Internationalization of business expenditures on R&D (BERD)

A European perspective

Kevin Schaap

TU Delft Delft University of Technology

Challenge the future

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Internationalization of business expenditures on R&D (BERD)

Master thesis

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Preface

This report presents my master thesis titled "*Internationalization of business expenditures on R&D- A European perspective*". This document marks the end of my study at the faculty of Technology, Policy and Management at the Delft University of Technology and serves as the final element of my master Management of Technology. This master has been trained me in the world of innovation and technology management and serves as great enrichment to my technical background in chemical engineering. The past two years attending the master program Management of Technology has allowed me to acquire both the scientific and social skills that were needed to successfully complete this master thesis.

Acknowledgement

I would like to thank the members of my graduation committee for guiding me to through this graduation process. Foremost, I would like to express to my sincere gratitude to my first supervisor Dr. Zenlin Roosenboom-Kwee for her continuous support, guidance and motivation. Your feedback and insightful comments have helped me in the process of research and writing this thesis. My sincere thanks also go to Dr. Eric Molin for his advice and knowledge in conducting statistical analyses. Furthermore, I am grateful to my chair, Professor Cees van Beers, for his constructive feedback during our meetings.

Finally, I want to thank my parents for their unconditional support in this intensive and challenging period.

I hope you will enjoy reading this thesis as much as I enjoyed the final process of conducting research leading to my graduation.

Kevin Schaap
Delft, December 2015

Executive summary

R&D internationalization is an increasingly observed phenomenon in today's economy. That is, firms are locating their R&D departments in another country than the country where their headquarters are located. To get an insight in the current state of research in the field of R&D internationalization, a literature review has been conducted in which seven articles have been evaluated. The data of the articles have been visualized in a network representation. These visualizations indicate the relationships between concepts that have been studied in the selected articles. Ultimately, these tools helped to identify a knowledge gap that offers an opportunity to contribute to existing research. This research thesis aims to study the impact of domestic innovation capacity *with a focus on entrepreneurship* on the internationalization of R&D business expenditures. The corresponding research question that forms the foundation of this master thesis is:

What is the relationship between R&D internationalization and national innovation capacity and how does this relate to entrepreneurship?

This research consists of quantitative data analysis using software tools like Stata. The data have been collected from sources such as EU(Eurostat) and OECD databases. The sample used in our panel data regression analysis represents 19 EU countries over the 2000-2012 period.
The constructs of domestic innovation capacity, entrepreneurship and R&D internationalization have been quantified in a certain metric to investigate the relationships between these concepts. After careful evaluation of indicators used in existing research, several individual and composite indicators have been selected for the purpose of quantifying the concepts of interests in a particular metric.

The results of our regression models has provided evidence that inward BERD by foreign affiliates is positively related to the national innovation capacity of the host country. These findings support the idea found in literature that countries locate their R&D activities in foreign countries to delve in local competences to enhance their innovative activities (Archibugi & Michie, 1995) (Bartholomew, 1997). Furthermore, it was found that entrepreneurship, measured by the firm birth rate, makes a positive contribution to the inflow of foreign BERD. These findings can be understood by acknowledging the importance of knowledge spillovers in the development of innovations and new technologies. Both Schumpeter(1934) and Kirzner(1973) theorized that entrepreneurs are an important source of innovations. The findings suggest that managers of multinational companies recognize the opportunity to benefit from the potential of knowledge spillovers between R&D facilities and local entrepreneurs in a foreign country.

"The knowledge spillover theory of entrepreneurship" by Acs et al. (2005 & 2009) suggests that the knowledge stock in a country has positive impact on the level of entrepreneurship as an increase in the knowledge stock creates entrepreneurial opportunities. This also has an implication for the effect of R&D internationalization as it is widely accepted that R&D investments will lead to an increase of the knowledge stock. The findings of our regression analysis suggested that the inflow of R&D business expenditures by foreign affiliates will indeed lead to an increase of the knowledge stock. According to *"The knowledge spillover theory of entrepreneurship"* this would mean that R&D internationalization positively impacts entrepreneurship (by increasing the knowledge stock available

to entrepreneurs). However, the outcome of our regression model focusing on the effect of the knowledge stock (measured by the number of patents) on firm entry proved to be inconclusive.

The findings of this research have some important implications for policymakers of countries which are looking for ways to attract R&D investments from foreign firms. For instance, they should stimulate people to become entrepreneurs by reducing barriers to entrepreneurship. In addition, national governments should consider investments in education as our findings suggest that the availability of high-skilled people lead to the inflow of R&D business expenditures by foreign affiliates.
This research has implications for managers and entrepreneurs as well. The findings of this research stresses the importance of knowledge spillovers and both managers of foreign R&D affiliates and local entrepreneurs can benefit from each other. Therefore, it is recommended that both managers of foreign R&D facilities and local entrepreneurs invest their time and energy to establish a relationship with each other.

Keywords: R&D internationalization, Innovation capacity, Entrepreneurship, Knowledge spillovers, National Innovation Systems, Panel data regression.

Abbreviations

BERD:	Business Expenditure on R&D
ICT:	Information and Communication technology
FDI:	Foreign Direct Investment
GDP:	Gross Domestic Product
NIS:	National Innovation System
OECD:	Organization for Economic Cooperation and Development
R&D:	Research & Development
SII:	Summary Innovation Index
SBS:	Structural Business Statistics, database of Eurostat
SDBS:	Structural and Demographic Business Statistics, database of OECD
TFP:	Total Factor Productivity

Definitions of core concepts

This section will give a definition of the core concepts that will be used in this master thesis. Furthermore, these concepts will be leading in the subsequent literature review.

R&D internationalization/globalization

Enterprises do not only produce and sell in domestic markets, but increasingly also develop goods and services outside their home countries. R&D internationalization and R&D globalization has been defined as the process of firms relocating their R&D activities to foreign countries (Peters & Schmiele, The contribution of international R&D to firm profitability, 2011). In addition, firms have to determine whether they want to do the R&D in-house or externally. In literature, setting up an internal R&D department in a foreign country is called R&D offshoring while R&D that is done external to the organization of the company is called R&D outsourcing (Grimpe & Kaiser, 2010). R&D outsourcing can for example be in the form of a 3rd-party that is contracted to conduct R&D activities (Tiwari & Buse, 2007). Both outsourcing and offshoring will be considered in this research as forms of R&D internationalization.

Innovation systems

The concept of an innovation system can be applied to a local, sector or national level. This research will take a perspective on national innovation systems. The term 'National Innovation Systems' (NIS) emerged during the late 1980s. The concept was defined for the first time in literature by Freeman. However, other scholars like Bengt-Åke Lundvall and Richard Nelson made important contributions to the field (Fagerberg & Sapprasert, 2011). Lundvall defined National Innovation Systems as: "*The interaction between different actors who are needed in order to turn an idea into a successful process, product or service on the market*" (Lundvall, 1992, p. 2). Although, many different definitions exist in literature, but the definitions all have one thing in common, i.e. Innovation Systems have to do with interactions between actors that lead to innovations.

Knowledge spillovers

Knowledge flows between countries and regions are of an increasing importance to policy makers. A particular type of knowledge flows that economists focus on are knowledge spillovers. In literature, knowledge spillovers are defined as the exchange of ideas between individual entities which fosters innovation (Carlino, 2001).

This research will particularly focus on the exchange of ideas between firms (inter-firm knowledge transfer) in the host and home country, promoting creativity and innovation.

Innovation capacity

The innovation capacity defines the potential for innovation of a firm, region or nation. This research will take a national perspective. Therefore, the focus will be on national innovative capacity. Ste rn et al. define national innovative capacity as "the country's potential(...) to produce a stream of commercially relevant innovations" (Furman, Porter, & Stern, 2002)

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Chapter 1. Introduction

1.1 Background

Firms increasingly offshore R&D activities to facilities in foreign countries (OECD, 2008). Figure 1 compares the total level of business expenditures on R&D in a country to the level of business expenditures on R&D in the same country by foreign owned firms. The percentage of R&D expenditures by foreign owned firms in the total R&D expenditure is frequently used as a measure of R&D internationalization. Figure 1 compares the percentages for the years 2003 and 2007. The development of this percentage shows that the R&D internationalization has increased in many of the selected countries. As a result of this process, there is an increasing rise of global innovation networks where foreign affiliates are operating research and development units within both a global as well as a local network.

In the past decades, R&D globalization has rapidly accelerated and has been associated with advances in communication technologies (Dunning & Lundan, 2009). The recent advances in communication and information technologies, named by some as the ICT revolution, has made it possible for firms to exchange information in a global network. This is particularly important for R&D activities as the exchange of ideas and information is crucial. As such, the revolution in ICT has reduced the cost of coordinating decentralized R&D (Rao, 2001). Therefore, it can be argued that the ICT revolution is an important enable of R&D globalization.

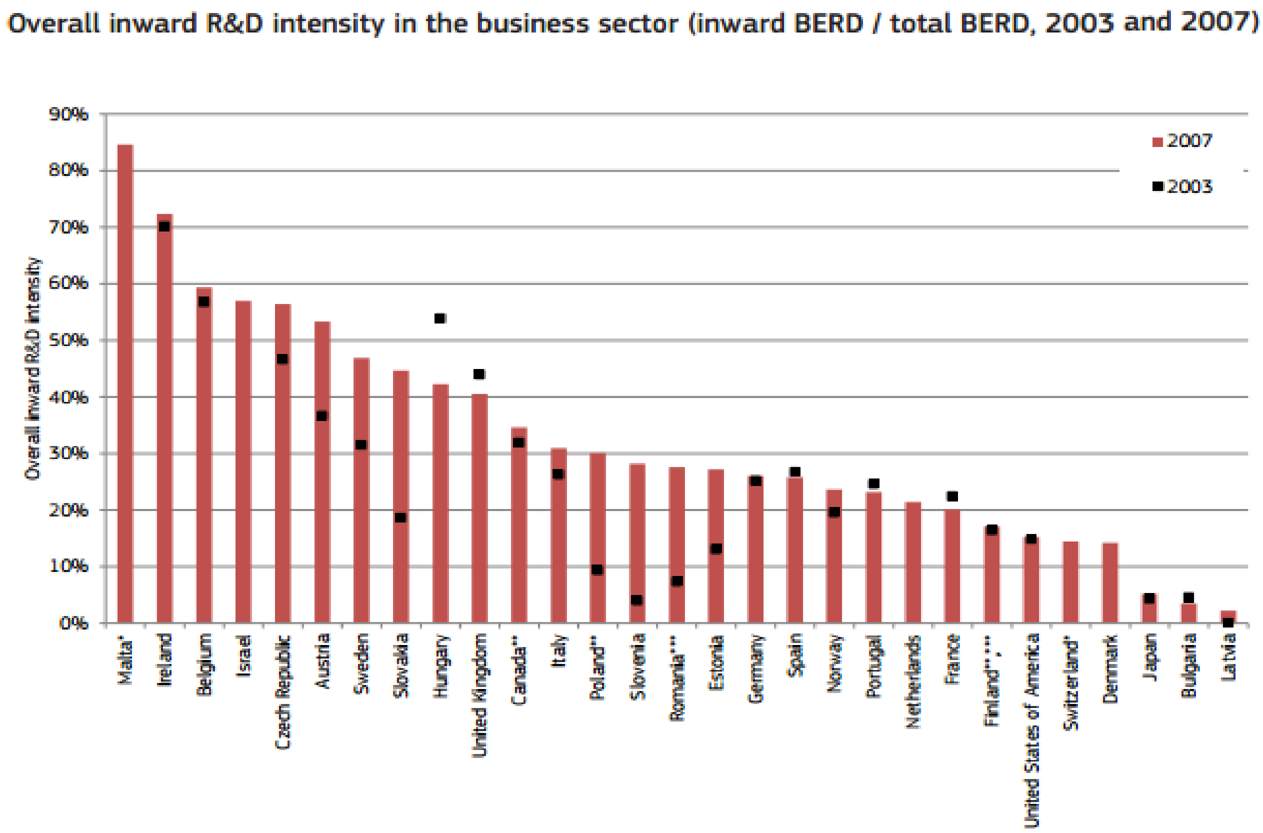

Figure 1: Investment in R&D by foreign-owned firms relative to the total R&D business expenditures of a nation.

Numerous reasons have been identified in literature for firms to locate their R&D activities in a foreign environments. The various reasons can be broadly classified into two categories: 1) demand side forces and 2) supply side forces (Gassmann, Beckenbauer, & Friesike, 2012) (Narula & Zanfei, 2005). The first category is characterized by a motivation factor to get access to local markets. As firms target foreign markets there is a need to adopt their product to local preferences. A way through which firms try to accomplish this is by locating their R&D activities in the host country. Firms try to exploit their technological assets and modify it to specific local demands.
Supply side forces, on the other hand, are based on the motivation to tap into foreign local capabilities. Firms locate their R&D activities in host country to benefit from the potential of local innovation capabilities and technological spillovers.

However, the potentials of R&D internationalization are not solely restricted to the firm in question. R&D internationalization has several impacts on the economy in the host and home countries. The impacts range from effects on employment rates and labour productivity (European Commission, 2012). Furthermore, as argued in this thesis, entrepreneurs can benefit from potential knowledge spillovers that arise by the presence of foreign affiliates in the host country. In addition, the presence of foreign affiliates offers the potential for local firms to form linkages to get access to foreign markets and integrate in a global network (Guimón, 2011). In general, we can say that through interaction in a global network the potential benefits of R&D internationalization are not merely restricted to the multinational that offshores their R&D, but can be beneficial for various actors in the host and home country.
All in all, it is clear that R&D internationalization has become an increasingly important issue for national governments. As R&D internationalization has become a highly relevant issue on the agenda of policy makers, there has been a growing interest of researchers to study the aforementioned effects and drivers of R&D internationalization. Cost-related benefits and the presence of a skilled workforce are two examples of drivers that have been confirmed in literature (Reddy P. , 1997).

Foreign controlled firms are currently seen as an important actor in national innovation systems as inward R&D FDI brings benefits to the host country such as technology transfers, access to foreign markets and integration in global innovation networks (Guimon, 2009). As a result, there is a growing base of literature that studies the effectiveness of policies to attract foreign business R&D.

As described before, one of the reasons for a firm to locate their R&D activities in a foreign host country is to benefit from the potential of local innovation capabilities. Therefore, the potential of a country to produce innovations, commonly captured by the term *national innovation capacity*, is an important topic in attracting business R&D of foreign firms.

Entrepreneurship is another topic that is of great importance to policy makers. The recent economic crisis has led to a global recession and record rates of unemployment. The European Commission suggests that entrepreneurs are needed to return to a period of economic growth and higher employment levels (European Commission(EC), 2013). This view is in accordance with Schumpeter's arguments who argues that entrepreneurs have a role as a key driver of economic growth (Schumpeter, 1934).

It is clear that both R&D internationalization and entrepreneurship are of great interest to governments and policy makers. Although both subjects have been studied and further contributions to the fields (apart from one other) are still being made, it is highly surprising that the research fields of R&D internationalization and entrepreneurship have not been coupled in the existing research. This master thesis focuses on this research gap and aims to make a contribution to this research area by studying the relationship between R&D internationalization and entrepreneurship.

1.2 Research goal

The main goal of this research is to evaluate the impact of domestic innovation capacity with a focus on entrepreneurship in home and host countries on offshore R&D business expenditures. As a result, this study will make a contribution to fill a knowledge gap in the existing literature. The knowledge gap concerns an unexplored area: the relationship between entrepreneurship and offshore R&D business expenditures. In other words, this master thesis will combine the research fields of **Entrepreneurship** and **R&D internationalization**. A more in-depth review of literature, leading to the revelation of this knowledge gap, will be discussed in section 2.

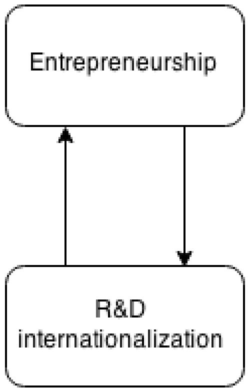

Figure 2: Focus of this research

More specifically, the research investigates the link between domestic innovation capacities with a focus on entrepreneurship and business expenditures along the lines of R&D internationalization.

1.3 Practical relevance of research

The objective of this research is to give policy advice to governments that want to stimulate entrepreneurial activity in their country and/or want to attract FDI in R&D. The focus of the scope of study will be on R&D business expenditures in the European Union . As a result, the outcome of this research will have important implications for the European Union and the governments of the individual countries. In other words, this research can provide key information for policy makers in Europe that want to attract additional inflow of R&D expenditure from foreign-owned firms or want to stimulate domestic entrepreneurs. Furthermore, this research aims to give policy advice to stimulate innovation that results from an interplay between R&D internationalization and entrepreneurship.

1.4 Research questions

To meet the aforementioned objective, this research should answer several research questions. The main research question that will be answered at the end of this research is formulated as follows:

What is the relationship between national innovation capacity and R&D internationalization and how does this relate to entrepreneurship?

To answer this central question, however, four sub question are defined that will narrow down on the topic and provides guidance in answering the main research question.

Sub questions

As it is understandable that the attractiveness to invest in R&D depends on its returns and costs, the first sub question has been defined as:

- *What is the relation between national innovation capacity and the benefits and costs of R&D internationalization in both home and host countries?*

As this research investigates effect of the construct of innovation capacity on the propensity to offshore R&D, the following sub questions have to be answered.

- *What are the main drivers for off shoring R&D?*
- *What is the impact of the relative levels of (technological and economic) development, measured by the national innovation capacity, of the home and host countries on internationalization of business expenditures on R&D (BERD)?*

The previous sub questions deal with the relationship between innovation capacity and R&D internationalization. However, the ultimate aim is to extend this to investigating the relationship between entrepreneurship and R&D internationalization. Therefore, the subsequent sub questions have been formulated.

- *What is the relation between entrepreneurship and domestic innovation capacity?*
- *What is the impact of entrepreneurship on internationalization of business expenditures on R&D?*

1.5 Outline of the thesis

This first section served as an introduction to our research topic and provides the practical background information. Subsequently, the research goals and objectives were formulated. Furthermore, the main research question is presented and a number of sub questions have been formulated to aid in the process of answering the main research question.

The remainder of this master thesis is structured as follows. Chapter 2 will present the research approach and the methods that have been used to conduct a literature review. Chapter 3 will provide an initial overview of the current state of research in the field of R&D internationalization. Furthermore, it provides the theoretical background of this thesis. Based on the findings in the previous section, Chapter 4 will develop the conceptual model and hypotheses that form the framework of this master thesis.

Chapter 2. Research approach

This chapter will discuss the methodology of the research project and as such will elaborate on the methods that are used in this research.
The first subsection will discuss the approach that have been used in the process of reviewing literature. This chapter will conclude with the research approach and sampling technique that have been used to answer the research question and to evaluate the formulated hypotheses.

2.1 Literature review

This section will discuss the selection process of literature by explaining which criteria are used. The selected articles are subsequently collected in a database. Subsequently, the process proceeds by aggregating and unification of concepts that are used in different studies that have been collected in this database. These subsequent steps are discussed in more detail for the case of R&D internationalization.

2.1.1 Search process and study selection

The electronic databases ScienceDirect(Scopus), Springerlink, EconBiz and RePEc were searched to get an overview of prevailing studies in this discipline. Only studies after 1980 were included in this analysis. This time window was chosen because globalization has rapidly accelerated since the (mid-)1980s (Gerybadze & Reger, 1999) (Reddy & Sigurdson, 1994); .The following key terms were used in the search engine of the electronic databases: "R&D internationalization "and/or "R&D globalization" or "R&D offshoring" ;"Innovation system"; "Innovation capacity";"Knowledge spillovers".

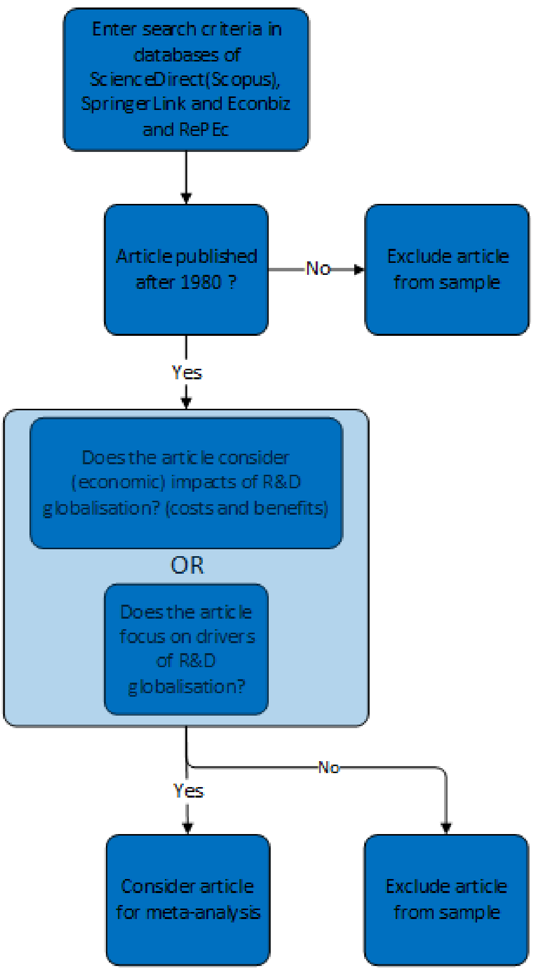

Figure 3: Flowchart illustrating the search process and eligibility criteria of scientific articles.

Figure 3, on the left, gives a visual representation of the search process and the eligibility criteria of the articles for inclusion in the literature review.
After key words were entered in the search engine, the abstracts of the most cited articles were read. This was done to get an indication of the research conducted in the study. The article was included in the sample for this literature review if the article focused either on drivers of R&D globalization or the impacts of R&D globalization. Articles that did not meet these criteria were excluded from the literature review.

Ultimately, seven articles(see Table 1) were chosen that have been studied in more detail. These articles were analyzed to be able to build a conceptual model.

2.1.2 Database creation

Subsequently, data has been extracted from the articles that were selected in the previous section. The articles have been analyzed and hypotheses were extracted from the studies. The information that has been gathered about the articles is represented in the spreadsheet below. This spreadsheet summarizes the hypotheses of the articles by indicating the independent and dependent variables, the type of relationship and indicates the result of the research.

