – hence the motivation to change partners – as assumed by transaction costs theory (Williamson 1979). These challenges can be leveraged by strategic use of IP as offered by the main reasoning of open innovation.

One very important institutional setting, as discussed above, is the legal and regulatory framework offered by the government for NIS. The regulatory settings may vary dramatically between countries. From the transaction costs view (Williamson 1979) the cost occurring within the process of knowledge sharing can be very high. However, the strong regulations regarding intellectual property rights acknowledgment and protection could counterweight the costs of knowledge transaction (Williamson 1979). IPR protection is an important instrument for governments in order to manipulate the behaviour of firms through regulatory institutions within NIS. An assumption is made that firms are less likely to share unprotected knowledge as compared to formally protected one. Weak appropriability means e.g. that each individual firm will have less incentive to conduct in-house R&D (Malerba and Orsenigo 1993) and, hence, less “research surplus” will be produced. Strong IPR protection, in turn promotes efficient trade in technology markets (Chesbrough et al. 2006). Strong IPR protection creates a basis for “commodification” and technology transfer (Graham and Mowery, 2004) and therefore for cooperation within an open innovation model. On the other hand, the IPR protection by itself is a rather complex and costly process in many countries, and the cost-benefit balance is not same for each NIS and not always clearly seen. With regard to collaborative innovation, the role of IPR formalities increases even more regarding the question, who owns the outcome. Additionally, internal knowledge may become exposed while joint R&D process (Busom and Fernandez-Ribas 2008) and the protection mechanisms should be sound to minimise the risks of valuable knowledge loss.

While formal institutions, to a considerable degree, shape the external relationships among key actors (firms, universities, public research institutes, etc.) in the NIS, there are also structural factors that moderate the knowledge flows between firms. In particular, the industry/market structure influences, and is dependent on, firms' rent appropriation strategies (e.g., the use of patents and technology licensing (Arora, 1997) and therefore also the flows of knowledge between them. Indeed, diverse industries may represent distinct "systems" of innovation even within a nation (Nelson and Rosenberg, 1993). In the cross-country comparisons of NISs, it is therefore important to take industry specific factors into account as well.

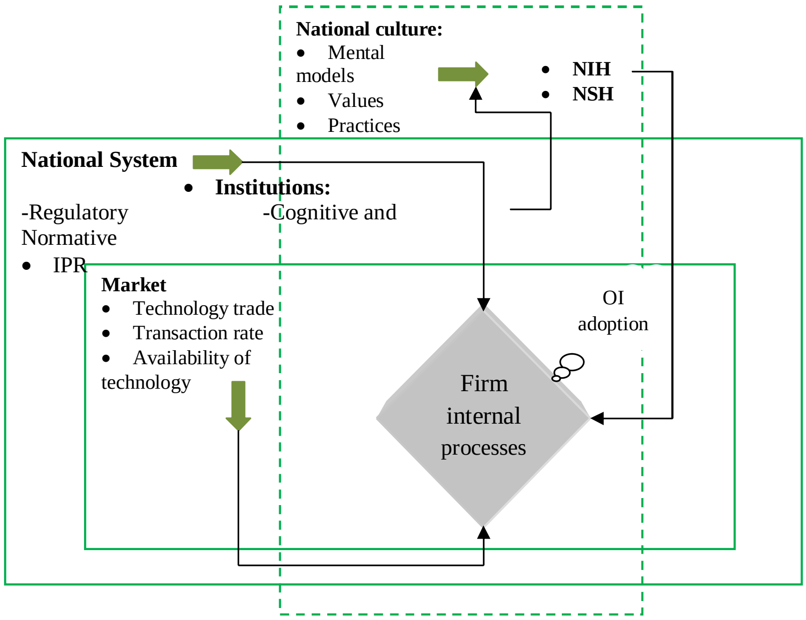

Figure 5 Different levels of environmental influences on open innovation adoption

One of the most basic assumptions behind the emergence of the open innovation approach is the shortening of product life cycles and intensified technological competition as well as competition in terms of business models (Chesbrough 2003). These factors can be unified under a common title – market dynamics (Figure 5). The research on market dynamics demonstrated that dynamic markets have a positive impact on the technology output (Savitskaya 2011) and when combined with the classical assumption of open innovation - that the impact of shortening product life cycles increases amount of outsourced and acquired R&D - the assumption for the model is that *higher dynamic markets will have positive impact* *on Open Innovation output* (approximated through technology commercialisation into product launch).

Another challenge arising from IPR area relates to the costs of IP protection and the procedure of claiming intellectual property. Strong IPR protection encourages disclosure and promotes efficient trade on markets for technology (Chesbrough *et al.* 2006). Weak appropriability implies the prevalent existence of knowledge externalities (Malerba and Orsenigo 1993). Consequently, within weak appropriability regime, each individual firm will have lower motivation to conduct in-house R&D hence the amount of research surplus produced will be smaller as well. Weak IPR protection, in the end, may lead to the overall rate of private sector R&D decreasing below the levels needed to sustain long-term private returns from innovation, and may therefore necessitate public support for in-house R&D. Hence, avoiding the aforementioned externalities through strong formal IP protection is supposed to increase the motivation in companies to develop their own technologies in-house. A tight IP regime mean that it is easier for firms to acquire technologies in the marketplace; and similarly easier to sell or license their own technology. IP creates a platform for "commodification" and transfer of technology (Graham and Mowery 2004) and hence for cooperation under an open innovation framework. Hence, the involvement of companies in open innovation may depend on the strength of IRP protection and associated with it costs and formal arrangements, and the *greater the complexity and cost of IPR protection, the less likely firms will engage in open innovation.*

The third major factor influencing open innovation deals with national and organisational cultures. Some researchers (e.g. Takada and Jain, 1991; Straub, 1994; Dwyer *et al*, 2005) suggest that culture has an influence on the diffusion of innovations. The five dimension index scores of culture offered by Hofstede (1991, 2001) give an explanation as to the behaviour of individuals and organisations by their cultural peculiarities, defined through collectivism versus individualism, level of power distance, uncertainty avoidance, masculinity or femininity and long- or short-term orientation. For instance, in the case of Russia, collectivism is ranked higher than individualism **(**Hofstede 1991, 2001*) which should have a positive influence on open innovation since collectivistic culture is more prone to form cooperative ventures*. Russia has a long-term orientation culture, and it scores the highest of all national cultures in the long-term orientation score. This is of the highest importance for open innovation practices adoption, since people in long-term orientated culture focus on saving (Hofstede 2001). Hence the habit of shelving technology comes from long-term orientation as well as the resistance to sell the research surplus. The Not Sold Here syndrome – can be connected to the long cultural tradition of waiting to obtain a reward in the long-term; while the resistance to sell out the technology will emerge from a believe that it will be useful to the company in long-run. From the aforementioned, it can be assumed that *cultural peculiarities do have an impact on OI practices, both inbound and outbound.*

The resulting simulation model is an operationalisation of the respective theories and the assumptions drawn from the theory and supported throughout the publications. The parameters used in the analysis are represented as the influencing factors on the open innovation processes, as well as the data on perceived barriers to open innovation.

The aforementioned assumptions and relationships within the theoretical framework created for external influences on open innovation are implemented into the system dynamics simulation model (Figure 8, Publication 5) described in the methodology section.

3. RESEARCH METHODOLOGY

3.1. Triangulation as a methodological approach

Good research practice obligates the researcher to use multiple methods, data sources, and researchers to enhance the validity of the research findings, hence to triangulate (Mathison, 1988). Triangulation is usually considered to be a strategy for enhancing the validity of research or evaluation findings.

Triangulation as defined by Dezin (1978: 291) is “the combination of methodologies in the study of the same phenomenon” and it should support a finding by showing that independent measures agree with it or do not contradict it (Miles and Huberman, 1984). The term was created by Webb et al. (1966) and further elaborated on by Denzin (1978) who offered detailed descriptions of how to triangulate. Denzin (1978) lists four types of triangulation: (1) data triangulation comprising time, space and person, (2) investigator triangulation, (3) theory triangulation, and (4) methodology triangulation.

Data triangulation refers primarily to using several types of data sources, e.g. inclusion of more than one case in order to study the phenomenon. Time and space are included by Denzin (1978) as extensions of the original understanding of the data triangulation, suggesting validation by observing the same object at different periods of time and at different locations.

Investigator triangulation involves more than one researcher in the process and this type of triangulation is widely used as it is often required to have more than one individual conducting the research (Mathison, 1988).

Theoretical triangulation involves the use of several different perspectives or frameworks in the analysis of the same data set. This method usually involves testing related or rival hypothesis for the effect of diverse explanatory theories to the emergence of same phenomenon (Duffy, 1987).

The last and the most commonly used is methodological triangulation, also known as multimethod, mixed-method, or method triangulation (Mathison, 1988; Greene and Caracelli, 1997). There are a few different views on methodological triangulation. Duffy (1997) sees it as the use of two or more methods of data collection procedures within a single study; whereas others refer to it as research designs (Lincoln and Guba, 1985). Most commonly, it is the combination of qualitative and quantitative methods of data collection, analysis, and interpretation. By using multiple methods, the researcher targets a decrease in the deficiencies and biases that might be produced from a single method.

Method triangulation can further be classified into two types: within-method and between-/across-method triangulation. Within method triangulation uses at least two data collection approaches within the same research design (Thurmond, 2001), e.g. combining data from questionnaires and existing databases within a quantitative method or focus group with an interview within the qualitative one. Whereas the across or between method triangulation employ both qualitative and quantitative data collection methods in the same study (Denzin 1978), e.g. interviews and questionnaires.

Triangulation has widely acknowledged benefits, but is not completely positive. On the one hand, it allows confidence in the research data reveals unique finding, challenges or integrates theories and provides better understanding of the problem (Jick, 1979). Qualitative data gained from interviews or case studies can be used as the basis for selecting survey items; case studies can be used to explain outliers of quantitative data. On the other hand, it has certain disadvantages such as increasing the amount of time when comparing single strategies; the difficulty of dealing with abundant data, and conflicts in theoretical frameworks.

3.2. Within thesis triangulation – research design

The suitability of triangulation in data collection and analysis within this thesis can be supported by the patterns of theory building from cases (Eisenhardt and Graebner, 2007; Jick 1979) and justified by the targets set by this research, as well as the novelty of a major theoretical paradigm.

As emphasised by Thurmond (2001), for methods triangulation, every separate method must be rigorous enough to be able to sustain the study by itself. As every publication has only one method applied, it supports the rigorousness of isolated methods, at the same time as providing within thesis triangulation. The data collected through qualitative methods is used as the input data for the quantitative methods (for selecting quantitative constructs) and the results of four primary publications are then implemented in the final model.

The initial items for questionnaire design are obtained from the literature review (Chapter 2). Qualitative primary data (case studies at the level of the firm and region) is collected through in-depth interviews with companies and regional experts in Russia. The qualitative data is then used to create the framework and develop a working hypothesis when combined with the literature evidence on the subject. The quantitative data is collected through surveys in Finland, China, and Russia (Figure 6).

Certain barriers and motives towards open innovation are distinguished at the level of four companies and linkages within the innovation system perspective is added through expert interviews, these findings are then further tested and compared against quantitative data in three countries. The challenges towards open innovation are studied, first within one country and then in a cross-country comparison. The distinguished differences and similarities in barriers towards open innovation are then analysed through the aspects of certain innovation systems peculiarities, as well as national culture impacts. Hofstede’s dimensions of culture are obtained through freely available online databases in the form as SPSS and Excel and are used as external parameter input for the simulation model.

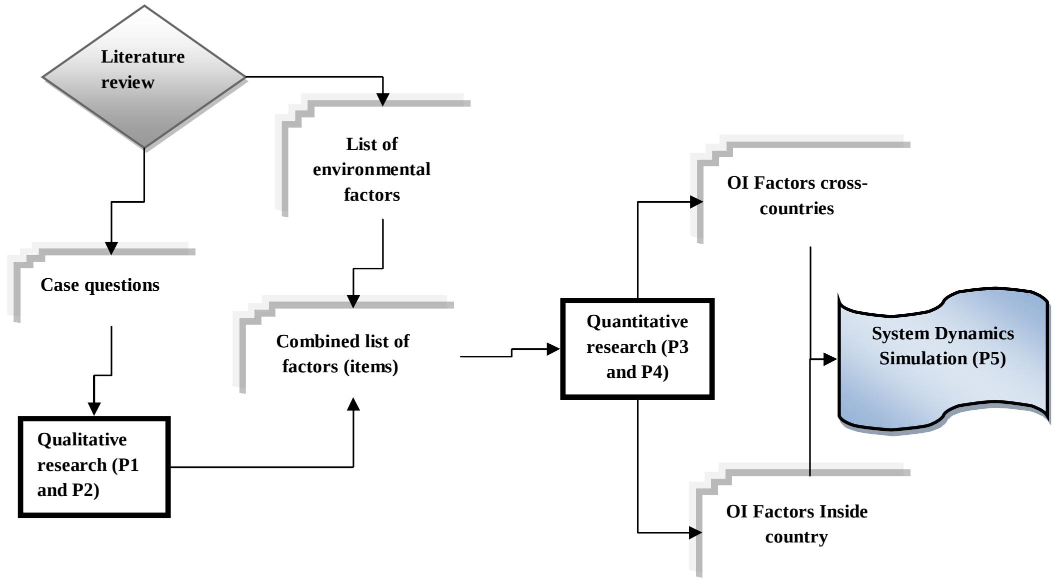

Figure 6 Research design presented through method triangulation

3.3. Qualitative and Quantitative techniques – data collection

3.3.1. Case studies

The qualitative research method was chosen for the first step in the research process (Publicaitons 1 and 2), and was implemented as an exploratory multiple-case study targeting the analysis of open innovation practices in firms inside the innovation system. It was also used to gain a deeper understanding as regards the problem area, as case studies are a preferred strategy when the focus is on a contemporary phenomenon within some real-life context (Yin 1994).

The choice of case study as a method was based on the relative novelty of the concept and a need to collect primary responses to the stated question – as case studies are a preferred strategy when "how" or "why" questions are being posed, and when the focus is on contemporary phenomenon within some real-life context (Yin 2004). Eisenhardt (1989) describes case study research as "a type of research that targets the individual situation and attempts to reveal an understanding of the multi-layered processes at work". For conducting the case study, multiple sources of evidence were used (Yin 1994) such as in-depth interviews, information presented on official companies' web pages, companies' related publications.

Therefore, these qualitative techniques are applied in the thesis to examine an ongoing process (open innovation implementation) in a given context (for Publication 1 and 2 - St. Petersburg, Russia) and under certain circumstances (innovation system) rather than testing a hypothesis.

The limitation of the research method selected is the impossibility of generalising the findings however, this is not the goal at this stage. The case methodology provides a unique opportunity to collect the information on the novel phenomenon, which can be later integrated into a quantitative research design.

The interpretation bias is eliminated by the careful preparation of interview questions, which cannot be interpreted in several ways. The interviews were held in the native language of interviewer and interviewee, which allowed the avoiding of language related misinterpretations.

The data collection was conducted between September 2008 and January 2009. Descriptive empirical research was conducted by collecting data from secondary sources, such as the Internet, scientific and periodical publications, and specialised events. The case studies were conducted by means of semi-structured in-depth interviews with the business-leaders in charge of innovation, cooperation, and R&D in the case companies (four companies, two persons per company interviewed either separately or simultaneously as group interview). The companies for the case studies represent small and middle-sized enterprises, from 5 to 250 employees. The companies have been selected from the list of the active innovative companies in St. Petersburg. Additional expert interviews were conducted at public organisations responsible for innovation support in the city. In total three high-level experts were interviewed.

3.3.2. Survey

The quantitative research methodology has its roots in philosophical positivism (Burrell and Morgan, 1979) and refers to the systematic empirical investigation of quantitative characteristics and phenomena. It emphasises the search for facts and causes of phenomena through objective, observable and quantifiable data (Duffy, 1987; Jick, 1979). The quantitative researcher targets were to obtain independent, detached data, from an objective view, which is hypothetically free of bias (Duffy, 1987). Usually, quantitative data for scientific research is collected under controlled conditions, adopting highly structured procedures and designed to support or reject predetermined hypothesis (Duffy, 1987). Hence, the planning and strict execution of quantitative methods is very important.

One of the methods to reach this is by conducting a survey. The surveys can be conducted by means of personal interviews and (anonymous) questionnaires (Burns, 2000). Perhaps the earliest kind of survey is the census, historically conducted by governments to gather knowledge on the population. A prominent reason for a survey is to gain understanding of a social problem (Groves et al, 2009).

When planning a survey, it is important to consider two perspectives: survey design (i.e. move from abstract ideas to concrete actions) and survey quality (distinguishing major sources of error and its effect on statistics). Groves et al. (2009) suggest that the survey to be successful should follow the strict design (Figure 7). This starts from defining objectives, then choosing a mode of data collection and a sampling frame (which depend on each other), selecting samples and pretesting the questionnaire implementation with later adjustments and analysis of data.

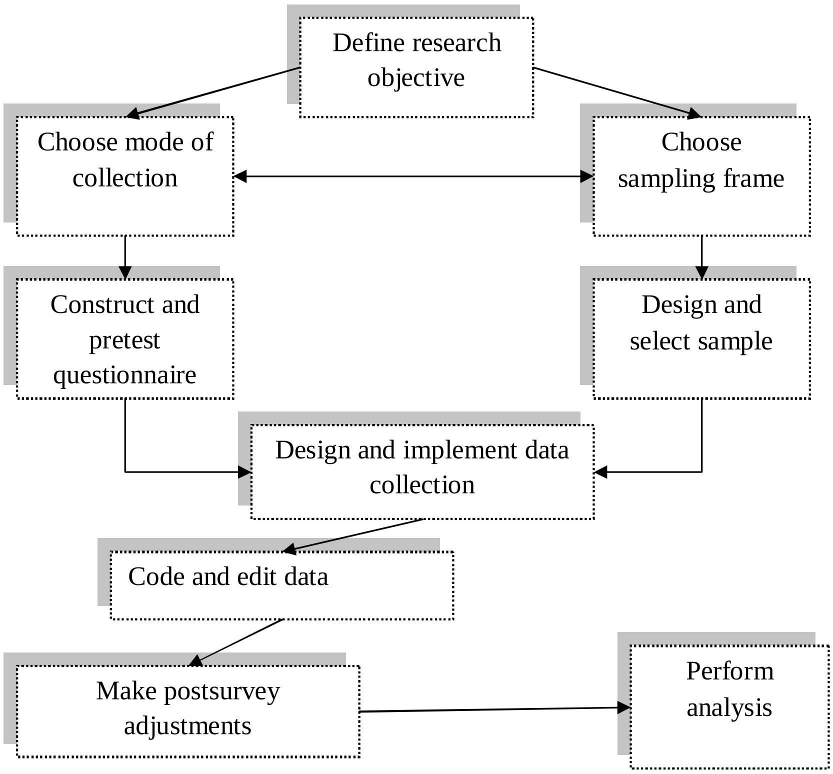

Figure 7. A survey from a process perspective (Groves et al. 2009)

The construction of a questionnaire is an important step in obtaining useful data. It is often advised that the existing measurement scales should be relied on and built upon. In innovation management research, there is set of framing documents, which are used as a basis for individual questionnaires (e.g. Oslo Manual (1992, 1996, 2005), providing the guidelines for innovation research and Community Innovation Study (CIS) emerging from it). The items in the CIS are widely used in innovation research.

Within the framework of this thesis, the empirical data comes from a set of surveys on open innovation practices conducted in China, Finland, and Russia. The surveys consisted of 35 general questions divided into sections A, B and C. The questions concerned attitudes, descriptive statistics on basic company information, and multiple option selection questions dealing with R&D, technology acquisition, technology sale and public-private relationship.

In the case of China, the data were collected through email and a paper survey, and also by phone in a few cases. Around 800 target companies for the survey were selected from the firms operating in the Yunnan Province and of these 501 responded to the survey. In Finland, the survey was executed by using a web-based survey instrument. An email containing both the cover letter and a link to the web page was sent to 510 persons employed in executive or

R&D management positions in Finnish firms. The firms were selected from a commercial business database (www.inoa.fi) by choosing the largest companies having their own R&D activities. A total of 59 surveys were completed, giving an overall response rate of 11.6 %. In Russia, the data was collected by means of structured interviews, usually of people from top management. Totally, 158 forms were filled in for the survey; the response rate equalled 16 %.

In each of the three countries, the survey responses covered the whole spectrum of industries. However, while Standard Industrial Classification (SIC) codes were used in the surveys in China and Finland, a somewhat different industry classification scheme was used in the case of Russian companies. Both in China and Finland, manufacturing and services constituted the major sectors in the sample: the proportion of firms in manufacturing industries in China and Finland was 69.5% (348 firms) and 42.4% (25 firms), respectively, whereas the proportions of firms in service industries were 16.8% (84 firms) and 23.7% (14 firms). In Russia, the largest sectors in the sample were electronics (22.2%, 35 firms), food production (15.2%, 24 firms) and machinery building (13.9%, 22 firms).

3.4. System Dynamics and model building

The system dynamics philosophy as stated by Roberts (1978) rests on a "*belief that the behaviour (or time history) of an organization is principally caused by the organization's structure. The structure includes not only the physical aspects of plant and production process but, more importantly, the policies and traditions, both tangible and intangible, that dominate decision-making in the organization".* This type of structural framework contains time elements, information feedback, and sources of amplification. Engineering and management systems comprising these elements display complicated response patterns to relatively simple system or input changes. The subtleties and complexities in the management area make these problems even more severe.

Compared to other social studies, the use of simulation in the field of innovation management has been relatively limited (Repenning 2001, Morecroft 2002), but its suitability to management and organisational studies has been argued by many researchers (Davis et al, 2007; Harrison et al., 2007; Kortelainen, 2011). However, simulation as an instrument for advancing a theory can overcome the limitations of classic approaches. Additionally, analysing multiple simultaneous and interconnected processes (Harrison et al. 2007) it offers new opportunities for discovering and building theories (Gilbert ja Troitzsch 2005, Axelrod 1997, Dooley 2002).

System dynamics can be viewed from two different aspects – as a way to analyse the dynamics of a selected system (Sterman 2000) and as a simulation tool to implement mathematical models (Forrester 1958, Sterman 2000). The former builds on the use of causal mapping to define the structure of a system and created feedback loops in the model to analyse the behaviour of the system.

Simulation underlies the idea by Simon (1996) that complex behaviour can emerge from simple actions. The added value of applying simulation methods is the possibility it gives for creating conceptual models, based on theoretical literature, as opposed to the more classic research techniques, which require knowledge of the exact cause and effect of the interaction of the system elements (Dooley, 2002).

One of important features of system dynamics noticed by Axelrod (1997) is in the fact that even simple models might lead to an important discovery and understanding of the interconnections between systemic elements and their impact on the overall system behaviour. Hence, the principle of the simplification of models is reasonable in simulation research in order to provide an understanding of the model and its replicability.

What concerns the role of system dynamics modelling in this thesis is that it is applied to an operationalisation of the model (Publication 5) build from the literature and empirical evidence (Publications 1-4). A system dynamics model of different environmental factors influencing product development and commercialisation was created using Vensim simulation software. The model is conceptual and is not built on quantitative data. The relationship between the variables is described based on existing literature on the topic.

The model, presented below (Figure 8), describes the relationship between different factors of product development and commercialisation inside the industry. The model builds on the simplification of innovation processes into three stages of ideation, conceptualisation/technology development, and product commercialisation. Though many authors suggest that development process consist of five stages (Cooper, 1994; Cooper et al, 2002), the three-stage approach is applied here for the sake of simplicity for the model. The concept of gates is also implemented to filter the projects passing from one stage to another. The gates are defined by (1) *Accept rate* (set as 50% for ideas and dependent of (P) Balance R&D, IPR and Delay for concepts), and (2) *Number of ideas rejected* of total number of ideas (as function of Total number of ideas corrected for Accept rate). New concepts are formed as a number of total amount of ideas per accept rate. More details on the model building and the constituting of its parameters can be found in Publication 5.