Bibiliographic information			Independent variable	Dependent variable	Relationship	Result
Short	Title	Year				
Criscuolo09	Inter-firm reverse tech	2009	Foreign R&D investment	Inter-firm RTT, a technological knowledge flow from foreign based R&D	main	Supported
Criscuolo09	Inter-firm reverse tech	2009	Home country embeddedness	Inter-firm RTT	moderating	Supported
Criscuolo09	Inter-firm reverse tech	2009	Engagement in asset-augmenting R&D activities	Inter-firm RTT	moderating	Supported
Criscuolo09	Inter-firm reverse tech	2009	technological gap between the host and home countries	Inter-firm RTT	moderating	Supported
Reddy09	New Trends in Globaliz	1997	Availability of R&D personnel	Establishment of R&D in India	main	Strong relationship(positive)
Reddy09	New Trends in Globaliz	1997	Low cost of R&D	Establishment of R&D in India	main	Intermediate relationship(positive)
Reddy09	New Trends in Globaliz	1997	Proximity to manufacturing	Establishment of R&D in India	main	Intermediate relationship(positive)
Reddy09	New Trends in Globaliz	1997	Proximity to Indian market	Establishment of R&D in India	main	Intermediate relationship(positive)
Reddy09	New Trends in Globaliz	1997	Availability of raw materials	Establishment of R&D in India	main	Weak relationship(positive)
Reddy09	New Trends in Globaliz	1997	Government incentives	Establishment of R&D in India	main	Weak relationship(positive)
Reddy09	New Trends in Globaliz	1997	Company's image building	Establishment of R&D in India	main	Weak relationship(positive)
Reddy09	New Trends in Globaliz	1997	Technology monitoring	Establishment of R&D in India	main	Intermediate relationship(positive)
FeGu04	KNOWLEDGE SPILLO	2004	Total R&D expenditure by other same industry firms in host country	Probability offshoring R&D	main	Supported
FeGu04	KNOWLEDGE SPILLO	2004	Interfirm dispersion of R&D within host country	Probability offshoring R&D	main	Supported
FeGu04	KNOWLEDGE SPILLO	2004	Proportion of the subsidiary's revenues derived from local sales	Probability offshoring R&D	main	Supported
FeGu04	KNOWLEDGE SPILLO	2004	Total number of foreign R&D units already in place	Probability offshoring R&D	main	Supported
CaViVo11	Drivers and impacts in	2011	Internationalization of corporate R&D	Get access to other sources of expertise and innovation	main	Not tested
CaViVo11	Drivers and impacts in	2011	Internationalization of corporate R&D	Enhance access to foreign markets	main	Not tested
CaViVo11	Drivers and impacts in	2011	Availability of researchers	Internationalization of corporate R&D	main	Supported
EurCom11	Internationalisation of	2012	Market size	Business expenditure R&D in foreign countries	main	Not tested
EurCom11	Internationalisation of	2012	Skilled workforce	Business expenditure R&D in foreign countries	main	Not tested
EurCom11	Internationalisation of	2012	Labour cost difference host country vs home country	Business expenditure R&D in foreign countries	main	Not tested
EurCom11	Internationalisation of	2012	Business expenditure R&D in foreign countries	Job loss in home country	main	Not tested
EurCom11	Internationalisation of	2012	Business expenditure R&D in foreign countries	Hollowing out of domestic innovation capacity	main	Not tested
EurCom11	Internationalisation of	2012	Business expenditure R&D in foreign countries	Reverse knowledge transfer	main	Not tested
EurCom11	Internationalisation of	2012	Business expenditure R&D in foreign countries	Market expansion	main	Not tested
DeKo08	Domestic Employment	2008	Offshore outsourcing of R&D	Anticipated domestic employment	main(positive)	Supported
DeKo08	Domestic Employment	2008	In-house offshoring of R&D	Anticipated domestic employment	main(negative)	Supported

Figure 4: Database of selected articles.

2.1.3 Concept aggregation

In order to create a concise model, it is needed to unify and aggregate similar concepts from different studies.
For example, both the article by Reddy(1997) and the report by the European Commission(2012) formulate hypothesis on potential drivers of R&D internationalization. Reddy(1997) hypothesizes that R&D expenditure is dependent on low cost of R&D, while the report by the European Commission(2012) proposes the dependence of R&D expenditure on the labour cost difference between host country and home country. The total cost of R&D consists mainly of wages (Reddy P. , 1997). So the two concepts, low cost of R&D and labour cost difference can be aggregated in the single concept of relative labour cost.

In addition, several concepts have be unified in one broader concept. For example, the article by Criscuolo(2009) studies the dependence of inter-firm knowledge flows as a function of 'Home country embeddedness', 'Engagement in asset-augmenting activities' and 'Technology gap between host and home country'. These three concepts have been unified in the broader concept of 'Innovation System'.

2.2 Research approach and design

An exploratory research of existing literature has been performed to acquire insights in the topics of R&D globalization, innovation capacity and entrepreneurship. This exploratory research provides the foundation in the formulation of the hypotheses that will be tested in this thesis.
This thesis takes a quantitative research approach by examining and quantifying the relationships between R&D internationalization and other variables of interest to test the previously formulated hypotheses. A cross sectional time series design, also named panel design, is used in this study. Panel data studies are a type of studies in which data is collected for multiple groups (cross section) over several time periods (time series) (Baltagi, 2005). In our case, the panel dataset consists of the annual observation of several variables for a cross-section of countries.
This econometric study relies on national accounts covering data on economic activities in the fields of R&D globalization and entrepreneurship. In other words, this research is based on secondary data analysis which is a type of analysis that uses existing data that has been collected by other researchers or institutions . The data collection process and the relevant data sources are discussed in more detail in section 366.1.

2.3 Sampling technique

As the original aim of this thesis was to study R&D globalization in European countries, the focus of our dataset will be on European Union(EU) member states. Unfortunately, data on key variables is not available for each individual EU-member state. This research relies upon existing data, and as a result those countries for which there was no data available for our key variables were excluded from our sample. Data availability on R&D globalization and entrepreneurship has proven to be the limiting factors in the process of selecting countries for the sample. In total, 19 countries are included in our sample (the full list of countries can be found in Appendix I).

Chapter 3. Literature Review

3.1 R&D internationalization

As R&D internationalization is the concept that forms the centre of our research, this section will provide a more extensive review on existing research of this concept.

There is a growing base of research that studies the phenomenon of R&D internationalization .This section provides a review of the existing research conducted in the field of drivers and impacts of R&D internationalization. This review ultimately culminates in a network representation of existing research which visualizes what drivers and impacts have been identified with R&D internationalization. The software package UCINET have been used to visualize the current state of research of R&D globalization

The seven selected articles and their key finding are summarized in the table below.

Table 1: Prior research on R&D internationalization

Author	Focus	Sample	Key findings/implications
Criscuolo (2009)	Home country effects of R&D internationalization	17 European multinationals performing R&D activities in the U.S. over the period 1985-2005	Foreign R&D investment by multinationals(MNC) can lead to transfer of foreign technologies to the home country of the MNC (inter-firm reverse technology transfer)
Reddy (1997)	Drivers for conducting R&D in foreign countries	Transnational corporations (TNC) conducting R&D activities in India	The reasons of TNC to locate their R&D activities in India consists of: low cost of R&D, availability of R&D personnel, proximity to local market and monitoring the development of foreign technology.
Feinberg & Gupta (2004)	Drivers for conducting R&D in foreign countries	Foreign affiliates of US based MNCs for the period 1989-2006	Probability of locating R&D in foreign country is positively correlated with total R&D expenditure by other US subsidiaries in the host country.
Moncado-Paterno-Castello, Vivarelli & Voigt (2011)	Drivers for conducting R&D in foreign countries	EU companies	A key driver of locating R&D in a foreign country is the availability of researchers.
European Commission(2012)	Drivers for conducting R&D in foreign countries	EU companies	Market size, skilled workforce and labour cost difference have a positive effect on business expenditure on R&D FDI

Deschryvere & Koritanta (2008)	Home country effects of R&D internationalization	Finland	Offshore outsourcing of R&D has a positive effect on anticipated domestic employment in the home country. In-house offshoring of R&D has a negative effect on anticipated employment
Veliyath & Sambharya (2011)	Drivers for conducting R&D in foreign countries	25 countries for the period 1990-2003	The level of national innovation capacity, political stability and intellectual property rights have a positive impact on R&D expenditure of foreign affiliates

Two articles from Table 1 will be discussed in more detail to provide more background to the key findings of the articles and discuss the implications for this research.

The article by Feinberg & Gupta makes an important contribution to the research field that studies the drivers of MNC's choices regarding the location of their R&D activities. They suggest that the decision of a multinational to locate their R&D activities in a foreign country is influenced by the **knowledge spillover opportunities** that are present in the host country. Their analysis uses R&D expenditure as a measure of supply of knowledge that has the potential to spill over. Their results concerning the role of knowledge spillovers in the decision of locating R&D activities abroad is somewhat ambiguous. They conclude that the probability of assigning R&D activities to a foreign location is positively associated with R&D expenditure by other US multinationals. However, their analysis shows that R&D expenditure by non-US firms in the host country has no effect on the probability of assigning R&D activities to that host country. Their analysis makes no explicit statements about the effect of total domestic R&D expenditure on attracting FDI R&D.
Other studies, however, find that the total domestic R&D expenditure in a host country has a positive effect on attracting FDI R&D (Kumar, 2001).

In addition, an extensive investigation in the literature has yielded an insight into the relationship between national innovation capacity and R&D expenditures in foreign countries. An example that studies this relationship is the account by Veliyath & Sambharya(2011). The data on national innovation capacity used in this study is somewhat dated (1987-1990 and 1997-2000). As a result, it doesn't take into account recent developments in national innovation capacity of emerging economies. Furthermore, this research has taken a very broad approach using an index, consisting of a ranging set of variables, to measure innovation capacity (Veliyath & Sambharya, 2011). Therefore, future research can make a contribution by narrowing down on the effect of innovation capacity on R&D internationalization by taking a particular focus on innovation capacity, e.g. entrepreneurship.

3.1.1 Network representation

The network of empirically validated hypothesis is presented in figure 5. This method of using a network approach towards literature review provides novel insights by visualizing the existing state of research. The sizes of the nodes represent the frequency of the effect in the studies that were considered in this literature review (Van de Wijngaert, Bouwman, & Contractor, 2012).

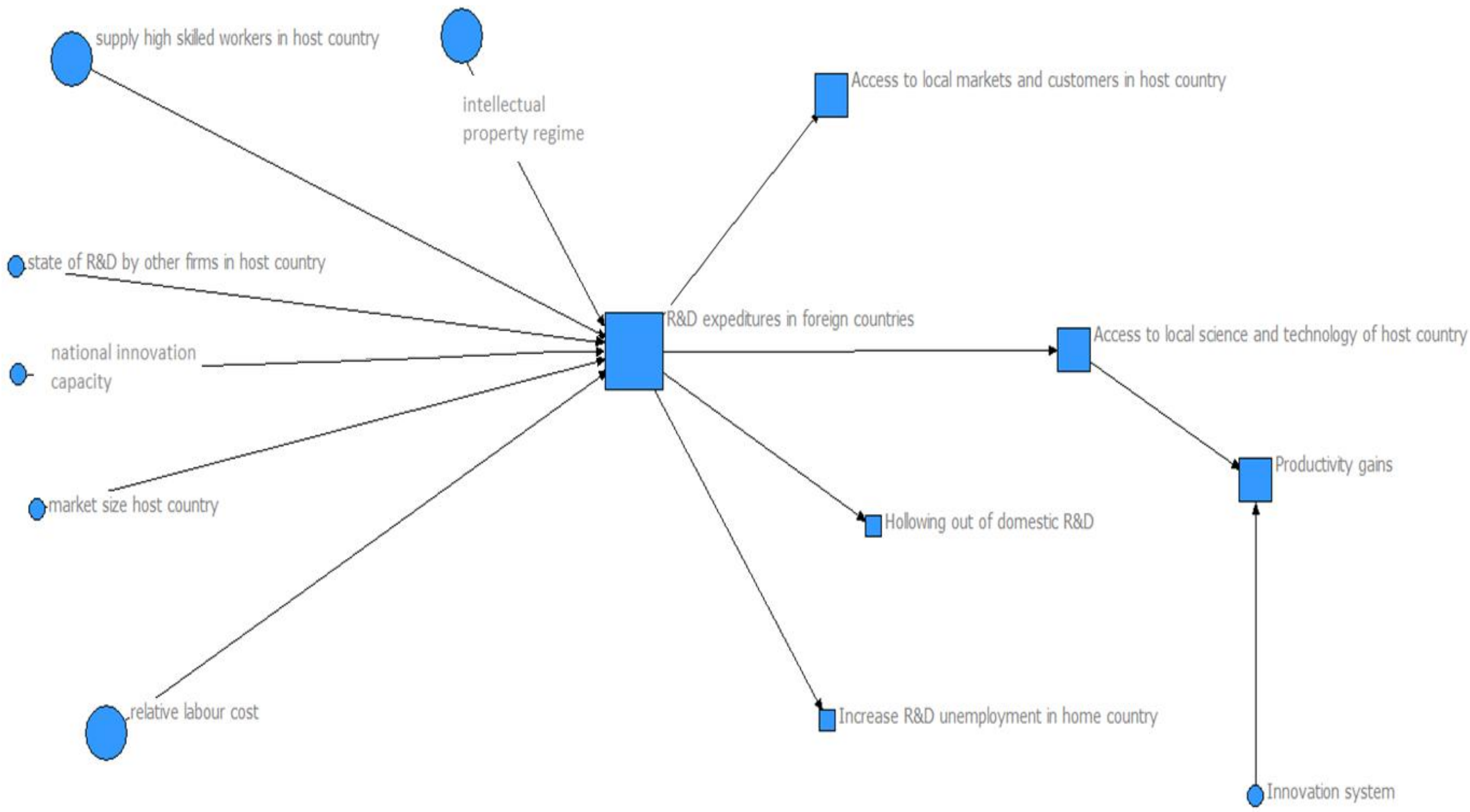

Figure 5: Visualization of the supported (or empirically validated) effects derived from literature

The network visualization provide an important additional insight into the current state of research of R&D globalization. It exposes the existence of a critical knowledge gap. This knowledge gap concerns an unexplored area of the impact of domestic innovation capacity *with a focus on entrepreneurship* on offshore R&D business expenditures.

The impact of R&D internationalization on domestic firm entry and exit

In addition, there are indications that R&D internationalization and entrepreneurship are correlated. Although, this area of research studying the relationship between these two concepts is still in an early phase. There are some premature signs that confirm this relationship. For example, a study by Anwar & Sun (2015) argue that the internationalization of innovations affects the probability of domestic firm entry and exit into industry. The paper suggest that FDI in R&D increases the likelihood of firm exit due to increased competition but the impact on the likelihood of entry of domestic firms is statistically insignificant (Anwar & Sun, 2015). However, the relationship in the reverse direction: the impact of entrepreneurship on R&D internationalization has not been evaluated.

Furthermore, theory suggests that FDI in R&D will increase labour productivity and profitability in industry. As a result, more firms will be founded as entrepreneurs observe an opportunity to achieve a profit. This theory goes directly against the findings by Anwar & Sun(2015) as they do not observe a relation between FDI in R&D and the likelihood of entry of domestic firms. However, they do observe that forward and backward linkages arising from FDI in R&D can facilitate entry as well as exit of domestic firms depending on the type of industry. Their analysis is based on limited data that concerns only 1 country (China) for a period between 2005-2007. As a result, the findings can not be generalized. This master thesis will include a larger dataset as more countries are included in this analysis.

3.2 Entrepreneurship

The term 'entrepreneur' comes from the French word "entreprendre" meaning "to undertake" and was first introduced by the French-Irish economist Richard Cantillon. In his view, an entrepreneur was "a risk-taker committing himself to purchasing the factors of production at a known price in order to market their output at an unknown (...) price in the future" (Murphy, 1986, p. 98). Other scholars like Say, Marshall and Schumpeter contributed to the field and further refined the concept of entrepreneurship (van Praag, 1999). The World Bank has defined entrepreneurship as: "the activities of an individual or group aimed at initiating economic activities in the formal sector under a legal form of business" (Klapper, Amit, & Guillen, Entrepreneurship and Firm Formation Across Countries, 2007). Typical measures of entrepreneurial activity consist of new business density, entry(birth) rates and exit(death) rates.

3.2.1 Kirznerian and Schumpeterian opportunities

The generally accepted view of an entrepreneur is someone who identifies and exploits entrepreneurial opportunities. As formulated by Martin & Osberg entrepreneurs are someone who "have an exceptional ability to see and seize upon new opportunities (...)" (Martin & Osberg, 2007, p. 31). As a result, entrepreneurial opportunities play a central role in the area of research of entrepreneurship. It has been suggested that entrepreneurship should be observed in a framework that arises from the interplay of enterprising individuals and opportunities (Shane & Venkataraman, 2000). In short, the importance of entrepreneurial opportunities is widely recognized in the field of entrepreneurship.

Two different views on entrepreneurial opportunities exist in literature, the Schumpeterian(1934) and Kirznerian view(1973). The big difference between these views on entrepreneurial opportunities lies in the fact that Kirzner argues that opportunities are discovered whereas Schumpeter argues that opportunities are created by the entrepreneur (Acs & Audretsch, Handbook of Entrepreneurship Research: An Interdisciplinary Survey and Introduction, 2003) & (Parker, 2009).

According to Schumpeter(1934), entrepreneurs are innovators who actively create opportunities and push the away from equilibrium by disrupting the existing system in a process what he names creative destruction.
Kirzner's theory of entrepreneurship, on the other hand, argues that the fundamental quality of entrepreneurs is alertness to recognize previously unidentified profit opportunities. According to Kirzner, entrepreneurs have an equilibrating role as they observe an opportunity to earn supernormal profits when the market is disequilibrium (Kirzner, 1973). Entrepreneurs act upon the identified profit opportunities to equilibrate the market (Holcombe, 2003).

Furthermore, Kirzner does not believe that new information is important for the existence of opportunities as he argues that the opportunities arise due to differential access to existing information. Kirzner explains that people use information to make decision about how to allocate resources. In order words, entrepreneurs try to benefit from market inefficiencies that arise from information asymmetries (Shane S. , 2003). A classic example of Kirznerian opportunities is a situation of arbitrage in which an entrepreneur makes use of price differences in different markets to make a financial gain.
The contrasting view of Schumpeter suggests that opportunities are dependent on new information. Macro-economic or political changes, new technologies and social trends create new information

which is the source of Schumpeterian opportunities (Shane S. , 2003). As Schumpeterian opportunities are founded on new information, it is usually identified with more radical innovations in contrast to Kirznerian opportunities that are of a more incremental nature. However, Schumpeter and Kirzner both acknowledge that entrepreneurs have a pivotal role for creating innovations.

The important differences between the contrasting views of Schumpeter and Kirzner on entrepreneurial opportunities are summarized in Table 2.

Table 2: Schumpeterian opportunities vs. Kirznerian Opportunities

Schumpeterian Opportunities	Kirznerian Opportunities
Disequilibrating	Equilibrating
Requires new information	Does not require new knowledge
Very innovative	Less innovative
Rare	Common
Involves creation	Limited to discovery

Source: Scott Shane(2003), A General Theory of Entrepreneurship

3.2.2 Factors influencing new firm entry

As mentioned before, typical measures of entrepreneurial activity consist of new business density and entry(birth) rates. These indicators are based on changes in business demography and is in line with the reasoning of Schumpeter and Kirzner who argue that entrepreneurship reflect "changes" (Iversen, Jorgensen, & Malchow-Moller, 2008).

The conventional wisdom in theoretical textbooks often argue that the entry rate of new firms onto the market is a function of economic growth, technological opportunities and profit expectations (Mansfield, 1962).

This section will discuss the empirical evidence of factors that influence the level of new firm entry. Roughly, two approaches can be observed in literature that study the determinants of firm entry: individual and environmental determinants. Individual factors focuses on the personal characteristics such as education and risk aversion while environmental factors deal with factors such as the level of economic development and technology.

Klapper, Amit, Guillén and Quesada(2010) use a cross-country longitudinal dataset to study the determinants of entrepreneurial activity in the form of firm formation. They find that barriers to starting a business (number of procedures and cost of starting a business) are negatively correlated with firm entry. In addition, they find that economic development and access to credit are both positively correlated with entry rates. Economic development is measured as the GDP per capita. They note, however, that the direction of causality should be studied further to determine whether economic growth influences firm entry or whether a higher firm entry leads to economic growth.

Highfield and Smiley (1987) study what factors influence new firm creation in the U.S. economy. They make a distinction between macroeconomic and microeconomic (or cross sectional) factors that leads to firm entry. They conclude that sales growth, **higher R&D intensity** and higher profit expectations in a industry lead to higher rates of firm entry. In addition, they find that lower growth of GNP positively correlated with the rate of firm entry as they argue that a lower economic growth and resulting higher unemployment growth rates lead to lower opportunity costs of setting up a new firm.

Acs, Audretsch, Braunerhjelm and Carlsson(2005 & 2009) formulate what they call the "***knowledge spillover theory of entrepreneurship***". They argue that the knowledge stock of a country spills over to third parties and creates entrepreneurial opportunities. They define the knowledge stock of a country by measuring the domestic expenditures on R&D. Their analysis include approximately 20 OECD countries and they find that the knowledge stock is positively related to entrepreneurial opportunity. In line with the reasoning of Schumpeterian opportunities, they conclude that new knowledge leads to new opportunities for entrepreneurs to start a firm.

In addition, there are several studies that focused on the spatial determinants of entrepreneurship within a country. Močnik (2010), for example, studies the determinants of firm entries in Slovenia. He argues, in contrast to Highfield and Smiley (1987), that GDP growth will drive demand for products and goods which will lead to an increase in firm entry. Močnik does realize the role of unemployment and he argues in accordance with Highfield and Smiley (1987) that when more people become unemployed they try to find new employment opportunities by forming their own business. However, he argues that also a reverse effect is taking place as aggregate reduces aggregate demand (and in result demand for goods and services) unemployment falls. The final effect of unemployment on firm formation depends on the relative strength of the fall in demand vs. unemployment push. Ultimately, Močnik concludes that GDP per capita, unemployment rate and productivity growth have a positive significant impact on firm entry.

Armington and Acs (2002) focuses on determinants of regional variations in firm entry in the U.S. economy. In their study, the U.S. is divided into 394 geographical regions. Although they do not observe little variation over time in firm entry, they do observe considerable variation in the firm birth rate across regions. Based on their analysis they conclude that the variation in firm entry can be explained by differences in industry intensity, population growth, income growth and education levels. The positive effect of industry intensity (no. of establishments divided by population) on firm entry reflect the potential of regional spillovers between firms that are located in the same region.

Table 3: Prior research on the factors influencing new firm entry

Author	Focus	Sample	Key findings
Klapper, Amit, Guillén and Quesada(2010)	Determinants of firm entry	Comparison across 101 countries over the time period 2000-2008	Positive effect of economic development and access to credit to firm entry. Negative effect of barriers(regulation) on firm entry.
Highfield and Smiley (1987)	Determinants of firm entry	Four digit industries in the U.S. economy over the time period 1976-1981	Positive correlation of sales growth, R&D intensity and profit expectations on firm entry. Negative effect of GNP growth on firm entry.
Acs, Audretsch, Braunerhjelm and Carlsson(2005 & 2009)	Determinants of firm entry	19 OECD countries over the time period 1981-2002	Positive effect of the level of knowledge stock on firm entry(not tested).
Močnik (2010)	Determinants of firm entry	12 statistical regions in Slovenia over the period 2000-2005	Positive impact of GDP per capita, unemployment rate and productivity growth on firm entry.
Armington and Acs (2002)	Determinants of regional variation of new firm formation	U.S., divided over 394 geographical regions, across 6 industries over the period 1991-1996	Positive impact of industry intensity, population growth, income growth and education level on firm entry rate.

3.2.3 Effects of new firm entry

This section will discuss the empirical evidence of the effects on the economy that arise from entrepreneurial activity and firm births. The traditional (neo-) classical growth theory does not attribute a role to entrepreneurship as it treats technology and knowledge production as exogenous variables (Solow, 1956). Solow argues that economic output is a function of capital and labour inputs and the level of technological progress. He defines the following production function in which Y refers to output, L refers to labour, K refers to physical capital and A refers to knowledge or technology.

$$Y = K^{\alpha}(AL)^{1-\alpha}$$

However, the variable A (technology) is treated as something that is determined outside the model (Solow, 1956).
In contrast to the (neo-)classical growth theory which treats technology as something that is given and determined outside the model(exogenous), endogenous growth models tries to explain how technological progress can be influenced (Romer, 1990). Hence technological progress is determined within the model. Romer(1990) emphasize the influence on knowledge spillovers in his growth model.

Several scholars argue that entrepreneurship has an important role in economic development (Schumpeter, 1934) . The importance of entrepreneurship to a nation's economy is exemplified by the following statement: "(...)Entrepreneurship lies at the heart of national advantage" (Porter, 1990, p. 125).

Several endogenous growth models have addressed the role of entrepreneurship in economic growth (Aghion & Howitt, 1992) & (Peretto, 1998). Aghion and Howitt base their model on Schumpeterian creative destruction which links innovation with entrepreneurship. An important insight that is integrated in this model is the concept of knowledge spillovers. As argued by the **"knowledge spillover theory of entrepreneurship"** entrepreneurship is a vehicle through which knowledge spillovers occur.

Empirical evidence

The empirical evidence of the impact of entrepreneurship on **economic growth** appears to be ambiguous at best. Van Stel, Carree and Thurik(2005), for example, have studied the relation between entrepreneurial activity and economic growth. Their analysis is based on data taken from the GEM Adult Population Survey which defines entrepreneurial activity as the percentage of the adult population that is involved in a new venture(less than 42 months old). They conclude that entrepreneurial activity has a positive effect on economic growth in developed countries, but the impact on economic growth is negative in the case of developing countries.

Carree and Thurik(2008) find that the impact of firm entry on economic development consists of 3 stages(a positive direct effect which is followed by a negative and positive stage). They conclude that the net effect of firm entry on GDP growth and employment is positive and the effect on labor productivity is non-significant.

Audretsch and Keilbach(2004) tested the relation between entrepreneurship and regional economic performance in Germany. They find a positive relation between entrepreneurship capital (measured as no. of startups per capita) and productivity.

Erken, Donselaar and Thurik(2008) perform a country level analysis to investigate the link between entrepreneurship and total factor productivity (TFP). They find a positive impact of the business ownership rate on TFP.
However, other studies contradict these findings and find no such relationship between entrepreneurship and economic growth or productivity. For example, Bosma, Stam and Schutjens (2011) find no relation between firm entry and total factor productivity(TFP) in the manufacturing industry.

The key findings of the articles described in this section are summarized in the table below. Based on the literature described above, it should be concluded there is mixed evidence about the impacts of firm entry on economic outputs such as GDP growth and productivity.

Table 4: Prior research on the effects of new firm entry

Author	Focus	Sample	Key findings
Van Stel, Carree and Thurik (2005)	Economic impacts of firm entry	A set of 36 countries over the period 1999-2003	Increased business ownership activity has a positive impact on economic growth is dependent on the level of economic development. The relation is positive for developed countries, while it is negative for developing countries.
Carree and Thurik (2008)	Economic impacts of firm entry	21 OECD countries over the period 1972-2002	A change in the number of business owners has a positive impact on employment and GDP growth, while it has no impact on productivity.
Audretsch, and Keilbach (2004)	Regional economic impacts of firm entry	327 regions across (West) Germany for the year 1992	Positive impact of entrepreneurship capital on productivity.
Erken, Donselaar and Thurik(2008)	Economic impacts of firm entry	20 OECD countries over the period 1970-2001	Business ownership rate has a positive impact on TFP
Bosma, Stam and Schutjens (2008)	Impacts of firm entry and exit on the competitiveness of regions	40 regions across the Netherlands over the period 1988-2002	No relation between firm entry and TFP for manufacturing industry. Positive relation between firm entry and TFP for service industry.

Chapter 4. Conceptual framework

The literature review of the existing research conducted in the field of drivers and impacts of R&D internationalization has provided some vital insights. Most importantly, it yielded the recognition of an existing knowledge gap. This knowledge gap concerns an unexplored area of the impact of domestic innovation capacity and entrepreneurship on offshore R&D business expenditures.

Based on the literature review above, the conceptual model relating the concepts of innovation systems, domestic innovation capacity, entrepreneurship and business expenditures has been developed. This conceptual model shown in Figure 6 forms the foundation of this research.

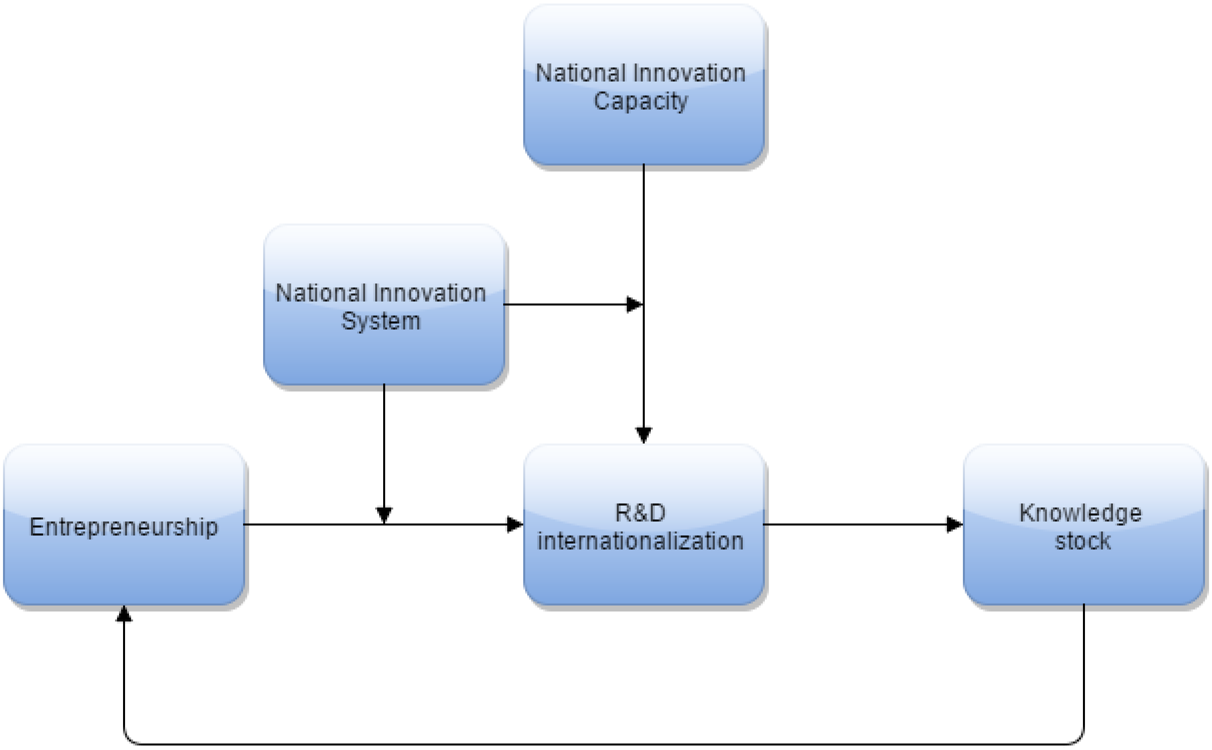

Figure 6: Conceptual framework of research project

Firms that locate their R&D activities at a particular location have the opportunity to benefit from potential knowledge spillovers that can occur between their R&D facility and local industry.

This thesis builds on existing research which claims that entrepreneurs play a central role in the transfer of knowledge between different actors as entrepreneurship is considered to be a channel through which knowledge spillovers occur. The facilitating role of entrepreneurship in the process of knowledge spillovers has important implications for the decision of firms where to locate their R&D departments. This thesis will address this issue by evaluating the relationship between entrepreneurship and R&D globalization.

Based on the literature review and the conceptual framework that has been constructed, a number of testable hypotheses are developed.

Technological capability and innovation of countries has become increasingly important for their global competitiveness (Bartholomew, 1997). Endogenous growth theory, also referred to as new growth theory, has underlined the role of technology and innovation for economic growth (Romer, 1990). Endogenous growth theory and literature on National Innovation Systems (NIS) emphasize the importance of country-specific factors such as education and R&D investments in shaping innovative and technological capabilities. This means that technological development is location-specific and can be unique for each country.
It is argued that these differences between countries start to fade as national economic and technological borders disappear by the process of globalization (Ohmae, 1990). In this view, national policies are becoming less effective in a globalized world and the terms 'global' and 'national' are seen as two opposites . However, this view is too narrow as it disregards the role of differences between nations. As a matter of fact, it could be argued that exactly the differences in technological capabilities between nations is the driving force of globalization as firms resort to foreign countries to exploit the technological capacity in these host countries (Archibugi & Michie, 1995) (Bartholomew, 1997). In other words, firms will try to tap into technological competences that are differentiated across countries. For example, firms can utilize local technological competences through access to high-skilled workforce by carrying out R&D activities in foreign countries. In addition, firms can benefit from potential knowledge spillovers from existing organizations in the host country such as universities, research institutes and innovative competitors (Kuemmerle, 1999). This argument results in our first hypothesis:

- **Hypothesis 1**: The inflow of R&D expenditure from foreign-owned firms is positively related to the innovation capacity of the host country.

The first hypothesis focuses on the effect of the technological and innovative capabilities in the host country on the inflow of FDI on R&D. But it can be argued that the capabilities of the home country will have effect as well as we argue that firms locate their R&D in a foreign country to get access to local innovation capabilities. Therefore, it is expected that firms in (home) countries with high innovation capacity will have less incentive to locate their R&D activities in a foreign country compared to firms in (home) countries with low innovation capacity. This argument results in our second hypothesis:

- **Hypothesis 2**: The outflow of R&D expenditure from the home country is negatively related to the innovation capacity of the home country.

Albeit there are some differences between their views, Schumpeter's theory of entrepreneurship as well as Kirzner's theory of entrepreneurship acknowledge the important role of entrepreneurs have in generating innovations. This suggests entrepreneurs are an important source of innovation capacity in a country. Our first hypothesis argues that the innovation capacity positively impacts the inflow of R&D expenditure of foreign owned firms. As Schumpeter(1934) and Kirzner(1973) suggest that entrepreneurship is an important source of innovations, we argue in accordance with hypothesis 1 that the level of entrepreneurship in a country will have an impact on the inflow of R&D expenditures. This reasoning results in our third hypothesis:

- **Hypothesis 3**: The inflow of R&D expenditure from foreign-owned firms is positively related with the level and quality of entrepreneurship in the host country.

The concept of National Innovation Systems(NIS) was defined by Christopher Freeman(1987) as : "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1987). This approach suggests that the potential to benefit from spillovers and knowledge transfer is dependent on the embeddedness of a firm in the National Innovation System. In other words, the embeddedness of a foreign-owned firm in the National Innovation System of the host country will affect the extent to which the company can benefit from the innovation capacity in the host country.
This argument leads to our fourth hypothesis:

- **Hypothesis 4**: The embeddedness in the National Innovation System of the host country has a moderating effect on the relationship between the inflow of R&D expenditure from foreign-owned firms and innovation capacity/entrepreneurship.

The knowledge spillover theory of entrepreneurship suggests that the knowledge stock in a country positively influences the level of entrepreneurship as it creates entrepreneurial opportunities. According to this theory, the knowledge stock in a country will lead to knowledge spillovers that "give rise to opportunities to be identified and exploited by entrepreneurs" (Acs, Audretsch, Braunerhjelm, & Carlsson, 2005, p. 1). Furthermore, R&D can be defined as "creative work undertaken (...) to increase the stock of knowledge (...), and the use of this stock of knowledge to devise new applications (OECD, 2002, p. 30). As R&D expenditures is considered to be an important source of generating new economic knowledge, we argue that the inflow of R&D expenditure from foreign affiliates will impact the level of entrepreneurship in that country. This argument results in our fifth hypothesis that can be further subdivided into two hypotheses:

- **Hypothesis 5:** The inflow of R&D expenditure from foreign-owned firms has a positive effect on firm entry (entrepreneurship) where the increasing knowledge stock in the host country acts as a mediator.

- **Hypothesis 5a:** The inflow of R&D expenditure from foreign-owned firms has a positive effect on the knowledge stock of the host country.
- **Hypothesis 5b:** The knowledge stock of the host country has a positive effect on firm entry.

The predicted relationships that are formulated in the hypotheses are visualized in the conceptual model in Figure 7. The figure depicts the relationship between the various variables. R&D internationalization and entrepreneurship form the central two concepts in this conceptual model. Please note the potential feedback loop in the relation Entrepreneurship-R&D internationalization-Knowledge stock-Entrepreneurship

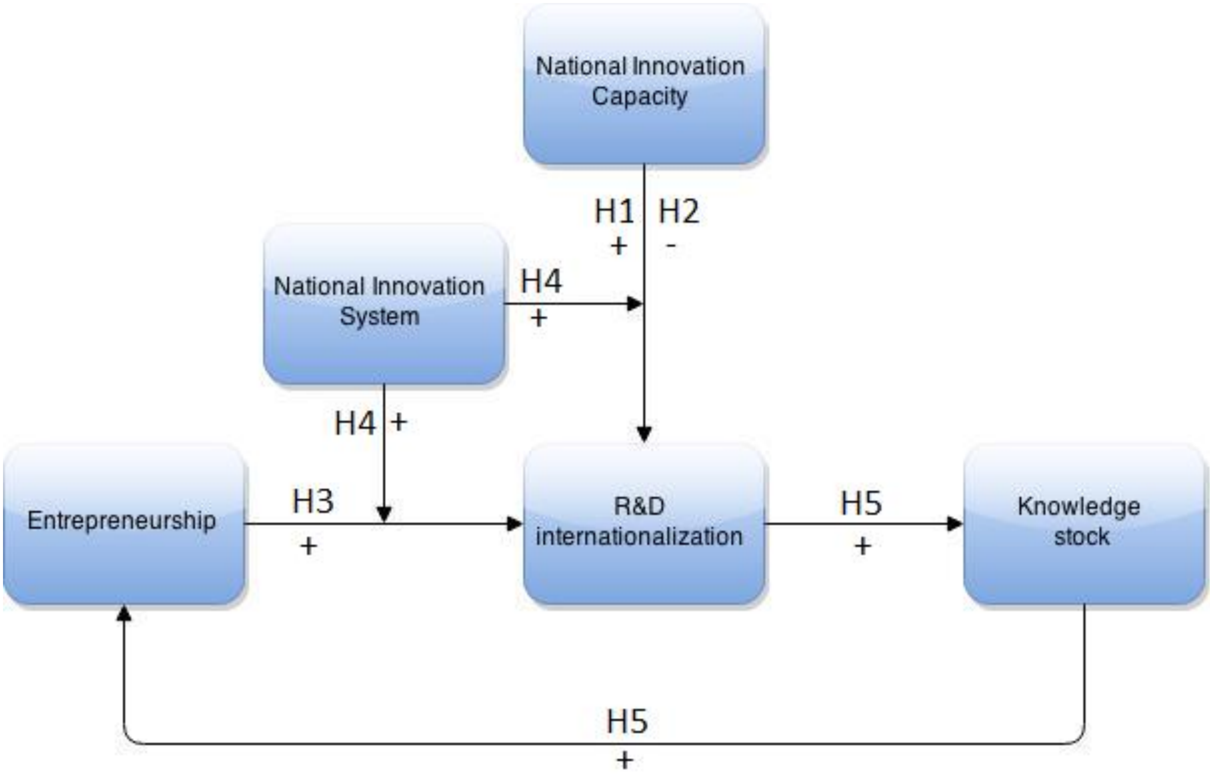

Figure 7: Conceptual model with predicted relationships in hypotheses

Chapter 5. Data and measures

The concepts R&D internationalization, domestic innovation capacity, national innovation systems and entrepreneurship have to be defined in a measurement factor in order to evaluate the relation between the aforementioned concepts. This operationalization process of the key variables is described below.

5.1 R&D internationalization

The decision of a metric to be used as a measurement factor for the concept R&D internationalization appears to be the most straightforward of the four concepts. R&D internationalization (or equivalently R&D globalization) has been defined as the process of firms relocating their R&D activities to countries other than their home country. The foreign country where the company relocates their R&D activities to is called the host country.

As a result, R&D internationalization is usually identified with the inflow of FDI in R&D. Following existing studies conducted by the European Commission, R&D internationalization is evaluated through measurement of R&D business expenditures (BERD). More specifically, R&D expenditures by foreign affiliates will be measured. The operationalization of the concept is shown in Figure 8.

The data concerning R&D business expenditures that will be collected in this research consists of:

> *R&D expenditures by foreign affiliates = Business expenditure on research and development (BERD) by foreign owned firms in the examined country. The BERD by foreign affiliates represents the inflow of R&D investments in the country that serves as a host country.*

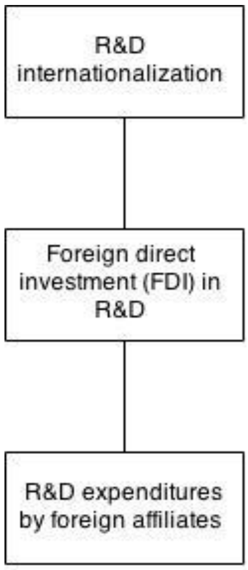

Figure 8: Operationalization of R&D internationalization

5.2 Innovation capacity

The (national) innovation capacity defines the potential of a country to produce innovations. Existing research and reports has yielded various indicators to measure innovation capacity. Broadly, speaking two type of indicators for innovation capacity can be distinguished: individual indicators and composite indicators. The next section will provide a survey of composite indicators that have been formed to measure innovation capacity. Subsequently, we will zoom in and discuss the main individual indicators that are used in existing research and form the basis of the composite indicators to measure innovation capacity.

5.2.1 Composite indicators

Composite indicators are based on a combination of several individual indicators. All individual indicators will be assigned a certain weight and are compiled into a single index. The benefit of this method is that it provides a broader view as it measures multiple dimensions of innovation capacity that can not be captured by a single indicator.

Examination of literature reveals that several indices have been used to measure the innovation capacity of a country. The most well-known indices that have been constructed and their time periods are shown in the Table 5.

Table 5: Innovation capacity indices.

Index	Time frame
Summary Innovation Index (SII)	2001-2014
Global Innovation Index (GII)	2007-2014
ArCo Technology Index	1987-1990 & 1997-2000
Innovation Capacity Index (ICI)	2009/2010
National Innovation Capacity Index(NICI)	2003
UNCTAD Innovation Capability Index	1995 & 2001

The remainder of this section will evaluate the innovation capacity indices that are presented in Table 5. Ultimately, a decision is made which of the aforementioned indices will be used in this research to assess national innovation capacity.

Summary Innovation Index (SII)

The Summary Innovation Index (SII) is constructed by the European Union since 2001 and is annually published in the Innovation Union Scoreboard. The SII measures innovation performance by combining the performance of collections of different indicators. In total, 25 indicators are combined in this index which are distributed over 3 main types of indicators. The Innovation Union Scoreboard call distinguishes between the types "**Enablers, Firm activities and Outputs**". In addition, these indicator types are further subdivided in 8 innovation dimension (European Commision, 2014). It should be emphasized that *Entrepreneurship* is one of the innovation dimensions. The complete measurement framework of the Innovation Union Scoreboard is visualized below.