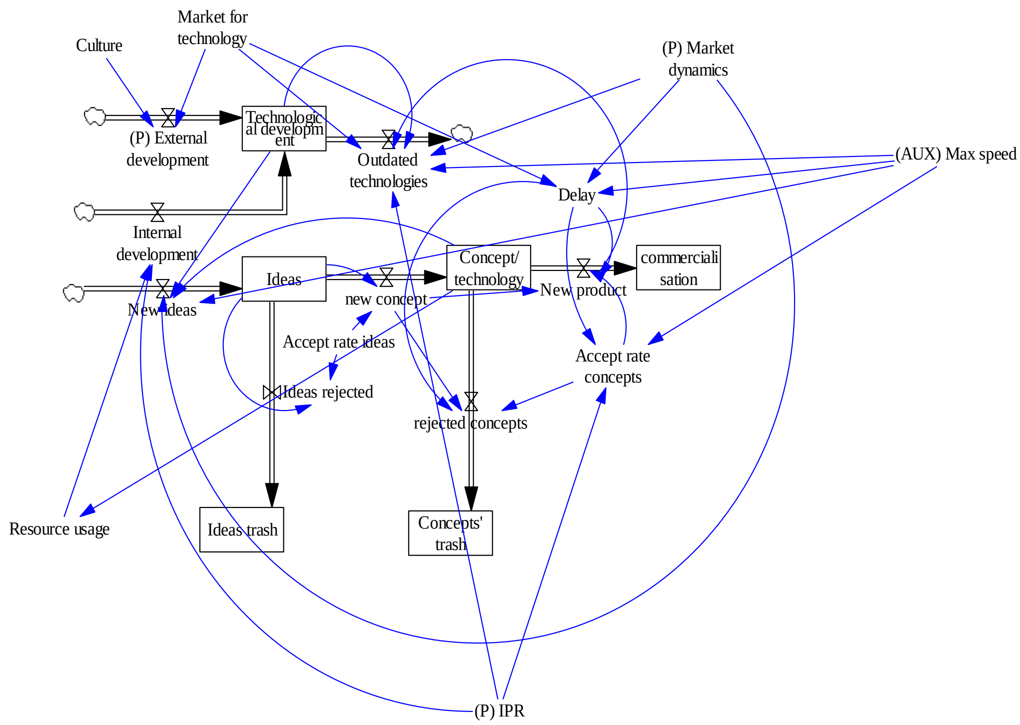

Figure 8. A Simplified System Dynamics model for external impacts on Open Innovation Processes.

3.5. Assessment of validity and quality of the research

The purpose of triangulation in research, as described in Chapter 3.1, is to increase the credibility and validity of the results. Method triangulation is often considered to be self-validating, since it represents the combination of diverse approaches to the same problem and hence is often used as the validation mechanism by itself. The application of method and data triangulation in this research allows shortcomings to be avoided, which could arise from an inability to generalise findings commonly associated with case study methods, and limitations coming from incompleteness and the unrepresentativeness of samples. These shortcomings are often mentioned among quantitative method drawbacks.

However, it is important to make sure that the internal method validity and reliability still hold. According to Yin (1994) there are four main criteria for judging the quality of case study research:

• Construct validity: establishing correct operational measures for the concepts being studied. Yin (1994) proposes to use both data and method triangulation to deal with problems of construct validity, since the multiple sources of evidence essentially provide multiple measures of the same phenomenon (Yin, 1994), which is applied in this thesis.

• Internal validity (for explanatory or causal studies): establishing a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships.

• Reliability: demonstrating that the design of a study, such as, e.g. data collection, can be repeated with the same results. Reliability for data collection for the case study research was achieved by preparing guiding questions for semi-structured interviews, recording the interviews and using the case study protocol, i.e. the case procedures were carefully documented. The findings of the case studies were also carefully reviewed and compared to the literature reviews.

• External validity: addresses the question of *generalisability* **-** to whom can we generalise the findings? The results of the case studies were later confirmed by results of surveys and theory, which through method triangulation secures external validity of the study.

For the quantitative part of this thesis, the reliability and validity were achieved by following the exact procedure of performing statistical analysis: from data collection to interpretation, which is addressed in Chapter 3.3.2. To ensure the quality of research, the following factors of *credibility* **(**verification that the research is objective and not influenced by personal researcher's opinion), *transferability* (the potential to replicate the research findings to other environments), *dependability* (proxy to reliability, including the evaluation of researcher's biases) and *confirmability* (the sufficiency of the research process) are assessed (Denzin and Lincoln 2000; Robson, 1993)

In terms of the entire thesis, the credibility is achieved by strict design of interviews and protocols as well as questionnaires including previously tested scales. The design of the final framework was based on and identified from data and prior literature problems. Transferability is ensured by the uniformity of interviews and the questionnaire allowing for replication of the research and findings in an environment sharing similar characteristics. Replication of findings in completely diverse environment would need adaptation to environment specifics. The conclusions coming from the simulation model are transferable to any environment comprising of the same elements as the one, created in simulation. The transferability to other environments can be done with minor adjustments of the final simulation model. Dependability of the research is eliminated by careful documentation of research and publication of preliminary results. Confirmability of the research is based on the thorough comparison of research interim results to the literature and the previous studies of the phenomena. The simulation model assumptions are heavily grounded in the previous empirical studies in the field, as suggested by the conceptual simulation model building.

The validity of the simulation models can be divided into three types (Zeigler, 1985):

- Replicative validity – the model matches data already acquired from reality
- Predictive validity – the model matches data before data is acquired from reality
- Structural validity – the model both reproduces observed real system behaviour and reflects the way the system operates to produce the behaviour

Hence, the only data input to the simulation model introduced in this thesis is the causal relationship of parameters, the predictive validity is in question. As stated by Gilbert and Troitzsch (2005) validity can be ascertained by comparing the output of the simulation data with data collected from the target (literature in our case). The thorough literature overview for distinguishing input parameters was conducted for the simulation model building (Table 1). Additionally, as model and constituting processes are stochastic, the correspondence is therefore not expected on every occasion (element of randomness). Moreover, since the simulation model is path-dependent (i.e. the outcomes depend on precise input) the validation by input factors impact and causality is tested through hypotheses in quantitative studies (Publication 3 and 4). The simulation is used in this thesis to predict the possible behaviour of the target under the influence of the system and to discover possible unexpected consequences the system may impose on the target (Harrison et al. 2007).

4. PUBLICATIONS

4.1. Overall

This thesis includes five scientific writings on topics related to the firm's perception of challenges in adoption of open innovation and analyses of certain environments where these companies operate. The publications describe the research process, starting from the initial approach to the companies and identification of challenges and ending in conceptual model building in order to analyse the environmental influence on open innovation. Figure 9, reflects the input-output relationship between the publications in this thesis. Where Publication 1 is the initial content input for Publications 2 and 3, and Publication 5 is cumulative research output-wise.

These papers can be seen as the iterative part of the research process, where each publication increases the understanding on the initial problem and at the same time provides the input for further research and validation data for previous ones.

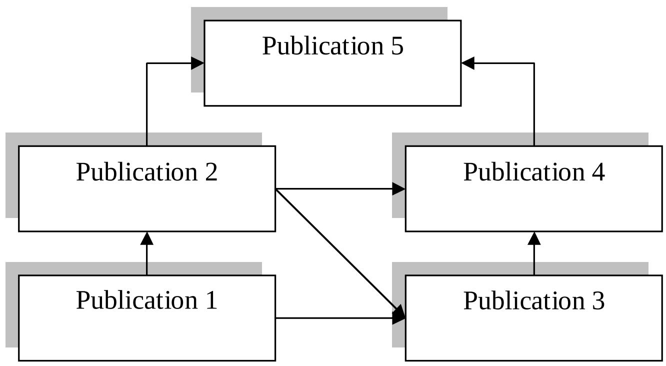

Figure 9. Content input-output based interdependencies between publications

This chapter is structured so that the next section will provide the overview of the methodological issues in the publications, their objectives and relation to certain research questions in the thesis. This discussion is followed by a brief look at each of the publications, describing the research findings and contributions as well as the role of the publication for the thesis research design.

Table 3. Summary of the publications and their main findings

	Publication 1	Publication 2	Publication 3	Publication 4	Publication 5
Title	Markets for Technology in an Emerging Economy: Case of St. Petersburg, Russia	A Framework for comparing regional open innovation systems in Russia	Barriers to Open Innovation: Case China	National Innovation System for Open Innovation: facilitator or impediment?	Innovating within the System: simulation external impacts on innovation process
Research targets	What motivates companies in transitional economy to embrace open innovation and what hinders the OI adoption? What kind of industry specific factors influence (positively or negatively) OI adoption?	What are the linkages between different players of innovation system inside one Russian region? What is the level of openness?	What is the relative importance of different institutional, structural and cultural factors that may affect the spread of open innovation practices in China?	Does national system of innovation through its institutions and organizations support the open innovation initiative by firm, or is the institutional environment a barrier to OI? If the latter, then in which aspects.	Publication sets to analyze the open innovation success in the companies through simulation of innovation process outcomes under systemic influence of environmental factors.
Method	Qualitative (case study)	Qualitative (interviews)	Quantitative	Quantitative	System Dynamics, conceptual
Data	Four companies' case study	Case study of a region and data triangulation within the case – few types of data – seven interviews (3 experts and 4 SME) and secondary data	Survey of 501 firms	Survey of companies in Finland – 59 companies, Russia 158 companies, China – 501 companies	Conceptual simulation model
RQ	**RQ 1**	**RQ 1**	**RQ 2**	**RQ 2**	**RQ 3**
Main Results	Barriers to OI: -Innovation system incompleteness (e.g. lack of intermediary players; unclear rules of the technology markets) -Internal: time and finance to invest to OI. -Industry specifics (structure of competition; market) -Regulatory aspect (IPR, partner agreements)	-Outstanding role of government in Russia -OI as a result of system failures – partnerships targeted to compensate for them. -New elements: education, role of universities in technology transfer (technology markets), state finance and support for R&D -availability of technology on trade (markets for technology aspect)	- Economic systems and institutions have an effect on firm's behaviour. -IPR protection can promote innovation and economic development - the strength of cultural impacts should be further researched in a cross-country sample -Barriers identified: NSH, NIH, no technologies on market, no buyers, IPR, resource constraints	- Certain country specific characteristics of OI interactions with the system have been distinguished. - institutional (regulatory) failures have the negative effect on companies involvement in open innovation - underdeveloped market for technologies confirmed to be a barrier to open innovation - Countries demonstrated differences in such aspects as source of knowledge, public-private partnership, and perception of barriers to OI.	- Individualistic culture as a hindrance to open innovation under condition of IPR protection or technological market development tending to zero - Importing of balancing point in market dynamics, what demonstrates the need to decrease the competition hostility to favour open innovation - Prove of IPR, markets for technology and market dynamics impact to open innovation success,
Role in the thesis	Input factors for the publication 2 analysis.	Input data for Publications 4 and 5.	The publication serves as a first empirical support and provides the input data for the Publication 5 and general Framework	The publication 4, in-line with publication 3, serves as a major input for Publication 5 and provides it with important causal information on the external factors	Concluding publication. Represents the results of research journey by analyzing open innovation related barriers and estimates the relative impact of these barriers

4.2. Research methodologies in the publications

The research methodologies applied in the publications, as well as the research questions they are targeted to address, are summarised in Table 4 (p.60). Methodologically, the publications follow the method triangulation pattern, beginning with the qualitative case studies applied to research into the phenomena, an understanding of which is not yet complete. Publication 1 deals with case-study analysis and presents the results, initiating publication 2 and being the first input for the framework. Publication 2 is also qualitative; however, the object of the study has shifted from firm to region. Hence, the initial results from the case studies in publication 1 and 2 add to the information obtained through the literature review and together constitute the basis for further quantitative studies. The further analysis of the problem is continued in publication 3, where a quantitative research of a large company sample is studied in order to confirm or reject the initial assumptions and add more elements to the framework. The findings of publication 3 are then partly integrated into publication 4, which is again quantitative, applying descriptive statistics, and logit regression to do the cross-country comparison of certain aspects of the problem.

Publication 5 differs from the others by applying system dynamics methodology, which is rather uncommon in innovation management research and especially in open innovation research. The simulation model built from the theoretical framework created throughout this thesis is conceptual, deterministic, and hence simplified. The model simplification of course restricts the applicability of the final results of the simulation; however, it creates the opportunities for further development and advancement.

4.3. Publication 1

Markets for Technology in an Emerging Economy: The case of St. Petersburg, Russia

Objective

Publication 1 presents the results of case studies conducted in St. Petersburg, Russia. This research is one of the first detailed looks into the open innovation penetrating to the Russian markets. The study approaches open innovation at the firm level and analyses perceived factors influencing the decisions of companies to go open. It also highlights the motives to embrace open innovation with regard to certain industry specific features. The publication results provide input for research question one (RQ1) in the thesis.

Main contribution

Publication 1 reviews the state-of-the art of the open innovation research in Russia, and represents one of the first attempts to analyse open innovation practices in a) SMEs and b) transitional economies. Furthermore, the conducted research adds to an understanding of industry specifics having an influence on open innovation and motivating or deterring companies from high open innovation involvement. The case studies used to answer the research questions were targeted at defining in detail the innovation processes in case companies, their attitudes to opening up and the incentives and barriers on the way.

Table 4. Research questions, objectives, methods and publication

Research questions	Objectives	Method	Objectives of publication	Publication
Research Question 1: What are the factors influencing open innovation adoption?	To analyze what motivates companies to get involved into open innovation and what hinders the OI adoption. What are the interconnections of open innovation actors in the region and what affects these linkages.	Case study	To identify the attitudes towards open innovation by SMEs in transitional economy. What are the difference in the way they see and implement open innovation?	**Publication 1** Markets for Technology in an Emerging Economy: Case of St. Petersburg Russia
			To analyse the linkages between different innovation players in the region, their interconnection and mutual impacts. To identify factors influencing open innovation cooperation between regional players.	**Publication 2** A Framework for Comparing Regional Open Innovation Systems in Russia
Research Question 2: How do external factors influence tendency to open innovation in the companies in different environments?	To study how the external to company factors are influencing the open innovation behaviour of the firm. To analyse the perceived barriers towards open innovation by companies in different countries and cultures.	exploratory and quantitative, Survey of 501 firms	To study the relative importance of different institutional, structural, and cultural factors that may affect the spread of open innovation practices in China.	**Publication 3** Barriers to Open Innovation: case China
		Exploratory, quantitative, cross-country: Finland – 59 companies, Russia 158 companies, China – 501 companies	This publication targets to analyze the barriers to open innovation and the relative importance of them for companies in diverse national and cultural contexts. The impact of innovation system context and institution is studied through cross-country comparison.	**Publication 4** National Innovation System for Open Innovation: facilitator or impediment
Research Question 3: How do environmental factors influence open innovation performance in companies?	To analyse the open innovation success in the companies through under systemic influence of environmental factors.	Literature review, system dynamics simulation	To analyze the open innovation success in the companies through simulation of innovation process outcomes under systemic influence of environmental factors. To estimate the relative impact of environmental factors to open innovation and raise the discussion for further research. Testing the conceptual simulation model	**Publication 5** Innovating within the System: simulation external impacts on innovation process

The results of the case analyses show that companies have demonstrated certain levels of open innovation implementation, however not at strategic levels. The knowledge of companies about open innovation transpired to be rather limited. However, companies have demonstrated active involvement into inbound innovation processes, joint R&D, and user innovation. On the other hand, only one company has demonstrated something close to outbound OI. Among the reasons for this failure, innovation system incompleteness, and internal factors as well as industry specifics were mentioned.

As was discovered, there exists a *passive OI,* which is the way SMEs are often pulled into the global OI process by their large partners (in IT sector – vendors). Among motives for OI companies mentioned cutting time and financial costs for development as well as avoiding an overload of personnel and obtaining access to external competences and facilities (especially crucial for micro companies). Among the barriers, regulatory aspect of partner agreements in IT-outsourcing (industry specifics and regulatory pillar of institutional settings), e.g. the ownership of IPR on research surplus were mentioned

The research demonstrated that the firm's involvement in the OI process is more resource driven, than strategic, which also emerges from innovation system incompleteness as a compensation for its failures.

Role in the thesis

The paper serves as the very first insight into the external factors and its results serve as an input for the following publication 2. Moreover, the use of Russia as the initial case example provide us with a wider palette of both external and internal factors than e.g. the case analysis of a large company in a developed country would show. The main input factors are: *innovation system incompleteness, lack of innovation intermediaries and understandable "rules of the game" at technology market; lack of financial and time resources (internal), and industry specifics.*

4.4. Publication 2

A Framework for comparing regional open innovation systems in Russia

Objective

Publication 2 focuses on the development of an integrated regional open innovation system (ROIS) and introduces a framework for analysis of OI implementation within regional innovation system. The paper aims to highlight to what extent the OI approach to collaboration shapes the relationship within RIS and corresponds to RQ1 in the thesis.

Contribution

The paper contributes to the field of research of regional systems of innovation by adding a perspective of openness to the system. It offers the framework for analysing the linkages between the participants of collaborative (open) innovation process based on the triple-helix approach to viewing the main actors of the innovation system. It emphasises the peculiar form triple-helix model takes in Russia, and integrates an open innovation relationship to the model.

The study confirms that the implementation of open innovation is mainly of an inbound type, which confirms that companies do recognise the value of externally available knowledge and are willing to exploit it for their own benefit. Additionally, research supports previous claim that partnership relations between different innovation actors in the region arise from certain innovation system failures (as e.g. business compensates for the lack of skilled personnel they need by early involvement into an education process and investment in a university scientific base; on the other hand, to compensate for the gap between the basic research and applied research required by business, universities act as centres for technology transfer).

Moreover, the analysis revealed a very strong relationship of every element to the government, in the case of business this was through public tenders, state ownership and subsidies; in case of universities – by financing education; and in the case of research – as a sole source of finance for research centres, which still remain public. To stimulate a better interconnection between the actors in an innovation system, the government plays an active regulatory role, hence the strong involvement of government into all spheres, which hinders the independent development of each of the system actors. This observation brings in the need for better control over the role of the government in further research on environmental influences.

The analysis of triple-helix based linkages from the relational OI point of view makes it possible to conduct the comparison of regional open innovation systems, based on the introduced framework, which allows the distinguishing of the commonalities and differences in ROISs. Hence, the publication contributes to the stream of research into OI practices and regional systems within transitional economies.

Role in the thesis

Added elements: system failures, e.g. education (weak and old technical base of universities and insufficient financing), the role of the universities as technology transfer centres (failure of markets for technology), the role of state financing in every field of triple-helix, the lack of an adequate supply of suitable to commercialise research results. The outcomes of this Paper serve as input for Publications 4 and 5.

4.5. Publication 3

Barriers to Open Innovation: Case China

Objective

Publication 3 examines the implementation of open innovation by Chinese firms. In particular, it focuses on the relative importance of different institutional, structural, and cultural factors that may affect the spread of open innovation practices in China. Publication 3 corresponds to RQ2 of the thesis.

Contribution

The barriers to open innovation are viewed in this paper at three levels – (1) internal firm factors as R&D intensity and availability of surplus technologies, (2) innovation system level as e.g. influence of innovation policies and public funding on firm's involvement into open innovation and (3) level of culture, defining attitudes to open innovation practices.

The research is based on four hypotheses, tested with the data obtained through an open innovation survey conducted in China, with 501 company-respondents. It was hypothesized that: (1a) Firms with a high level of R&D intensity are less eager to embrace inbound open innovation; (1b) Firms with a high level of R&D intensity tend to produce more surplus technologies; (2a) Public funding increases R&D output and the amount of surplus technologies; (2b) Firms are less inclined to sell intellectual property and technologies that result from publicly funded research projects; (3) The greater the complexity and the cost of the IPR protection, the less likely it is that firms will engage in open innovation; (4) The high cultural long-term orientation of the firms causes strong Not Sold Here syndrome and decreases the tendency to utilise outbound open innovation.

Results of logit regression supported hypothesis 1a and 1b, hence proving that the higher level of a firm's R&D intensity, the less likely it will acquire external technologies, and then more likely it will have its own surplus technologies. The results also indicated that the industry has a substantial impact on open innovation practices. Regarding firm size, the research confirmed the common assumption that smaller firms are more active on both sides of open innovation, as they do not have enough resources to research everything by themselves as well as to commercialise the surplus. With regard to hypothesis 2a and 2b, which were formulated as competing hypothesis, the data supported hypothesis 2a, hence the positive effect of public funding is stronger than negative as proposed by hypothesis 2b. Hypotheses 3 and 4 were supported through descriptive statistics, as to the responses of companies noticing the most significant barrier to inbound open innovation (the top three are listed below):

- No adequate technologies on offer (288 responses)
- Too much time/resources (141) response
- Not Invented Here syndrome (73 responses)

In respect to outbound open innovation, the main barriers were ranked as the following (the top three list):

- Complexity of IPR, fear of infringement (94 responses)
- Not Sold Here syndrome (54)
- The difficulty of finding buyers (49)

These findings can be grouped into the categories mentioned above: cultural aspect (attitudes and mindset coming through NIH or NSH syndromes), national system level (regulatory institutions for IPR protection, markets for technology for finding sellers, buyers, and technologies themselves) and internal factors (as time/resource constraints and R&D funding).

Overall, our findings indicate that economic systems and institutions (in particular regulatory ones) may have significant effect on a firm's behaviour. IPR protection, in its turn, can promote innovation and economic development, by attracting FDI and strengthening the incentives for domestic firms to innovate. The strength of cultural impacts should be further researched with a cross-country sample.

Role in the thesis

The article serves as a first empirical support for classification of environmental factors and provides the input data for Publication 5 and empirical support for The Framework

4.6. Publication 4

National Innovation System for Open Innovation: facilitator or impediment?

Objectives

Publication 4 targets an analysis of the specific role a national innovation system and its institutions play in the open innovation adoption by companies. Their effect is observed through the perceived barriers of companies to open innovation. The publication's intention was to answer the question as to whether national system of innovation has an impact on open innovation processes, and is the effect mainly positive or negative. This contributes to answering RQ2 of the thesis.

Contribution

By examining various barriers to open innovation in China, Finland, and Russia – countries with rather different innovation systems – publication 4 tests three hypotheses and presents cross-country comparison on matters of sources of knowledge, impacts of public finding on innovation, and the main barriers to open innovation.

The hypothesis tested are close to the ones in publication 3, however, now the cross-cultural element and more descriptive data is added, to control for the relative context of the environment rather than the absolute, as in publication 3. By relative context is understood the innovation systems of three countries and the significance of the results in a comparison between them. Hence, by hypothesis 1a and 1b, the effect of an increase in R&D funding is analysed, assuming that an increase in R&D funding (coming from public sources) has a positive impact on research surplus (1a) and a negative impact on inclination towards selling this surplus (1b). Hypothesis 2 deals with IPR protection and suggests that the complexity of IPR protection has a negative effect on a firm's engagement in open innovation. Following the assumption from publication 1 on the influence of company size, this factor is used as a control variable.

The most interesting systemic outcomes concern the knowledge flows, as e.g. in China the main sources of knowledge are universities and research organisations, whereas suppliers play secondary role. In Finland, cooperation for knowledge is strongest with suppliers, and in Russia the major sources of knowledge are revealed to primarily be publications and conference with patent databases as secondary sources. Only Finland mentioned explicit market players as knowledge source, which can be interpreted as a relative indicator of technology market development.

The comparison of participation in publicly funded projects demonstrates that whereas both China and Finland benefit from it mainly in terms of gaining information on the location of external knowledge and increased collaboration with universities, Russian companies treat governmental R&D support as a direct fiscal measure and utilise it for purchase of IP and technological solutions; hence, this public money has a direct impact on inbound open innovation.

In terms of more general results, within publication 4 it is confirmed that:

- certain country specific characteristics of OI interactions with the system do exist;
- institutional (regulatory) failures have a negative effect on companies involvement in open innovation;
- underdeveloped market for technologies is a barrier to open innovation.

Some illustration of finding in terms of outbound open innovation barriers is presented in Table 5.

Table 5. Ranking of perceived barriers to outbound open innovation in China, Finland and Russia (1 – highest rank, i.e. strongest barrier, 5- lowest)

	China	**Finland**	**Russia**
Barrier			
NSH	2	5	5
Complexity of IPR, fear of infringements	1	2	3
Difficulty to find buyers	3	1	1
Lack of marketplaces for technologies	4	3-4	2
Other	5 (0,4% responses)	3-4 (6,8% responses)	4 (5,1% responses)

Role in the thesis

Publication 4, in-line with publication 3, serves as a major input for Publication 5 and provides it with important causal information on the external factors. It indirectly supports the claim of the importance of innovation systems and regulative institutions and brings cultural aspects to the picture.

4.7. Publication 5

Innovating within the System: the simulation model of external impacts on new product development

Objectives

Publication 5 introduces a conceptual, system dynamics, simulation model, comprising the most important environment-originating factors distinguished throughout the research flow and supported by the theoretical background. The target of the publication 5 is to analyze the open innovation success in the companies through simulation of innovation process outcomes under systemic influence of environmental factors. Publication 5 responds to RQ3 and concludes the thesis research.

Contribution

The simulation model follows the influence of environment on a simplified open innovation process measured through product output. The environment is described in terms of existence and level of development of the markets in technologies, the mechanisms for protection of IPR, the speed of user needs change (standing for market dynamics, as this factor is a view that is influenced by hostility of competition), and national culture.

Based on the analysis of literature, the factor of culture included in the simulation model, is measured through collectivistic versus individualistic cultures, since these factors were earlier defined as having a major influence on knowledge sharing practices. Following the study of three countries, the simulation targeted to analyse the innovation system behaviour under approximated to certain country cultural environments, using Hofstede's cultural dimensions scores as input data. All other parameters were kept random, defined only in terms of interconnections and positive/negative impacts.

The results obtained suggest, among other things, that when IPR or technological market development tends to zero, countries with higher individualistic scores start to lose the edge compared to countries with higher collectivism.

Another interesting and perhaps the most important finding suggests that there exists a tipping point for the speed of users' needs change (and hence market dynamics), meaning that when change happens too quickly, the system fails. Additionally, for this effect to happen, the technology market ought to be sufficiently developed.

The simulation results also confirm the positive influence of market dynamics to the innovation outcome, but again until certain level, and it requires IPR protection to be strong in order to support optimal amount of product launches.

These results contribute to the growing literature on open innovation in several ways: 1) by confirming claims of market dynamism and IPR protection influences as well as technology markets development; 2) by introducing measure of national culture as an important determinant of open innovation; 3) by providing the first system dynamics simulation model to open innovation research.

Role in the thesis

Publication 5 represents the model built on the knowledge acquired throughout the entire research process from theoretical and empirical sources and concludes with the current research, and at the same time opens perspectives for a multitude of future research approaches to open innovation determining environments.

5. CONCLUSIONS

5.1. Overview

The purpose of the thesis was to analyse the possible external impacts on companies' perception and adaptation of open innovation practices. It is studied in the thesis through perceived barriers and the systemic impact of the simultaneous influence of different factors to open innovation output by companies (seen as the number of new products commercialised) inside the industry. The main research question was split into three sub-questions introduced to support the research design by dividing the study into three major stages as guided by the research questions. The sub-questions lead to a literature review and empirical research, in order to form a basis for interpreting and analysing the results of the attached publications.

The role of the five publications attached to this thesis was to demonstrate the flow of research from initial identification of potential answers to the research question, through supporting these initial answers by further research and finally leading to the development of a conceptual simulation model in the final publication. Hence, the publications are the outcome of constant dialogue of theoretical and empirical research, presented in this thesis. Final attached paper (Publication 5) represents the conceptual model, which comprises the insights from the two qualitative papers, the two quantitative papers and an extensive literature review. The end result of this research is the conceptual simulation model describing the causal interconnection of certain factors in the environment and firms' innovative performance. The results of this conceptual model are used as a theoretical conclusion of the thesis and further research suggestions, whereas managerial conclusions are derived from all the included papers.

This chapter is structured so that this introductory note is followed by a contribution to theory offered by this research and continued with practical implementations of results. The thesis is concluded by delimitating the research, and introducing avenues for further research.

5.2. Contribution to theoretical discussion

The topic of the interconnection of a company's open innovation strategy with a national innovation system, its institutions, and national cultures, has rarely, if ever, been studied. Hence, the issues raised by this thesis may establish an interesting academic discussion on the topic.

The research question - *how does the environment affect the adoption of open innovation by companies,* raised in the first chapter of this research, was answered through three sub-questions as the research proceeded, with particular publications devoted to answer each question. In the discussion on results, it is logical not to divide the listing of important external factors from the impact they make, hence Table 6 presents the summary of the factors proposed in one of the publications, classification into structural, institutional, and cultural influences and direct implications. The discussion of major factors and their impact is also presented below, as responses to the question of **-** what are *the factors influencing open innovation adoption* and h*ow do external factors influence tendency to open innovation in the companies in different environments?*

The existing business environment does impose certain problems. The findings indicate that economic systems and institutions (in particular the protection of IPRs) would have substantial effects on the behaviour of firms with respect to their engagement in open innovation practices. Thus, complexity of intellectual property rights (and fear of infringement) decreases the willingness of firms to engage in OI, especially on the outbound side.

Table 6. Classified environmental factors and their impact to open innovation.

FACTOR	COMPONENTS	IMPACT	IMPLICATION
STRUCTURAL	• Information asymmetry • Technological distance • Transaction cost and rate • Asset specificity • Development level of technology trade • Industry • Intermediaries • Competitive intensity/ Hostility • Technological turbulence	The involvement into open innovation is often resource-driven, rather than strategic Industry structure drives open innovation Lack of innovation intermediary bodies hinders the open innovation processes. Asset specificity drives smaller companies to participate in open innovation more actively.	Openness as a result of lack of specific assets Openness is impossible in the closed by characteristic industries. The role of innovation intermediation is often performed by universities.
INSTITUTIONAL	• Regulatory policies • Appropriability • Property rights claiming • Norms • Coordinating role of institutions • Public funding	Regulatory norms are industry dependent. Unclear IPR appropriability discourages OI. Complexity and cost of protecting of IP discourages OI Governmental policies drive innovation in emerging economies. The additionality effect of public funding is stronger than the negative effect of appropriability of R&D related to it.	Openness as compensation for systemic failures. IPR contracts restrict use of surplus. Government can influence the level of openness in the innovation system through regulations, laws, fiscal measures and infrastructure creation. Lack of technologies on offer demonstrates the incompleteness of technology market-need for intermediation for innovation.
CULTURAL	• National culture: individualistic vs collectivistic • Mindset • Attitudes	Protective attitudes towards knowledge are confirmed to be a serious barrier to open innovation (NSH) as well as the resistance to “outsiders” knowledge also takes place	The cultural attitudes can be leveraged through managerial structures and incentives inside the company.

An interesting finding is that the governmental support of R&D is a stronger motivator for OI than the negative effect of unclear appropriability of state funded research. Hence, even despite it not always being clear, who owns the rights to research surplus created inside the project with state ownership of an overall IP, the benefit to the developing company and its open innovation activity is rather high as perceived by the companies themselves.

The main barriers indentified for firms active in open innovation are similar to the firms who implement open innovation from time to time. Hence, it is possible to assume, that the external influences are stronger in creating barriers to open innovation than internal practices, which companies may develop and improve over time.

Such challenges as the difficulty of finding buyers for technologies, on the one hand, and a lack of desired technologies on offer on the other, reflect the underdeveloped state of markets for technology.

With regard to the cultural aspect, Not Invented here and also Not Sold Here syndromes are substantial challenges (i.e., firms have protective attitudes towards the external exploitation of knowledge). The influence of national culture as a determinant of these specific attitudes was previously analysed in knowledge sharing literature. As a possible implication of this, the dimension of culture can be taken into account when formalising the open innovation processes in organisations, which is discussed further in the following subchapter.

Regarding the question *how environmental factors influence open innovation performance in companies,* the results of the simulation runs need to be discussed. When the performance of a company is approximated to a number of commercialised innovations (new products) developed in open innovation mode, the same factors as previously mentioned tend to have an impact (IPR, market of technology, market dynamics and national culture). What is of considerable interest in the thesis results, is the *tipping point of open innovation,* when under certain environmental conditions, considered to be favourable, performance drastically decreases reacting to the saturation of the environment and revealing the existence of the point, where the system starts to seek a balance. This situation happens as saturation, when the abundance of positive influences turns to negative. It explains why often in research the same factor in different environments has both positive and negative impacts. Thereby, the important implication of this result is search for a balance point to optimise the outcomes within system of innovation. This opens a vast avenue for further research, in line with the question on the balance of openness vs closeness for innovation.

Hence, as demonstrated by the system, optimal market dynamics exist, and in an overly active market have a negative effect; however, the effect of this dynamics can only come in action when the market for technology is developed enough.

Regarding the cultural aspect of open innovation, the results achieved in this thesis bring the cultural dimension into the discussion as to the reasons why some countries are better at open innovation than others. As previously stated, knowledge sharing underlies the philosophy of open innovation and at the same time, knowledge sharing hostility is a known concept in cross-cultural research. Only one aspect of cultural dimensions was introduced to the simulation model – collectivism vs. individualism - and yet it gives interesting insights into the matter, previously not explicitly discussed in open innovation literature: when an appropriability regime or technological market development tends to zero, countries with higher individualistic scores start to lose their edge compared to countries with higher collectivistic scores.

Hence, the research presented in this thesis has distinguished the major factors (perceived barriers) having an impact on open innovation practices, classified them into three categories, defined their impact through causal relationships, analysed the factors, and controlled for the multifactor systemic influence on the open innovation performance of the company. As well as the existence of tipping point for open innovation being discovered, a new tool (system dynamics simulation) for analysing open innovation behaviour of companies has been brought from the cross-disciplinary approach.

The research also directed attention to the cultural aspect of open innovation, which does not precisely support the claim by Hofstede and Bond (1984) and Shane (1992) that societies, which score high on individualism and low on the power dimension, have higher economic growth and a greater tendency to innovate - as present research demonstrates, under some conditions of the environment, the individualistic cultures are outperformed by the collectivistic ones.

5.3. Practical implications

Due to the strength of the method used allowing for modelling of abstract concepts in conceptual research, the introduced simulation model facilitates developing the most suitable scenarios of external factors combination, which can be applied in practice by policy makers. The balance in the system is crucial for sustainability of innovation output, and as seen from the results, there is a point of saturation in almost every factor, after which the performance starts to decrease. Hence, it is impossible to talk about positive effects of e.g. market dynamics or competitiveness, without keeping in mind that it can become too much at some point.

An interesting implication arises from the causal connections of strategic company decisions, institutions, and open innovation. Thus, the institutional settings (especially regulatory ones) may cause the higher perceived transactions costs, which will in turn decrease the level of openness and motivation to collaborative innovation as a change of partners become costly. On the other hand, with the presence of markets for technology, favourable IRP and appropriability regimes, the transaction costs decrease thus motivating involvement in more frequent collaborative partner change, and hence to be more open to co-innovation. The development of an open innovation strategy and embedding it in everyday processes of monitoring the market and elaborating the procedures for partners' selection and IPR contracting, would allow for leveraging the institutional failures in these areas.

Strategic management of IP – development of practices of utilising the company's own intellectual property and the external exploitation of irrelevant ones can be one of approaches to leveraging institutional impact. The motives can be not only monetary but strategic – to build an image, goodwill, to establish the dominant design in the industry. Finally, strong IPR protection at the policy level can promote innovation and economic development, through attracting FDI and strengthening incentives to innovate by domestic firms.

At the same time, regarding the interference of state institutions - according to the previous research, public subsidies have a positive (additionality) effect on a firms’ R&D output, which may lead to their increased propensity to engage in activities on the selling side of open innovation despite the weak appropriability regime often associated with publicly funded projects. However, this again should be leveraged through a strategic approach to public-private partnership.

It may be stated, that the development of a more supportive environment and strategies for open innovation (an “open innovation system”) should be an extremely important goal in regional and national innovation policies. Moreover, including open innovation into company strategy would give an internal leverage to the institutional settings.

The proposed conceptual simulation model can be used as a starting point for building the tool for managerial decision making when deciding which country to cooperate with inside an open innovation framework, as it allows for analysing the elements of certain environment provided that the input numbers are known. However, it must be stated that further testing and validating of the conceptual model with real data is needed before it can be used in managerial decision-making. Even applied conceptually, the model reflects which aspect of environment can be leveraged through rethinking strategy and business processes of the company.

Furthermore, the results emphasise the role of policy makers, as they are the only ones who can use the environmental factors to stimulate OI in their domain.

Useful insights also come from the cultural and behavioural aspects as they are important elements of national institutions and should be taken into account when developing innovation strategies as their impact on openness through imposing cognitive barriers to the buying and selling of knowledge and technology.

As demonstrated by the conceptual model, the existing cultural dimensions defined by Hofstede (1981) can provide the insights on structuring the processes in a company in order to facilitate open innovation and fight knowledge sharing hostility. For instance, if the country scores high on power distance dimension, the solution to overcome the resistance of personnel might be to introduce a stronger hierarchy and assign certain amount of leader empowering authority. Employees in high power distance cultures do not usually question the managerial decisions from a higher authority and hence the attitudes to knowledge sharing should not become an issue. In low power distance context, employees might be motivated to do what the management wants after they are given the explanation that the company is a team with common goals and they should all work equally to reach them. With regard to the implications of individualistic versus collectivistic cultures, the roles and responsibilities of each and every employee should be defined to leverage an individualistic society. Employees will gladly fulfil the task if they have individual responsibility for it. Collectivists, on the other hand, need to be assigned into teams with shared responsibility – identification of themselves as a part of a group will allow sharing responsibility and increase willingness to take risks. This would also explain the attitudes to collaborative innovation and general knowledge sharing challenges.

Above are oulined the examples of managerial implications drawn from the resulting assumptions of the model; elaboration of practices to overcome open innovation related challenges might be a topic of further research.

Overall, the results of the research presented in this paper are beneficial to both academics (as it brings new insights to the research on external factors influencing open innovation processes) and practitioners (for understanding the impacts of external environment and being able to anticipate these effects). It is also of considerable importance for policy makers to recognise the effects of the measures they impose on the general level of innovative performance of companies in a particular industry/region, i.e. the development of a more supportive environment is an extremely important goal for achieving sustainability in innovation.

5.4. Limitations and Future research

The focus of the thesis is on the influences of external factors on open innovation adoption, based on the theory of innovation systems (including institutional theory) and explained further through a study of national culture. The restriction to these theories only limits the study in terms of including other possible influencing factors. However, the case study approach for primary data collection targets a counterbalance to this aspect by keeping open questions in case new items should be mentioned.

Since the study focuses on external impacts, the internal company processes are acknowledged but not viewed separately in this context. Hence, the influence of the external environment is viewed in absolute terms, disregarding the internal company processes. The simultaneous influence of internal and external environments might provide somewhat different results, and should be addressed by future research.

Further limitation is derived from the data collection: 1) purposive sampling in case selection allowed for analysing only companies which are involved in open innovation to some extent, whereas studying completely closed companies and their barriers could bring additional insights on companies' reluctance to embrace open innovation. 2) Misbalanced country samples for Finland, China and Russia may be regarded as not representative enough and decrease the generalisability and reliability of findings, however, taking into account the total number of businesses operating in theses countries, the misbalance does not seem to lead to an unrepresentative sample. 3) The use of system dynamics as a method has some identified limitations, which need to be acknowledged. The greatest concern here is in the trade-off between the generality, the realism and level of detail in the model (Axelrod 1997). These aspects counterbalance one another, as e.g. higher realism in the model will lead to an accurate case description with quantitative predictions, but simultaneously to less generalisable results (Kortelainen, 2011). The research has also some limitations originating from both the method used and the nature of innovation. Since the model is conceptual and tests no real data, it can only be validated against existing literature. Moreover, in reality innovation has a high stochastic element, but as traditional system dynamics suggests the deterministic model, the innovation had to be simplified, which of course has an impact on the results. Additional limitation related to simulation model building comes from a simplification of the underlying processes. This is justified by keeping the lower level of complexity of the model (Repenning 2001) less heavy, but on the other hand this also brings some limitations in terms of inclusion of more possible factors, defining system behaviour. 4) The country scores used as input data for the cultural parameter (Hofstede's dimensions) are relative since societies are compared to other societies. The recent global processes should be taken into account prior to claiming the long-term stability of cultural measures.

Hence, to further advance the discussion initiated in this thesis, the next version of the model should be developed. Factors to be included might be:

a) quantitative data,

b) more precise and explicit factors unlike those used in this study (e.g. IPR can be divided into cost, level of protection, complexity to file the patent etc.);

c) additional cultural dimensions from Hofstede's datasets (power distance, uncertainty avoidance etc.), which will give a better insight into managerial implications and the human side of open innovation in the companies.

In order to better understand the influence of environment, the identification of the locus of the discovered tipping point would be useful; a more sophisticated mathematical model will thus be needed.

The basic assumption underlying this research is that open innovation is beneficial to companies; hence, interesting results may come from the targeting a simulation of the losses from opening up under certain environments (what sort of environment does it take to start losing from OI). Additionally, to eliminate the bias of comparing different companies with different procedures, the study of one company and its performance in different environments (e.g. subsidiaries of MNC) should be performed.

This thesis only starts the discussion on the role of culture in the spreading of open innovation, hence further research into the role of culture and mindsets on open innovation should be conducted, including the role of cultural proximity/distance in open innovation cooperation, technology transfer and partner selection. Moreover, since this thesis makes a claim that cultural differences do influence the emergence of certain open innovation associated barriers, this claim might be further validated by a larger number of countries and higher sample sizes. To tackle the cultural factors, more research on a human resources approach in order to open innovation might be of considerable value.

On the other hand, since the results also suggest that the importance of an appropriability regime may differ in the buying and selling sides of knowledge, the effects of property rights protection and its relationship to other structural issues ought to be more fully explored in future research.

Overall, a more complex understanding of the relationships between environmental factors are needed, together with test on real datasets, which would give a deeper understanding of what the environmental drivers to open innovation performance are. In addition, this data should be further compared with a real environment analysis, taking a closer look into the innovation systems and regulations supporting every relational claim.

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PART II: PUBLICATIONS

Publication 1

Savitskaya I. and Torkkeli M. (2010) Markets for Technology in an Emerging Economy: Case of St. Petersburg Russia, ***Innovacii (Инновации), Special Issue on Open Innovation,*** **Vol. 6 (140), 2010, pp. 6-10.**

Markets for Technology in an Emerging Economy: Case of St. Petersburg Russia

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Open innovation as an empowering model for knowledge economy has changed the world of innovation management. Apparently, as Russia is in transition towards innovation based economy, its companies could not escape opening up their innovation process according to western patterns. The paper presents the results of case studies on open innovation implementation in St. Petersburg, Russia. The research approaches open innovation at the firm level and highlights motives to embrace open innovation approach with regards to certain industry specific features. The paper contributes to a better understanding of open innovation implementation and demonstrates that beside big multinational companies the value from open innovation can be captured as well by small and middle-sized enterprises.

Keywords: open innovation, Russia, SMEs, trade in technology.

1. Introduction

Business cannot escape the influence of the change in the operating environment: competition is becoming more intensified, knowledge diffuse wider and faster, R&D investments grow and at the same time the life-cycles of products and technologies are shortening. In order to optimize product development and fit it into shortened time frames, the firms need to be able to utilize multiple (external as well) knowledge sources, and apply new approaches to management of intangible assets. (Miller and Morris 1999)

During the last decade the intensified global competition resulted in emergence of new approaches to cooperation for innovation. “Do-it-by-yourself” mentality became outdated. The rapid development of information and communication technologies has enabled integration of customers and suppliers into innovation process despite of physical distances between them. The propensity to cooperate and open up the company borders came intensified in 1990s (Gassmann 2006) and the movement towards open innovation have started, reaching its peak when Chesbrough (Chesbrough 2003b) raised the issue of whether open innovation is “*the new imperative for creating and profiting from technology*”. Since that the open innovation related practices of the companies have attracted great attention (Gassmann and Enkel 2004; Herstad 2008; Laursen and Salter 2006; Huston and Sakkab 2006).

Traditional closed innovation model do not anymore meet the needs of companies operating in fast changing environment. However, it should be stressed that the transition of certain industries to open innovation model does not seem to be justified, hence, open innovation implementation has certain industry specifics (Chesbrough 2003b; Chesbrough et al. 2006; Laursen and Salter 2006). At the same time with increasing relevance of external knowledge sources (Gassmann 2006; Van de Vrande et al. 2006), emerge the understanding of benefits of disseminating previously shelved internal knowledge and ideas (Chesbrough 2003a; Lichtenthaler 2009).

We study the status of open innovation implementation in SMEs in St. Petersburg, Russia. Russia has a long tradition of technology development and innovation. Nevertheless, its innovation system as well as a whole economy is still in transition. St. Petersburg is the second main scientific region in Russia. With Russia having one of the most educated populations in the world, St. Petersburg, has a total of 8% of Russian students (having 3.4% of total population of the country) and 15 % of total amount of country postgraduate students (Vertjachih 2007).

The knowledge creation is intensive in the region, which leads to an assumption that the knowledge flow between innovation actors may be intensified through application of open innovation model for collaboration between innovation actors. This paper studies open innovation practices in Russia by means of case study research of four SMEs, and aims at answering the questions of what motivate companies in transition economy to embrace open innovation approach and what kind of industry-specifics may exist for open innovation. The paper starts with theoretical overview on open innovation paradigm, further on the features of open innovation implementation in Russia are described and finally the results of case studies are discussed.

2. Theoretical background

Open innovation paradigm can be viewed as a symbiosis of such its antecedent trends as: *globalisation of innovation* (Gassmann and von Zedtwitz 1998), happening due to modern information and communication technologies providing virtual work opportunities and access to new markets and resources (Gassmann and von Zedtwitz 1998; Gassmann and von Zedtwitz 2003); *outsourcing of R&D*, applied due to cost saving, speeding up innovation process and limited proprietary resources (Katz and Allen 1982; Pisano 1990); *vertical and horizontal integrations* with suppliers (Hagedoorn 1993; Hagedoorn 2002; Tidd et al. 2005) and users (von Hippel 1986; von Hippel 2005; Keupp and Gassmann 2009) to name just a few. Additionally, the resource based view of the firm can advocate the appearance of open innovation paradigm as e. g. absorbed external knowledge while integrated with valuable and rare proprietary resources may generate the unique product, that is difficult to imitate or substitute (Kock and Torkkeli 2008). Although open innovation is not a new theory as such (being built on existing concepts); it urges to create interconnections between innovation and strategy, rational resource management, networking and many other existing concepts (Butler 2004; Chiaroni et al., 2007; Vanhaverbeke and Trifilova 2008).

Hence, the core of open innovation idea lies in the assumption that firms open their boundaries to let the externally existing knowledge flow in and the internally unsuitable knowledge flow out to be utilised outside the company with mutual benefits for sender and receiver (Chesbrough 2003a, b, 2006; Chesbrough et al. 2006; Lichtenthaler 2009, van de Vrande 2006). Vanhaverbeke (Vanhaverbeke and Trifilova 2008) stresses that open innovation is a well-directed effort of organisations for knowledge inflows and outflows aiming at increasing their innovation activities. The word *organisations* is used to underline that not only firms are involved into open innovation — universities, research laboratories, users and intermediaries are the main partners within open innovation framework (Vanhaverbeke and Trifilova 2008).

Open innovation can be described in terms of blending two differently directed processes: inbound and outbound. Inbound process stands for in-sourcing external knowledge through licensing in, spinning in, acquisition (in order to get valuable technology, personnel etc.) and collaboration alongside value chain. The latter can be illustrated at the example of Procter & Gamble, who cooperate with customers, suppliers, competitors and other institutions to pursue ideas, which can be utilised in the process of new product development (Huston and Sakkab 2006). Outbound process stands for external utilisation of internal knowledge. The 'surplus' of research, not fitting to current business model, used to sit on the shelf within close innovation model (Chesbrough 2003b). This means that the company had to fiercely protect this surplus by intellectual property rights in order not to lose it (as even the employees of the company could utilise the surplus for establishing own business with venture money). Open innovation approach states that the surplus can be used for realising some potential value through selling it away to the other company, which could utilise it better within its resource base and business model. (Chesbrough 2003a,b)

Open innovation can be viewed both as a business model (Chesbrough 2006) and as a strategy development tool (Vanhaverbeke and Trifilova 2008). Hence, open innovation can be announced by company as a strategy towards collaboration, openness etc.; on the other hand open innovation can be actively implemented in low-technology industries for invention of new business model allowing to enter new market segments (Chesbrough 2006, Chesbrough and Crowther 2006).

3. Open innovation in Russia

The attention to innovation activities in Russia was attracted relatively recently, when Russia announced refocusing its economy from natural resource dependency to more competitive spheres. The base for innovation development in Russia is quite strong: the inherited from Soviet Union scientific base and strong university education facilitates the knowledge creation (OECD 2005). However the knowledge flow is not that well regulated, the linkages between innovation actors are very weak and the public-private partnership is not that well developed (Dezhina and Zashev 2007).