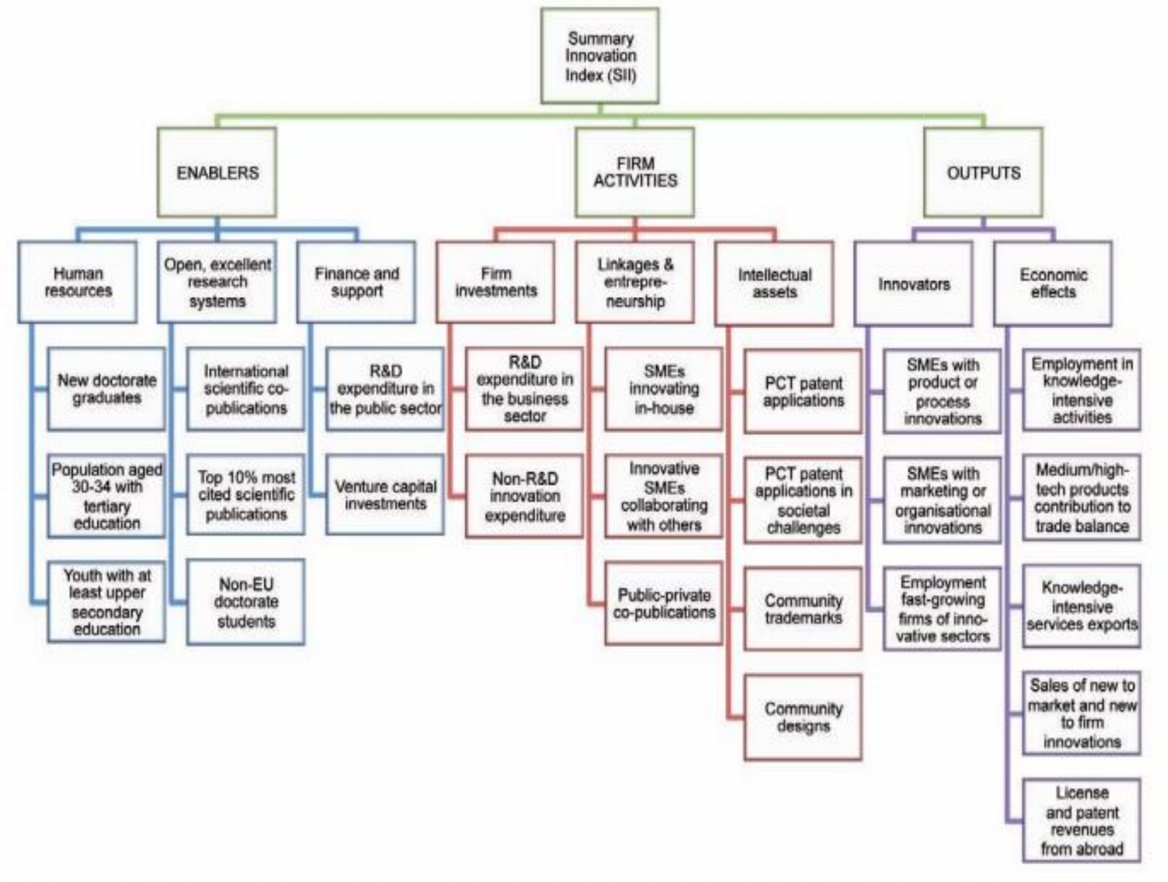

Figure 9: Framework of the Innovation Union Scoreboard (Source: Innovation Union Scoreboard 2014)

The indicator type "**Enablers**" represents the main drivers external to firms that affects the innovation performance. The innovation dimensions that fall inside this type of indicator are *'Human resources*'; '*Open, excellent and attractive research systems'* ; and *'Finance and support'*.
'Human resources' captures the measure of workforce availability that are highly skilled and completed higher education.
'Open, excellent and attractive research systems' focus on the level of the scientific base of the country and how competitive the scientific community is internationally.
'Finance and support' captures the difficulty to attract finance for innovation-related projects.

The indicator type "**Firm activities**" concern the efforts of firms that lead to innovation. Three innovation dimensions fit inside this indicator type: *'Firm investments*'; *'linkages and entrepreneurship*' and *'Intellectual assets'*.
'Firm investments' include the investments of firms that lead to the generation of innovations.
'Linkages and entrepreneurship' capture the innovation capacity of new start-ups and SMEs.As mentioned above, this dimension is of special interest to this research as the focus of the study will take an entrepreneurship-based perspective. In addition, this dimension measures knowledge spillover and research collaboration between private firms and public institutions.
The *'Intellectual assets'* dimension captures the intellectual property of firms and is quantified by measuring the quantity of trademarks and patent applications.

"Outputs" is the final indicator type in the framework of the Innovation Union Scoreboard and measures the effect of the effort by firms to innovate. Two innovation dimensions have been formed that are included in the **"Outputs"** type of indicator: *'Innovators'* and *'Economic effects'.*
'Innovators'
The dimension *'Innovators'* captures to what extent innovations have introduced onto the market. Furthermore, the dimension measures employment effects of innovational efforts by firms.
'Economic effects' is the final dimension and measures the economic effects of innovation activities in terms of employment, sales and exports.

Global Innovation Index (GII)

The World Intellectual Property Organization (WIPO) has published the Global Innovation Index (GII) since 2007. This index takes input as well as output sub-indices into account. The Innovation input sub-index is built on 5 pillars and the Innovation output sub-index on 2 pillars (Cornell University, INSEAD & WIPO, 2014). The pillars and underlying sub pillars are shown in figure 8. A total of 81 individual indicators are included in the Global Innovation Index.

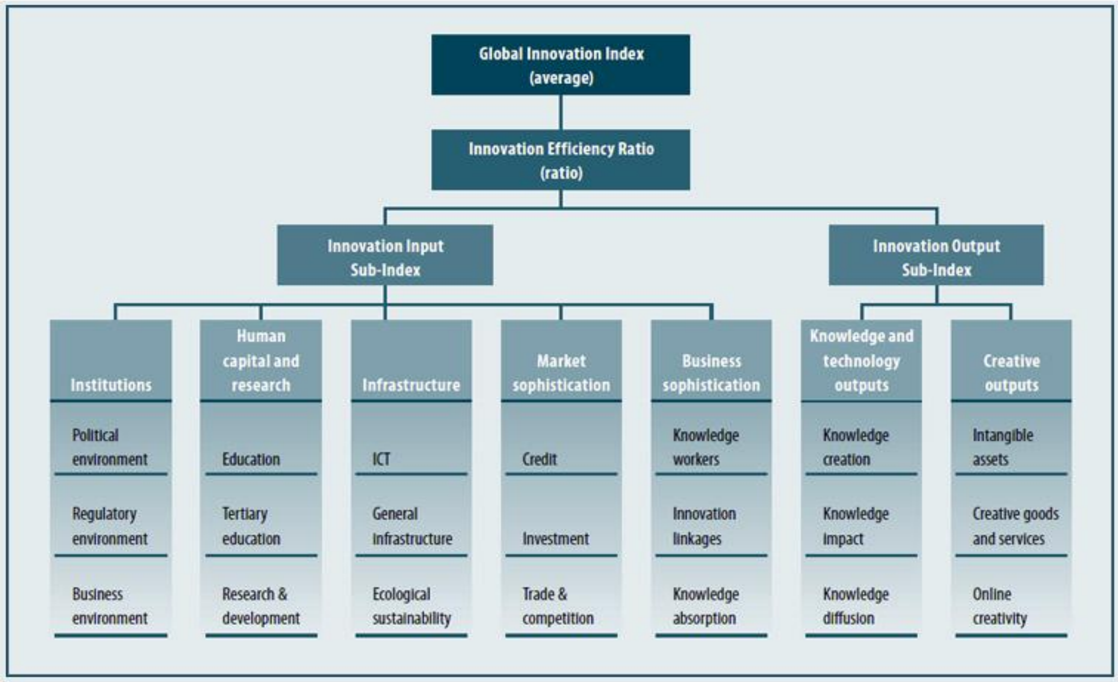

Figure 10: Framework of the Global Innovation Index

Many of the pillars and underlying indicators of the GII partially overlap with the indicators of the Summary Innovation Index (SII) described in section 9.2.1.
However, the Global Innovation Index also captures some concepts that haven't been taken into account in the SII in the European Union Scoreboard. Most notably, the Global Innovation Index incorporates institutional aspects, infrastructural inputs and creative inputs in their index.

The pillar 'institutions' is measure of the institutional environment of a country. The pillar consists of 3 sub pillars which aims to capture the government influences, regulations and business environment in a country.

'Infrastructure ' is a pillar that captures the quality of the 1) ICT network in the country; 2) the general infrastructure concerning electricity and logistics; 3) ecological sustainability which measures environmental performance.

The pillar 'creative outputs' measures one of the two pillars that captures the output of innovations. It is constructed from three sub-pillars: intangible assets, creative goods and service; online creativity. The sub pillar intangible assets includes the quantity of trademark application and survey question involving the use of ICT in the organization of businesses. The second sub pillars includes the output of media and information services. The final sub pillar 'online creativity' measure the activity on the internet of the population.

However, the issue with the Global Innovation Index (GII) is that the scoring mechanism has evolved over time. As a result, it is not possible to compare values for different years and track the longitudinal evolution of the index.

ArCo Technology Index

The ArCo Technology Index was created by Daniele Archibugi and Albert Coco in 2004. The index measuring technology capacities covers two time periods (1987-1990 and 1997-2000) and examines 162 countries.
The index considers three main dimensions (Archibugi & Coco, 2004):

- Creation of technology
- Technological infrastructure
- Development of human skills

The work by Veliyath & Sambharya has used the ArCo Technology Index as an indicator for the national innovation capability to study its effect on international R&D investments by MNC in a country.

Innovation Capacity Index (ICI)

The Innovation Capacity Index (ICI) measures the national potential to produce innovations for 131 countries for the years 2010/2011. The index is built on 5 pillars that compromise a total of 61 variables (Lopez-Claros & Mata, 2011).
The 5 pillars that form the foundation of ICI framework are:

- Institutional environment
- Human capital
- Legislation
- R&D
- Information and communication technologies.

National Innovation Capacity Index (NICI)

Porter and Stern constructed the National Innovation Capacity Index to measure the "country's potential ... to produce a stream of commercially relevant innovations" which represents the national innovation capacity (Porter & Stern, Ranking National Innovative Capacity: Findings from the National Innovative Capacity Index, 2004). The NICI was published in the WEF Global Competitiveness Report 2003-2004 and constructed the index for 78 countries in 2003. As emphasized by the authors, the index doesn't merely focus on the scientific or technological part but takes economic and political aspects into account as well. The index is constructed from five sub-indices:

- Innovation policy
- Cluster innovation environment
- Linkages
- Company operations and strategy
- Science and engineering manpower

In total, 34 measures are used to form the National Innovation Capacity Index.

UNCTAD Innovation Capability Index

In the World Investment Report of 2005 a new measure of national innovation capability was introduced. The Index was named the UNCTAD Innovation Capability Index (UNICI). The index takes two dimension into account: "innovative activity" and "skills availability for such activity" (human capital). This index takes a limited amount of individual indicators into account that form the UNICI (6 indicators distributed over 2 dimension). As a result, this index of national innovation capability is rather limited and the author themselves emphasize that the indices should be seen as broad indicators (UNCTAD, 2005).

Outcome of evaluation of innovation capacity indicators

The evaluation of the different innovation capacity indices constructed by several scholars and institutions (section 9.2.1. until 9.2.6) has provided some important insights in the similarities differences between the different indicators.
Based on the assessment of the innovation capacity indices above, it was decides to primarily use the *Summary Innovation Index (SII),* constructed by the European Union.

First of all, the SII is the index that contains the most recent data and span the largest time period. The SII has constructed the index since 2001. Furthermore the index has been updated annually. This allows the possibility to track changes of nation's innovation capacity in the last decade. Furthermore, the *Summary Innovation Index* and the *Global Innovation Index* are the sole indices that include entrepreneurship as one of the dimensions of innovation capacity. This is particularly important as this research will take a focus that is based on the entrepreneurship element of innovation capacity.

The Summary Innovation Index, as all other annual composite indicators, is based on figures that lag behind the year for which the SII refers. As stated in the Innovation Union Scoreboard(IUS) 2014 report: ' *For most indicators this reference year will be lagging 1 or 2 years behind the year to which the IUS refers'.* This means that the SII 2014 score is based on data from 2012/2013 and therefore captures the innovation capacity in the year 2012/2013.

5.2.2 Individual indicators

R&D expenditure

R&D expenditure is often considered to be the most important input to innovation. Therefore, R&D expenditure is used as a proxy of innovative activity (Greenhalgh & Rogers, 2010). This research focuses on innovation in the business environment. As a result, it is appealing to use the total business expenditure on R&D(BERD) will be used as an indicator of innovative activity. However, the dependent variable R&D expenditure by foreign affiliates is included in the total BERD as:

Total BERD=Total business expenditure on research and development (BERD) in a country. The total BERD includes investments done by domestically owned firms as well as foreign-owned affiliates in the examined country. As a result, this study will use domestic R&D business expenditure as an indicator of domestic innovation activities.

Education level

The education level is often argued to contribute to the innovation capacity of a country (Shapiro, Haahr, Bayer, & Boekholt, 2007). The education indicator tries to measure the availability of high-skilled workers and the quality of human capital and skills that form the basis of an individual's capacity to innovate. In line with the measures used in the SII and GII, the percentage of the population who has completed tertiary education is used as an indicator for the education level.

R&D personnel

The availability of R&D personnel is also an important contributor to the innovation capacity of a nation and is used in the framework of the GII. Several studies has shown that the availability of R&D personnel positively impacts the inflow of R&D investments (Reddy P. , 1997) (Moncado-Paterno-Castello, Vivarelli, & Voigt, 2011). As a result, this indicator is included in the set of individual indicators of national innovation capacity.

High-tech exports

The share of high-technology exports is the final individual indicator used in this study as a measure of a nation's innovation capacity. This indicator calculates the exports of high-technology products as a percentage of total manufactured exports. It can be argued that the share of high-technology exports captures the technological intensity of the national economy. As such, it provides a downstream measure of the outcome of national innovation capacity (Furman, Porter, & Stern, 2002). The importance of high-tech exports in assessing the national innovation capacity is exemplified by the inclusion of high-tech exports in various composite indicators such as the SII and GII.

The operationalization the innovation capacity concept is shown in Figure 11. The solid lines and boxes at the bottom represent individual indicators where the dashed box and lines represent composite indicator.

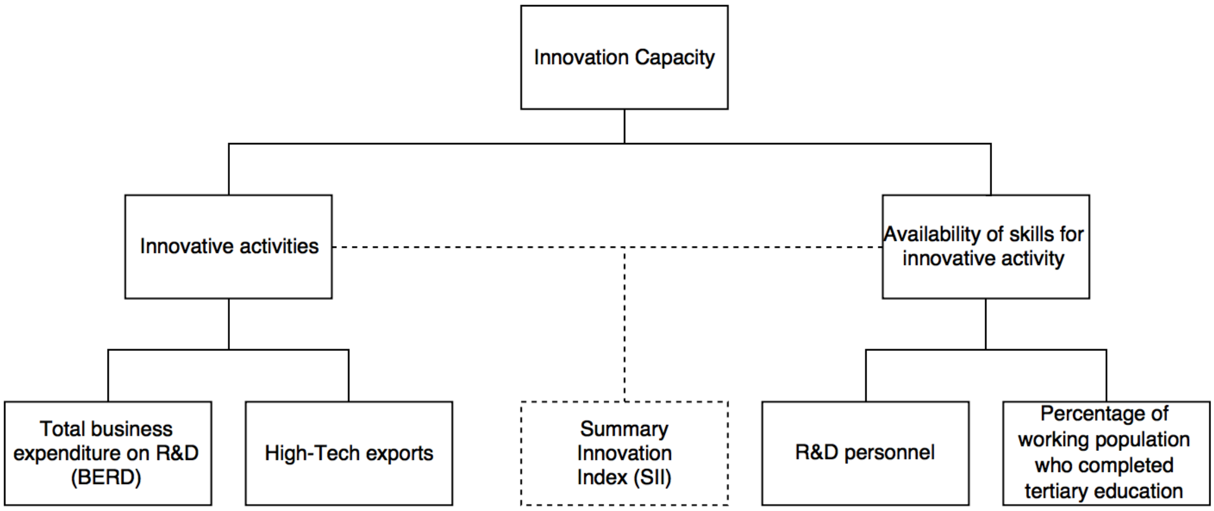

Figure 11: Operationalization of the concept innovation capacity

5.3 Entrepreneurship

Literature proposes a variety of indicators as a proxy of the level of entrepreneurship in a country. Indicators of entrepreneurship commonly used in literature consists of the number of new firms in a year, the firm birth rate, and the firm entry density.

New firm birth

This first category measures the number of new firms (firm births) per year as a proxy of entrepreneurship. However, this is not as straightforward as at it sounds. There is no general agreement on which firms should be included in the number of firm births. For example, the Eurostat Structural Business Statistics(SBS) database includes firms of all sizes in their statistic of firm births. The database includes employer firms as well as non-employer firms.

The joint OECD-Eurostat Entrepreneurship Indicator Program (EIP) and the OECD Structural and Demographic Business Statistics(SDBS) database, in contrast, includes only employer enterprises in their business demography. The SBDS database excludes non-employer firms (firms with zero employees). It is argued that the birth of employer enterprises is economically more relevant and increases the international comparability compared to data on birth of non-employer enterprises (OECD, 2014). However, data on employer business firm creation is limited as the indicator has been recently developed. As a result, the time span for which the data is available is limited. Just 7 countries in our sample have reported the number of employer enterprise birth since 2005 while the total enterprise birth data is available for the majority of the countries in our sample since 2002. Therefore, due to data availability reasons it is decided to use the total firm birth (as presented by the Eurostat SBS database) as it offers data for larger time span compared to employer enterprise birth data.

Beside the variation in firm birth data based on enterprise size considerations, another factor is the legal form type of the firm included in firm birth data. For example, the World Bank entrepreneurship database presents firm birth data of limited liability firms. The Eurostat SBS database makes a distinction between limited liability companies, sole proprietors and partnerships. This thesis will focus on the total of all legal forms of firms.

The disadvantage of the total number of firm births in a country as an indicator of entrepreneurship is that it does not take into account the size of the nation. Therefore, the number of firm birth should be adjusted in order to meaningfully compare the level of entrepreneurship across countries. Two indicators that have been developed for this reason are the enterprise birth rate and the firm entry density.

Enterprise birth rate
The enterprise birth rate is calculated by dividing the number of enterprise births by the total number of active enterprises in the same period. As a result, the enterprise birth rate reflects the dynamism in firm demography.

Firm entry density
The firm entry density is calculated as the number of enterprise births per 1,000 working age people(between ages 15 and 64). In other words, the firm entry density measures the firm entry on a per capita basis.

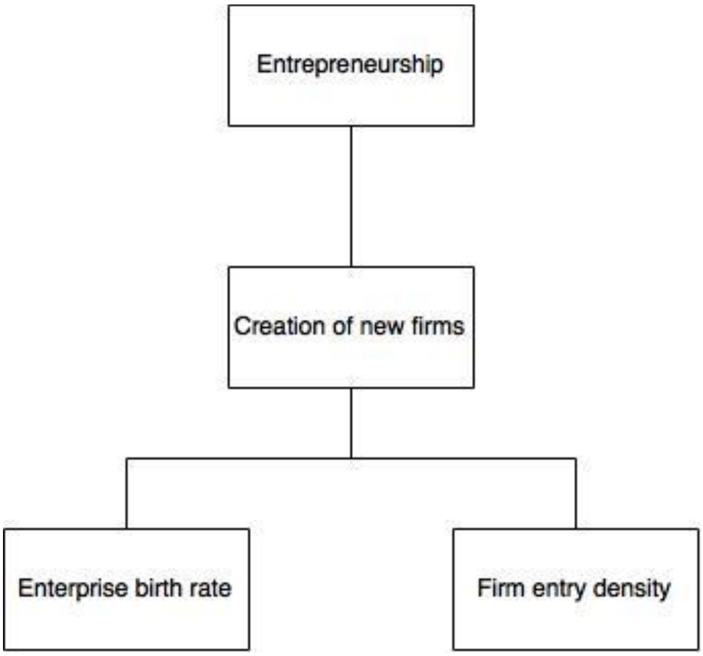

Figure 12: Operationalization of the concept entrepreneurship

5.4 Knowledge stock

Patent data

A conventional indicator that has been used to assess innovation output or activity is patent data (Hu & Mathews, 2005). The significance of patent data is exemplified by the fact that all 5 indices discussed above include patent data as an indicator of innovative performance. The innovation output reflected by the number is patents is used in this study as a measure of the knowledge stock.

Where the focus of this study is on Europe, the number of patent applications to the European Patent Office(EPO) will be used as a measure of knowledge stock.

5.5 Innovation system

After close inspection, a suitable indicator that directly measures the embeddedness of the national innovation systems of two countries was not found. However, the embeddedness or connection of the innovation systems can be proxied by assessing the overall connection between the two national economies. As a result, the total Foreign Direct Investment(FDI) stock between countries is used to assess the connection between two countries(e.g. the home and host country).
To clarify, the FDI stock that country Y(the home country) holds in country X(the host country) is used as an indicator for the embeddedness of country Y in the National Innovation System of country X.

Chapter 6. Research methodology

6.1 Data Collection

Collection of R&D expenditure data

As discussed in chapter 4.1, this research will use R&D expenditures by foreign affiliates as a measure of the concept R&D internationalization. In addition, total R&D expenditures will be used as one of the indicators of the innovation capacity of a country.

The R&D expenditure data were extracted from the OECD Main Science and Technology Indicators (MSTI database). The data on R&D expenditures by foreign affiliates extracted from the MSTI database are originally given in current PPP dollars and thus are in nominal values. These nominal values will include increases in R&D expenditure that arise due to price changes or inflation. As a result, nominal R&D expenditure data are not directly comparable from year-to-year. To overcome this issue, nominal values are converted into real values through the use of the GDP deflator which was calculated with the following formula:

$$GDP\ deflator = \frac{Nominal\ GDP}{Real\ GDP} * 100$$

The real R&D expenditure data isolates the effect of price changes and enables to compare R&D expenditures from one year to another.

Collection of Summary Innovation Index(SII)

The scores of the different countries on the SII framework has been collected through the IUS 2014 Interactive tool. As described earlier, the figures that are used in calculation the composite indicator SII lags 1 or two years behind to which the SII refers(e.g. SII 2014 is based on values of the indicators in the year 2012 and 2013). Therefore,

Collection of education level data

Data on the education level, measured by the percentage of the working age population in the age group 25-64 years who completed tertiary education, was retrieved from the OECD Education at a Glance database.

Collection of high-technology exports

This indicator calculates the exports of high-technology products as a percentage of total manufactured exports and is retrieved from the World Development Indicators database by the World Bank. High-technology exports that are included consist of products with high R&D intensity such as in the field of aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery (World Bank, 2014).

Collection of business entry data

Data on the number of business entries is retrieved from the Eurostat business demography database. The data includes both non-employer and employer firms. This means that business entry of firms with zero employees is included in the data as well.