This situation makes the open innovation research in Russia very important, as it demonstrates the implementation of open innovation approach in country in transition and can be viewed also at a regional level as a strategy to activate missing linkages between innovation system players.

The research on open innovation in Russia is currently at its seed stage. The first results were presented by Torkkeli et al. (Torkkeli et al. 2008; 2009) who conducted a survey of 158 R&D oriented enterprises in Russia. One of the major outcomes of the research is the assumption that Russian companies have week connections with stakeholders and weak relationship networks. At the inbound side, companies are rather active, as 60% stated that they acquire external technologies regularly or from time to time. At the outbound side, only 27% of surveyed companies are active in searching for surplus buyers. The surplus is usually sold as patents and licenses. The conclusion was drawn that the Russian companies are not very active in open innovation implementation, and are open mainly in terms of utilization of external knowledge.

To understand better how the open innovation implementation is possible in Russian companies, few case studies were undertaken aiming to distinguish in details the R&D processes in companies, their attitudes to opening up and the incentives and barriers on their ways.

4. Methodology

Multiple case-study method was applied to this study, implemented through in-depth interviews with companies' representatives in charge of either company strategic decisions or R&D and general management. As the companies are rather small, in average two persons per company were interviewed. The interviews were following semi-structured open questions and lasted in average 90 minutes. Additional information on the studied companies was obtained though official releases at their corporate web pages, exhibitions and mass media publications related to the companies. The selection of companies was done on a random basis from the list of participants of I[st] St. Petersburg Innovation Forum.

5. Four cases from St. Petersburg

5.1. Companies' description

Med-byte is a very small company of about 5 employees specialized on development and production of medical devices for diagnosis and cure of diabetes. The first two generations of its products are actively sold in Russia and some EU countries. However the production of next generation requires higher investment in the device development hence currently company is in the process of finding a partner from telecommunication industry to offer their blood sugar tracking solution as an application to mobile phones.

Arcadia is a middle-size, IT outsourcing specialized company. It belongs to those companies, who develop technologies (here software) for external organizations. However, their development process is from time to time built on technology in-sourcing and always built on certain licensed-in platform (what is rather common for IT companies).

Digital Design (DigDes) is another IT specialized company, having two directions in its business: development of technologies (software) for external companies and selling own program — IT solutions for business management. The company is rather big — 360 employees; however it defines itself to be a middle-size company.

Speech Technology Centre (STC) is a middle-size company, specialized on speech technologies and voice recognition programs' development. Its main competence lies within Russian language codification and recognition, which allow offering many security programs based on voice recognition for Russian speaking consumers. The importance of the speech technologies is demonstrated by the fact that STC has cooperation within state criminalist projects.

5.2. Open Innovation in case companies

Case companies have demonstrated a certain level of open innovation implementation, however not at the strategic level. The knowledge of companies about open innovation concept is limited or in some cases absent. However companies' have formed suitable for them model of operation which on closer examination has a resemblance to open innovation model. Companies have demonstrated active involvement into inbound innovation processes as licensing in, technology in-sourcing, joint research and development with such organizations as universities, non-straight competitors, suppliers, research institutions and in some cases users.

Nevertheless the outbound element of innovation processes is almost absent — only one of case companies has tried to sell the surplus (in a form of patent) but failed as it had no competence of finding the buyer for it. In general, companies state that the research surplus selling out is hindered by certain innovation system incompleteness, including lack of innovation intermediaries and understandable 'rules of game' at technology market; lack of financial and time resources for developing surplus into sell-ready form and certain industry specifics. Such element of outbound process as company acquisition for reaching required technology or/and competence is not applied by any of the studied companies, what can be to certain extend explained by their relatively small size.

5.2.1. Motivation and barriers

In the environment where innovation system is still not functioning properly and the general level of openness among innovation players remains rather low, the understanding of *what motivate firms to embrace open innovation approaches* becomes crucial.

For such companies as Arcadia and Digital Design, operating in the IT field, the integration of their vendors into innovation process is essential and unquestionable. It follows the widespread model of software development on the platforms provided by vendors as Microsoft and others. Hence, one of the reasons to embrace open innovation approach lies in industry and business specifics. Most of the clients of Arcadia are located in either USA or Nordic countries, and some of the clients are active in open innovation implementation. This means that for these clients cooperation with Arcadia goes not only in terms of technology outsourcing but also inside the open innovation model. Hence, Arcadia is involved into global open innovation processes through its clients. Digital Design in its turn has partnership relations with such a famous company operating within open innovation model as IBM.

Accordingly, another reason for embracing open innovation approaches may lie in the partner/client relationships with the active open innovation users.

The reason for technology in-sourcing for these two companies may lie in cutting time and financial costs for development as well as project overload, which need attracting additional people. Arcadia has a few constant partners, whom they engage in case of need. For Digital Design collaboration with universities is more relevant.

On the other hand there are certain barriers which prevent companies from more profound open innovation process embracement, including e.g. business-model specifics, as outsourcing involves at certain extend non-disclosure agreements with clients. Non-disclosure agreement prevents some kinds of involvement of third parties into development process as e.g. utilization of open source can be done only after approval from client.

The intellectual property (IP) rights always belong to the client and this imposes some restrictions on the surplus, which can be created during the development process. Consequently, surpluses are usually left without further development to avoid IP disputes.

For Med-Byte the main reason and barrier to embrace open innovation is its size. Company of five employees has no own R&D and production facilities, and these processes are conducted with partners at their sites. The partnership relations of Med-Byte are rather strong; every partner plays an important role in the innovation process. Among partners are such innovation players as universities, medical research institutions and hospitals, IT and manufacturing companies. Without high involvement of suppliers and other partners the operations of the company would be complicated if at all possible.

However, the small size of the company hinders the possibility of selling out the research surplus as there is no special personnel to be engaged into search for technology buyers and the technology intermediary services are not developed in the region.

For STC one of the main motives to embrace open innovation processes is to get access to certain competences, which somebody possesses. For example they collaborate with universities and specifically with departments of Russian language studies, who provide for STC certain Russian language bases etc. The industry of operation imposes certain barriers to both inbound and outbound processes, but the industry specifics are to be more details described further.

In general, three of four case companies are very active in collaboration with universities, motivated by the low average level of current university education in certain fields in Russia. The outdated university technical base and separation of education from real business creates a gap between business demand and university 'supply' of employees. To minimize this gap and to capture further employees the case companies are tightly connected to certain city universities and participate in their educational processes.

5.2.2. Industry-specifics

As was mentioned above, certain barriers and motives for open innovation evolve from industry peculiarities. So, what kinds of variations in open innovation adoption does industry impose?

For IT outsourcing the implementation of open innovation is stimulated by partner/client involvement into open innovation practices. The nature of IT products, which are easy to transfer across the distances, allow the tight collaboration of e.g. USA and Russian companies and knowledge and information transfer between developed and developing countries. Hence, the influential innovations are disseminated faster. However, the specificity of client-executor relations in the sphere of technology development for the external company creates barriers to integration of additional participants into innovation process (as described above).

The medical equipment industry creates certain preconditions for international collaboration. Every produced lot of medical device is subjected to certification when imported to EU from non-EU countries. In case of Med-Byte this leads to licensing out of few major products to European competitors, who were turned into partners by these licensing agreements. Further joint research has been undertaken together with these European companies.

The speech technology industry is hardly developed in Russia. This creates such situation for STC as almost total absence of national companies to collaborate with.

Another influence of industry is in low technology trade within it. STC explains it by the peculiarities of speech technologies — the trade in this market happens with companies and not with technologies. This happens due to the inseparable nature of technology from the company, who has developed it. The way STC chooses in such environment is close collaboration with the ones, who can add to STC own research and competences to develop needed technology, rather than acquiring existing technologies through the company buyouts.

6. Conclusions

The paper presented certain examples on what can motivate SMEs to embrace open innovation processes and be actively involved in 'trade' at technology markets; which kind of barriers they meet and how does the belonging to certain industry influence the level of involvement into technology exchange.

The conclusion can be made, that application of certain elements of open innovation model is company size specific. However this assumption need further empirical testing and further research.

Additionally it can be assumed that the level of openness may depend on company business model as e.g. production of technology for external companies as a main business involves companies from the very first days into open innovation chain.

As a concluding remark on open innovation in Russian companies can be stated, that the firms' involvement into this process is more resource driven, than strategic; this may have emerged from innovation system incompleteness in order to compensate its failures.

The paper demonstrated few examples rather than gave an answer on motivation factors and industry influence at embracement of open innovation approach by companies and their inclination to be involved into technology trade relations. Further research of a bigger sample is needed in order to be able to generalize results. The empirical quantitative research would be preferable in this case, as the research on open innovation still lacks the statistical proof.

The paper contributes to the research on open innovation, providing results from Russia as a transition economy and from SMEs companies, which are not yet widely covered in literature.

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Publication 2

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A framework for comparing regional open innovation systems in Russia

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Abstract: Like many of the post-soviet countries, Russia has entered the new century targeting at creation of competitive economy, based on knowledge and innovation with strong emphasis at the role of the regions. At the same time, the western world has entered an era of a new approach to innovation, shifting from a closed to an open innovation (OI) paradigm. This paper focuses on the development of an integrated regional open innovation system (ROIS) and introduces a framework for the analysis of OI implementation within regional innovation system in Russia. St Petersburg region of Russia is studied as an example for the developed framework. This paper contributes the ROIS and related constituting concepts by offering a framework for studying and comparing ROISs in Russia.

Keywords: OI; open innovation; RIS; regional innovation system; Russia; ROIS; regional open innovation system; BREG framework.

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1 Introduction

The importance of regions as drivers of economic growth has become increasingly acknowledged in the literature (Braczyk et al., 1998; Cooke et al., 1997; Howells, 2005). The concept of the regional innovation system (RIS), elaborated in the 1990s, approaches innovation as a systemic process (Cooke, 1992). Florida (1995) states that due to the nature of economic transformation, regions become key economic units in the global economy. The development of a broad infrastructure at the regional level is a basis for firms' growth in the knowledge economy (Aaboen and Lindelöf, 2008; Elfving et al., 2006; Florida, 1995). Howells (2005) sees the role of universities to be of highest importance for the region, as they are involved in knowledge creation and transfer. Nelson and Winter's evolutionary theory views industrial firms as the only players at the market (Leydesdorff and Etzkowitz, 1996). Leydesdorff's Triple Helix model adds beside industrial firms such market players as academic institutions and governmental agencies (Leydesdorff and Etzkowitz, 1996), introducing the three main elements of the innovation system.

The above-mentioned concepts view innovation from the systemic perspective. On the other hand, the open innovation (OI) paradigm sees innovation as a result of joint collaborative efforts of many organisations, such as firms, universities and public agencies (Aaboen and Lindelöf, 2008; Rothwell, 1992; Vanhaverbeke and Trifilova, 2008), however some researchers entitle such collaboration as open system approach (Czuchry et al., 2009). The actors within the OI paradigm are the same (but not limited to) as the main players within the Triple Helix model. Hence OI adds rather than contradicts the principles of the RIS and the Triple Helix model. This complementarity creates an opportunity to synthesise the three concepts (OI, Triple Helix and regional system of innovation) into elaborating a framework for a regional open innovation system (ROIS) (Torkkeli et al., 2007).

This paper aims at highlighting to what extent the OI approach to collaboration shapes the relations within the RIS. The RIS of St. Petersburg (Russia) has been chosen as the background for the research as it represents an indicative case of a shift from evolutionary RIS development to the construction of a top–down purposeful ROIS. Adapted to the city RIS, the Triple Helix model is used as a tool for describing relationships between the main players in the region. The analysis of Triple Helix-based linkages from the relational, OI point of view makes it possible to develop an analytical framework for analysing and comparing the ROISs of countries with similar erosion of Triple Helix model – e.g. post-soviet countries.

This paper is structured as follow: Section 2 discusses the theoretical background for emergence of ROIS and it constituting concepts. Section 3 describes research design and methodology, followed by analysis of the Triple Helix adaptation to specifics of St. Petersburg in Russia in Section 4. In Section 5, a framework for studying and comparing ROISs within Russia and other post-soviet countries is discussed. This paper concludes with the outcomes and suggestions for further research.

2 Theoretical background

ROIS has been described by Torkkeli et al. (2007) as an innovation network comprised different actors working towards the creation of innovations in a certain region.

The concept represents an integration of such approaches as RISs, the Triple Helix model and the OI paradigm, with certain roles for each of them. OI acts within this framework as a stimulating approach to collaborate inside the region of innovation; Triple Helix is viewed as a tool to describe collaboration between universities and other actors of the system, and the regional system creates a background and backs up this collaboration (Etzkowitz and Leydesdorff, 2000). The role of OI for national system of innovation has been well discussed by Santonen et al. (2008), however with a major focus on the customers' role as a resource for business community to fulfil governmentally defined national innovation strategy. ROIS approach in this paper addresses the transformation of linkages within regional system into relationships as presumed by OI approach.

While the OI approach sees innovation emerging from relationship-based collaboration between such partners along the value chain as the public sector, businesses and academic world, etc. (Chesbrough, 2004), the Triple Helix explains linkages and communications between these partners reinforced by infrastructural organisations within the regional system (Etzkowitz and Leydesdorff, 2000). A certain amount of similarities and overlapping between OI and Triple Helix approaches create an opportunity for a RIS functioning as a platform for the open model of innovation (Torkkeli et al., 2007).

Within the OI system, businesses behave as the main actors, while the universities and the public sector are supposed to be drivers stimulating and facilitating the knowledge exchange (Torkkeli et al., 2007). The most recent research on regional systems of innovation increasingly often addresses the modes and incentives for business and university collaboration (Coccia, 2008; Czuchry et al., 2009; Piperopoulos 2007; Salmi and Torkkeli, 2009). Indeed, the academic–industry collaboration became intensified throughout recent years and is seen to be gradually more crucial for industrial innovativeness (Coccia, 2008; Piperopoulos, 2007; Salmi and Torkkeli, 2009). The involvement of government (through creation of business supporting infrastructure (Aaboen and Lindelöf, 2008; Pynnönen and Kytölä, 2008) in collaborative relations with academy and industry leads the return the stream of research to the systemic view and concept of joint regional innovation (Aaboen and Lindelöf, 2008), where open system approach plays one of central roles (Pynnönen and Kytölä, 2008).

2.1 Regional innovation systems

The concept *RIS* emerged in the early 1990s (Cooke, 1992). It can be defined as an 'institutional infrastructure supporting innovation within the production structure of a region' (Asheim and Coenen, 2005). Cooke suggests analysing the RIS in terms of two subsystems of knowledge exploitation and knowledge generation (Braczyk et al., 1998). The former reflects such regional production structures as firms and their clusters; the latter is constituted by supportive infrastructure, such as technology transfer agencies, public and private research laboratories, universities, etc. (Braczyk et al., 1998). Innovations emerge from the interaction of these elements. Thus, the stronger the linkages and collaboration, the more rapid is new knowledge creation and dissemination in the region.

The economic growth in the region is believed to be fostered by efficient regional innovation policies; the economic growth of the whole country is in turn constituted by the regional one (Howells, 2005; Torkkeli et al., 2007; Ronde and Hussler, 2005). The RIS represents on one hand a smaller replica of the national innovation system, and on the other hand a subsystem, a detached but related element of national innovation system. This allows discussing the application of the Triple Helix model at the regional level as well.

The RIS can be defined as a set of innovative networks and institutions located in a certain geographic area, with regular and strong internal interaction that promotes the innovativeness of the companies in the region. Schiuma and Lerro (2008) approach the region from the perspective of its innovation capacity meaning 'overall innovation capabilities that a region can express, practically and potentially', distinguishing regional stakeholders, networking and local resources as main dimensions affecting this capacity. The openness of the regional firms adds to a certain extent to the efficiency of the RIS by integrating business into different types of relationships, such as business-to-business collaboration, public private partnerships, etc.

2.2 Open innovation

The propensity to collaborate for innovation and to open up the company's borders became intensified in the 1990s (Gassmann, 2006; Gassmann and von Zedtwitz, 1998), and the movement towards OI began, culminating when Chesbrough raised the issue of whether OI is 'the new imperative for creating and profiting from technology' (Chesbrough, 2004).

The OI model emerged as an opposite to the traditional closed innovation model, where every step of the innovation creating process was done inside companies (Gassmann and von Zedtwitz, 1998): own ideas generation, their development, product manufacturing, marketing and distributing were the spheres of the strategic interest of the company. Companies invested heavily in R&D, aiming to surpass competitors in launching new products, and tried hard to hire and hide the 'best brains' to make sure that the industry's smartest people worked for them (Chesbrough, 2003).

However, due to such factors as the increased availability and mobility of skilled workers, emergence and fast development of the venture capital market, external options for unutilised ideas (as opportunities to sell IP, spin offs, etc.) and the increasing capabilities of external suppliers and their integration into the innovation process, erosion of the traditional model has happened, leading to the OI paradigm (Chesbrough, 2003, 2004; Enkel et al., 2009; Gassmann, 2006). OI represents an approach to innovation which goes far beyond the boundaries of a single organisation, where a company commercialises both its own ideas as well as ideas from other sources (other firms, research institutions, etc.). On the other hand, the paradigm also implies that the newest inventions can be realised outside the firm, bringing in additional value (Chesbrough, 2003, 2004; Enkel et al., 2009; Kock and Torkkeli, 2008).

Based on the extensive research, Gassman and Enkel introduced three core archetypes of the OI process (Enkel et al., 2009), describing the direction of the collaborative efforts of the company:

1 the *outside-in process* implies the integration of the external knowledge of suppliers, customers, etc. into the company's own knowledge base in order to increase innovativeness

2 *the inside-out process* approaches by increasing the profit by bringing ideas to market, selling IP and transferring ideas outside the company

3 the *coupled process* integrates (1) and (2) by utilising both external sources for acquiring knowledge and disseminating it and by working with complementary partners.

The OI model adds to the understanding of innovation management, treating external knowledge as important as internal one. OI implies opening up for collaboration, hence an OI approach by regional companies adds an important characteristic to the RIS – openness, which brings intensified collaboration between the market players, creates strong relationships between innovative actors and fosters knowledge flow.

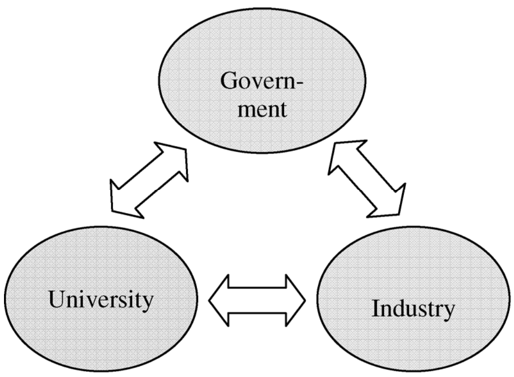
2.3 Triple Helix

Triple Helix was developed as a model explaining linkages within a national innovation system where university, industry and government feature as major actors and ‘university’ represents all scientific institutions (Saad and Zadwie, 2005). Since its emergence, the Triple Helix approach has been developed through three generations (Etzkowitz and Leydesdorff, 2000) and currently, in the OI era, the forth generation is emerging (Torkkeli et al., 2007).

If the RIS is treated as a smaller local replication of the national innovation system, the Triple Helix model can be applied to explain the linkages within the regional system. Indicating industry, university and government to be the main elements within both RIS and Triple Helix (Figure 1) demonstrates that despite these concepts assign the central roles of regional development drivers to different actors (firm and university, respectively), the concepts are more supplementary than contradictory.

Nowadays countries and regions try to utilise the Triple Helix model by creating an innovative environment consisting of university spin offs and strategic alliances (Torkkeli et al., 2007), and implementing OI within their business model. The Triple Helix model explains the types of linkages and communication within the innovation system, whereas OI implies the relationship nature of all collaboration links. Additionally, the Triple Helix of university–industry–government model does not hold for each and every innovation system, as the structure and composition of the RIS may vary from region to region.

Figure 1 Triple Helix model of university–industry–government relations



3 Research design

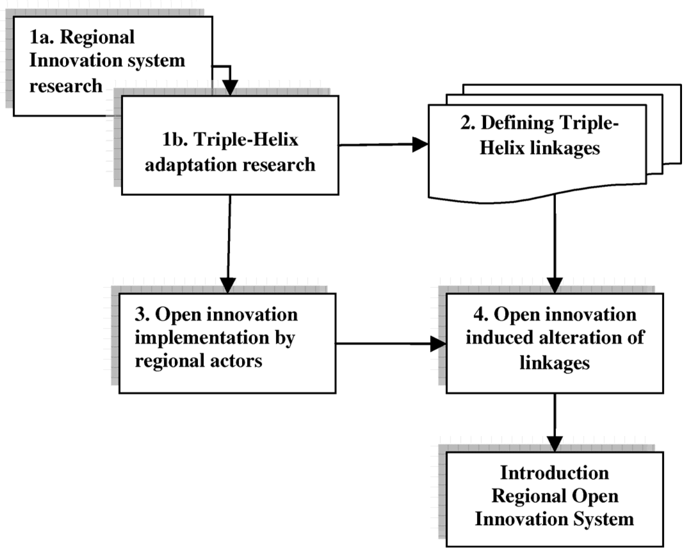
3.1 Methodology

The qualitative research method is deployed in a form of exploratory multiple case study. The case analyses is conducted using multiple sources of evidence (Yin, 1994), such as in-depth interviews, publicly available information, related scientific publications about the case area. Such type of data collection can be referred as data triangulation approach (Jick, 1979). The research of case organisations within St. Petersburg RIS was undertaken by analysing primary and secondary data sources. The primary data was collected through in-depth semi-structured interviews with four innovative SMEs in the region and three universities. The companies were interviewed about their OI implementation practices and their position within and involvement in the RIS. The secondary data was used to complete the analysis of the RIS of St. Petersburg and the Triple Helix model adaptation and to analyse not covered by interviews elements of the framework. Legislative acts, seminar proceedings, published interviews, etc. were used as sources as data.

3.2 Research layout

The research follows some lines of separated analysis, like RIS research; analysing the Triple Helix model in Russia, resulting in adapting it to county peculiarities and research on OI implementation by regional firms in St. Petersburg (Figure 2). The results of each line of analysis are integrated to form a description of a ROIS. Detection of the alteration of Triple Helix linkages by OI implementation practices is the key to distinguish ROIS from RIS.

Figure 2 Research model for RIS description



The selection of St. Petersburg as the region for research can be justified by existence of an active innovation policy in the city, probably the most active in the whole Russia, making the region one of the most innovative throughout the country. On the other hand, the research of innovations systems in Russia is rather scarce and current paper contributes to this stream of research.

4 Business–research–education–government model for ROIS

4.1 Triple Helix within the RIS in St. Petersburg

St. Petersburg is an example of city in transition towards a ROIS. The initiatives of local authorities have created certain prerequisites for such a transition, but the system cannot be viewed without taking into account innovation policies and legal initiatives issued at the country level. Nevertheless, the city was chosen for studying ROIS development as it possesses the potential to omit the phase of creating a traditional RIS and advance towards a ROIS.

This potential lies within the scientific concentration in the region, including large number of research organisations and universities (8% of all students in the county are studying in the city). Besides, St. Petersburg has over 3,000 SMEs (Dezhina and Kiseleva, 2007), about 500 of which have reported themselves to be innovative.

In 2009, Russia still demonstrates remaining features of a command innovation system as a major volume of scientific research is produced not only by universities but also by branches of the Russian Academy of Science (RAS). Moreover, RAS carries out primarily basic research; hence applied research remains undone. On the other hand, the new generation of future research personnel receives education at universities, where science is not strongly integrated into the educational process. Thereby, the creation of innovation supports infrastructure around either RAS or universities is problematic due to lack of young scientists in the former case and lack of scientific potential in the latter.

Such linkage within Triple Helix model, as industry–government, functions similarly to describe models of other countries; however, the specifics of Russian education and research sectors create certain erosion: the university element does not maintain the initial meaning imposed by traditional Triple Helix model. In developed countries universities carry out the major amount of research, whereas in Russia the research function is divided between universities and research institutions, with the latter conducting most of the basic research (Vanhaverbeke and Trifilova, 2008). The system of separating research from education goes back to the Soviet Union where research institutions were tightly connected to certain industry and were specialised in certain research field. This draw to assumption that after the collapse of Soviet Union the infrastructural component of innovation systems in newly created countries, including Russia, was inherited by them.