Collection of patent data

As the focus of this research will be on the European Union, European patent data will be used as one of the indicators of knowledge stock. Data on the number of patent applications to the European patent office (EPO) was retrieved from Eurostat.

Table 6 provides an overview of the different indicators described above and specifies the source where the data was retrieved from. Furthermore, the table below includes additional control variables such as population size and GDP.

Table 6: Data sources

Variable	Indicator	Unit	Data source
R&D internationalization	R&D business expenditure by foreign affiliates	Constant prices 2010 dollars (millions)	OECD MSTI Database
Innovation capacity	• Summary Innovation Index(SII) • Domestic business expenditure on R&D • R&D personnel • Share of population that completed tertiary education (age 25-64) • High-tech exports	Scale 0-1 Constant prices 2010 dollars (millions) No. of people Percentage Percentage	European Commission OECD MSTI OECD MSTI OECD Education at a Glance World Development Indicators
Entrepreneurship	Business entry Firm birth rate	No. of firm entries	Eurostat Business Demography Eurostat Business Demography
Knowledge stock	Patent applications	No. of applications	Eurostat
Population size	Working age population (age group 15-64)	No. of people	Eurostat Population Demography
Economy size	GDP	Constant prices 2010 dollars (millions)	OECD
Innovation system embeddedness	FDI stock	Constant prices 2010 dollars (millions)	UNCTAD FDI database

6.2 Statistical analysis

A substantial part of the research will consist of quantitative data analysis. The collected data retrieved from the various databases is analyzed with the aid of the software package Stata 13. Stata was chosen over other software packages such as SPSS due to its superior handling of panel data. The statistical techniques that are used to test the formulated hypotheses consist of fixed effect regression and random effect regression models.

6.2.1. Fixed effect regression vs Random effect regression

Fixed effect and random effect regression models are a type of multiple regression technique that is used as a statistical test for panel data. The 'traditional' multiple regression equation is given by:

$$y_1 = \alpha + \beta_1 x_{11} + \beta_2 x_{12} + \cdots + \beta_m x_{1m} + \varepsilon_1$$
$$y_2 = \alpha + \beta_1 x_{21} + \beta_2 x_{22} + \cdots + \beta_m x_{2m} + \varepsilon_2$$
$$\vdots \vdots \vdots$$
$$y_n = \alpha + \beta_1 x_{n1} + \beta_2 x_{n2} + \cdots + \beta_m x_{nm} + \varepsilon_n$$

$$\rightarrow y_i = \alpha + \beta X_i + \varepsilon_i \qquad for\ i = 1,2 \ldots n$$

where y is the dependent variable, α is a scalar, β denotes the regression coefficients, X measures the regression variables and ε is an error term. The subscript i refers to the cross-sectional dimension by indexing individuals, firms, cities, countries or other cross section units.

A panel data regression is different compared to the traditional multiple regression equation since it contains a double index reflecting both the time series and cross sectional component:

$$y_{it} = \alpha + \beta X_{it} + \varepsilon_{it} \qquad for\ i = 1,2 \ldots n\ and\ t = 1,2 \ldots T$$

where the error term ε_{it} *can be decomposed into an individual specific effect* c_i *and an idiosyncratic error term* u_{it}

$$y_{it} = \alpha + \beta X_{it} + c_i + u_{it} \qquad for\ i = 1,2 \ldots n\ and\ t = 1,2 \ldots T \qquad (1)$$

Once again, the subscript i refers to observations of *n* distinct cross-sectional units(e.g. *n* countries). The t subscript is used for the time dimension by indexing observations at different moments in time. Typical time units that are used consists of monthly, quarterly or annual observations. This type of regression that combines cross sectional and time series dimensions is called panel data regression. As such, a panel data set can for example comprise of observations of n countries over a period of T years.

Unobserved characteristics of a group(e.g. a country's culture or geography) could be a source of omitted variable bias (Cameron & Trivedi, 2005). The individual specific effect c_i accounts for unobserved heterogeneity across individuals . Similarly, we can speak about 'country specific effects' when the cross sectional units consists of a set of countries. In this way, panel data analysis allows to correct for unobserved time-invariant differences between individuals, groups or countries. This means that the individual specific effect (or equivalently country specific effect) term c_i varies across observational units but do not change over time (Meyers, 2011).

In the **fixed effect regression model**, the individual(or country) specific effect c_i is allowed to correlate with the regression variables (Baltagi, 2005) (Wooldridge, 2002). The **random effect model**, on the other hand, assumes that the individual specific effect c_i is not correlated with the regression variables such that $E(c_i|X_{it}) = 0$ (Schmidheiny, 2014).
The fixed effect model can be estimated by using an approach called the within estimator to estimate the regression coefficients β. As individual specific effects are unobserved, this approach eliminates c_i by computing the average of the variables for each cross sectional unit. The mean of a variable over time is denoted with a horizontal line above the variable, such that:

$$\overline{y_i} = \frac{1}{T}\sum_{t=1}^{T} y_{it}$$

$$\overline{y_i} = \alpha + \beta\overline{X_i} + c_i + \overline{u}_i \qquad (2)$$

Please note that both the intercept α and the individual specific effect c_i do not change over time

$$\overline{\alpha} = \frac{1}{T}\sum_{t=1}^{T} \alpha = \alpha \qquad and \qquad \overline{c_i} = \frac{1}{T}\sum_{t=1}^{T} c_i = c_i$$

Therefore the terms α and c_i are eliminated by subtracting the demeaned equation (2) from the original multiple regression equation (1). This transformation is called the within transformation.

$$(y_{it} - \overline{y_i}) = \beta\left(X_{it} - \overline{X_i}\right) + (u_{it} - \overline{u}_i) \qquad (3)$$

The notation in equation 3 can be simplified through the substitution of $\ddot{y_{it}} = (y_{it} - \overline{y_i})$ to give

$$\ddot{y_{it}} = \beta\ddot{X_{it}} + \ddot{u_{it}}$$

Subsequently, this equation is solved using Ordinary Least Squares(OLS). The software package Stata uses the method described above to solve a fixed effect model.
Alternatively, the fixed effect model can be solved by defining a dummy variable for every cross sectional unit i. This method is known as the Least Squares Dummy Variable (LSDV) model and will produce identical results as the method based on the previously described within estimator.

An important limitation of the fixed effect model is that the coefficients of time invariant explanatory variables can not be estimated. This is due to the fact that this model uses only variation over time within a cross sectional unit and disregards variance between units in order to estimate the model .

The **random effect model**, in contrast to the fixed effect model, assumes that the individual specific effect c_i is not correlated with the regression variables such that $E(c_i|X_{it}) = 0$ (Schmidheiny, 2014). In other words, this model assumes that the individual specific effect is randomly distributed across cross sectional units. In this case, using a transformation as in the fixed effect model to eliminate c_i will result in inefficient estimators (Wooldridge, 2009).
In the random effects model, an composite error term is defined as $v_{it} = c_i + u_{it}$ and substituted in equation (1) to give:

$$y_{it} = \alpha + \beta X_{it} + v_{it}$$

Since c_i is constant over time, this term is in the composite error term v_{it} for each time period. Therefore, the v_{it} series is serially correlated.

$$corr(v_{it}, v_{is}) = \frac{\sigma_c^2}{\sigma_c^2 + \sigma_u^2} \quad \forall \ t \neq s$$

where $\sigma_c^2 = Var(c_i) \ and \ \sigma_u^2 = Var(u_{it})$

The Generalized Least squares (GLS) technique is used to solve this serial correlation issue

$$y_{it} - \lambda \overline{y_i} = \alpha (1 - \lambda) + \beta \left(X_{it} - \lambda \overline{X_i}\right) + (v_{it} - \lambda \overline{v_{it}}) \qquad (4)$$

$$where\ the\ GLS\ transformation\ is\ given\ by\ \lambda = 1 - \sqrt{\frac{\sigma_u^2}{\sigma_u^2 + T\sigma_c^2}}$$

Recall that the fixed effect estimator is given by:

$$(y_{it} - \overline{y_i}) = \beta\left(X_{it} - \overline{X_i}\right) + (u_{it} - \overline{u}_i) \qquad (3)$$

At first glance, equations 3 and 4 may seem similar. However, there is an important difference as the time averages in equation 3 are weighed by a factor λ. The fixed effect estimator(equation 3) uses fully time demeaned variables while the random effect(equation 4) involves quasi-demeaned data. This means that fixed effects considers only variation within a cross sectional unit while random effects takes into account the variation both within as well as between cross sectional units. As a result, the random effect model is more efficient compared to the fixed effect model (Allison, 2005). However, in the case that the random effect assumption (c_i and X_{it} are not correlated) does not hold, the random effects model is not consistent (Asteriou & Hall, 2007). Therefore, it is needed to test whether the condition is fulfilled that c_i and X_{it} are not correlated and thus, to decide if the fixed effect or random effect model should be used.

The Hausman test is used to decide whether it is appropriate to use the fixed effect or the random effect model in our regression analysis. This test assesses whether there is a difference between the regression coefficients of the fixed effect and random effect models and tests whether there exists correlation between the individual specific effect and the regression variables.
When the regression coefficients of the random and fixed effect model β_{RE} and β_{FE} are similar, it indicates that there is no correlation between the individual specific effect and the regression coefficients (Clark & Linzer, 2012). The null hypothesis of the Hausman test is that β_{RE} and β_{FE} are not different from each other. When this test rejects the null hypothesis (p<0.05), the two models are significantly different from each other and the fixed effect model is preferred (Hausman, 1978).

6.3 Empirical models

The first part of the analysis focuses on the host country determinants of the inflow of business R&D expenditure by foreign affiliates. In other words, it will give an analysis of the factors of the host country that drives inward business R&D expenditure. The regression equation takes the following form:

$$\log(R\&D\ inflow_{it}) = \alpha + \beta_k X_{itk} + \varepsilon_{it} \quad (1.1)$$

where $R\&D\ inflow_{it}$ represents the business R&D expenditure by foreign affiliates in country i at time period t. X_{it} represents a matrix of k explanatory variables in country i at time period t and β indicates the coefficients of the explanatory variables. ε_{it} represents an error term. For simplicity of notation, this error term is dropped in all following equations but remains implied.

The dataset of several variables are skewed. Therefore, the logarithmic transformation is taken for the appropriate variables to ensure a normal distribution.

Model 1

The first model will focus on national innovation capacity as a determinant of the inward BERD. When the proposed indicators of innovation capacity are filled into Equation 1.1, the regression model takes the following form in Equation 1.1A and 1.1B:

$$\log(R\&D\ inflow_{it}) = \alpha + \beta_1\ SII + \beta_2 \log(GDP) \qquad (1.1A)$$

$$\begin{aligned}\log(R\&D\ inflow_{it}) = \alpha + \beta_1 \log(Domestic\ BERD) + \beta_2\ Education\ level \qquad (1.1B)\\ + \beta_3\ R\&D\ personnel + \beta_4\ Hightech\ exports\\ + \beta_5\ Wage\ cost + \beta_6 \log(GDP)\end{aligned}$$

$where,$

$R\&D\ inflow = Business\ expenditure\ on\ R\&D\ in\ host\ country\ by\ foreign\ affiliates$
$SII = Summary\ Innovation\ Index$
$Domestic\ BERD = Business\ expenditure\ on\ R\&D\ in\ host\ country\ by\ domestic\ enterprises$
$Education\ level = share\ of\ population\ who\ attained\ tertiary\ education$
$R\&D\ personnel = R\&D\ personnel\ per\ 1000\ population$
$Hightech\ exports = share\ of\ hightech\ exports(\ as\ \%\ of\ total\ exports)$
$Wage\ cost = average\ annual\ wages$
$GDP = Gross\ Domestic\ Product$

The first four explanatory variables(SII, Domestic BERD, Education level, R&D personnel and Hightech exports) in equation 1.1A and equation 1.1B are indicators of the innovation capacity of the host country. The final two variables (GDP and wage costs) are included to control for the economy size and cost of labour in the host country.

Model 2

The second model builds onto model 1 by adding entrepreneurship as one of the explanatory variables. As a result, the regression equation is formulated as follows:

$$\log(R\&D\ inflow_{it}) = \alpha + \beta_1 \log(Domestic\ BERD) + \beta_2\ Education\ level + \beta_3\ R\&D\ personnel + \beta_4\ Hightech\ exports + \beta_5\ Wage\ cost + \beta_6 \log(GDP) + \beta_7\ Entrepreneurship \quad (2)$$

$where,$

$$Entrepreneurship = firm\ birth\ rate = Number\ of\ new\ firms\ entering\ the\ market.$$

Model 3

The next model is based on the gravity model of FDI and includes both host and home country determinants of the inflow of business expenditure on R&D. The gravity model for FDI finds its foundation in Newton's law of gravitation which explain the gravitational force between two bodies is dependent on their masses and the distance between them. In FDI terms, the gravitational force phenomenon equivalent is the FDI flow between two countries and the 'mass' equivalent is indicated by factors as the size of the countries such as GDP level or population size (Talamo, 2007). In other words, the basic underlying idea is that the interaction between two countries is dependent on variables of both country 1 and country 2.

The gravity model could also be applied for R&D expenditure by foreign affiliates as this can be considered to be a special type of FDI. The third regression model used in our analysis is an extended version of the 'traditional' gravity model which includes innovation capacity of the home and host country as an explanatory variable in addition to the traditional variables in the gravity model (e.g.GDP of the home and host country).

The third model is formulated as follows,

$$\log\left(R\&D\ inflow_{ijt}\right) = \alpha + \beta_1 \log(GDPi) + \beta_2 \log(GDPj) + \beta_3\ SII_i + \beta_4\ SII_j \quad (3)$$

Model 4

The fourth models builds on the previous models and includes the moderating effect of the national innovation system.

$$\log\left(R\&D\ inflow_{ijt}\right) = \alpha + \beta_1\ FDI_{ijt} * \log(GDPi) + \beta_2\ FDI_{ijt} * \log(GDPj) + \beta_3 FDI_{ijt} * \ SII_i + \beta_4\ FDI_{ijt} * SII_j \quad (4)$$

where,

$$FDI_{ijt} = FDI\ stock\ possessed\ by\ country\ j\ in\ country\ i$$

Model 5 & 6

The fifth and sixth regression model will be used to test the influence of the inward BERD on entrepreneurship as reflected in hypothesis 5. This hypothesis states that inward BERD will positively affect domestic entrepreneurship by increasing the knowledge stock in the host country.

Model 5 will investigate the impact of inward BERD on the national knowledge stock in the host country. The focus will be on the contribution of foreign-controlled enterprises to the national knowledge stock as foreign-controlled affiliate enterprise are the self-evident source of inward BERD. The foreign ownership of domestic patent applications is a straightforward indicator of the foreign contribution to the knowledge stock of a host country.

Several studies have studied the impact of R&D activity on patent applications and found a positive and significant impact of R&D expenditure on the number of patent applications (Bound, Cummins, Griliches, Hall, & Jaffe, 1984). Based on these findings, the fourth regression model takes the following form:

$$\log(Foreign\ Patent_{it}) = \alpha + \ \log(R\&D\ inflow_{it}) \qquad (5)$$

The sixth model focuses on the relationship between the knowledge stock and the level of entrepreneurship in a country. As a result, the fifth regression model is formulated as follows:

$$Entrepreneurship_{it} = \alpha + \beta_1 Foreign\ Patent_{it} + \ \beta_2(\ GDP\ growth)_{it} \qquad (6)$$

Table 6 provides an overview of the five models and the corresponding hypotheses that are tested in each individual model.

Table 7: Overview of models and corresponding hypotheses that are tested.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Hypothesis 1	x	x	x	x		
Hypothesis 2			x	x		
Hypothesis 3		x				
Hypothesis 4				x		
Hypothesis 5a					x	
Hypothesis 5b						x

Chapter 7. Descriptive statistics

Our sample includes data on a subset of countries that are a member of the European Union. As shown in Figure 13, all Western European countries except Denmark, Iceland and Luxembourg are included in our sample. In addition, several (East) Central European such as Poland, Slovakia, Slovenia and Czech Republic are included. In total, our data sample consists of 19 EU countries. The primary reason for excluding several European countries is due to data availability reasons.

Figure 13: Countries included in our sample

The development of R&D internationalization over time is visualized in Figure 14. This figure shows how the inflow of R&D expenditures by foreign affiliates has progressed over the years for the individual countries. Please note that this figure only includes those countries for which R&D expenditure data is available for at least 4 years. Based on this figure, we can observe that R&D globalization has played an increasingly prominent role as the inflow of R&D expenditure by foreign affiliates has increased in the majority of the countries. All countries in Figure 14 except Austria, Italy and Turkey show an upward trend of R&D expenditure by foreign affiliates.

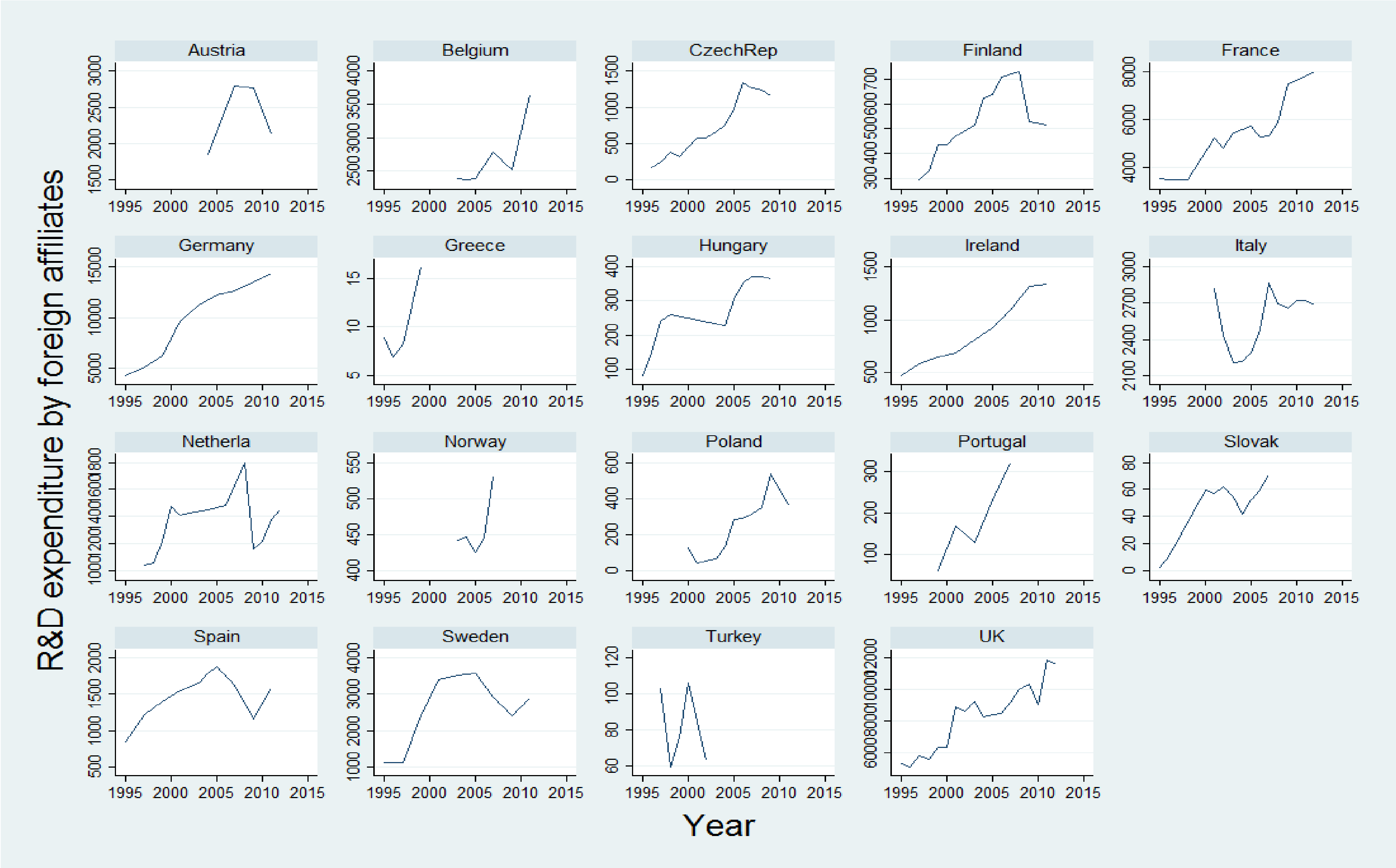

Figure 14: Development of R&D expenditure by foreign affiliates over time

The share of BERD by foreign affiliates in the total amount of BERD is illustrated in Figure 15. This figure shows the percentage of total BERD that originates from foreign affiliates in 19 host countries for the years 2000(2001), 2003, 2007 and 2011.

This figures illustrates there are huge differences between countries in the intensity of foreign R&D expenditures. The percentage of total BERD that originates from foreign firms accounts for 70 and 80 percent respectively for Belgium and Ireland. The percentage in Finland, on the other hand, is steady around 10%.

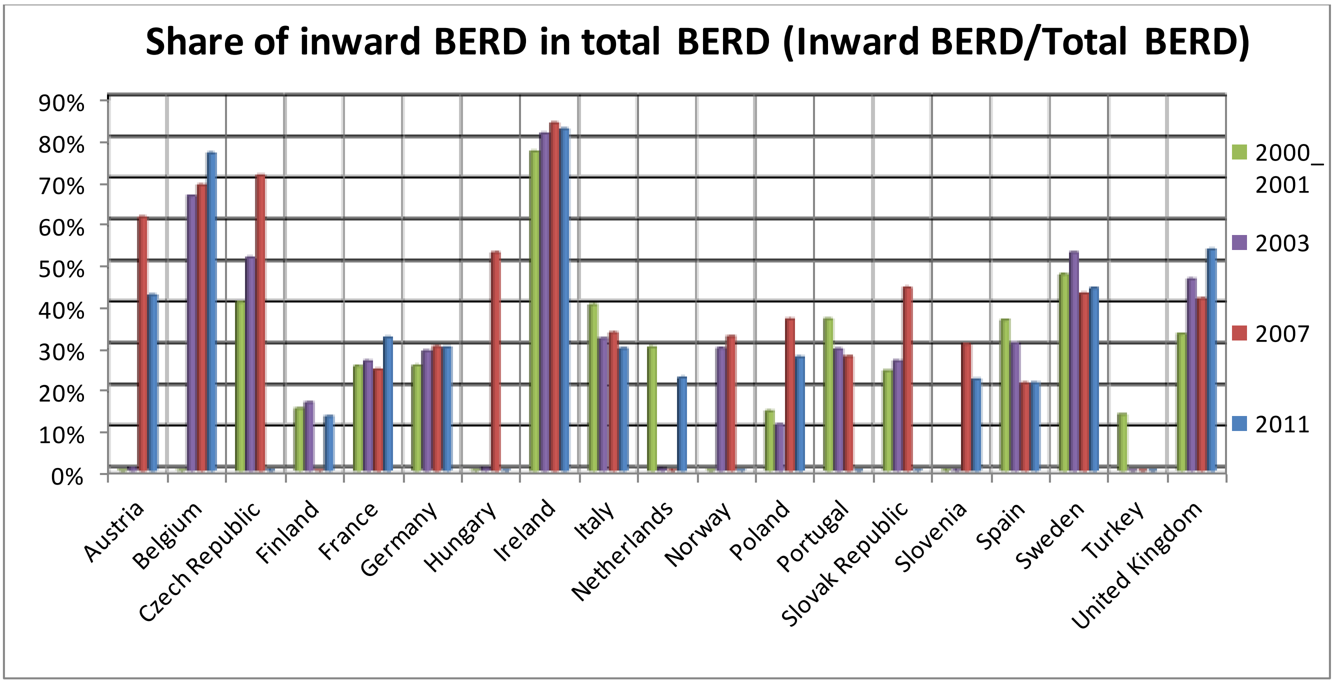

Figure 15: Intensity of inward BERD as a percentage of total BERD

Figure 16 visualizes the overall inward BERD intensity for European countries in 2007.The size of the blue spheres in the figure corresponds to the inward BERD expressed in constant PPP dollars. It can be observed that the UK and Germany are the two main countries that attract the highest amount of BERD investments from foreign businesses. It should be noted that while Germany and the UK attracted a roughly equal amount of foreign BERD at the start of 21st century, Germany has surpassed the UK as the country with the highest inward BERD intensity during the first decade in the 21st century.

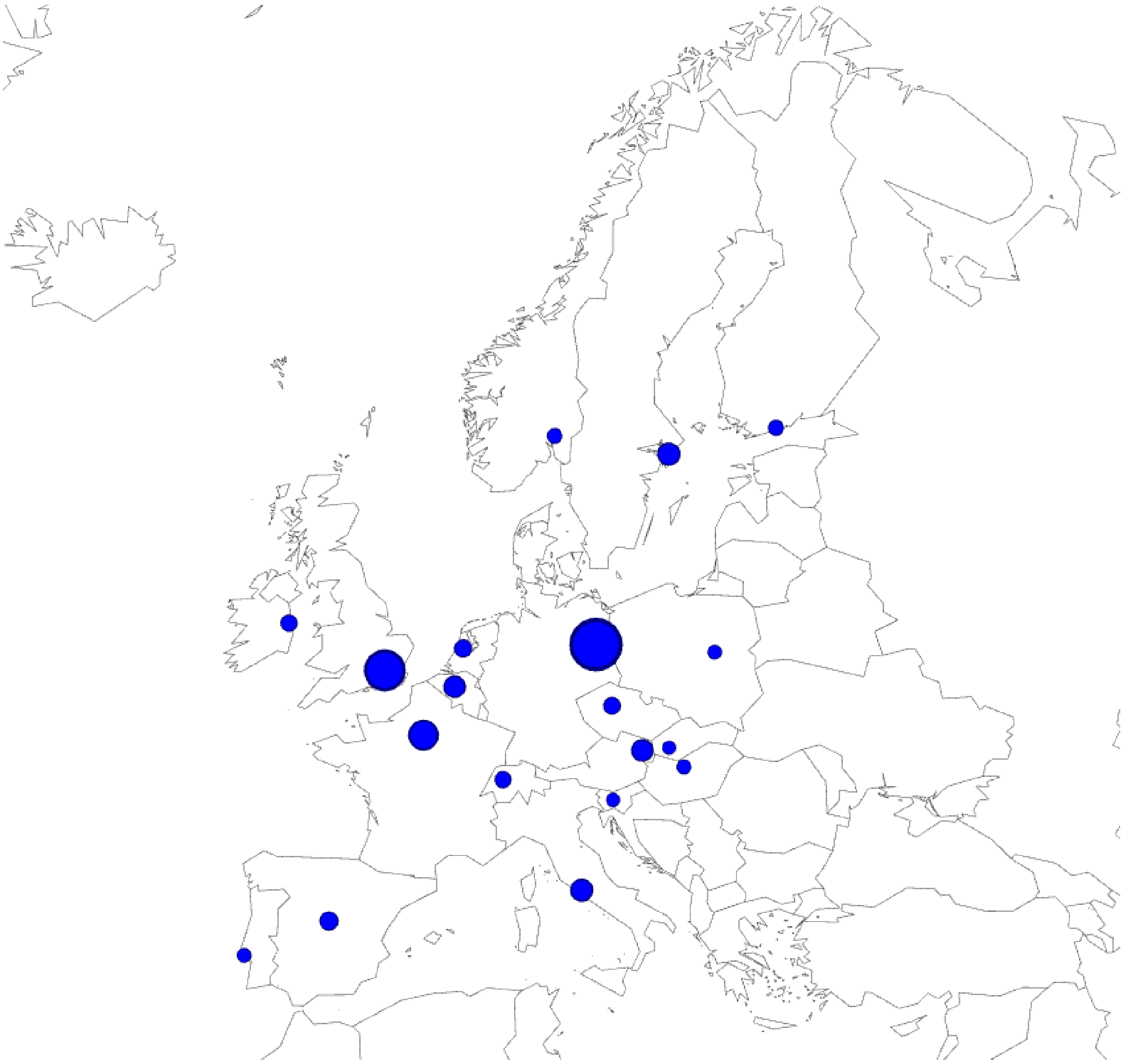

Figure 16: Inward BERD intensity of European countries in 2007

Now we focused at the inward BERD intensities of the various countries in Europe, it is time to have a closer look at the BERD network by focusing on the R&D investment flows between the various countries in the EU. The OECD globalization database has been utilized for this goal. The outcome is visualized in the figure on the next page. The sizes of the blue spheres again represent the inward R&D intensity in much of the same way as they did in Figure 16. However, Figure 17 only accounts for the manufacturing sector instead of the entire business sector which explains the minor discrepancies between the different figures. The blue lines between the countries represent the total

R&D flows (in both directions) between countries. To clarify, the line connecting France and Germany represents the added total expenditure of French firms investing in R&D activities in Germany and German firms investing in R&D activities in France. Again, the expenditure flow data between countries used in figure 16 applies to the manufacturing sector.

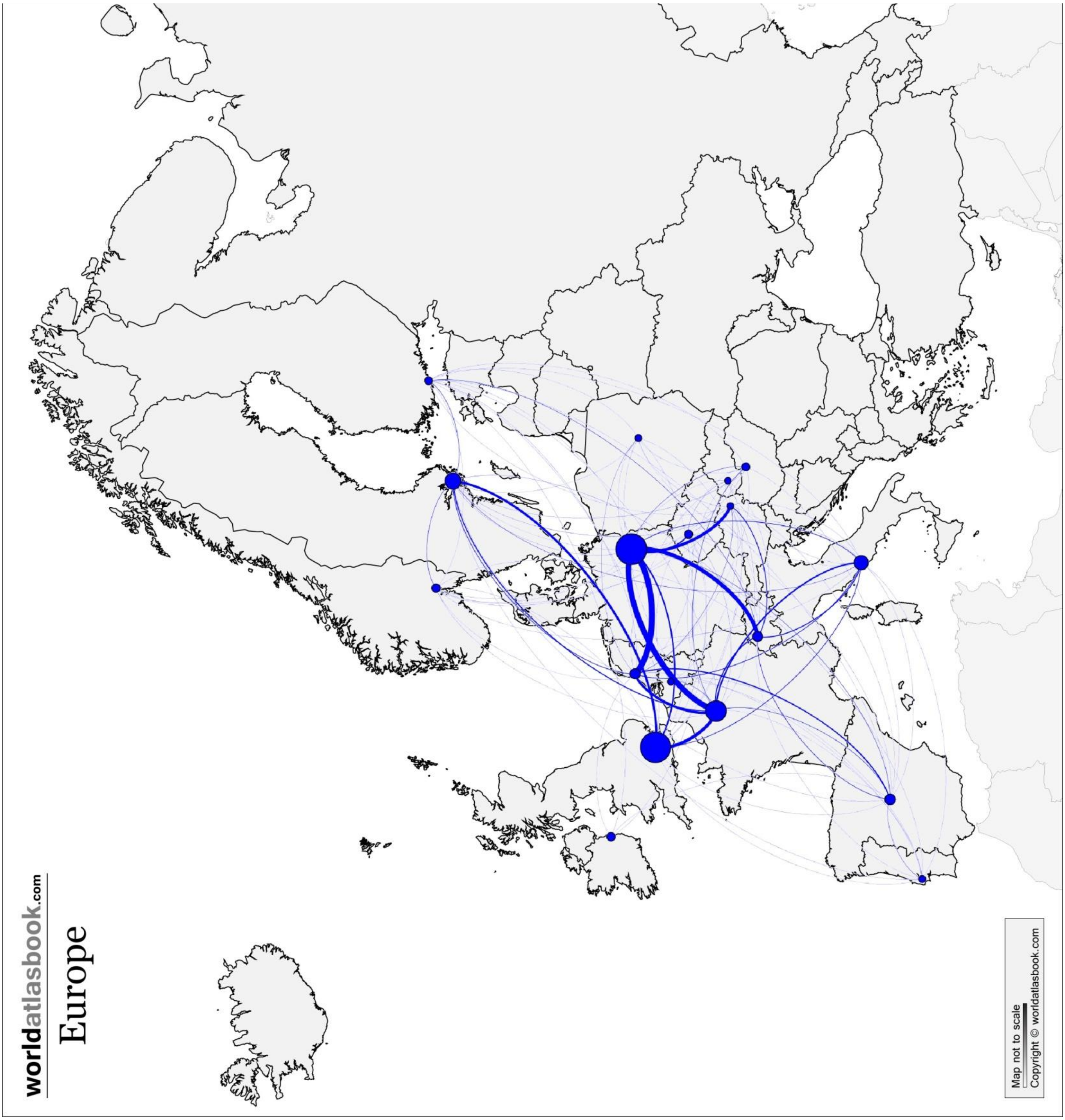

Figure 17: R&D expenditure flows between European countries

Chapter 8. Results and Discussion

Model 1

Table 8 presents the regression output of the first empirical model. This table and the remaining tables that summarizes the regression output for the different models (Table 8 to table 12) report the regression coefficient (β), the standard error (Std. Err.), the t-statistic(for fixed effect regression), the z-statistic(for random effect regression) and the significance level.
The complete regression outputs of the different mode nl can be found in Appendix II.

The Hausman test statistic(p=0,1051> 0.05) for model 1A, has revealed that the random effect model is preferred over the fixed effect model. The comparison of the fixed effect and random effect models and the output of the Hausman test is included in the Appendix.

Table 8: Regression output model 1A

Dependent variable		**Log(BERD by foreign affiliates)**		
Random effect regression	β	Std. Err.	z-value	Significance
Model 1A				
SII	2.60003	0.6510213	3.99	0.000
Log(GDP)	1.098541	0.1329572	8.26	0.000
Constant	-8.443733	1.738185	-4.86	0.000

The predictor variables have a VIF value well below 10, or a tolerance(1/VIF) above 0.1. A threshold value of the VIF above 10, or equivalently a tolerance below 0.1, is generally used as a rule of thumb to determine whether the regression suffers from multicollinearity issues (Hair, Black, Babin, & Anderson, 2009). Therefore, we conclude that there is no problem of collinearity among the predictor variables.
The table shows that both SII and GDP make a positive contribution to the prediction of the dependent variable. This finding is in line with the expectations based on theory which suggests that the innovation capacity of a country(in this analysis measured as the composite indicator SII) is an attractor of R&D globalization.

Table 9 shows the regression output for model 1B. The Hausman test statistic(p=0.0271< 0.05) for model 1B, has revealed that the fixed effect model is preferred over the random effect model.

It turned out that the domestic BERD and GDP are strongly correlated and caused a VIF value above 10. To overcome this issue, domestic BERD as a ratio of GDP was used as a explanatory variable. After this transformation, all predictor variables had VIF below 10. However, the VIF of the variables Log(Domestic BERD/GDP) and R&D personnel is above 5(respectively 5.46 and 7.13) which indicates that there is still moderate collinearity. Therefore, the R&D personnel variable is eliminated from the regression.
The regression with and without R&D personnel included in the model are shown in Table 9 and

Table 10. It should be noted, however, that the model in Table 10 is to be preferred as multicollinearity is less of an issue in this model.

Table 9: Regression output model 1B

Dependent variable	Log(BERD by foreign affiliates)			
Fixed effect regression	β	Std. Err.	t-value	Significance
Model 1B				
Log(Domestic BERD/GDP)	0.1600008	0.132848	1.20	0.231
R&D personnel	0.0397572	0.0248313	1.60	0.112
Education level	0.0331656	0.0128151	2.59	0.011
Wage costs	-0.433924	0.196747	-2.21	0.029
Log(High tech exports)	0.3324036	0.1159389	2.87	0.005
Log(GDP)	2.236398	0.5074915	4.41	0.000
Constant	-22.16339	5.92204	-3.74	0.000

Table 10: Regression output model 1B(R&D personnel variable excluded)

Dependent variable	Log(BERD by foreign affiliates)			
Fixed effect regression	β	Std. Err.	t-value	Significance
Model 1B				
Log(Domestic BERD/GDP)	0.2184426	0.1286005	1.70	0.092
Education level	0.0347468	0.0128635	2.70	0.008
Wage costs	-0.3696108	0.1939078	-1.91	0.059
Log(High tech exports)	0.3544398	0.115899	3.06	0.003
Log(GDP)	2.413768	0.4986079	4.84	0.000
Constant	-24.12276	5.833472	-4.14	0.000

The regression coefficients in both Table 9 and

Table 10 indicate that the education level, high-technology exports and GDP positively impacts the dependent variable R&D expenditure by foreign affiliates. This is in line with the findings in model 1A and hypothesis 1 that states that the innovation capacity of the host country is positively related to the inflow of R&D expenditure from foreign-owned firms.
Although, the regression coefficient of domestic BERD on the inflow of foreign R&D in

Table 10 is positive, this result is inconclusive as the significance level equals 0.092. For $p<0.05$, we can not conclude that domestic BERD positively impacts foreign R&D inflow. Nonetheless, there is weak evidence of the existence of a positive correlation between domestic and foreign BERD.
The regression coefficient of wage costs in Table 9 is negative and significant as it meets the criterion $p<0.05$. However, the result in

Table 10 is non-significant for $p<0.05$. Therefore, the resulting impact of wage costs on the inflow of R&D is inconclusive, but shows a weak evidence of a negative relation between the two variables.

Based on the regression results of model 1A and 1B we can conclude that our first hypothesis is supported. These findings support the idea found in literature that countries locate their R&D activities in foreign countries to delve in local competences to enhance their innovative activities (Archibugi & Michie, 1995) (Bartholomew, 1997). The positive regression coefficient of the education level in the host country suggests that the availability of a high-skilled workforce is an important reason for a firm to invest in R&D activities in a foreign country. In addition, the positive effect of the technological intensity of the host country(captured by the share of high-technology exports) on R&D expenditure by foreign affiliates is in line with literature that suggests that locating in innovative countries offers the opportunity benefit from potential knowledge spillovers from existing organizations such as universities, research institutes and innovative competitiors (Kuemmerle, 1999).

Model 2

Table 11 presents the regression output for model 2 where the firm birth rate is used as the entrepreneurship indicator. This second model builds on the previous model 1A by adding the entrepreneurship variable to predict the inward BERD by foreign affiliates.
The Hausman test statistic($p=0.0209< 0.05$) for model 2, has revealed that the fixed effect model is preferred over the random effect model.

Table 11: Regression output model 2

Dependent variable	Log(BERD by foreign affiliates)			
Fixed effect regression	β	Std. Err.	t-value	Significance
Model 2				
Log(Domestic BERD/GDP)	0.1140215	0.1271144	0.90	0.372
Education level	0.0258126	0.0129363	2.00	0.049
Wage costs	-0.6802438	0.24159	-2.82	0.006
Log(High tech exports)	0.2584989	0.1146687	2.25	0.026
Log(GDP)	2.551438	0.5284875	4.83	0.000
Firm birth rate	0.0427053	0.012694	3.36	0.001
Constant	-25.44521	6.129866	-4.15	0.000

The table shows that the entrepreneurship variable makes a significant (positive) contribution as a predictor of the dependent variable. This finding is in line with what we expected based on our theoretical framework as captured in hypothesis 3 which states that inward BERD by foreign affiliates is positively related to the entrepreneurship level.
This finding suggests that managers of multinational corporations acknowledge the potential of knowledge spillovers between R&D facilities and local entrepreneurs. Both Schumpeter(1934) and Kirzner(1973) theorized that entrepreneurs play an important role in generating innovations. The findings of the second regression model suggest that multinational corporations embrace this argument as the decision for the location of setting up an R&D facility in a foreign country appears to be affected by the entrepreneurship level(among other features) in the host country.

Furthermore, the regression coefficients of education level, high-tech exports and GDP are positive and significant for $p<0.05$. Domestic BERD did not prove to be a significant determinant of inward BERD by foreign affiliates. The regression coefficient of the cost of labour (reflected in wage costs) is negative and significant at the 0.05 significance level. These findings are similar to the findings of model 1B in Table 9.
Overall, the significance level of the regression coefficients of the explanatory variables in model 2 is lower compared to model 1B. This is possibly a result of a smaller number of observations (139 observation in model 1B vs. 122 observations in model 2) due to limitations in the data availability of entrepreneurship data.

Model 3

Table 12 shows the regression output of model 3. Unlike the previous models, this model also takes the source into account of the inflow of foreign BERD. In other words, model 3 considers both the host and home country determinants of inward BERD. The Hausman test statistic($p=0.0602>0.05$) has revealed that the random effect model is preferred over the fixed effect model.

Table 12: Regression output model 3

Dependent variable	**Log(BERD by foreign affiliates)**			
Random effect regression	β	Std. Err.	z-value	Significance
Model 3				
SII host country	3.845895	0.7315062	5.26	0.000
SII home country	5.796819	0.816781	7.10	0.000
Log(GDP host country)	1.004486	0.1085862	9.25	0.000
Log(GDP home country)	0.8180619	0.1064639	7.68	0.000
Constant	-26.78542	2.105019	-12.72	0.000

The regression coefficient of the innovation index SII for the host country is positive and significant. This finding is in line what we expected based on theory and agrees with our findings in model 1A, model 1B and model 2.
Furthermore, the regression coefficient of the SII for the home country is positive as well and significant. This finding opposes our hypothesis that *the innovation capacity of the home country is negatively related to the outflow of R&D expenditure from the home country.* Therefore, we can conclude that this hypothesis is not supported. This contradicts our argument that firms in (home) countries with high innovation capacity will have less incentive to locate their R&D activities in a foreign country compared to firms in (home) countries with low innovation capacity.
In fact, the opposite situation in which the *innovation capacity of the home country is positively related to the outflow of R&D expenditure from the home country* appears to be supported. This could suggest that a technological disadvantage or lower innovation capacity of the home country(with respect to potential host countries) impedes R&D investments in countries with a higher technological capability or innovation capacity. A possible explanation of this behavior could be that firms originating from a less developed home country lack the knowledge stock and human capital to benefit from knowledge spillovers if the initial technological distance to the host country is too large (Hofmann, 2013).

The results of regression model 3 should be treated with great care, however. The reason for this caution lies in the underlying data which is troubled with gaps in availability due to confidentiality reasons. Some countries such as Belgium has been excluded as a host country in the sample as a consequence of data unavailability due to these confidentiality reasons. In addition, multiple host countries do not specify all home countries from which the inward BERD originates. For most host countries only the bigger contributors of inward BERD are specified. For example for the UK, only inward BERD originating from the home countries France and Germany are specified. As a reason of this data availability, the data distribution seems to be tended towards including large and more developed home countries while excluding the smaller and less developed home countries.

Model 4

Table 13 presents the results of the fourth regression model. This fourth model builds on the previous model by including the effect of FDI stock. The regression model includes both the direct effect of FDI stock on the inflow of BERD and the interaction effect with SII host and SII home. This interaction effect captures the moderating effect of the relation SII host, SII home < --- > inflow of BERD as formulated in hypothesis 4.
The Hausman test statistic($p=0.0857> 0.05$) for model 4, has revealed that the random effect model is preferred over the fixed effect model.

Table 13: Regression output model 4

Dependent variable	**Log(BERD by foreign affiliates)**			
Random effect regression	β	Std. Err.	z-value	Significance
Model 4				
SII host country	0.5501785	0.1242804	4.43	0.000
SII home country	0.5969637	0.144104	4.14	0.000
FDI stock	0.8887313	0.1873643	4.74	0.000
Log(GDP host country)	0.649666	0.1085862	9.25	0.000
Log(GDP home country)	0.5482572	0.1064639	7.68	0.000
SII host country* FDI stock	0.00173	0.1482529	0.01	0.991
SII home country* FDI stock	0.2556961	0.1827411	1.40	0.162
Constant	-14.02904	2.314115	-6.06	0.000

In agreement with the previous model, the regression coefficients of SII and GDP for the host and home country remain positive and significant. Furthermore, the regression coefficient of FDI stock is significantly positive as well. The interaction term of FDI stock with SII for the host and home country, on the other hand, is non-significant.

The findings suggest that the FDI stock in the host economy by country of origin has a positive impact on the inflow of foreign BERD originating from the corresponding home country. This means that the home country that possesses a higher FDI stock(compared to countries holding a lower FDI stock) in a host country will make a larger BERD investment in this host country.
The mathematical product of SII host(or SII home) and FDI stock captures the moderating effect of FDI stock on the relationship between SII host(or SII home) and the inflow of foreign BERD. As the regression coefficients of SII host country* FDI stock and SII home country* FDI stock are both non-significant, this mediating effect is not observed. Therefore, we can conclude that our fourth hypothesis is not supported. Instead, the results in

Table 13 suggest that the FDI stock(which captures the embeddedness of the home country in the National Innovation System of the host country) is positively correlated with the inflow of foreign BERD through a direct relationship.