The role of business in the creation of scientific knowledge in Russia is rather small, with R&D expenses less than 8% and expenses for patent and license acquisition under 2% (Dezhina and Kiseleva, 2007); however, the tendency to increase R&D investments is emerging, as well as an inclination of large companies to acquire former branch research institutes.

The OI concept at the theoretical level is not yet well known in St. Petersburg region, nevertheless, with closer examination, the features of OI adoption can be found within local SMEs. The implementation of OI is mainly of the inbound type, demonstrating that companies have recognised the value of externally available knowledge and are eager to exploit it. Additionally, partnership relations between different innovation actors in the region are created due to certain innovation system failures, e.g. the level of education is estimated by businesses to be rather low because of the outdated technical base of universities and insufficient financing. Understanding that the universities are important sources of human resource creation, companies are becoming actively involved in adjusting the quality of education to their personal needs by high involvement in the education process and integration of students into business processes at rather early stages of the education cycle, as stated by the head of scientific cooperation department at one of interviewed companies:

> "University graduates are seldom well prepared to start professional working straight after university. We have developed a special course of lectures to educate the newcomers for the company. Besides, we provide internships as well as participate in education process at universities through lecturing and commenting on curriculum."

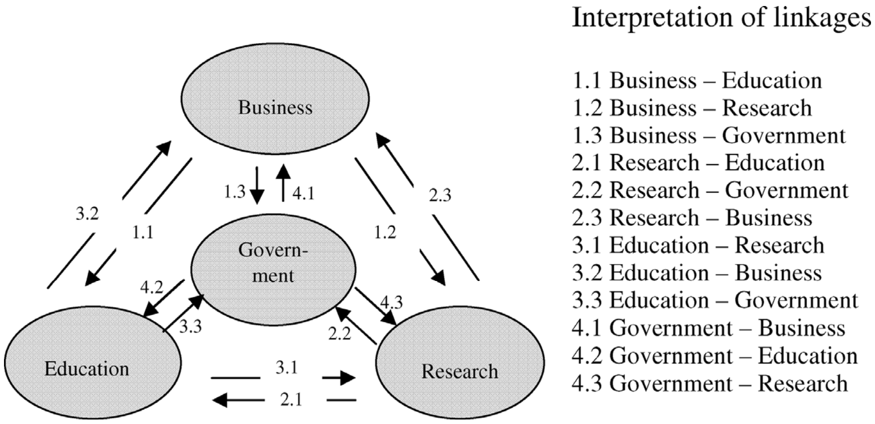
The division of basic and applied research between public and private research institutes and universities creates a need for formation of strong research–education–business relations, since universities are able to apply the outcomes of basic research into technology development projects. As companies do little research, their absorptive capacity is rather low and hence the universities act as transformers of not-ready-to-absorption knowledge into more appropriate one. The role of universities as technology transfer institutions is increasingly important in countries with a post-command innovation system where research is separated from the universities.

4.2 Business–research–education–government interconnections

As mentioned above, the research and education functions are divided mainly between universities and the Academy of Sciences, which should be reflected in the Triple Helix model by splitting one element into two (Figure 3), resulting in the appearance of a business–research–education–government (BREG) model. Every interconnection can be viewed as a double loop: in terms of what every agent receives from another and what it gives back.

There are certain specifics in the interconnections inside the Russian model of Triple Helix: the *government–business* relations are strong in two cases: when dealing with state holding ownership in the enterprise and when the enterprise personnel has informal connections to the government and the same applies to science–government relations (Dezhina and Kiseleva, 2007). However, the growing number of governmental research projects creates prerequisites for more profound cooperation. As one of companies clarified these relations: "governmental research projects are done through tenders. We participate, often win and conduct research".

Figure 3 Business–research–education–government



The research–business interconnection seems to be weakly developed, enforcing the government–research interconnection – a large share of public financing of science exists due to the low demand for scientific results from the business side. According to statistics, only 0.8% of research institutions have collaboration with business and 8% with universities (Dezhina and Kiseleva, 2007). The *research–government* connection is the only formal relationship of science in this model; all other science connections are not specified and have a random nature, which makes the scientific component the weakest in the whole model (Figure 3).

The cooperation within research–government–business–education framework is currently highly stimulated by governmental policies as stated by head of Science Park by one of the interviewed universities:

> "One of very important prerequisites to obtain governmental financing for a certain project is a formation of research consortium between research and/or educational institution and business entity"

The research–education connection is quite undeveloped due to full separation of these two spheres in the command system, and no visible interceptions. However, the trend of intensifying the university research is noticeable, and with proper support from industry, the integration of these separated components (research and education) is possible, although it would involve the restructuring of RAS and elimination of its numerous research centres.

The government–education interconnection is stronger than it should be, breaking the balance in the system, as education is primarily state financed, and the share of university research is rather small and is done mainly during the academic degree-acquiring process, which again involves governmental financing. One more complication lies within the fact that all the possessions of universities (as land, buildings etc.) are in practice owned and strictly controlled by the state, meaning that university. As mentioned by the university Science Park interviewee, "being a governmental organization, university cannot give premises for rent for SMEs, which hinder the cooperation between former and latter; it applies above all to academic spin-off organizations".

However, the *business–education* link is intensifying, demonstrating the growing interest of business in collaboration with universities and participation in educational processes, as well as in outsourcing research. Interview results demonstrated the growing acknowledgement of such cooperation by companies, as one of interviewed strategic development managers stated:

> "We do collaborate with universities. They conduct research and development for needs of our company on the basis of contractor's agreements or within partnership. We actively participate in educational programs, being involved into development and supervision of specialized education in the field at one of leading city universities."

However, this situation cannot be generalised, as there are a limited number of universities capable of doing state-of-the-art research, and the business–education linkage works only towards some selected ones. As head of scientific cooperation department of interviewed companies' state:

> "We cooperate with limited amount of universities; we have selected the best ones. The rest do not meet our requirements as their research expertise is outdated."

The government is the only element having true strong connections with every other element, which demonstrates active involvement of the state in all spheres, and which again hinders the independent development of each of system participants, which can be interpreted as a need for switching from public administrating to more flexible approaches of cooperation (Dezhina and Kiseleva, 2007).

5 Discussion

The role of OI implementation in regional development cannot be overemphasised. OI modifies every connection within the developed BREG model from a simple linkage to a strategically important relationship. The connections between the elements described above hold more or less for every region of Russia today. However, St. Petersburg with a proactive approach to create a RIS of an open type is currently in the transition towards it. To estimate the results of transition and to describe ROIS more thoroughly the longitudinal study is needed further on. Tables 1–4 represent a summary of how openness within the RIS described through the BREG model adds value to all connections between each and every elements of the system and modifies it.

5.1 Relations between business and others

Business is the most common unit for research within OI framework (Chesbrough et al., 2006) and firm-central network of partners is common to be examined. In case of St. Petersburg, the dissemination of OI philosophy revealed accumulated demand for collaboration between regional actors. Thereby, the relationship of industry and the other actors is the most obviously affected by OI adoption (Table 1).

5.2 Research networks

As defined by this study, 'research' represents the weakest element within open BREG model, positioned quite aside from other elements. Nevertheless, positive tendency towards research institutions being involved into OI can be noticed through increasing amount of governmentally initiated projects involving research parties as well as business R&D departments. The direction of movement of 'research' networks is described in Table 2.

5.3 Educational institutions and OI

The involvement of higher educational institutions in OI activity within the region is already on a very high level. The main functions though remain education and training of human resource and technology transfer services. However, following the recent regulations, the relationships between business and industry are loosing the last barriers for open cooperation – the IP issues are being clarified for governmentally funded projects involving business and research. This fosters the involvement of all actors in joint research and development projects (Table 3).

Table 1 Open innovation approach in 'business-to-REG' collaboration

	Business	*Research*	*Education*	*Government*
Business	(1) Intensified partnership links between competitors, suppliers and clients Integration of value chain participants into innovation process; exchange of technology and IP, creation of spin off companies	(1.2) Integration of research organisations into R&D by outsourcing part of research, initiating joint research, subemployment of research personnel for certain projects of organisation	(1.1) Acquiring intellectual capital (e.g. human resources), utilising university publications, collaboration within educational programs	(1.3) Collaboration within different kinds of projects to meet the needs of public agencies; business as a supplier for the government

Table 2 Open innovation approach in 'Research-to-BEG' collaboration

	Business	*Research*	*Education*	*Government*
Research	(2.3) Collaboration within research projects, academic spin offs Research creates knowledge which can be utilised by business in its R&D Academic entrepreneurship	(2) Inter-organisational networks of research institutions Networking, conferences, scientific publications OI stimulates networking and speeds up knowledge creation	(2.1) Joint research, integration of newly generated knowledge into education process; preparing postgraduates and post-doctoral students for involvement into education; basic research for further applied research by universities	(2.2) Research agencies take part in the development of state innovation and science policy, and provide research for strategic sectors of the government

Table 3 Open innovation approach in 'education-to-BRG' collaboration

	Business	*Research*	*Education*	*Government*
Education	(3.2) Human resource transfer to industry, obtaining financing through providing educational and applied research services Training and additional education for employees Technology transfer intermediation; university spin offs	(3.1) Production of human resources for research; the educational sector can act as a buffer between purely academic research and business life	(3) University collaboration for research, development of education processes; dissemination of newly acquired knowledge within university networks and its integration into curriculum	(3.3) Research within federal projects Supply of human resources for public service Participation in innovation policy definition

Table 4 Open innovation approach in, 'government-to-BRE' collaboration

	Business	*Research*	*Education*	*Government*
Government	(4.1) Intellectual property from governmentally financed business research Government may donate IP to business, carrying out publicly financed research. The government issues policies which secure the openness of business and create an infrastructure to stimulate knowledge flow	(4.3) Financing; the government acts as a client (tenders) Providing favourable conditions for new knowledge generation within basic research fields	(4.2) Cooperation within federal projects Development of legal basis for stimulating innovative activity of universities, IPR of university research outcomes, and university spin offs	(4) Collaboration between different public agencies, synchronisation of their policies, and initiatives for stimulating innovation development in the region

5.4 Government within OI networks

Government of St. Petersburg can be identified as the most active local administration what comes to innovation and support of innovation activities in Russia. Government often acts as a regulatory body developing the rules for involvement into cooperational projects as well as initiating many of them through creating support infrastructure, attracting venture capitalists and other investors to the region and stimulating creation and development of innovative start-ups (Table 4). The interconnection of government with the other elements within OI framework is rather strong however still remains more on regulatory-coordinating, than on partnership level.

6 Conclusions

Cooperation of regional actors currently reaches new heights following OI approach, widely accepted in western business practices. However, the contribution of 'OI way' of cooperation is not always obvious for public actors. This research demonstrated the situation when all the participants of regional system are moving towards cooperation in an open way. Taking into account the specific historical heritage of national system of innovation in Russia and most post-soviet countries the certain adaptation of Triple Helix model was suggested, following at the example of Russia the phenomenon of separation education and research in post-soviet countries. The further research is needed in order to asses the state-of-the-art situation in some other post-soviet countries for verifying the offered framework for analysis.

This paper contributes to the stream of research on OI practices at the regional level of analysis as well as to the research of OI practices and regional systems within transitional economies. Introduced in this paper BREG model allows describing the ROISs of countries having similar innovation system paces of development as Russia. On the other hand, the BREG model facilitates comparing the RISs within Russia and demonstrates the influence of OI adoption in the region on innovation system development.

Since this was single-region case study, there are certain limitations to apply the results to every other region in Russia, though studied region can be used as a benchmark for development of the other regions.

The OI approach in the management of innovation has shaped the relations within the RIS and led it to transition towards a regional OI system. The concept is increasingly important for countries in transition as a target point at the evolutionary development of their RISs. Future research directions should address the studies of other regions in Russia and to define the differences at the regional level of OI adoption throughout the country. The movement towards openness within RIS can be assessed following the BREG model and its characteristics presented in this paper.

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Barriers to Open Innovation: Case China

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Abstract

The notion of open innovation suggests that firms can boost their innovative performance by both acquiring knowledge from outside the company and deploying external paths to market for commercialization of non-core technologies. As innovations emerge increasingly from interorganisational cooperation, the background for such cooperation can also have an impact on the involvement of companies into open innovation processes. Thereby this paper proposes to analyze the barriers towards open innovation from three different aspects, such as internal firms' environment, institutional factors or innovation system and cultural background. Our findings indicate that economic systems and institutions (in particular the protection of IPRs) may have large effects on the behaviour of firms with respect to their engagement in open innovation practices. On the other hand, our results also suggest that the importance of appropriability regime may differ in the buy and sell sides of knowledge, and finally we demonstrate the influence of peculiarities of national cultures upon the adoption of certain elements of open innovation model.

Keywords: Open innovation; markets for technology; intellectual property rights; organizational culture.

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Introduction

Business cannot avoid the influence of the recent change in the operating environment: competition has become intensified, knowledge diffusion is becoming increasingly broad and fast, amounts of R&D investments growth rapidly and at the same time the life-cycles of products and technologies are shortening. In order to optimize product development and fit it into shortened time frames, the firms need to be able to utilize multiple knowledge sources, and apply new approaches to management of intangible assets. (Miller and Langdon, 1999)

The concept of open innovation suggests, among other things, that firms can enhance their innovative performance by acquiring knowledge from external sources, as well as benefit financially by using external paths to market for internally generated technologies that do not fit the current business model (Chesbrough, 2003; Gassmann and Enkel, 2004). An open innovation model also emphasizes that innovations emerge increasingly as a result of inter-organizational cooperation, which means that the concept is relevant not only at a company level, but also at the regional and country levels. When examining implementation of open innovation in a regional context, however, it is important to notice that economic systems and institutions in different regions and countries differ in their support for open innovation practices (Nelson 1993). For example, the strength of IPR protection varies between countries, which may significantly affect firms' desire to buy, sell or collaboratively create new knowledge. Moreover, countries differ in various structural and cultural issues that may affect firms' willingness to use open innovation practices. It is therefore of great interest to identify which factors have the most significant effect on knowledge flows between organizations within a given region or country.

In this paper, we will examine implementation of open innovation in Chinese firms. In particular, we focus on the relative importance of different institutional, structural and cultural factors that may affect the use of open innovation practices in China. Hence, we view the barriers and motivators to adoption of open innovation practices from three different levels of analysis: (1) internal factors of the firm, such as e.g. R&D intensity and availability of surplus technologies; (2) innovation system level as for instance influence of innovation policies and public funding on firm's involvement into open innovation processes and (3) cultural level, i.e. certain features of national and organizational culture creating an attitude towards the use of open innovation practices within the company.

The paper is structured as follow: first, the theoretical background on open innovation is presented and hypotheses introduced, followed by the overview of national innovation system of China as the important environment influencing the adoption of open innovation practices; next the data and methodology are described and the paper concludes with the results of analysis.

Theoretical Background on Open Innovation

The notion of "open innovation" was first proposed by Chesbrough (2003 a,b) and has quickly gained the interest of both researchers and practitioners. The model stands for the way of innovation management when company provide internally generated knowledge for the market and external knowledge to flow in for maximizing the benefit of the company. It is also described as "both a set of practices for profiting from innovation and a cognitive model for creating, interpreting and researching those practices" (West et al, 2006, p. 286).

Open innovation can be described in terms of combination of two differently directed processes: inbound and outbound. Inbound process stands for in-sourcing external knowledge through licensing in, spinning in, acquisition (in order to get valuable technology, personnel etc.) and collaboration alongside value chain. The latter can be illustrated at the example of Procter & Gamble, who cooperate with customers, suppliers, competitors and other institutions to pursue ideas, which can be utilized in the process of new product development (Huston and Sakkab, 2006). Outbound process stands for external utilization of internal knowledge. The 'surplus' of research, not fitting to current business model, used to sit on the shelf within close innovation model (Chesbrough, 2003). This means that the company had to fiercely protect this surplus by intellectual property rights in order not to lose it (as even the employees of the company could utilize the surplus for establishing own business with venture money). Open innovation approach states that the surplus can be used for realizing some potential value through selling it away to the other company, which could utilize it better within its resource base and business model.

As described by Chesbrough (2003a,b) the opportunities for sourcing the external knowledge have increased significantly and the outside-in process, or more specifically knowledge acquisition has been widely studied in the academia (Granstrand et al. 1992; Kurokawa 1997; Veuglers and Cassiman 1999), as well as practiced by the business (e.g. Procter & Gamble's Connect and Develop case (see Chesbrough et al. 2006).While the acquisition of external technologies is nowadays commonplace, the exploitation of technologies and intellectual property (IP) outside the company (outbound open innovation as defined by Chesbrough (2003) and Gassmann and Enkel (2004)) is still observed infrequently (Athreye and Cantwell 2007; Mendi 2007).

According to open innovation model, innovations emerge increasingly as a result of inter-organizational cooperation; hence, the environment of this cooperation attracts attention to the national and regional systems of innovation. The national system of innovation (NSI) refers to a framework that aims to explain the differences in innovation performance of nations through differences in their institutional support for such innovation (Lundvall, 1992; Nelson, 1993). The NSI framework stresses the idea that the flow of knowledge (and technologies) between individuals and organizational actors is key to the innovative process. While there are numerous factors that affect these knowledge flows, among the most important is the existence of various "institutions". These include, for instance, a nation's intellectual property (IP) policy, which by determining the formal appropriability of innovations (through patenting and other laws) has a significant effect on the development and diffusion of knowledge. The set of institutions also provides the framework within which innovation policies (concerning, e.g., public funding of research and development) are formed and implemented (Metcalfe, 1995).

While formal institutions to a considerable degree shape the external relationships among key actors (firms, universities, public research institutes, etc.) in the NSI, there are also structural factors that affect the flows of knowledge between firms. In particular, the industry/market structure affects, and is dependent upon, firms' rent appropriation strategies (e.g., the use of patents and technology licensing; Arora, 1997) and therefore also the knowledge flows between them. Indeed, diverse industries may represent distinct "systems" of innovation even within a nation (Nelson and Rosenberg, 1993). In the cross-country comparisons of NSIs, it is therefore important to take industry specific factors into account as well.

One of the key determinants of Open Innovation practices is the investments made by companies in research and development (R&D) activities, as well as the environmental conditions that foster the development of capabilities and on a regional and national level (Porter and Stern, 2001). On one hand, firms need to invest into R&D for development of new products and offering them to market faster than competitors. Additionally, creating knowledge assets by intensive R&D often results in surplus technologies available for sale to gain additional profit to reinvest in R&D which in its turn bring to producing new portion of surplus technologies. Active R&D activities of the company would also foster the development of high absorptive capacity (Cohen and Levinthal 1990) and hence the ability of firm to insource the external knowledge would be higher. On the other hand, intensive R&D, as it used to be in the closed innovation model, would supply companies with a lot of product ideas and new technologies, and the need for acquiring the external knowledge would decrease. For two of very first cases of open innovation – IBM and P&G studied by Chesbrough (2003) the adoption of open innovation practices came as a consequence of layoffs in R&D departments and the need to find new sources of product ideas and technologies. Hence, the intensive R&D investments may create a barrier to company openness:

Hypothesis 1a: Firms with high level of R&D intensity are less eager to embrace inbound open innovation.

Hypothesis 1b: Firms with high level of R&D intensity tend to produce more surplus technologies

Companies that operate in open innovation environment do not have to rely only on internal funding for R&D, and since firms do exist in regional systems the open innovation benefits are best achieved in regional clusters. This fact was explained yet by economists (Romer 1987; Krugman 1991) pointing out the benefits of geographical proximity and regional concentration of network partners due to reduced production and transport costs and lower costs of accessing information locally. Hence, the role of regional systems for fostering innovation activation and open innovation interactions of the firms is increasingly high, especially for small and middle-sized companies. The regional innovation system is enabled by knowledge exchanges among different actors of regional network, including governmental institutions. The nature of such knowledge exchange is in large scale defined by national policies enabling the creation and incorporation of innovation within a national economy. The studies on national innovation systems (NIS) focus on the role of nation-state in supporting the innovation activities of local enterprises and to large extent on the government-sponsored research. Such state-financed research creates benefits for both the direct recipient and related firms through the spillover effects (Nelson 1993; Bresnahan and Malerba 1999). Additionally, researchers have examined the additionality effects of public funding (Buisseret et al., 1995; Davenport et al., 1998) meaning that public funding motivates company to invest more of its own fund into R&D (since the prerequisite to obtaining the public finance is a certain amount of own capital input to the project). As we have already claimed the increase in amount of R&D funding has a positive effect on the amount of surplus technologies produced by the company. Hence:

> *Hypothesis 2a: Public funding increases R&D output and amount of surplus technologies*

However, alongside with public finding certain restrictions come in act. The national policies on innovation differ from country to country, however the general feature of every additional funding is the concern of who owns the result. A general intellectual property rights (IPR) system and particularly strong, established rules for the protection of intellectual property are referred as appropriability regime in Teece's, 1986. While a reasonable assumption is that under a weak appropriability regime firms are encouraged to protect their innovations, and are thus less inclined to share their internally generated knowledge with others, even the strong appropriability regime cannot endure the ownership of the technology made with the public finance. The national policies on innovation are the ones regulating the matters of ownership of research results (Braczyk et al., 1998); however, if the ownership of direct research results can be insured by strong appropriability regimes, the ownership of research surplus which emerged from publicly funded research is still undefined issue for most innovation policies. This leads to the contradictory to hypothesis 2a assumption that:

> *Hypothesis 2b: Firms are less inclined to sell intellectual property and technologies that result from publicly funded research projects*

Another barrier arising from IPR area relates to the costs of IP protection and the procedure of claiming intellectual property. Strong IPR protection encourages disclosure and promotes efficient trade on markets for technology (Chesbrough et al. 2006). Weak appropriability implies widespread existence of knowledge externalities (Malerba and Orsenigo 1993). Consequently, within weak appropriability regime, each individual firm will have less incentive to conduct in-house R&D; hence the amount of research surplus would decrease as well. Weak IPR protection in the end may lead to the overall rate of private sector R&D decreasing below the levels needed to sustain long-term private returns from innovation, and may therefore necessitate public support for in-house R&D. Hence, avoiding the above mentioned externalities through strong protection of formal IP is supposed to increase the willingness of companies to develop own technologies in-house. A tight IP regime does mean that it is easier for firms to acquire technologies in the marketplace; and similarly easier to sell or license own technology. IP creates a platform for "commodification" and transfer of technology (Graham and Mowery 2004) and hence for collaboration within open innovation model. Hence, the involvement of companies into open innovation may depend on the strength of IRP protection and associated with it costs and formal arrangement:

> *Hypothesis 3: The greater the complexity and cost of IPR protection, the less likely firms will engage in open innovation.*

The third level of analysis of barriers to open innovation deals with national and organizational cultures. Some researchers (e.g. Takada and Jain, 1991; Straub, 1994; Dwyer et al, 2005) suggest culture has an influence on the diffusion of innovations. The five dimension index scores of culture offered by Hofstede (1991, 2001) explains behavior of individuals and organizations by their cultural peculiarities, measured through collectivism versus individualism, level of power distance, uncertainty avoidance, masculinity or femininity and long- or short-term orientation. In case of China, collectivism ranking is high against individualism (Hofstede 1991, 2001) which should have a positive influence on open innovation since collectivistic culture is more prone to form cooperative ventures. Power distance is ranking high in China which means that the governance is very much centralized. This creates the barrier to research surplus and new ideas circulating within organization. Additionally, China is characterized by high level of uncertainty avoidance, which means that Chinese are less risk-taking. Compared with old brands, new products are more risky because the function and performance are more ambiguous. In this case, people from countries characterized by strong uncertainty avoidance are less innovative than people from countries characterized by weak uncertainty avoidance.

China has a long-term orientation culture, and it scores the highest of all national cultures in the long-term orientation score. This is of the highest important for open innovation practices adoption, since people in long-term orientated culture focus on saving (Hofstede 2001). Hence the habit of shelving technology comes from long-term orientation as well as the resistance to sell the research surplus - Not Sold Here syndrome – can be connected to the long cultural tradition of waiting to get the reward in long-term; when the resistance to sell out the technology will emerge from believe that it will be useful to the company in long-run. Since, the long-term orientation is the strongest feature of Chinese culture (Hofstede 2001), we claim that it has an impact on development of strong Not Sold Here syndrome and utilization of outbound open innovation.