Based on our literature review, we expected that the National Innovation System is an important concept in explaining R&D flows between home and host countries. As defined by Freeman(1987) the National Innovation Systems forms the network of actors whose activities and interactions lead to new technologies and innovations. Therefore, we expected that the connection of the National Innovation Systems of the host and home country would affect the extent to which companies from the home country could benefit from the innovation capacity present in the host country. However, the nature of the relationship between National Innovation System and R&D internationalization that is different than foreseen. The results suggest that the embeddedness of the home country in the National Innovation System does affect the extent to benefit from the innovation capacity of the host country. Instead, the home country's embeddedness in the National Innovation System of a host country directly impacts the R&D investments in the host country. The findings could signal that firms prefer to invest in host countries they are familiar with. This tendency of firms to invest in R&D activities in foreign countries they are closely connected with (holding a high FDI stock in host country) can be explained by the complexity of R&D activities. It would be understandable that firms try to reduce risk by investing in R&D activities in foreign countries they are familiar with as it is easier to assess local competences and making a cost-benefit analysis for locating R&D activities in countries they already share a close relationship with.
If a country holds a high FDI stock in another host country, it could imply that the host country is an important target market. As a result, this finding could also be an indication that firms locate their R&D activities in countries they target to sell their products as they acknowledge the need to adopt their product to local preferences (Gassmann, Beckenbauer, & Friesike, 2012) (Narula & Zanfei, 2005).

Model 5

Table 14 shows the regression output of model 5 where the dependent variable is the number of domestic invention patents that are foreign owned. The Hausman test statistic has revealed that the fixed effect model is preferred over the random effect model.

Table 14: Regression output model 5

Dependent variable	Log(Foreign ownership of domestic inventions in patent applications)			
Fixed effect regression	β	Std. Err.	t-value	Significance
Model 5				
Log(BERD foreign affiliates)	0.5073056	0.0622811	8.15	0.000
Log(Domestic BERD)	-0.0370961	0.1026942	-0.36	0.719
Constant	2.465914	0.8733526	2.82	0.006

The predictor variables have a VIF value well below 10, or equivalently a tolerance(1/VIF) above 0.1. Therefore, we conclude that there existed no multicollinearity problems.

Table 14 shows that both BERD by foreign affiliates have a positive significant influence on the foreign ownership of domestic invention in patent applications. The impact of Domestic BERD, on the other hand, is non-significant.

The same picture emerges when the total number of patent applications is taken as the dependent variable(the regression output is presented in Table 15). Surprisingly, the Domestic BERD makes no positive significant contribution in the prediction of the total number of patent applications.

Table 15: Regression output model 5

Dependent variable	Log(Total number of patent applications)			
Fixed effect regression	β	Std. Err.	t-value	Significance
Log(BERD foreign affiliates)	0.54405665	0.0663647	8.15	0.000
Log(Domestic BERD)	-0.0574765	0.1081123	-0.53	0.596
Constant	3.416481	0.9272706	3.68	0.000

All in all, we can conclude that the findings in Table 14 and Table 15 support our hypothesis that *The inflow of R&D expenditure from foreign-owned firms has a positive effect on the knowledge stock of the host country.* This supports the common perception that R&D activities lead to the accumulation of knowledge and forms the basis of technological progress.

Model 6

Table 16 presents the regression output of model 6 where the dependent variable is the number of firm entries per 1000 persons (firm entry density). In step 1, the number of foreign ownership of patent applications is a positive significant predictor of firm entry density. However, in step 2 the cost of starting a business is included in the regression as well and the significance of the number of foreign ownership of patent applications has increased to 0.051 (slightly above the 5% significance level).

Table 16: Regression output model 6

Dependent variable	Log(Firm entry density)			
Fixed effect regression	β	Std. Err.	t-value	Significance
Model 6				
Step 1				
Log(Number of foreign ownership of patent applications)	0.1605001	0.0629782	2.55	0.012
GDP growth	0.0018416	0.0051606	0.36	0.722
Constant	2.911351	0.3626888	8.03	0.000
Step 2				
Log(Number of foreign ownership of patent applications)	0.1537058	0.0779662	1.97	0.051
GDP growth	0.0072856	0.0053184	1.37	0.173
Log(entrepreneur cost)	-0.0602875	0.0318625	-1.89	0.061
Constant	3.0221	0.4649527	6.50	0.000

The findings of our sixth model are inconclusive as the impact of the number of foreign patent applications (as a measure of the growth in knowledge stock) on firm entry is not significant at the 0.05 significance level. However, it should be noted that the significance of the regression coefficient (p=0.051) does approach the cut off value of 0.05.

Although the tests on the influence of knowledge stock on firm entry proved to be inconclusive, the results showed a trend towards significance. The positive regression coefficient of Log(Number of foreign ownership of patent applications) is in line with "The knowledge spillover theory of entrepreneurship". This theory suggests that the knowledge stock in a country positively influences the level of entrepreneurship as it creates entrepreneurial opportunities. In this view, the knowledge stock in a country will lead to knowledge spillovers that give rise to opportunities that can be recognized by entrepreneurs (Acs, Audretsch, Braunerhjelm, & Carlsson, The Knowledge Spillover Theory of Entrepreneurship, 2005) (Acs, Audretsch, Braunerhjelm, & Carlsson, 2009).

Table 17: Summary of test results relating to the formulated hypothesis

Hypothesis	Model 1A	Model 1B	Model 2	Model 3	Model 4	Model 5	Model 6
H1: *The innovation capacity of the host country is positively related to the inflow of R&D expenditure from foreign-owned firms*	Not Rejected	Not Rejected	Not Rejected	Not Rejected	Not Rejected	-	-
H2: *The innovation capacity of the home country is negatively related to the outflow of R&D expenditure from the home country.*	-	-	-	Rejected	Rejected	-	-
H3: *The level and quality of entrepreneurship in the host country is positively related with the inflow of R&D expenditure from foreign-owned firms*	-	-	Not Rejected	-	-	-	-
H4: *The embeddedness in the National Innovation System of the host country has a moderating effect on the relationship between innovation capacity/entrepreneurship and the inflow of R&D expenditure from foreign-owned firms*	-	-	-	-	Rejected	-	-
H5a: *The inflow of R&D expenditure from foreign-owned firms has a positive effect on the knowledge stock of the host country.*	-	-	-	-	-	Not Rejected	-
H5b: *The knowledge stock of the host country has a positive effect on firm entry*	-	-	-	-	-	-	Inconclusive

Chapter 9. Conclusion and recommendations

9.1 Conclusion

This study aimed to investigate the phenomenon of R&D internationalization by analyzing the impact of entrepreneurship and innovation capacity on the inflow of business expenditure on R&D by foreign affiliates . A time series cross-sectional study or panel data study on a sample of 20 countries for the time period between the years 2000 and 2012 was performed to address this issue. An extensive literature review was performed to give a clear and concise representation of the relevant research done in the field of R&D internationalization. Based on these findings, combined with additional theoretical frameworks, a conceptual model was developed that. This conceptual model presents the predicted relationships between the various relevant concepts as captured in the accompanying hypotheses. Before the formulated hypotheses can be tested, the concepts have to be transformed into measurable constructs. This process, also known as operationalization of variables, is based on variables that have been used in existing literature to measure the underlying concept.

In total, six hypotheses have been tested that provide empirical evidence on the role of innovation capacity and entrepreneurship in the inflow of R&D expenditure by foreign firms. The conceptual model and the corresponding hypotheses that predict the relationships between the concepts are illustrated in Figure 18.

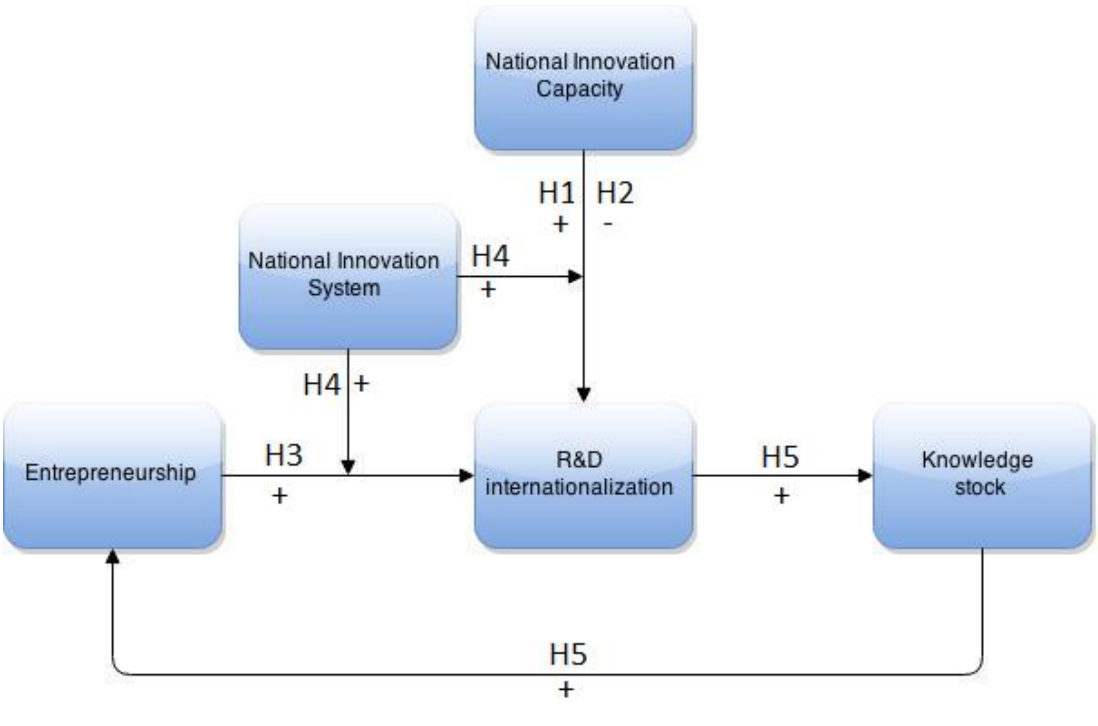

Figure 18: Conceptual model

The central research question that has been addressed in this research was formulated as: " *What is the relationship between R&D internationalization and national innovation capacity and how does this relate to entrepreneurship?"*

Regression analysis of three different models consistently supported the hypothesis that inflow of BERD by foreign affiliates is positively related with the national innovation capacity of the host country. The regression model that tested the influence of the national innovation capacity of the home country on the inflow of foreign BERD gave surprising results. These findings support the idea found in literature that countries locate their R&D activities in foreign countries to delve in local competences to enhance their innovative activities (Archibugi & Michie, 1995) (Bartholomew, 1997). This occurs, for example, through access to local skilled workforce. In addition, foreign firms capture positive effect from knowledge spillovers between their R&D facility and local organizations such as universities, research facilities or competitors (Kuemmerle, 1999).
Our second hypotheses which states that the inflow of BERD by foreign affiliates is negatively related with the national innovation capacity of the host country was rejected. In contrast, the relation that was found between inward BERD and innovation capacity of the home country proved to be positive and statistically significant. This suggests that firms originating from less developed home countries lack the knowledge stock and human capital to benefit from knowledge spillovers if the initial technological distance to the host country is too large (Hofmann, 2013).

The regression results of our second model supported hypothesis 3 and provides evidence that entrepreneurship makes a positive significant contribution to inward BERD. As suggested by Kirzner(1973) and Schumpeter(1934), entrepreneurs are important agents for generating innovation and technological change. The findings of this research signals that inward BERD is related to entrepreneurship in the host country and suggests that foreign affiliates acknowledge the innovation capabilities of entrepreneurs and recognize the opportunity to benefit from knowledge spillovers between foreign firms and entrepreneurs.

Our fourth hypothesis which argues that the home country's embeddedness in the National Innovation System of the host country moderates the relationship between innovation capacity and the inflow of foreign BERD is rejected. However, the findings in our fourth regression model does support the existence of a direct relationship between the home country's embeddedness in the National Innovation System of a host country and the inflow of foreign BERD in a host country. This finding could indicate that firms locate their R&D activities in countries they target to sell their products as they acknowledge the need to adopt their product to local preferences (Gassmann, Beckenbauer, & Friesike, 2012) (Narula & Zanfei, 2005). Furthermore, firms may try to reduce their risk of investing in R&D in a foreign country they are familiar with as this reduces the obstacle to assess local competences.

Tests on the influence of R&D internationalization on entrepreneurship (through a mediating mechanism of knowledge stock) gave mixed results. The regression coefficients of model 5 provided evidence that the knowledge stock is positively correlated with inflow of foreign BERD.
According to *"The knowledge spillover theory of entrepreneurship"* by Acs et al. (2005 & 2009), this increase in the knowledge stock in a country will lead to knowledge spillovers that "give rise to opportunities to be identified and exploited by entrepreneurs. Tests on the influence of knowledge

stock on firm entry, however, proved to be inconclusive. We recommend future researchers to take a closer look at this issue.

The findings of this research has important implications for policymakers of national governments that are looking for ways to attract inward BERD by foreign affiliates. The results of the regression models has provided evidence that the innovation capacity and entrepreneurship level in the host country are important concepts for attracting foreign BERD. Therefore, policymakers should focus on improving the national innovation capacity by, for example, investing in education to stimulate the education level of the population.
Furthermore, the findings of this research have implications for managers and entrepreneurs as well. The findings of this research stresses the importance of knowledge spillovers and both managers of foreign R&D affiliates and local entrepreneurs can benefit from each other. Therefore, it is recommended that both managers of foreign R&D facilities and local entrepreneurs invest their time and energy to establish a relationship with each other.

9.2 Research limitations

One major limitation of this research can be found in the limited availability of data. These data limitations are especially profound in model 3. This model focuses on the impact of the innovation capacity of both the host country and the home country on the inflow of foreign R&D expenditure. Therefore, this model relies on bilateral R&D data which specifies the R&D flow from the country of origin(home country) to the recipient country(host country). For most host countries, however, only the bigger contributors of inward BERD are specified. Confidentially issues appear to be the main reason for these data gaps. The forced exclusion of the observations creates a bias in our analysis. Our suspicion is that the missing data causes bias in the regression coefficient of the home country's innovation capacity on the inflow of R&D expenditure in the host country as the largest portion of missing data is for the smaller and less developed home countries.

Another limitation can be found in the research methodology and the nature of the data that was analyzed. The data that used in this thesis consists of econometric data which are of observational nature. It is difficult to infer causality from analysis of observational data as it is not possible to manipulate a variable to study the effect on the other variable (which is the case for experimental data) (Hansen, 2015).
As previously described in Chapter 6, a panel data regression technique was used for our analysis. The regression coefficients represents the expected change in the dependent variable y for the increase of one unit in the independent variable x. So the regression analysis determines whether there is a relationship between the variables. Regression analysis implicitly presumes the direction of causality by the selection of dependent and independent variables(the independent variable causes the dependent variable). The selection of the dependent and independent variables and the direction of causality is derived from theory (Dunn, 2011).
However, it is difficult to prove the direction of the causality as it can't be determined from the output of regression analysis whether x causes y or the other way around such that y causes x. In other words, regression analysis cannot confirm causality.

9.3 Future research

As a suggestion for future research we recommend to repeat this analysis on a larger sample by including countries outside the EU as well.

As stated in section 9.2, one of the limitations of this research is that the findings of the regression analysis alone does not tell anything about the direction of causality. A possible method to confirm the assumed direction of causality is to test for Granger causality. In 1969 Clive Granger introduced a test for the causal relation between two time series that involves regressing Y against lagged values of itself and lagged values of variable X (Granger, 1969). Granger causality is based on the assumption that causes must precede the effects. A variable X is said to Granger cause Y if the lagged value of X improve the prediction of Y that is obtained from using only lagged value of variable Y itself. This indicates that changes in variable X precede changes in variable Y. Although the estimation becomes more complex in the case of panel data, the Granger causality test for time series models can be extended to panel data (Hurlin & Venet, 2001). Future research could apply the Granger causality test for panel data to confirm the direction of causality.

This research is based on regression analysis of country level panel data. Therefore, a suggestion for future research is to use firm level data in the explanation of the drivers and effects of R&D internationalization. Furthermore, this opens the possibility to gather information through surveys from firms that invest in R&D located in a host country. This will add rigor to the research outcome as the analysis is based on multiple data collection methods and not confined to solely economic data.

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Appendices

Appendix I: Sample

Countries included in sample

1. Austria
2. Belgium
3. Czech Republic
4. Finland
5. France
6. Germany
7. Greece (Not included in Model 1A, 1B and 2)
8. Hungary
9. Ireland
10. Italy
11. Netherlands
12. Norway
13. Poland
14. Portugal
15. Slovak Republic
16. Slovenia
17. Spain
18. Sweden
19. Switzerland
20. Turkey (Not included in Model 1A, 1B and 2)
21. United Kingdom

Appendix II: Regression outputs

Model 1A

Fixed effect regression

```
. xtreg log_RD_foreign SII log_real_gdp, fe

Fixed-effects (within) regression               Number of obs      =        95
Group variable: Country_no                      Number of groups   =        19

R-sq:  within  = 0.3256                         Obs per group: min =         2
       between = 0.7060                                        avg =       5.0
       overall = 0.6782                                        max =         8

                                                F(2,74)            =     17.87
corr(u_i, Xb)  = -0.7342                        Prob > F           =    0.0000

------------------------------------------------------------------------------
log_RD_for~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         SII |   1.223855   .9932625     1.23   0.222     -.755264    3.202973
log_real_gdp |   1.780523   .3766719     4.73   0.000     1.029988    2.531059
       _cons |  -16.85497   4.812946    -3.50   0.001    -26.44497   -7.264962
-------------+----------------------------------------------------------------
     sigma_u |  1.1081904
     sigma_e |  .16396542
         rho |  .97857746   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(18, 74) =    85.73              Prob > F = 0.0000
```

Random effect regression

```
. xtreg log_RD_foreign SII log_real_gdp, re

Random-effects GLS regression                   Number of obs      =        95
Group variable: Country_no                      Number of groups   =        19

R-sq:  within  = 0.2937                         Obs per group: min =         2
       between = 0.7915                                        avg =       5.0
       overall = 0.7443                                        max =         8

                                                Wald chi2(2)       =     92.64
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
log_RD_for~n |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         SII |    2.60003   .6510213     3.99   0.000     1.324052    3.876008
log_real_gdp |   1.098541   .1329572     8.26   0.000     .8379495    1.359132
       _cons |  -8.443733   1.738185    -4.86   0.000    -11.85051   -5.036952
-------------+----------------------------------------------------------------
     sigma_u |   .6604716
     sigma_e |  .16396542
         rho |  .94194725   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

	Fixed effect model	Random effect model
Model 1A		
SII	1.223855	2.60003***
	(1.23)	(3.99)
Log(GDP)	1.780523***	1.098541***
	(4.73)	(8.26)
Constant	-16.85497***	-8.443733***
	(-3.50)	(-4.86)

Notes: t-statistics for fixed effect and z-statistics for random effect in parentheses, Asterisks *, ** and *** indicate signficance at 10%, 5% and 1% respectively (***p<0.01 **p<0.05 *p<0.1)

Hausman test

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
         SII |    1.223855      2.60003       -1.376175        .7501611
log_real_gdp |    1.780523     1.098541        .6819827         .352426
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        4.51
                Prob>chi2 =      0.1051
```

Model 1B (R&D personnel included as independent variable)

Fixed effect regression

```
. xtreg log_RD_foreign log_Dom_BERD_ratioGDP Tertiary_education RD_personnel wages1000 log_hightech_export log_real_gdp, fe

Fixed-effects (within) regression               Number of obs      =       139
Group variable: Country_no                      Number of groups   =        19

R-sq:  within  = 0.5095                         Obs per group: min =         2
       between = 0.6613                                        avg =       7.3
       overall = 0.6725                                        max =        13

                                                F(6,114)           =     19.74
corr(u_i, Xb)  = -0.8314                        Prob > F           =    0.0000

------------------------------------------------------------------------------------
       log_RD_foreign |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
----------------------+-------------------------------------------------------------
log_Dom_BERD_ratioGDP |   .1600008    .132848     1.20   0.231    -.1031702    .4231717
   Tertiary_education |   .0331656   .0128151     2.59   0.011      .007779    .0585521
         RD_personnel |   .0397572   .0248313     1.60   0.112    -.0094334    .0889478
            wages1000 |   -.433924    .196747    -2.21   0.029    -.8236783   -.0441697
  log_hightech_export |   .3324036   .1159389     2.87   0.005     .1027296    .5620776
         log_real_gdp |   2.236398   .5074915     4.41   0.000     1.231061    3.241734
                _cons |  -22.16339    5.92204    -3.74   0.000    -33.89491   -10.43188
----------------------+-------------------------------------------------------------
              sigma_u |  1.5530326
              sigma_e |  .22470237
                  rho |  .97949516   (fraction of variance due to u_i)
------------------------------------------------------------------------------------
F test that all u_i=0:     F(18, 114) =    45.29             Prob > F = 0.0000
```

Random effect regression

```
. xtreg log_RD_foreign log_Dom_BERD_ratioGDP Tertiary_education RD_personnel wages1000 log_hightech_export log_real_gdp, re

Random-effects GLS regression                   Number of obs      =       139
Group variable: Country_no                      Number of groups   =        19

R-sq:  within  = 0.4794                         Obs per group: min =         2
       between = 0.8024                                        avg =       7.3
       overall = 0.8026                                        max =        13

                                                Wald chi2(6)       =    173.12
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------------
       log_RD_foreign |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
----------------------+-------------------------------------------------------------
log_Dom_BERD_ratioGDP |   .0403762   .0957531     0.42   0.673    -.1472964    .2280488
   Tertiary_education |   .0377174   .0107207     3.52   0.000     .0167053    .0587295
         RD_personnel |   .0499439   .0229096     2.18   0.029     .0050419     .094846
            wages1000 |  -.0567451   .1394322    -0.41   0.684    -.3300273     .216537
  log_hightech_export |   .4326384    .098309     4.40   0.000     .2399562    .6253206
         log_real_gdp |   1.035426   .1400708     7.39   0.000     .7608919    1.309959
                _cons |  -8.526199   1.690298    -5.04   0.000    -11.83912   -5.213275
----------------------+-------------------------------------------------------------
              sigma_u |  .63876037
              sigma_e |  .22470237
                  rho |  .88987895   (fraction of variance due to u_i)
------------------------------------------------------------------------------------
```