> *Hypothesis 4: The high cultural long-term orientation of the firms causes strong Not Sold Here syndrome and decreases the tendency to utilize outbound open innovation.*

Innovation System in China

Civil research and development (R&D) activities in China were for decades limited in scale, scope and depth and separated from production. In the early phase of the economic transformation prompted by the "open door" policy, new knowledge and innovation still played a modest and largely passive role in economic growth and were mainly embodied in the growing capital stock, including the first wave of foreign investment. (OECD 2007)

The origin of the Chinese innovation system can be traced back to the mid-1980s (Gu and Lundvall 2006) when reform of the science and technology system was included in the broader agenda of economic reforms. Science and technology industrial parks, university science parks and technology business incubators were started as new infrastructures to encourage industry-science relationships, and spin-offs from public research organizations started to fill the gap. The maturing of the system was accelerated in the 1990s through the combined effect of continued international opening (e.g. accession to the World Trade Organization in 2001), improvement of corporate governance and key framework conditions for innovation (e.g. protection of intellectual property rights) as well as further reforms of the university and public research sectors (OECD 2007).

By the turn of the century, a combination of experimental national policies in special zones, bottom-up initiatives supported by regional and local authorities, and top-down systemic reforms had created a Chinese NIS under construction.

As a result of external pressures and to meet its own economic objectives, China has been moving its intellectual property rights (IPR) regime closer to those found in many more developed nations. As China's economy grows, its transition from manufacturing-based to knowledge-based production, more comprehensive laws, and more attention to enforcement have led to an increase in the number of IPR infringement cases being brought before the courts or taken up through China's administrative procedures. Allowing IP owners to recover their economic damages from infringers is an important component of a system for IPR protection. Properly determined, damage awards can serve as an effective deterrent to IPR violations and protect the incentives to innovate (Sepetys and Cox 2009). China has got a comprehensive IPR legislation system, basically in conformity with international norms, and standards: Trademark law (1982), Patent Law (1984), Copyright's law (1990), however the IRP infringements are still commonplace.

Data and Methodology

We test the validity of our hypotheses with data that comes from a recent international survey on open innovation practices. In the case of China, the data were collected through email and a paper survey, and also by phone in a few cases. Around 800 target companies for the survey were selected from the firms operating in the

Yunnan Province and of these 501 responded to the survey. The majority of the responding firms (69.5 percent, 348 firms) belong to the manufacturing sector, but the service sector also represents a significant industry segment among the respondent firms (16.8 percent, 84 firms). With regard to size (number of employees) and the level of R&D intensity (investments per revenue ratio) of the companies, the distributions are as follows:

Size (employees)	No.	%
Micro (< 10)	3	0,6
Small (< 50)	146	29,1
Medium-sized (50-250)	203	40,5
Large(> 250)	148	29,5
Not defined	1	0,2
Total	**501**	**100**

R&D intensity	No.	%
0 - 1,5 %	116	23,2
1,5 % - 3 %	198	39,5
3 % - 5 %	156	31,1
5 % - 10 %	30	6,0
10 % -	0	0,0
Not defined	1	0,2
Total	**501**	**100**

Table 1. The size distribution and R&D intensity of the respondent firms

The questionnaire was designed in a straightforward way to collect primarily factual information on basic firm demographics, practices with respect to the acquisition of external knowledge as well as the selling of internally generated knowledge into the external market, and, finally, practices and experiences regarding research collaboration with other firms and public institutions.

In order to test hypotheses 1a, 1b, 2a and 2b, we created two variables for measuring the firms' propensity to engage in inbound and outbound open innovation. More specifically, the survey responses to the following questions were converted into two binary variables ***Open Innovation In*** and ***Open Innovation Out***:

- How well does the in-house R&D of your company match with your technology requirements?
    - Completely
    - We sometimes acquire external technologies
    - The utilization of external technologies (and knowledge) is vital in our business

- To what extent your R&D results in new technologies or intellectual property that you are not able to utilize in your current businesses?
    - We have no such technologies
    - "Surplus" technologies emerge unavoidably, because only a part of emerging technologies can be commercialized
    - The development of technologies and intellectual property for external organizations is a central element in our business model

If respondents checked the option 'completely' in the first question, we set the value of ***Open Innovation In*** to 0 and 1 otherwise. Similarly, if the respondent indicated that they have no surplus technologies (the first option in the second question), we set the value of ***Open Innovation Out*** to 0 and 1 otherwise. Since these two dependent variables are dichotomous, we employ binary logit regression models to test our hypotheses.
For hypotheses 1a and 1b, we use ***R&D intensity*** as an explanatory variable (an ordinal scale with 5 levels). Furthermore, for hypotheses 2a and 2b, we created a binary explanatory variable ***Public funding*** indicating whether the firm has received public subsidies for its own R&D projects (if the respondent answered affirmatively to the corresponding question, the value is set to one, zero otherwise). Finally, we use two control variables in the regressions: a dummy variable ***Non-manufacturing*** (indicating that the firm does not belong to the manufacturing sector) and ***Size***, which is modeled as a

series of three dummy variables to reflect the employee-based size classes (see Table 1). Size classes include ***small*** (number of employees less than 50), ***medium*** and ***large***, with the small dummy being excluded from the regressions.

Results

First, with regard to the effect of a firm's R&D intensity on its propensity to engage in inbound and outbound open innovation, our regression results can be found in Table 2. We find that the coefficient for the main explanatory variable ***R&D intensity*** is statistically highly significant and has the expected sign in both models 1 and 2, which include ***Open Innovation In*** and ***Open Innovation Out*** as dependent variables, respectively. We can therefore conclude that the data supports both hypotheses 1a and 1b, i.e., the higher the level of a firm's R&D intensity, the less likely it will acquire external technologies and the more likely it will have surplus technologies to offer for other organizations. The results from the first two models also show that a firm's industry has an effect on its open innovation practices. That is, the surveyed companies that do not belong to the manufacturing sector seem to be more likely to engage in both inbound and outbound open innovation. Moreover, while a firm's size does not seem to influence its utilization of external technologies, the results suggest that smaller companies are more likely to have surplus technologies and/or develop technologies for other organizations. This finding is quite consistent with the assumption that small firms rarely possess all the needed complementary assets to commercialize an innovation and therefore must license or sell their technologies to larger companies.

	Dependent variables		
	Model 1 ***Open Innovation In***	Model 2 ***Open Innovation Out***	Model 3 ***Open Innovation Out***
constant	2,579 *** (0,408)	-3,676 *** (0,411)	-3,998 *** (0,441)
R&D intensity	-0,570 *** (0,148)	1,242 *** (0,153)	1,094 *** (0,157)
Public funding			1,060 *** (0,264)
Non-manufacturing	0,941 *** (0,307)	0,417 * (0,244)	0,626 ** (0,259)
Size medium	-0,161 (0,300)	-0,644 ** (0,276)	-0,547 * (0,284)
Size large	0,381 (0,343)	-0,919 *** (0,319)	-1,099 *** (0,331)
N	498	498	485
LR (χ^2 test)	27,965	89,635	105,746

(Standard errors in parentheses. * Significant at 0.1 level, ** significant at 0.05 level, *** significant at 0.01 level; two-tailed tests. All χ^2 tests significant at 0.01 level.)

Table 2. The results from logit regressions

In order to examine the effect of received public subsidies on the extent to which a firm's R&D activities result in surplus technologies and, consequently, it's propensity to engage in outbound open innovation, ***Public funding*** is added as an explanatory variable to the regression in the third model. In this model (see Table 2 for the results), the coefficient of ***Public funding*** has a positive sign and is statistically highly significant, which means that from the two competing hypotheses, 2a and 2b, the first is supported by the data. In other words, the output additionality effect clearly dominates the restrictive effect caused by a weak appropriability regime (the low level of intellectual property protection) in the surveyed Chinese companies.

Next we turn to the most important barriers that firms perceive when it comes to engaging in open innovation. In the questionnaire, two questions were included to assess the importance of various barriers to both the utilization of external technologies (inbound open innovation) and offering (selling) technologies to other organizations (outbound open innovation). In addition to a field in which the respondent could specify other barriers, four previously identified key barriers were suggested in both checkbox -type of questions. First, Table 3 presents the results with regard to the main barriers to the utilization of external technologies.

Barrier	No.	%
"Not Invented Here" [B11]	73	14,6
No adequate technologies on offer [B12]	288	57,5
Takes too much time/resources [B13]	141	28,1
Fear of losing own innovation ability [B14]	49	9,8
Other barriers [B15]	4	0,8

Table 3. The main barriers to inbound open innovation.

As one can see, the lack of desired technologies on offer is most frequently perceived as a barrier to inbound open innovation. This finding therefore clearly reflects the underdeveloped state of markets for technology in China. Moreover, while the costs of and time requirements for external technology acquisition are seen as important barriers less often, almost thirty percent of the respondents had checked this option. The "Not Invented Here" syndrome was seen as a major barrier by only about fifteen percent of the respondents, but the result still shows that cultural barriers play a role in firms' willingness to utilize external technologies.

An interesting question is to what extent the perception of different barriers depends on the level of a firm's 'openness'. The following Table 4 presents the distribution of answers to the same question for firms in which 1) in-house R&D completely matches technology requirements, 2) external technologies are sometimes acquired, and 3) utilization of external technologies is vital for the business. While it is obvious that the firms that do not utilize external technologies have not considered, and therefore do not report on, different barriers, it is somewhat surprising that the four main barriers are identified almost equally often by firms that sometimes acquire external technologies and firms for which the utilization of external technologies is vital. On the other hand, the fact that both those firms that report utilizing inbound open innovation only occasionally and those that are crucially dependent on it perceive the different barriers similarly clearly suggests that the above factors may have a significant negative effect on open innovation practices.

Barrier / level of openness	B11	B12	B13	B14	B15	**Total**
1 (N = 90)	0	1	0	0	0	**1**
2 (N = 220)	40	167	65	29	2	**303**
3 (N = 190)	33	120	76	20	2	**251**
Total	**73**	**288**	**141**	**49**	**4**	**555**

Table 4. The main barriers to inbound open innovation with respect to firms' 'openness' (N = number of responses)

The results concerning the main barriers to offering technologies outside are in turn presented in Table 5. While the suggested factors are in general less often perceived as major barriers in the surveyed firms (as compared to the barriers to inbound open innovation), almost one fifth of the respondents indicated that the complexity of intellectual property rights (fear of infringements) has a negative effect on the firm's propensity to engage in outbound open innovation. This finding therefore provides support for our hypothesis 3. In other words, the complicated IPR protection issues create a barrier for firms to utilize open innovation practices.

Moreover, the fact that "Not Sold Here" syndrome is perceived as a major barrier to outbound open innovation by over ten percent of the respondents clearly supports our hypothesis 4, according to which cultural peculiarities impose a barrier towards outbound open innovation in Chinese firms creating protective attitudes towards the external exploitation of knowledge (expressed through Not Sold Here syndrome).

Finally, considering that the lack of desired technologies on offer is perceived as a major barrier to inbound open innovation, it is quite expected that the difficulty of finding buyers for technologies is a barrier to outbound open innovation. That is, both of these barriers result partly from the lack of marketplaces for technologies in China.

Barrier	No.	%
"Not Sold Here" [B21]	54	10,8
Complexity of IPR, fear of infringements [B22]	94	18,8
The difficulty of finding buyers [B23]	49	9,8
Lack of marketplaces for technologies [B24]	21	4,2
Other barriers [B25]	2	0,4

Table 5. The main barriers to outbound open innovation

If we again examine the importance of the above barriers with respect to firms' openness (see Table 6), we can see that the complexity of intellectual property rights is the most important barrier to outbound open innovation (relative to other barriers) especially among the firms for which the development of technologies for other organizations is core to their business model (3). In fact, 41 of the 48 respondents considered this factor to be a major barrier to the external exploitation of knowledge. On the other hand, in firms in which surplus technologies emerge unavoidably (2), three of the most often identified barriers to outbound open innovation are more evenly distributed among the answers.

Barrier / level of openness	B21	B22	B23	B24	B25	**Total**
1 (N = 374)	0	0	0	0	0	**0**
2 (N = 78)	40	53	35	15	0	**143**
3 (N = 48)	14	41	14	6	2	**77**
Total	**54**	**94**	**49**	**21**	**2**	**220**

Table 6. The main barriers to outbound open innovation with respect to firms' 'openness' (N = number of responses)

Taking all together, the results of the survey provide direct support for our hypotheses 1a, 1b and 2a, as well as indirect support for hypotheses 3 and 4. More specifically, of the various company level factors R&D intensity is inversely related to participation in inbound open innovation and directly related to participation in embracing outbound open innovation.

The effects of national level barriers (the firm's external environment), such as weak intellectual property protection and the complexity of intellectual property rights, in turn hinder the involvement of firms into open innovation practices. It was also found that public subsidies have a positive (additionality) effect on firms' R&D output, which may lead to their increased propensity to engage in outbound open innovation activities despite the weak appropriability regime often associated with publicly funded projects. Moreover, the underdeveloped state of markets for technology forms a barrier to open innovation practices in China.

Cultural factors explain certain attitudes towards openness of the firm as e.g. "Not Sold Here" syndrome can be explained by strong long-term orientation of Chinese culture and it creates an important barrier to outbound open innovation. Hence, it can be summarized that Chinese firms have protective attitudes towards the external exploitation of knowledge resulting from the cultural peculiarities.

Conclusions

Our findings indicate that economic systems and institutions (in particular the protection of IPRs) may have large effects on the behavior of firms with respect to their engagement in open innovation practices. On the other hand, since our results also suggest that the importance of appropriability regime may differ in the buy and sell sides of knowledge, the effects of property rights protection and its relationship to other structural issues ought to be more fully explored in future research.

IPR protection can promote innovation and economic development, through attracting FDI and strengthening incentives to innovate by domestic firms. The coherence between IPR and other policies and among the various entities involved in development and implementation of IPR policies is important. There is a great potential benefit for China from developing and exploiting intellectual property as part of its economic development strategy based on technological upgrading, and integration into the world economy.

We have claimed in this paper that the internal factors in the companies are influencing the adoption of open innovation alongside with institutional and cultural factors. However, to confirm the strong influence of latter the cross-cultural comparison might be considered as a direction of further research as well as the comparison of national systems of China and some developed countries.

One of the major limitations to the study is comes from the data collection, as only one region of China was studied and taking into account the possible differences in economic development between different regions of China, we cannot generalize all results to the whole country. However, such aspect as national culture and IPR issues (at the level of legislation and national policies) is similar across the whole country.

Overall this paper is relevant not only for academics, but also for policy makers interested in fostering innovativeness in their domains. That is, the development of a more supportive environment for open innovation (an "open innovation system") should be a highly important goal in regional and national innovation policies.

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National innovation system for open innovation: facilitator or impediment?

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Abstract: Barriers of open innovation result from both internal and external factors. One of the most important external/environmental factors affecting knowledge flows between organizations and, hence, the utilization of open innovation is the national innovation system (NIS) and its institutions. This study therefore aims at clarifying the influence of economic systems and institutions on open innovation practices by examining barriers to open innovation in three countries: Finland, China and Russia. The study distinguishes the main factors within national system of innovation influencing the open innovation practices of companies and the barriers arising from them.

Keywords: open innovation, national innovation system, NIS, institutions, barriers

1 Introduction

Open innovation can be defined as a constellation of knowledge exchange practices between the firm and its environment, consisting partner of public and/or private organizations, research institutions etc. (Chesbrough 2003). The systemic approach to co-existence of these actors within one geographically defined area is offered by stream of research on national innovation system (NIS) (Nelson, 1993, Lundvall 1992; Edquist 2006). It is important to acknowledge, that firms adopting open innovation approach to innovation management are operating inside diverse environments (Lichtenthaler 2009), and are exposed to the influences of these environments' mechanisms. The business environment can be analysed from the standpoint of business support infrastructure (Dezhina 2004; Elfving et al. 2006; Filho 2006) and mechanisms (regulations, norms, laws). According to NIS and open innovation main postulates, government can be one of the actors involved in collaborative innovation, it can moderate the collaborative relationships by providing support and incentives, as well as it can regulate them legally. NIS studies have mainly focused on the role of nation-state in supporting the innovation activities of local enterprises and to large extent on the government funded research (Bruton et al 2010). Some streams of the NIS research concentrate on the whole system benefits from spillover effects of public financed research (Nelson, 1993; Bresnahan and Malerba, 1999). Researchers have also discovered the additionality effects of public funding (Buisseret et al., 1995; Davenport et al., 1998) stating that public funding motivates a company to invest more of its own funds in R&D (due to the mechanisms created to issue public funding require the certain own investments from business). Hence, the main research question of this paper is *whether NIS through its institutions and organisations supports the open innovation initiatives of the firm*. By examining various barriers to open innovation in China, Finland, and Russia with rather different national innovation systems, we test the following assumptions: positive effect of R&D funding on the amount of surplus technologies produced by the company; their readiness to sell intellectual property and technologies that result from publicly funded research projects; and the impact IPR regulations have on technology transactions.

The paper is structured as follows. This introduction section is followed by an extended theoretical discussion, which analyses the interaction between NIS and OI concepts, outlines the main requirements for NIS development to facilitate OI implementation, and introduces key hypothesis to be tested in this research. Subsequently, we describe the data collection and discuss the methods applied to analyse the data. Thereafter, we present the results of data analysis and then discuss some key findings and the main conclusions that can be drawn from them.

2 Theoretical background

2.1Open Innovation

Traditionally, most industrial firms have focused on internal development of new technologies and implementation of them within company into own products. In 1990s, the situation started to change due to the development of markets for technologies (Arora et al. 2001). This has led to the situation when companies were using external technologies and knowledge in their R&D processes to bigger extent (Grandstrand et al. 1992). The essence of open innovation, introduced in 2003 (Chesbrough) is in combination of purposeful inflows and outflows of ideas, knowledge and technology to and from company respectively, aiming to increase company's performance in the long run. Gassmann and Enkel (2004) have distinguished three core processes of open innovation: outside-in, inside-out and coupled processes. The outside-in process refers to technology acquisition, the inside-out process – to the external commercialization of own technology. The coupled process represents the combination of the two mentioned and is not separately reviewed in this paper.

One of the major novelties of OI approach is the way it offers to manage the research surplus, previously considered to be the research “waste”. The inbound OI or acquisition side of open innovation is reviewed to big extend in the literature collaborative innovation etc (Allen and Cohen, 1969; Hagedoorn, 1990; Mowery 1983; Cohen and Levinthal 1990), horizontal and vertical integration (e.g. cooperation with users by von Hippel (1988), and network model of innovation (Rothwell and Zegveld 1985). The inside out process has attracted less attention in the literature, apart from extensive coverage recently by Lichtenthaler (2007, et al. 2010; and Ernst 2006, 2007). However, outbound open innovation is particular area of company activities, exposed to the influences from external environment.

2.2 National Innovation System

The expression “national system of innovation” (referred to as National Innovation System (NIS) in this paper) was first used by Freeman (1987). He defined it as “network of institutions in the public and private sectors whose activities and interactions initiate, import, and diffuse new technologies” (Freeman 1987). Two major followers are Lundvall (1992) and Nelson (1993) which represent theoretical and practical views on NIS respectively. Nelson (1993) emphasises country-case studies and focus some research on national R&D systems; Lundvall is on the other hand contributes to the theory developing by stating innovation, learning and user-producer interaction to be central (Lundvall 1992). Hence, the original definition focused on institutions within the system is not full. For sake of this paper we leave aside the question of arguing the definition of NIS but concentrate on different approaches to defining its actors and their interaction.

Lundvall defined “structure of production” and “the institutional set-up” as two most important dimensions that define system of innovation (Lundvall 1992). Nelson and Rosenberg (1993) emphasise organisations supporting R&D (i.e. promoting the creation and dissemination of knowledge) as the main innovation sources.

As mentioned above, the original definition of NIS emerged from viewing the set of institutions and their impact on new technologies. In regard to this, the stream of research on *Institutional theory*, seeking to examine the behaviour of organisations, individuals and other actors under institutional arrangements and settings (Ahlstrom & Bruton, 2010) can be mentioned here. Hillman and Keim (1995) state that to better understand the business-government interface the institutional settings should be incorporated. They stress, that apart from formal constraints (e.g. legal rules) the informal constraints (as culture and norms) should be recognised. According to North (1990) institutions together with the standard constraints of economics define the choice set of business operations, providing the incentive structure of economy. Though there is variety of approaches on how to organise various institutions (Hirsch & Lounsbury, 1997) the classification by Scott (2001) is often considered as central (Ahlstrom & Bruton, 2010). Scott (2001) differentiates between regulatory, normative and cognitive pillars of institutional theory. Regulatory one gives incentives and legal framework created by authoritative body for regulating the system actor’s behaviour (Ahlstrom & Bruton 2010); the normative and cognitive ones are social constructs, which strongly draw on culture. However, the differentiation should be made as normative pillar represents the actions the organisations ought to take, how they should behave in terms of rights and obligations (Ahlston & Bruton 2010) and cognitive one explains the actions by rather unconscious ideation structures. Busenitz et al (2000) emphasise that organisations are embedded in country-specific institutional settings based on the legal regime and the business environment. Institutions are often viewed as stable over time (Brint& Karabe 1991), which can be argued by the assumption that e.g. the regulatory framework of the country can be changed rather fast by any new regulatory document issued. Table 1 summarises main features of different approaches to system of innovation.

Table 1 Theoretical views on Innovation Systems

Approaches to environment for innovation creation	**Central actors**	**Mechanisms**	**Unit of analysis**
Traditional NIS	Industrial firms and institutions (Lundval 1992) & R&D support (Nelson, 1993)	Production of knowledge, regulating innovation environment, promoting creation and dissemination of knowledge	“structure of production” and “the institutional set-up” & organisations supporting R&D as the main innovation sources.
Triple-Helix	Government, University; Industry (Etzkowitz and Leydesdorff 2000)	Linkages between the actors operating in a helix mode	Academic institutions, governmental agencies, industrial firms
Quadruple Helix	Government, University; Industry & Civil society (Jensen & Tragardh 2004; Carayannis & Campbell 2009ab)	Innovation ecosystem meets financial and regulatory support by government to satisfy the ever-growing demand of civil society.	Academic institutions, governmental agencies, industrial firms, users
Institutional theorists	Organisations and individuals (Busenitz et al. 2000; Child, 2000),	Institutional arrangements influence the behaviour of central actors (Scott 1995, 2002) which impact firm decision making (Hitt et al, 2004 and strategies Peng Wang, 2008)	Regulatory, Normative & Cognitive institutions (Scott 2001)

Hence the institutions and the actors within the system should be viewed with more dynamic perspective as offered by Triple-Helix model (Leydesdorff & Etzkowitz 1996). In addition, the model introduces academic institutions and governmental agencies as the units of analysis to the industrial firms, formerly kept central in Nelson & Winter’s evolutionary view (Leydesdorff & Etzkowitz 1996). Howells (2002) among others sees the role of universities to be central inside the system, as they are active players in knowledge creation and transfer. What Triple Helix model emphasises the linkages between the actors of the system. Recently emerged Quadruple Helix model (Jensen & Tragardh 2004) adds the perspective of civil society (Carayannis & Campbell 2009b). In Quadruple Helix model academia and industry, together with support infrastructure provide the integrated innovation ecosystem; governments provide the financial support and the regulation system for the definition and implementation of innovation activities. Civil Society demands for ever innovating goods and services. Carayannis and Campbell (2009a) add that the participating elements in the Quadruple Helix Model are government, research and development (R&D) facilities, industrial R&D facilities, university laboratories and civil-society based sources of innovation and knowledge.

2.3 Synthesis of NIS and OI approaches

The aforementioned NIS approaches view innovation from the systemic perspective, emphasising the importance of interaction of different actors of knowledge creation and dissemination processes. On the other hand, the open innovation paradigm sees innovation as a result of joint collaborative efforts of many organisations (Aaboen et al. 2008; Rothwell 1992; Vanhaverbeke and Trifilova 2008). Besides, some researchers name such collaboration - “open system approach” (Czuchry et al. 2009), what stresses the systemic nature of co-innovation. At the first glance the players defined by the open innovation paradigm are the same as the main actors inside Triple Helix model. However, the differentiation is made in the nature of cooperation within the models: Triple Helix explains linkages, while open innovation explains relationships (Chesbrough et al, 2006). Hence, open innovation adds to rather than contradicts the principles of the national innovation system and the related models. This complementarity creates an opportunity to synthesise the evaluate the interaction of open innovation implementing firms with NIS elements and to see whether open innovation can be supported or hindered by NIS policies.

The involvement of government (through creation of business supporting infrastructure (Aabonen et al. 2008; Pynnönen and Kytölä 2008) and regulatory framework in collaborative relations with academy and industry lead the stream of research to the systemic view and concept of joint national innovation (Aabonen et al. 2008), where open system approach plays one of central roles (Pynnönen and Kytölä 2008).

Both Nelson and Lundvall define NIS in terms of factors influencing innovation process. Hence, any model of innovation process applied by firms inside NIS will be subject to external influences. According to NIS view, the main participants of innovation process are organisations and institutions, where organisations are firms, universities, venture capital organisations and public agencies responsible for innovation policy and support (Edquist 2006). The availability of funding and support organisations is included here not without a reason. The R&D intensity (or amount of R&D funding) is used in traditional innovation theory as an important measure on innovation input (Bloningen & Taylor 2000; Becker & Dietz 2004) and prerequisite of innovation output. In the open innovation settings, when not only the direct output of research effort is important, but the stock of knowledge available for sale, we view the effect which the increase of R&D funding of all kinds has on surplus technologies. Hence:

Hypothesis 1a: The increase in the amount of R&D funding has a positive effect on the amount of surplus technologies produced by the company

However, the availability of surplus resulted from R&D with participation of public money is not necessary going to be commercialised. In case when government-business link within NIS is operating well and innovation support mechanism are created, the concern does exist on how to utilise the results of publicly supported research and who would claim the ownership of the results (Braczyk et al., 1998). The concept of appropriability regime developed by Teece (1986) describes how the strength of intellectual property rights (IPR) affects the distribution of profits from innovation, as well as trade on markets for technology. The set of norms and regulations created inside NIS on how to operate in publicly-founded project are required in order to establish the suitable appropriability regime framework for such projects. Often, the reporting system for such a research is too complex and the appropriability of innovative output is not that clear. The decision on whether the outcomes of publicly funded research become a property of firm, government or joint is made at the country level. If this situation is often regulated at the stage of obtaining the public funding, the clause on who has a full right to manage the research surplus usually stays out of consideration. Not clear enough regulations in this field would lead to the result, when the research surplus will keep accumulating on the shelves since firms will be unsure whether they are allowed to commercialise it externally on their own. Hence:

Hypothesis 1b: Firms are less inclined to sell intellectual property and technologies that result from publicly funded research projects

One of very important institutional settings, as discussed above, is the legal and regulatory framework offered by the government for NIS. The regulatory settings may vary dramatically between the countries. From the transaction costs view (Williamson 1979) the cost occurring with the process of knowledge sharing can be very high. Yet, the strong regulations regarding intellectual property rights (IPR) acknowledgment and protection could counterweight the costs of knowledge transaction (Williamson 1979). IPR protection is an important instrument for government to manipulate the behaviour of the firm through regulatory institutions within NIS. An assumption is made that firms are less likely to share unprotected knowledge as compared to formally protected one. Weak appropriability means e.g. that each individual firm will have less incentive to conduct in-house R&D (Malerba and Orsenigo 1993) and, hence, less "research surplus" to be produced. Strong IPR protection, in turn promotes efficient trade on markets for technology (Chesbrough et al. 2006). Strong IPR protection creates a basis for "commodification" and technology trasfer (Graham and Mowery, 2004) and therefore for cooperation within open innovation model. On the other hand, the IPR protection by itself is rather complex and costly process in many countries, and the cost-benefit balance is not same for each NIS and not always clearly seen. When it comes to collaborative innovation, the role of IPR formalities increases even more regarding the question who owns the outcome. Additionally, internal knowledge may get exposed while joint R&D process (Busom and Fernandez-Ribas 2008) and the protection mechanisms should be sound to minimize the risks of valuable knowledge loss. Therefore:

Hypothesis 2: The greater the complexity and cost of IPR protection, the less likely firms will engage in open innovation

3 Methodology and Data Collection

Our empirical data comes from a set of surveys on open innovation practices conducted in China, Finland and Russia. In the case of China, the data were collected through email and a paper survey, and also by phone in a few cases. Around 800 target companies for the survey were selected from the firms operating in the Yunnan Province and of these 501 responded to the survey. In Finland, the survey was executed by using a web-based survey instrument. An email containing both the cover letter and a link to the web page was sent to 510 persons employed in executive or R&D management positions in Finnish firms. The firms were selected from a commercial business database (www.inoa.fi) by choosing the largest companies having their own R&D activities. A total of 59 surveys were completed, for an overall response rate of 11.6 %. In Russia the data was collected by means of structures interviews, usually of people from top management. Totally, 158 forms were filled for the survey; the response rate equalled 16 %.

In each of the three countries, the survey responses covered the whole spectrum of industries. However, while Standard Industrial Classification (SIC) codes were used in the surveys in China and Finland, a somewhat different industry classification scheme was used in the case of Russian companies. Both in China and Finland, manufacturing and services constituted the major sectors in the sample: the proportions of firms in manufacturing industries in China and Finland were 69.5% (348 firms) and 42.4% (25 firms), respectively, whereas the proportions of firms in service industries were 16.8% (84 firms) and 23.7% (14 firms). In Russia, the largest sectors in the sample were electronics (22.2%, 35 firms), food production (15.2%, 24 firms) and machinery building (13.9%, 22 firms). With regard to size (number of employees) and the level of R&D intensity (investments per revenue ratio) of the companies, the distributions are as follows:

Table 2 The size distribution and R&D intensity of the respondent firms

	China		Finland		Russia	
Size (employees)	No.	%	No.	%	No.	%
Micro (< 10)	3	0,6	1	1,7	3	1,9
Small (10-49)	146	29,1	7	11,9	38	24,1
Medium-sized (50-250)	203	40,5	19	32,2	58	36,7
Large(> 250)	148	29,5	31	52,5	59	37,3
Not defined	1	0,2	1	1,7	0	0
Total	**501**	**100**	**59**	**100**	**158**	**100**

	China		Finland		Russia	
R&D intensity	No.	%	No.	%	No.	%
0 - 1,5 %	116	23,2	23	39,0	14	8,9
1,5 % - 3 %	198	39,5	18	30,5	28	17,7
3 % - 5 %	156	31,1	5	8,5	41	25,9
5 % - 10 %	30	6,0	6	10,2	42	26,6
10 % -	0	0,0	6	10,2	12	7,6
Not defined	1	0,2	1	1,7	21	13,3
Total	**501**	**100**	**59**	**100**	**158**	**100**

The questionnaire itself was designed in a straightforward way in order to collect primarily factual information on basic firm demographics, practices with respect to the acquisition of external knowledge as well as the selling of internally generated knowledge into the external market, and, finally, practices and experiences regarding research collaboration with other firms and public institutions. The OECD country analyses and recent Global Competitiveness Indices are used to compare certain national innovation systems.

In order to test hypotheses 1a, 1b and 2, we first created a dependent variable for measuring the firms' propensity to engage in outbound open innovation. More specifically, the survey responses to the following question were converted into a binary variable ***Open Innovation Out***:

- To what extent your R&D results in new technologies or intellectual property that you are not able to utilize in your current businesses?
    - We have no such technologies
    - "Surplus" technologies emerge unavoidably, because only a part of emerging technologies can be commercialized
    - The development of technologies and intellectual property for external organizations is a central element in our business model

If respondents checked the option 'We have no such technologies', the value of ***Open Innovation Out*** was set to 0 and 1 otherwise. Since the dependent variable is dichotomous, binary logit regression models were employed to test the hypotheses.

As the main explanatory variables, we use a dummy ***Public funding***, which indicates whether the firm has received public subsidies for its own R&D projects or participated in publicly funded collaborative R&D projects (if the respondent checked either of these options in the questionnaire, the value is set to 1, 0 otherwise) and another dummy ***IPR complexity***, which has the value of 1 if the respondent indicated in the questionnaire that the complexity of intellectual property rights is a major barrier to offering (selling) technologies to other organizations, and 0 otherwise (more specifically, the questionnaire included a checkbox -type of question where four previously identified key barriers were suggested in addition to a field in which the respondent could specify other barriers). We also use ***Size*** and ***R&D intensity*** as control variables, which are ordinal scale variables with 4 and 5 levels, respectively (see Table 2).

4 Results

4.1 External sources of knowledge

We begin the comparison of the three countries and their innovation systems by looking at the firms' main sources of external knowledge, which demonstrate the collaborative innovation development processes between the actors of NIS. From tables 3a-c, we can see that the sources that were ranked most often as 'the most important' (1.) differ considerably (in the questionnaire, the respondents were asked to give a ranking of 1 to 12 to each source). First, 28.3 percent of the Chinese respondents indicated that universities and research institutions are the most important source of external knowledge and suppliers were ranked as the most important source by 21.2 percent of the respondents. In Finland, in turn, 28.8 percent of the respondents indicated that suppliers are the most important source, while only 10.2 percent saw universities and research institutions as the main source of external knowledge. Finally, in Russia 30.4 percent of the respondents stated that publications and conferences are the main source and almost an equally large share (27.8%) indicated that they most often acquire external knowledge from patent databases. Patent databases are usually main governmental source of data.

When taking into account also the external sources of knowledge that were ranked as the second and third most important, we can see that e.g. in China also contract developers are often used as knowledge sources. Moreover, in addition to suppliers, the Finnish firms often acquire knowledge from customers and companies in other industries. And in Russia, firms also acquire knowledge from competitors and universities, but less frequently. The results therefore seem to indicate that while suppliers are an important source of external knowledge for both Chinese and Finnish companies, the latter utilise knowledge from private companies much more often than their Chinese and Russian counterparts. The role of universities, and hence the Triple Helix model, in turn seems to be most pronounced in China. Finally, the fact that Russian companies use most often publications and databases as their knowledge sources suggests that collaborative innovation between different innovation system actors is less common in the country.

Table 3a. The main sources of external knowledge in China

	Ranking					
	1.		2.		3.	
Source	No.	%	No.	%	No.	%
Competitors	15	3,0	11	2,2	3	0,6
Suppliers	106	21,2	42	8,4	15	3,0
Customers	19	3,8	9	1,8	10	2,0
Contract developers (Brand-labeling)	63	12,6	67	13,4	25	5,0
Contract manufacturers	24	4,8	39	7,8	20	4,0
Companies in other industries	22	4,4	42	8,4	28	5,6
Start-up companies	6	1,2	8	1,6	1	0,2
Universities/ research organizations	142	28,3	88	17,6	44	8,8
Patent databases	3	0,6	10	2,0	10	2,0
Markets for technology	4	0,8	31	6,2	19	3,8
Publications, conferences, etc.	6	1,2	14	2,8	14	2,8
Other sources	0	0,0	2	0,4	3	0,6

Table 3b. The main sources of external knowledge in Finland

	Ranking					
	1.		2.		3.	
Source	No.	%	No.	%	No.	%
Competitors	4	6,8	4	6,8	3	5,1
Suppliers	17	28,8	8	13,6	5	8,5
Customers	3	5,1	10	16,9	3	5,1

Contract developers (Brand-labeling)	1	1,7	3	5,1	2	3,4
Contract manufacturers	3	5,1	2	3,4	2	3,4
Companies in other industries	5	8,5	6	10,2	3	5,1
Start-up companies	3	5,1	0	0,0	2	3,4
Universities/ research organizations	6	10,2	4	6,8	10	16,9
Patent databases	0	0,0	0	0,0	0	0,0
Markets for technology	3	5,1	1	1,7	0	0,0
Publications, conferences, etc.	1	1,7	6	10,2	7	11,9
Other sources	3	5,1	0	0,0	1	1,7

Table 3c. The main sources of external knowledge in Russia

	Ranking					
	1.		2.		3.	
Source	No.	%	No.	%	No.	%
Competitors	6	3,8	10	6,3	2	1,3
Suppliers	0	0,0	3	1,9	1	0,6
Customers	3	1,9	1	0,6	1	0,6
Contract developers (Brand-labeling)	0	0,0	1	0,6	1	0,6
Contract manufacturers	0	0,0	0	0,0	0	0,0
Companies in other industries	2	1,3	0	0,0	1	0,6
Start-up companies	1	0,6	0	0,0	0	0,0
Universities/ research organizations	23	14,6	9	5,7	3	1,9
Patent databases	44	27,8	2	1,3	1	0,6
Markets for technology	5	3,2	2	1,3	0	0,0
Publications, conferences, etc.	48	30,4	5	3,2	2	1,3
Other sources	0	0,0	0	0,0	0	0,0

4.2 Impacts of public funding on open innovation

With regard to different impacts of participating in publicly funded collaborative R&D projects, the results are shown in Table 4. Here, one should note that the percentage shares are not calculated from the total number of firms in the sample, but from the number of firms that had participated in publicly funded R&D projects (China: 69 firms; Finland: 33 firms; Russia: 14 firms). First, one can see that increases in knowledge about external technologies/knowledge and in collaboration with universities and other research institutions are the most frequent positive impacts of participating in publicly funded R&D project both in China and Finland. In Russia, by contrast, these impacts were reported much less frequently by the respondents. In fact, besides buying of technological solutions and intellectual property, which were reported by almost half of the respondents (6), other impacts were identified in only three or fewer companies.

When considering other frequent positive impacts in China and Finland, one may note e.g. that Chinese firms buy technological solutions quite often (in 58% of the cases) as a result of participating in a publicly funded R&D project. Another impact that is frequently reported by both the Chinese and Finnish respondents is an increased ability to absorb external knowledge (in fact, increased absorptive capacity is reported by two thirds of the Finnish respondents). An interesting finding is also that new collaboration contracts and alliances between project partners are quite common impacts in Finland, while they are reported significantly less often in China and Russia. This probably reflects the fact that firms' participation in publicly funded R&D projects is, in general, much more common in Finland than in either China or Russia (more than half of the surveyed Finnish firms had participated in publicly funded R&D projects, while only about one tenth of the respondents in China and Russia indicated that their firm had been involved in these kinds of collaborative endeavors). Finally, it is of interest to notice that although publicly funded projects result in buying of technologies and/or intellectual relatively often in China and Russia, the selling of knowledge and technologies is a much rarer impact. This finding is clearly in line with a more general observation that firms engage in outbound open innovation much less frequently than in inbound open innovation.

Table 4 The impacts of participation in publicly funded R&D projects

	China		**Finland**		**Russia**	
Impact	No.	%	No.	%	No.	%
Buying of patents/licenses/IPR	9	13,0	5	15,2	6	42,9
Buying of a technological solution	40	58,0	7	21,2	6	42,9
Selling of patents/licenses/IPR	1	1,4	2	6,1	2	14,3
Selling of a technological solution	5	7,2	6	18,2	0	0,0
New (research) collaboration contracts / subcontracting agreements	15	21,7	13	39,4	2	14,3
Alliances / coalitions between project partners	10	14,5	11	33,3	2	14,3
Emergence of spin-off companies	0	0,0	3	9,1	1	7,1
Acquisitions (as an acquirer or a target company)	0	0,0	0	0,0	1	7,1
Increased collaboration with universities and other research institutions	47	68,1	25	75,8	2	14,3
Increased patenting activeness	12	17,4	5	15,2	0	0,0
Increased knowledge about external technologies/knowledge	56	81,2	27	81,8	2	14,3
Increased ability to absorb external knowledge	30	43,5	22	66,7	3	21,4

In order to address hypotheses 1a and 1b, we also tested the possible effect of receiving public R&D funding on a firm's propensity to engage in outbound open innovation (as measured by the variable ***Open Innovation Out***). The results of the regression analysis, in which we used aggregate data from the three countries, are shown in the following Table 5 (Model 2). We can see that the coefficient of ***Public funding*** is positive and significant at 0.1 level, which suggests that a firm's participation in public funded R&D projects and/or public R&D subsidies increases the likelihood that it will engage in outbound open innovation. This also means that the results lend support to hypothesis 1a, while hypothesis 1b is not supported. On the other hand, verifying a direct causal relationship between engaging in publicly funded research projects and an increased/decreased propensity to sell intellectual property and technologies is difficult, so the results should be taken only as suggestive.

Table 5 also shows the results of a regression analysis, in which ***IPR complexity*** was used as the main explanatory variable (see Model 3). Here, one can see that the coefficient of ***IPR complexity*** is positive and statistically highly significant and that the observed dependence is opposite to the predicted one (hypothesis 2). Again, however, we must emphasise that the causal relationship is difficult to infer from the data and may in fact be in the opposite direction. That is, the result can be interpreted so that firms that are more likely to engage in open innovation simply report on different barriers more often.

Table 5 The results from logit regressions

	Dependent variables		
	Model 1	Model 2	Model 3
	Open Innovation Out	***Open Innovation Out***	***Open Innovation Out***
Constant	-2,297 ***	-2,450 ***	-4,177 ***
	(0,391)	(0,404)	(0,607)
R&D intensity	0,842 ***	0,844 ***	0,866 ***
	(0,095)	(0,095)	(0,127)
Size	-0,211 *	-0,225 *	0,050
	(0,116)	(0,116)	(0,169)
Public funding		0,327 *	
		(0,181)	
IPR complexity			6,756 ***
			(1,019)
N	694	694	694
LR test	93,336	96,635	437,493

(Standard errors in parentheses. * Significant at 0.1 level, ** significant at 0.05 level, *** significant at 0.01 level; two-tailed tests. All likelihood ratio tests are significant at 0.01 level.)

4.3 Barriers to outbound open innovation

In addition to the complexity of IPR, the respondents were also asked about other important barriers to outbound open innovation. More specifically, the questionnaire included a checkbox -type of question where four previously identified key barriers were suggested in addition to a field in which the respondent could specify other barriers. The results with regard to these barriers are shown in Table 6.

Table 6. The main barriers to outbound open innovation

	China		**Finland**		**Russia**	
Barrier	No.	%	No.	%	No.	%
"Not Sold Here"	54	10,8	3	5,1	1	0,6
Complexity of IPR, fear of infringements	94	18,8	10	16,9	30	19,0
The difficulty of finding buyers	49	9,8	16	27,1	42	26,6
Lack of marketplaces for technologies	21	4,2	4	6,8	35	22,2
Other barriers	2	0,4	4	6,8	8	5,1

One may first see from the table that the respondents in all of the three countries perceive the complexity of IPR (fear of infringements) as an important barrier to offering technologies to other organizations (this also supports the assumption of the relationship between this barrier and the propensity to engage in outbound open innovation made at the end of the previous section). In fact, the complexity of IPR is seen as the most important barrier in China, where other barriers clearly play a smaller role. This hence suggests that underdeveloped IPR regimes and policies (resulting in e.g. complicated IPR protection) have a negative effect on Chinese firms' propensity to engage in outbound open innovation. On the other hand, it is interesting to note that the "Not Sold Here" syndrome is more prevalent in Chinese companies than in their Finnish and Russian counterparts, which may reflect a higher propensity of these firms to engage in outbound open innovation activities.

Further, the difficulty of finding buyers is the most often reported barrier both in Finland and in Russia. This suggests that the firms in these two countries face more difficulties in outbound open innovation as a result of underdeveloped market for technologies. In the case of Russia, the fact that a lack of marketplaces for technologies is the second most often reported barrier also seems to support this view. On the other hand, since this barrier is significantly less often reported by the Finnish respondents, the problem in Finland may be related more to firms' attitudes toward open innovation practices than to structural barriers in the market. In other words, in Finland it is really the direct knowledge transactions between companies rather than the existence of intermediary organizations that is crucial to a more widespread adoption of open innovation practices.

5 Conclusions

The research presented in this paper demonstrated the interaction of NIS elements with OI practices of the firm in three countries: Finland, China and Russia. Certain country specific characteristics of NIS have been distinguished, as e.g. the role of universities, and hence the Triple Helix model importance in China and the less common use of collaborative innovation between different innovation system actors in Russia. One of overall finding is clearly in line with a more general observation that firms engage in outbound open innovation much less frequently than in inbound open innovation.

The results of the research show that the effects of national level barriers (weak intellectual property protection and the complexity of intellectual property rights) affect the involvement of firms into open innovation practices. Our results suggest that underdeveloped IPR regimes and policies (resulting in e.g. complicated IPR protection) have a negative effect on firms' propensity to engage in outbound open innovation. At the same time, public subsidies have a positive (additionality) effect on firms' R& D output, which may lead to their increased propensity to engage in activities on the selling side of open innovation despite the weak appropriability regime often associated with publicly funded projects.

Moreover, the underdeveloped state of markets for technology forms a barrier to open innovation practices. Economic systems and institutions (in particular the protection of IPRs) may have large effects on the behavior of firms with respect to their engagement in open innovation practices. The importance of appropriability regime may differ in the buy and sell sides of knowledge, however, which means that the effects of property rights protection and its relationship to other structural issues ought to be more fully explored in future research. Finally, strong IPR protection can promote innovation and economic development, through attracting FDI and strengthening incentives to innovate by domestic firms.

The results of the study are of high importance for policy makers at the national level and companies making decisions to internationalise to certain countries. Overall this paper is relevant not only for academics, but also for decision makers interested in fostering innovativeness in their domains. That is, the development of a more supportive environment for open innovation (an "open innovation system") should be a highly important goal in regional and national innovation policies.

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Innovating within the system: the simulation model of external influences on open innovation process

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Innovation research has been widely concerned with defining the process of new product development and factors influencing innovativeness. On the other hand, the open innovation research also started to look at what are the environments where openness brings higher benefits. In this paper we introduce the system dynamics simulation model to analyse how such external factors as markets for technology, IPR and appropriability regime as well as speed of market reactions and user needs changes are influencing innovative output of the firms inside one industry. The results show that e.g average speed of market and rather high IPR protection level increase amount of technologies introduced to the market. Additionally, the market speed change has a positive impact on new products introduction to the market; however after increasing to the certain point, the market speed becomes too high for product development to cope with, demonstrating the need for balance

Keywords: open innovation process, external environment, IPR, culture, NPD, system dynamics simulation

1 Introduction

Innovation research has been widely concerned with defining the process of new product development (NPD) and factors influencing innovativeness. The constellation of methods and processes for describing the innovation process has been introduced within last decades; however the factors influencing product development are still subjected to discussion. The internal settings of company (factors as organisational culture, R&D expenditures and overall structure) are often pointed out to be important for creating favourable conditions for developing innovation. However, the external factors might have even higher impact on the technology and product development, but often neglected.

In the age of open innovation, the NPD processes have evolutionized into the cooperative process, involving yet more intense interaction with the external to firm environment. The success of NPD under open innovation framework is highly dependent on the technology markets, IPR rights, and overall rate of competition in the market (Lichtenthaler 2009).

On the other hand, the environment of inter-firm cooperation for open innovation attracts attention to systems of innovation. National system of innovation (NIS) research (Lundvall, 1992; Nelson, 1993) assumes that the flow of knowledge (and technologies) between individuals and organizational actors is the key to the innovation-creating process. While there are numerous factors that affect these knowledge flows, among the most important is the existence of various “institutions”. These include, for instance, intellectual property rights (IPR) protection regimes, which has a significant effect on the development and diffusion of knowledge. The set of institutions also provides the framework within which innovation policies (concerning e.g., public funding of research and development) are formed and implemented.

While different viewpoints were presented to the matter of environmental influences, the relative influence of them and especially the simultaneous influence of them have not been much studied. For example, while analysing market environment, researchers have identified two factors – competitive intensity and market dynamism (Grewal & Tansihaj, 2001; Jap, 1999) and later compared between each other (Cui et al., 2006), however not taking into account simultaneous influence of other factors. Cultural environment is one more environmental factor which has not been deeply researched (Cui et al.2006).

In this paper we analyse the possible influences of external to firm environment to open innovation process and performance and hence target to answer the question *How external factors influence open innovation process and its outcomes?*

This introduction section is followed by overview of literature on the topic, emphasising studies of different environmental factors influencing innovation and specifically open innovation. The section three reviews the methodology and design of the research, comprising the components of the model described, and then followed by section four with major results of simulation. The paper concludes with general summary, overview of limitations and suggestions for further research.

2. Environmental influences to innovation

The influence of environment to the strategies and operations of companies has previously been studied mainly from the perspective of MNC entering new markets (Cui et al 2006; Luo and Park, 2001). The newer trend was to study technology transfer influencing environments, however the focus of these studies remained on intrafirm transfer (Cui et al 2006).

Classic business theories acknowledge the influence of such country-specific environments as institutional and economic, to the nature and intensity of competition and dynamics of local industries (Root, 1988; Ghoshal and Nohria, 1993). However, the shortcoming here lies in the fact that most of prior research has focused on institutional or economic factors (Contractor & Sagafi-Nejad, 1981; Marton 1986) and overlooked the importance of e.g. cultural environment (Cui et al. 2006).

Ghoshal and Nohria (1993) emphasise the critical role of environmental demands to the requirements of capabilities organisation needs in one or another settings. Shenkar (1990) stresses, that especially at emerging markets these influences will be strong due to the ambiguous property rights, imperfect markets and asymmetric information, and uncertainty in government actions.

Dess and Beard (1984) determine environments through dynamism, complexity and hostility. The high dynamism of environment is often associated with uncertainty in decision-making and fast changing demand, which is related to hostility (competition, entry barriers).

The importance of environment as an influencing factor in classic managerial theories is reflected through multiple paradigms of global competitive advantage, as firm- and location specificity (Kogut, 1985), configuration-coordination framework by Porter (1986), globalisation-localisation approach by Ghoshal (1987) and market context studies of subsidiaries of MNC by Birkinshaw (1997). Henderson and Mitchell (1997) proved the dependence of firm behaviour and industry structure and other environmental context.

Certain factors of environment have been empirically studied by previous research and proved to have a substantial impact on firm's strategies and behaviour. As such, work of Luo and Park (2001) demonstrated that market environment directly influences a firm's selection of strategy, where initiatives directly come from environmental context in which the firm operates.

Regarding the role of environment in open innovation, the work by Lichtenthaler (2009) concerns the outbound side of it, and proves the impact of outbound innovation to firm performance to be higher in the environment characterised by high degrees of technological turbulence (Gambardella et al., 2007), transaction rate (Teece, 1998), and competitive intensity (Cui et al, 2006; Lichtenthaler 2009; Fosfuri, 2006).

Among other factors of environment influencing open innovation can be mentioned development of technology markets (Gambardella et al., 2007; Arora and Ceccagnoli, 2006; Savitskaya et al., 2010), appropriability regime (Teece 1986) and IPR (regulatory institutions) (Andersen and Konzelmann, 2008; Yang and Kuo, 2008), industry structure (Savitskaya et al. 2010) and national culture (Ciu et al., 2006; Michailova and Hutchings, 2006). The main cultural aspect emerging in knowledge sharing (which underlies open innovation) is the dimension of individualism vs. collectivism (Hofstede, 2001) and universalism vs particularism (Michailova and Hutchings, 2006). These dimensions of culture are the explanations of emergence of Not Invented Here (NIH) and Not Sold Here (NSH) viruses (the structuring of aforementioned factors is suggested in Table 1).

The internal resistance to external innovations, known as Not Invented Here syndrome (Clagett, 1967; Katz and Allen, 1982; Chesbrough, 2003; van de Vrande, 2007) refers to a negative attitude to knowledge that originates from a source outside the own institution. The NIH syndrome is partly based on an attitude of xenophobia (Chesbrough, 2006) – fear and rejection of something different from us, something coming from outside. The NIH syndrome has been widely studied in the literature (for review see Lichtenthaler and Ernst, 2006) to describe the consequences that it may have in companies.

The change companies have to undergo to successfully participate in knowledge transactions require not only new operating routines and dynamic capabilities (Zollo and Winter, 2002), but also involve considerable changes into company's vision, strategy and culture (Kanter, 1983). However, the resistance to external ideas may be not only a result of business model of the company, but of each and every employee's values and beliefs, which may be a result of their national culture. But why do beliefs matter? People have

Table 1. Overview of background theories and environmental factors influencing innovation

THEORY/FRAMEWORK	OBJECTS (AUTHORS)	FACTORS	CATEGORY[1]	PROXY
International business (internationalisation of MNC)	Market environment (Grewal & Tansihaj, 2001; Jap, 1999; Cui et al, 2006)	Competitive intensity Market dynamism	2	Market Dynamics
	Cultural environment (Cui et al., 2006)	National culture Organisational culture	3	Culture
	Nature and intensity of competition and dynamics of local industries (Contractor & Segafi-Nejad, 1981; Marton 1986)	Institutions	1	IPR Culture
	Environmental demand to capabilities (Ghostal and Nohria, 1993; Shenkar 1990)	Property rights Imperfect Markets Asymmetric Information Government actions ((un)certainty)	1 2	IPR Market for technology Market Dynamics
	Dess and Beard 1984	Dynamism (uncertainty), complexity and hostility	2	
KBV	Knowledge transfer and sharing (Michailova &Hutchings, 2006)	National culture (mindset, beliefs, hostility) Technological distance	3 2	Culture Market for technology
Transaction cost	Coase 1937	Imperfect markets (asymmetric information & asset specificity) Coordinating role of institutions	2 1	Market for technology IPR
	Klein (1983)	Cost of transactions	2	Market for technology
Managerial Theory of the firm	Williamson 1966	Asset specificity of production	2	Market for technology
Cross-Cultural Management	Hofstede, 1984, 2001 Trompenaars, 1997 Michailova and Hutchings, 2006 Ethnocentrism, (Benett 1993)	Five cultural dimensions Seven dimensions Filter for external information	3 3	Individualism vs. collectivism (Culture) Culture
Open Innovation	Lichtenthaler 2009	Technological turbulence Transaction rate Competitive intensity	2	Market Dynamics
	Gambardella et al. 2007, Arora and Ceccagnoli, 2006)	Technology markets	2	Markets for Technology
	Regulatory institutions (Anderson and Konzelmann, 2008)	IPR	1	IPR
	NIH & NSH (Katz and Allen, 1982; Chesbrough 2003)	Mindset, attitudes	3	Culture
NIS	Knowledge flow (Lundvall, 1992; Nelson, 1993)	Existence of institutions as: IPR, Innovation policies (incl. public funding of R&D)	1	IPR

[1] 1. Institutional factor. 2. Structural factor. 3. Cultural factor (suggested classification)

formed those over time, mentally validated and are slow to shift substantially. Beliefs must be taken into account in order to figure out the potential for conflict, hidden resistance and improve organizational awareness and development potential. Bennett (1993) explains the tendency to filter the external information by ethnocentrism – the assumption that your own culture is central to all reality. Hence, unwillingness to accept anything created outside the culture, e.g. outside the organization. On the other hand, there may exist unwillingness to share, coming from individualistic cultures (Michailova and Hutchings, 2006; Hofstede, 2001). Hence, certain cultural values common for one whole nation might be reflected in their attitude of using results of somebody else's intellectual activity. Therefore, the attitude of not invented here will be higher in countries with high level of individualism than in collectivistic countries (Michailova and Hutchings, 2006).

While formal institutions to a considerable degree shape the external relationships among key actors (firms, universities, public research institutes, etc.) there are also structural factors that affect the flows of knowledge between firms. In particular, the industry/market structure affects, and is dependent upon, firms' rent appropriation strategies (e.g., the use of patents and technology licensing; Arora, 1997, Lichtenthaler 2009) and therefore also the knowledge flows between them.

At the market where the product development often happens as a collaborative effort, the concern does exist on how to utilise the results of combination of external and internal research inputs and who would claim the ownership of the results (Braczyk et al., 1998). The concept of appropriability regime developed by Teece (1986) describes how the strength of intellectual property rights (IPR) affects the distribution of profits from innovation, as well as trade on markets for technology. These factors do interfere with NPD process at different stages; however the impact of them to every stage is not widely studied, providing the research gap to be addressed by this submission.

3. Research method and design

The research is based on system dynamics. System dynamics can be defined as two distinctively different ways. First, system dynamics is a holistic way to analyze the dynamics of a selected system (Sterman, 2000). This approach has sometimes been labelled as 'soft' system dynamics that has been widely used by e.g. Senge (1990) in knowledge management topics. The main tool in such a research is causal mapping that is used to define the structure of system. By analyzing the system the behaviour of the system can be analyzed from the structural feedback loops in the model.

The second alternative way to define system dynamics is that it is a simulation tool used to implement mathematical simulations (Forrester, 1958; Sterman 2000). As such, system dynamics can be seen as one possible tool for a much wider set of computer aided simulation tools. Previous system dynamic research is limited in the field of innovation management (e.g. Reppenning, 2001; Morecroft, 2002), but its suitability in managerial literature has been since argued by many researchers (Warren, 2005; Harrison 2007, Gary et al. 2008). The strength of system dynamics in conceptual research is that the simulation approach allows modelling of more abstract concepts such as knowledge and know-how. The simulation tests are implemented with parameter variation where the focus is on the direct and combinatory effects of external factors to the performance of the innovation system.

Several system dynamic simulation processes have been built (Sterman, 2000, Dooley, 2002). Usually the actual simulation of system dynamic model is preceded by soft system dynamic to understand the structure of the system. The goal for this simulation stage is to identify different feedback loops in the model that are the main source of systemic complexity. Figure 1 shows a simple system that has both a reinforcing and a balancing loop. After the initial mapping is done, the actual mathematical simulation can be begun. The building blocks of mathematical simulation are stocks that are used for accumulated variables, and flows that change control the stocks. In addition to these components additional components such as information flows, variables, and delays can be included into the system. As the system becomes more complex mathematical analysis is usually needed to understand the behaviour of the system.

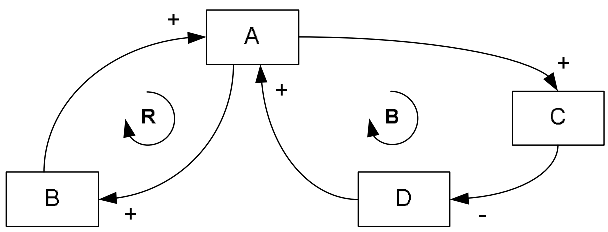

Figure 1. Examples of looks

4. Model

A system dynamics model comprising a number of environmental factors influencing innovation process was created using Vensim simulation software. The model is conceptual and is not built on real data. The relations between variables are described based on existing literature on the topic.

The presented below model is describing the relations between different factors of innovation process inside the system. The model builds on simplification of NPD process splitting it into three stages of ideation, conceptualisation/technology development and product commercialisation. Though many authors suggest that development process consist of five stages (Cooper, 1994; Cooper et al, 2002), the three stage approach is applied here in the interest of simplicity of the model. The model assumes that NPD process follows the open behaviour and does not specify it in particular in the NPD, but it is implied by nature of the factors in the environment. Following the exploration and exploitation ambidexterity, the technological development (basic R&D) is introduced as parallel process to NPD (applied R&D). The parameter *Resource use* states for the optimum combination of basic and applied research and is preset for convenience of this model. The basic assumption is that both types of R&D use same resource base and hence with increase in one the resources are lacking with other (Figure 2).

External development is first of environmental factors important for innovation process. It represents external input from such parties as government through subsidised research, academia through basic research, and other sources of external ideas/technology, which allow saving costs and other internal resources. Hence, the bigger is external input the more internal resources can be allocated to NPD.

The availability of external development is tightly connected to *markets for technology*, where trade in research results is happening. The better the markets are the lower is transaction cost and the higher is the input of external knowledge and sell of own.

However, the developed markets will be influencing also the product getting old faster, since the intensified trade in technologies will shorten the technology cycle.

Speed of user needs change stands for the competition at the market, user preferences and user understanding of their own needs. It reflects the consumers' reaction to competitive strategies of the firm and reflects some technology turbulence. For Vensim simulation model (Figure 2) speed of user need change can vary from 1 to 100.

IPR as a factor defining motivation and incentives for product development is introduced at the scale from 0 to 100 where 0 is weakest appropriability regime and 100 is strongest appropriability regime. The assumption is that the possibility to protect the technology influences on the amount of technologies developed and on the other hand the inability to protect leads to shortened development cycles.

Culture was coded as individualistic versus collectivistic countries, with data taken from Hofstede and Individualism being highest scores and collectivism – lower. Three countries were used in the modelling: China (20), Russia (30) and Finland (63).

Results

The results obtained from running the simulation rounds showed consistent with prior assumptions results, however revealed interesting behavior in terms of tipping point of open innovation performance. Thereby, the system demonstrates the interesting behaviour pattern: when IPR or technological market development tend to zero, countries with higher individualistic scores start to lose edge compared to countries with higher collectivism. In the Figure 3 it is demonstrated by viewing the performance (measured through new product output) difference between Finland and China, with China outperforming Finland. In the picture is reflected the difference in output of two contries, with China having higher output in absolute terms.

Another finding of the model suggests that there exists an optimal market dynamics; besides, if change is too fast the system does not work. In addition to this, the technology market ought to be developed enough for this effect to come in act (Figure 4). Excessively dynamic markets will lead to the behavior of the system, when the innovative output will start decreasing.

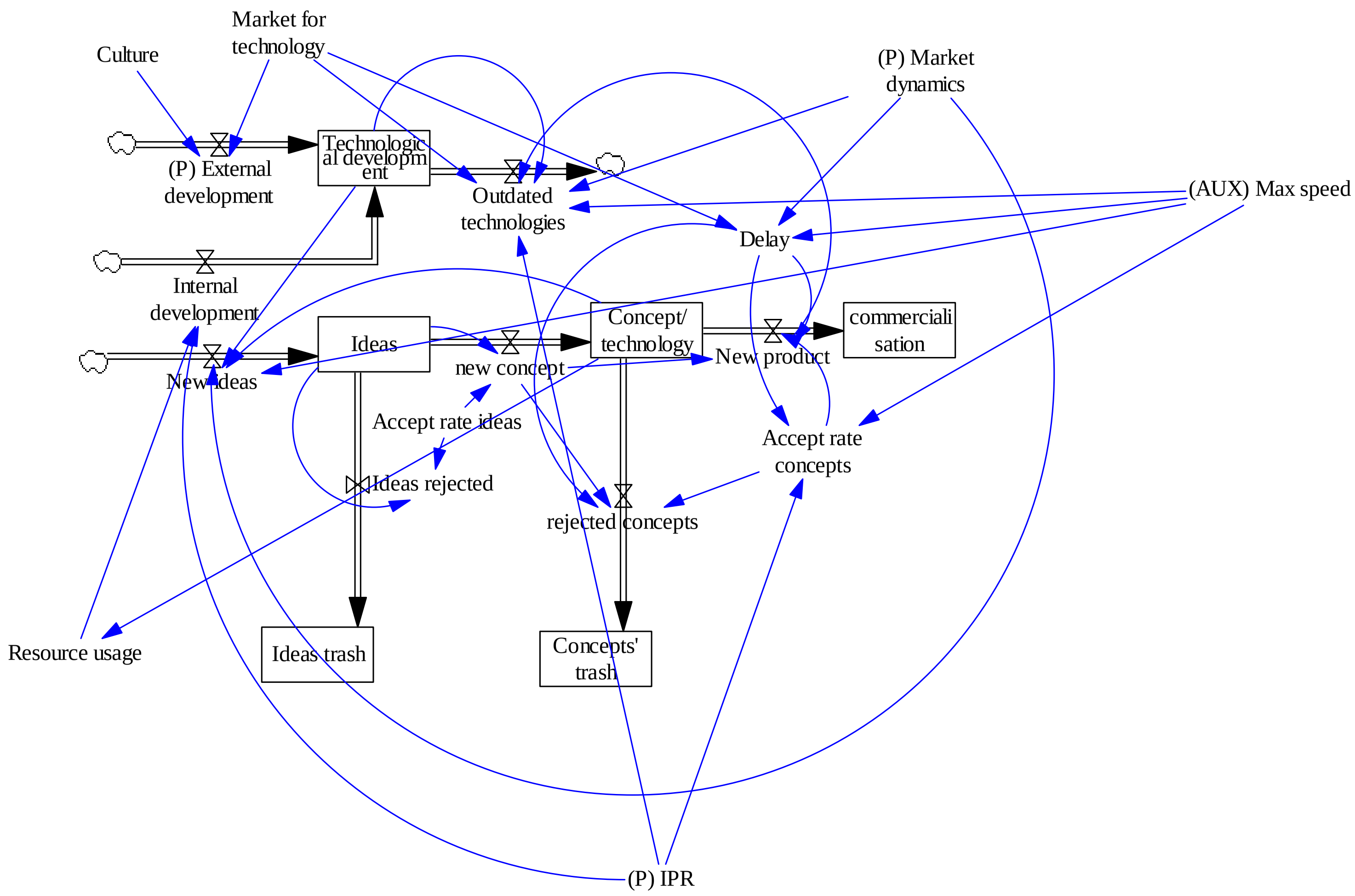

Figure 2 System Dynamics model for Open Innovation Process

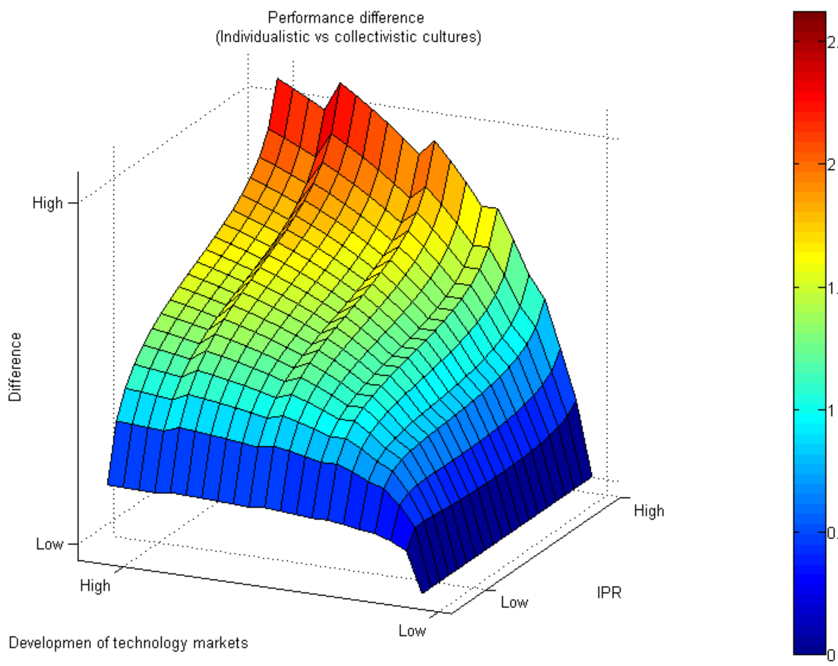

Figure 3 Innovation performance difference of individualistic vs collectivistic countries

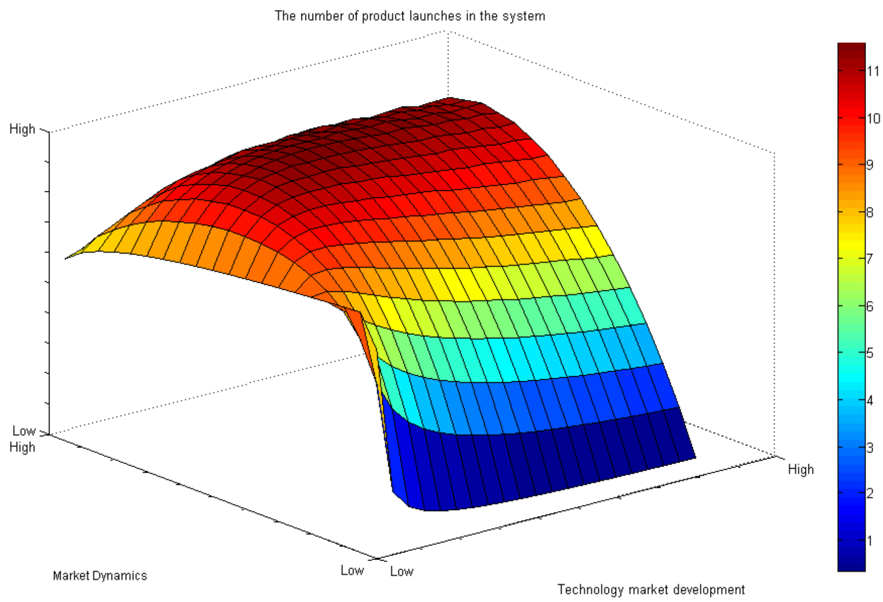

Figure 4. The number of product launches in the system.

Figure 5 demonstrates the new product outcomes under the influences of IPR regimes and Speed of user need change. The market dynamics is having positive impact at the product number, but until certain level. The high IPR protection is also needed for sufficient amount of product launches.

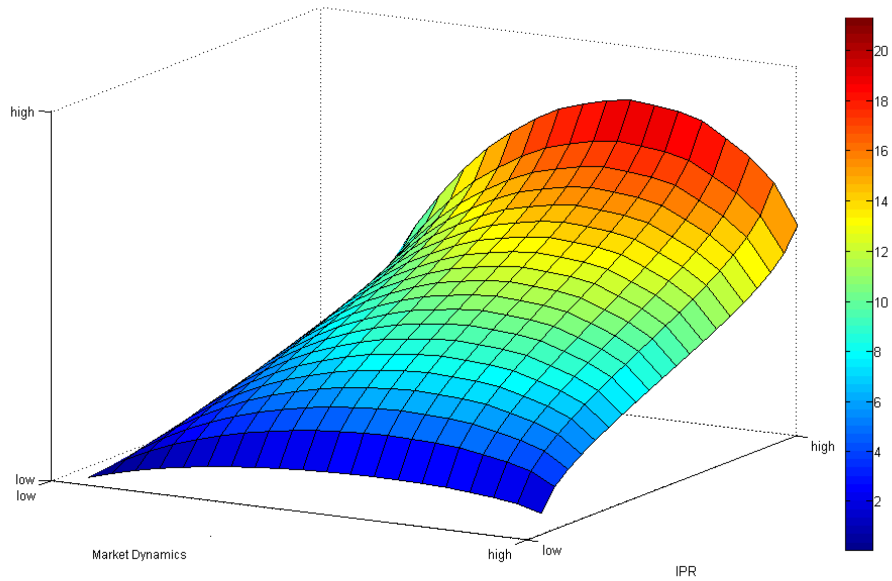

Figure 5 Number of new products under IPR and market dynamics influences

Conclusions

This paper demonstrates the effect of different levels of external factors (including IPR protection, market dynamics, competitiveness and cultural aspects) on the innovative performance in the industry. The system dynamics simulation method is used to analyse the innovation process performance under influences of different combinations of external to company factors, which allows simulating possible outcomes with numerous combinations of different factors. The results show that e.g average speed of market and rather high IPR protection level increase amount of technologies introduced to the market. Additionally, the market speed change has a positive impact on new products introduction to the market; however after increasing to the certain point, the market speed becomes too high for product development to cope with.

The paper offered conceptual system dynamics model to follow the impact of environment to the industry technology commercialisation process. The outcomes demonstrate that IPR and market dynamics do have an impact on the overall new product introduction to the market. Besides, the market speed change has a positive impact on new products at the market, but until the certain point, after which the speed is too high for product development to cope with.

These findings do not completely go in line with the previous research, where e.g. Dosi et al (2007) state that IPR has only second-order effect on innovation, firms' specialisation creates barriers to learning and imitation and the incentives of firm to innovate do not depend of appropriability regimes. However, the discovered results go in line with research by Kalanje et al. (2005) stating that strong IP hinders the competition and hence decrease the technology output. Due these contradictions can be drawn the conclusion that the IPR protection has rather complex effect for innovation development process and should be used strategically at the different NPD stages.

The study adds to discussion on external environment factors influencing NPD and innovativeness and brings in the system dynamics simulation to assess the impacts of these factors. Due to the strength of the method used, allowing for modelling of abstract concepts in conceptual research, the introduced simulation model facilitates developing the most suitable scenarios of external factors combination, which can be applied in practice by policy makers. For the theory, the new tool of analysing open innovation behaviour of companies has been brought from cross-disciplinary approach. The balance in the system is crucial for sustainability of innovation output, as seen from the results, there is the point of saturation in almost every factor, after which the performance starts to decrease. Hence, it is impossible to talk about positive effects of e.g. market dynamics or competitiveness, without keeping in mind that it can become too much at some point.

In overall, the results of research presented in this paper are beneficial to both academicians (as it brings new insights to the research on external factors influencing open innovation process) and practitioners (for understanding the impacts of external environment and being able to anticipate these effects). It is also of high importance for policy makers to recognise the effects of measures they impose on general level of innovative performance of companies in industry/region. That is, the development of a more supportive environment should be a highly important goal for achieving sustainability in innovation.

The research has also some limitations coming from both method used and nature of innovation. Since the model is conceptual and tests no real data, it can only be validated against existing literature. Besides, in reality innovation has high stochastic element, but as traditional system dynamics suggests deterministic model, the innovation had to be simplified, which of course has an impact on the results.

However, more complex relationships of environmental factors are needed, together with test on real datasets, to give better understanding of what are the environmental drivers to open innovation performance. Additionally, the mutual influence of internal and external factors influencing product development and commercialisation should be studied.

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