Hausman test

```
. hausman fixed random, sigmamore

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
log_Dom_BE~P |   .1600008     .0403762        .1196246        .0974005
Tertiary_e~n |   .0331656     .0377174       -.0045519        .0076592
RD_personnel |   .0397572     .0499439       -.0101867        .0112659
   wages1000 |   -.433924    -.0567451       -.3771788        .1465487
log_highte~t |   .3324036     .4326384       -.1002348        .0674095
log_real_gdp |   2.236398     1.035426        1.200972        .5026147
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       12.77
                Prob>chi2 =      0.0469
```

Collinearity

```
. collin log_Dom_BERD_ratioGDP Tertiary_education RD_personnel wages1000 log_hightech_export log_real_gdp
(obs=139)

  Collinearity Diagnostics

                        SQRT                   R-
  Variable      VIF     VIF    Tolerance     Squared
----------------------------------------------------
log_Dom_BERD_ratioGDP       5.46    2.34    0.1830      0.8170
Tertiary_education      3.72    1.93    0.2688      0.7312
RD_personnel      7.13    2.67    0.1403      0.8597
 wages1000      3.19    1.79    0.3136      0.6864
log_hightech_export      1.61    1.27    0.6229      0.3771
log_real_gdp      1.32    1.15    0.7594      0.2406
----------------------------------------------------
  Mean VIF      3.74

                           Cond
        Eigenval          Index
---------------------------------
    1     6.6973          1.0000
    2     0.1923          5.9018
    3     0.0447         12.2427
    4     0.0363         13.5798
    5     0.0233         16.9671
    6     0.0052         35.9629
    7     0.0010         83.7532
---------------------------------
 Condition Number        83.7532
 Eigenvalues & Cond Index computed from scaled raw sscp (w/ intercept)
 Det(correlation matrix)    0.0188
```

Model 1B(R&D personnel exduded as independent variable)

Fixed effect regression

```
. xtreg log_RD_foreign log_Dom_BERD_ratioGDP Tertiary_education wages1000 log_hightech_export log_re
> al_gdp, fe

Fixed-effects (within) regression               Number of obs      =       139
Group variable: Country_no                      Number of groups   =        19

R-sq:  within  = 0.4985                         Obs per group: min =         2
       between = 0.6564                                        avg =       7.3
       overall = 0.6647                                        max =        13

                                                F(5,115)           =     22.86
corr(u_i, Xb)  = -0.8675                        Prob > F           =    0.0000
```

log_RD_foreign	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
log_Dom_BERD_ratioGDP	.2184426	.1286005	1.70	0.092	-.0362903	.4731755
Tertiary_education	.0347468	.0128635	2.70	0.008	.0092667	.060227
wages1000	-.3696108	.1939078	-1.91	0.059	-.7537048	.0144832
log_hightech_export	.3544398	.115899	3.06	0.003	.1248662	.5840133
log_real_gdp	2.413768	.4986079	4.84	0.000	1.426122	3.401415
_cons	-24.12276	5.833472	-4.14	0.000	-35.67775	-12.56777
sigma_u	1.7436212					
sigma_e	.22622471					
rho	.98344513	(fraction of variance due to u_i)				

```
F test that all u_i=0:     F(18, 115) =    45.62             Prob > F = 0.0000
```

Random effect regression

```
. xtreg log_RD_foreign log_Dom_BERD_ratioGDP Tertiary_education wages1000 log_hightech_export log_re
> al_gdp, re

Random-effects GLS regression                   Number of obs      =       139
Group variable: Country_no                      Number of groups   =        19

R-sq:  within  = 0.4616                         Obs per group: min =         2
       between = 0.7979                                        avg =       7.3
       overall = 0.8014                                        max =        13

                                                Wald chi2(5)       =    165.47
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000
```

log_RD_foreign	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
log_Dom_BERD_ratioGDP	.0957064	.0934393	1.02	0.306	-.0874312	.278844
Tertiary_education	.0445334	.0103576	4.30	0.000	.0242328	.0648339
wages1000	.0211233	.1365001	0.15	0.877	-.246412	.2886586
log_hightech_export	.4653765	.0983962	4.73	0.000	.2725234	.6582296
log_real_gdp	1.026255	.1399022	7.34	0.000	.7520521	1.300459
_cons	-8.125387	1.683429	-4.83	0.000	-11.42485	-4.825927
sigma_u	.63063165					
sigma_e	.22622471					
rho	.88598665	(fraction of variance due to u_i)				

Hausman test

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
log_Dom_BE~P |    .2184426     .0957064        .1227362        .0883584
Tertiary_e~n |    .0347468     .0445334       -.0097865        .0076282
  wages1000  |   -.3696108     .0211233       -.3907341        .1377242
log_highte~t |    .3544398     .4653765       -.1109367        .0612434
log_real_gdp |    2.413768     1.026255        1.387513        .4785784
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       12.81
                Prob>chi2 =      0.0252
                (V_b-V_B is not positive definite)
```

Collinearity

```
. collin log_Dom_BERD_ratioGDP Tertiary_education wages1000 log_hightech_export log_real_gdp
(obs=139)

  Collinearity Diagnostics

                        SQRT                   R-
  Variable      VIF     VIF    Tolerance    Squared
----------------------------------------------------
log_Dom_BERD_ratioGDP      1.68    1.30    0.5946      0.4054
Tertiary_education      2.71    1.65    0.3690      0.6310
 wages1000      3.16    1.78    0.3161      0.6839
log_hightech_export      1.60    1.26    0.6249      0.3751
log_real_gdp      1.24    1.12    0.8041      0.1959
----------------------------------------------------
  Mean VIF      2.08

                           Cond
        Eigenval          Index
---------------------------------
    1     5.7926          1.0000
    2     0.1376          6.4887
    3     0.0363         12.6293
    4     0.0238         15.5887
    5     0.0074         27.9978
    6     0.0023         50.5110
---------------------------------
 Condition Number        50.5110
 Eigenvalues & Cond Index computed from scaled raw sscp (w/ intercept)
 Det(correlation matrix)    0.1340
```

Model 2

Fixed effect regression

```
. xtreg log_RD_foreign log_Dom_BERD_ratioGDP Tertiary_education wages1000 log_hightech_export firm_birth_rate log_real_gdp, fe

Fixed-effects (within) regression               Number of obs      =       122
Group variable: Country_no                      Number of groups   =        19

R-sq:  within  = 0.5243                         Obs per group: min =         1
       between = 0.4970                                        avg =       6.4
       overall = 0.5723                                        max =        13

                                                F(6,97)            =     17.82
corr(u_i, Xb)  = -0.8521                        Prob > F           =    0.0000

------------------------------------------------------------------------------
       log_RD_foreign |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
----------------------+-------------------------------------------------------
log_Dom_BERD_ratioGDP |   .1140215   .1271144     0.90   0.372    -.1382654    .3663084
   Tertiary_education |   .0258126   .0129363     2.00   0.049     .0001376    .0514875
            wages1000 |  -.6802438     .24159    -2.82   0.006    -1.159733   -.2007546
  log_hightech_export |   .2584989   .1146687     2.25   0.026     .0309132    .4860847
      firm_birth_rate |   .0427053    .012694     3.36   0.001     .0175112    .0678995
         log_real_gdp |   2.551438   .5284875     4.83   0.000     1.502537     3.60034
                _cons |  -25.44521   6.129866    -4.15   0.000     -37.6113   -13.27912
----------------------+-------------------------------------------------------
              sigma_u |  2.0254477
              sigma_e |  .21174048
                  rho |  .98918951   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(18, 97) =    44.07              Prob > F = 0.0000
```

Random effect regression

```
. xtreg log_RD_foreign log_Dom_BERD_ratioGDP Tertiary_education wages1000 log_hightech_export firm_birth_rate log_real_gdp, re

Random-effects GLS regression                   Number of obs      =       122
Group variable: Country_no                      Number of groups   =        19

R-sq:  within  = 0.4618                         Obs per group: min =         1
       between = 0.7756                                        avg =       6.4
       overall = 0.7916                                        max =        13

                                                Wald chi2(6)       =    143.65
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
       log_RD_foreign |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
----------------------+-------------------------------------------------------
log_Dom_BERD_ratioGDP |   .0973554   .0978596     0.99   0.320    -.0944459    .2891568
   Tertiary_education |   .0339126   .0110411     3.07   0.002     .0122725    .0555527
            wages1000 |   .0759888    .148862     0.51   0.610    -.2157754     .367753
  log_hightech_export |    .434083   .1015867     4.27   0.000     .2349767    .6331893
      firm_birth_rate |   .0416045   .0132812     3.13   0.002     .0155738    .0676353
         log_real_gdp |   .9941689   .1460064     6.81   0.000     .7080015    1.280336
                _cons |   -7.91473   1.754284    -4.51   0.000    -11.35306   -4.476397
----------------------+-------------------------------------------------------
              sigma_u |  .64131853
              sigma_e |  .21174048
                  rho |  .90170637   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Hausman test

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
log_Dom_BE~P |    .1140215     .0973554        .0166661        .0811268
Tertiary_e~n |    .0258126     .0339126       -.0081001        .0067411
   wages1000 |   -.6802438     .0759888       -.7562326        .1902782
log_highte~t |    .2584989      .434083       -.1755841        .0531889
firm_birth~e |    .0427053     .0416045        .0011008               .
log_real_gdp |    2.551438     .9941689        1.557269        .5079184
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       14.91
                Prob>chi2 =      0.0209
                (V_b-V_B is not positive definite)
```

Collinearity

```
. collin log_Dom_BERD_ratioGDP Tertiary_education wages1000 log_hightech_export firm_birth_rate log_real_gdp
(obs=122)

  Collinearity Diagnostics

                        SQRT                   R-
  Variable      VIF     VIF    Tolerance    Squared
----------------------------------------------------
log_Dom_BERD_ratioGDP      2.11    1.45    0.4736      0.5264
Tertiary_education      2.97    1.72    0.3363      0.6637
 wages1000      3.88    1.97    0.2576      0.7424
log_hightech_export      1.65    1.28    0.6059      0.3941
firm_birth_rate      1.37    1.17    0.7306      0.2694
log_real_gdp      1.45    1.21    0.6874      0.3126
----------------------------------------------------
  Mean VIF      2.24

                           Cond
        Eigenval          Index
---------------------------------
    1     6.7205          1.0000
    2     0.1673          6.3371
    3     0.0511         11.4717
    4     0.0355         13.7639
    5     0.0179         19.3904
    6     0.0054         35.4072
    7     0.0024         52.8129
---------------------------------
 Condition Number        52.8129
 Eigenvalues & Cond Index computed from scaled raw sscp (w/ intercept)
 Det(correlation matrix)    0.0846
```

Model 3

Fixed effect regression

```
. xtreg log_inw_berd siihost siihome log_gdp_host log_gdp_home, fe

Fixed-effects (within) regression               Number of obs      =       429
Group variable: combi12                         Number of groups   =       166

R-sq:  within  = 0.0557                         Obs per group: min =         1
       between = 0.0466                                        avg =       2.6
       overall = 0.0844                                        max =         7

                                                F(4,259)           =      3.82
corr(u_i, Xb)  = -0.8250                        Prob > F           =    0.0049

------------------------------------------------------------------------------
log_inw_berd |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     siihost |   1.260624   2.544002     0.50   0.621    -3.748936    6.270185
     siihome |   4.722473   2.705347     1.75   0.082    -.6048026    10.04975
log_gdp_host |   2.555728   1.136037     2.25   0.025     .3186836    4.792772
log_gdp_home |  -2.027134   1.746405    -1.16   0.247    -5.466095    1.411826
       _cons |  -6.305833   18.59275    -0.34   0.735    -42.91804    30.30638
-------------+----------------------------------------------------------------
     sigma_u |  3.6280545
     sigma_e |   .6667917
         rho |  .96732576   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(165, 259) =     9.97            Prob > F = 0.0000
```

Random effect regression

```
. xtreg log_inw_berd siihost siihome log_gdp_host log_gdp_home, re

Random-effects GLS regression                   Number of obs      =       429
Group variable: combi12                         Number of groups   =       166

R-sq:  within  = 0.0406                         Obs per group: min =         1
       between = 0.6040                                        avg =       2.6
       overall = 0.5465                                        max =         7

                                                Wald chi2(4)       =    247.31
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
log_inw_berd |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     siihost |   3.845895   .7315062     5.26   0.000     2.412169    5.279621
     siihome |   5.796819    .816781     7.10   0.000     4.195957     7.39768
log_gdp_host |   1.004486   .1085862     9.25   0.000     .7916607    1.217311
log_gdp_home |   .8180619   .1064639     7.68   0.000     .6093965    1.026727
       _cons |  -26.78542   2.105019   -12.72   0.000    -30.91118   -22.65966
-------------+----------------------------------------------------------------
     sigma_u |  1.2813478
     sigma_e |   .6667917
         rho |   .7869068   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Hausman test

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
     siihost |    1.260624     3.845895       -2.585271        2.436564
     siihome |    4.722473     5.796819       -1.074346        2.579102
 log_gdp_host|    2.555728     1.004486        1.551242        1.130835
 log_gdp_home|   -2.027134     .8180619       -2.845196        1.743157
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        9.03
                Prob>chi2 =      0.0602
```

Collinearity

```
. collin siihost siihome log_gdp_host log_gdp_home
(obs=1120)

  Collinearity Diagnostics

                        SQRT                   R-
  Variable      VIF     VIF    Tolerance    Squared
----------------------------------------------------
   siihost      1.01    1.01    0.9853      0.0147
   siihome      1.01    1.00    0.9909      0.0091
log_gdp_host      1.02    1.01    0.9851      0.0149
log_gdp_home      1.01    1.00    0.9906      0.0094
----------------------------------------------------
  Mean VIF      1.01

                           Cond
        Eigenval          Index
---------------------------------
    1     4.8458          1.0000
    2     0.0936          7.1960
    3     0.0520          9.6494
    4     0.0066         27.1404
    5     0.0020         49.0200
---------------------------------
 Condition Number        49.0200
 Eigenvalues & Cond Index computed from scaled raw sscp (w/ intercept)
 Det(correlation matrix)    0.9761
```

Model 4

Fixed effect regression

```
. xtreg log_inw_berd siihost_std siihome_std log_fdi_stock_cst_std log_gdp_host log_gdp_home ssi_host_x_fdi_stock sii_home_x_fdi
> ock, fe

Fixed-effects (within) regression               Number of obs     =        407
Group variable: host_home_id                    Number of groups  =        162

R-sq:                                           Obs per group:
     within  = 0.0607                                         min =          1
     between = 0.0481                                         avg =        2.5
     overall = 0.0889                                         max =          7

                                                F(7,238)          =       2.20
corr(u_i, Xb)  = -0.8293                        Prob > F          =     0.0352

------------------------------------------------------------------------------
         log_inw_berd |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
----------------------+-------------------------------------------------------
          siihost_std |   .3657888   .4475341     0.82   0.415    -.5158451    1.247423
          siihome_std |   .5698248   .5079913     1.12   0.263    -.4309086    1.570558
log_fdi_stock_cst_std |   .3136573   .3772695     0.83   0.407    -.4295567    1.056871
         log_gdp_host |   2.250484   1.266815     1.78   0.077    -.2451192    4.746086
         log_gdp_home |  -2.124866   1.891125    -1.12   0.262    -5.850348    1.600615
 ssi_host_x_fdi_stock |   -.081236   .2919256    -0.28   0.781    -.6563242    .4938521
 sii_home_x_fdi_stock |   .1519014   .3337295     0.46   0.649    -.5055397    .8093424
                _cons |   1.879194   21.19621     0.09   0.929    -39.87694    43.63533
----------------------+-------------------------------------------------------
              sigma_u |  3.5291919
              sigma_e |   .6797054
                  rho |  .96423376   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(161, 238) = 7.03                    Prob > F = 0.0000
```

Random effect

```
. xtreg log_inw_berd siihost_std siihome_std log_fdi_stock_cst_std log_gdp_host log_gdp_home ssi_host_x_fdi_stock sii_home_x_fdi_
> ock, re

Random-effects GLS regression                   Number of obs     =        407
Group variable: host_home_id                    Number of groups  =        162

R-sq:                                           Obs per group:
     within  = 0.0470                                         min =          1
     between = 0.6694                                         avg =        2.5
     overall = 0.6155                                         max =          7

                                                Wald chi2(7)      =     311.76
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
         log_inw_berd |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
----------------------+-------------------------------------------------------
          siihost_std |   .5501785   .1242804     4.43   0.000     .3065934    .7937635
          siihome_std |   .5969637    .144104     4.14   0.000     .3145252    .8794023
log_fdi_stock_cst_std |   .8887313   .1873643     4.74   0.000     .5215041    1.255959
         log_gdp_host |    .649666   .1136904     5.71   0.000      .426837     .872495
         log_gdp_home |   .5482572     .10846     5.05   0.000     .3356795    .7608348
 ssi_host_x_fdi_stock |     .00173   .1482529     0.01   0.991    -.2888404    .2923004
 sii_home_x_fdi_stock |   .2556961   .1827411     1.40   0.162    -.1024698    .6138621
                _cons |  -14.02904   2.314115    -6.06   0.000    -18.56463   -9.493461
----------------------+-------------------------------------------------------
              sigma_u |  1.1273566
              sigma_e |   .6797054
                  rho |   .7334002   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Hausman test

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
 siihost_std |    .3657888     .5501785       -.1843897        .4299316
 siihome_std |    .5698248     .5969637       -.0271389        .4871234
log_fdi_st~d |    .3136573     .8887313        -.575074        .3274553
log_gdp_host |    2.250484      .649666        1.600818        1.261703
log_gdp_home |   -2.124866     .5482572       -2.673124        1.888012
ssi_host_x~k |    -.081236       .00173        -.082966        .2514789
sii_home_x~k |    .1519014     .2556961       -.1037947         .279251
------------------------------------------------------------------------------
                         b = consistent under Ho and Ha; obtained from xtreg
          B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       12.48
                Prob>chi2 =      0.0857
```

Model 5 (foreign patents)

Fixed effect regression

```
. xtreg log_foreign_ownership_patents log_RD_foreign log_domestic_BERD, fe

Fixed-effects (within) regression               Number of obs     =        137
Group variable: Country_no                      Number of groups  =         20

R-sq:                                           Obs per group:
     within  = 0.3684                                         min =          2
     between = 0.8998                                         avg =        6.8
     overall = 0.8663                                         max =         12

                                                F(2,115)          =      33.54
corr(u_i, Xb)  = 0.8095                         Prob > F          =     0.0000

------------------------------------------------------------------------------
log_foreign~s |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
log_RD_fore~n |   .5073056   .0622811     8.15   0.000     .3839387    .6306724
log_domesti~D |  -.0370961   .1026942    -0.36   0.719    -.2405137    .1663214
        _cons |   2.465914   .8733526     2.82   0.006     .7359702    4.195857
--------------+---------------------------------------------------------------
      sigma_u |   .9644859
      sigma_e |  .21095153
          rho |  .95434594   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(19, 115) = 24.84                    Prob > F = 0.0000
```

Random effect regression

```
. xtreg log_foreign_ownership_patents log_RD_foreign log_domestic_BERD, re

Random-effects GLS regression                   Number of obs     =        137
Group variable: Country_no                      Number of groups  =         20

R-sq:                                           Obs per group:
     within  = 0.3356                                         min =          2
     between = 0.9342                                         avg =        6.8
     overall = 0.9189                                         max =         12

                                                Wald chi2(2)      =     249.06
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
log_foreign~s |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
log_RD_fore~n |   .6209015   .0578622    10.73   0.000     .5074936    .7343094
log_domesti~D |   .2857384   .0739801     3.86   0.000     .1407401    .4307367
        _cons |  -.9692087    .504767    -1.92   0.055    -1.958534    .0201165
--------------+---------------------------------------------------------------
      sigma_u |   .4290242
      sigma_e |  .21095153
          rho |  .80530234   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Hausman test

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
log_RD_for~n |    .5073056     .6209015       -.1135959        .0230412
log_domest~D |   -.0370961     .2857384       -.3228345        .0712253
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       24.81
                Prob>chi2 =      0.0000
```

Model 5 (total patents)

Fixed effect regression

```
. xtreg log_patents log_RD_foreign log_domestic_BERD, fe

Fixed-effects (within) regression               Number of obs     =        141
Group variable: Country_no                      Number of groups  =         20

R-sq:                                           Obs per group:
     within  = 0.3595                                         min =          2
     between = 0.8377                                         avg =        7.0
     overall = 0.7945                                         max =         13

                                                F(2,119)          =      33.40
corr(u_i, Xb)  = 0.7507                         Prob > F          =     0.0000

------------------------------------------------------------------------------
 log_patents |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
log_RD_fore~n |   .5405665   .0663647     8.15   0.000     .4091577    .6719754
log_domesti~D |  -.0574765   .1081123    -0.53   0.596    -.2715496    .1565966
       _cons |   3.416481   .9272706     3.68   0.000     1.580392    5.252569
-------------+----------------------------------------------------------------
     sigma_u |  1.2601781
     sigma_e |  .22620841
         rho |  .96878377   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(19, 119) = 27.66                    Prob > F = 0.0000
```

Random effect regression

```
. xtreg log_patents log_RD_foreign log_domestic_BERD, re

Random-effects GLS regression                   Number of obs     =        141
Group variable: Country_no                      Number of groups  =         20

R-sq:                                           Obs per group:
     within  = 0.2961                                         min =          2
     between = 0.9423                                         avg =        7.0
     overall = 0.9167                                         max =         13

                                                Wald chi2(2)      =     284.14
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
 log_patents |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
log_RD_fore~n |   .6512901   .0639415    10.19   0.000     .5259671    .7766131
log_domesti~D |      .4387   .0806448     5.44   0.000      .280639     .596761
       _cons |  -1.382607   .5435919    -2.54   0.011    -2.448027    -.317186
-------------+----------------------------------------------------------------
     sigma_u |  .43560632
     sigma_e |  .22620841
         rho |  .78760757   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Hausman test

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
log_RD_for~n |    .5405665     .6512901       -.1107236        .0177698
log_domest~D |   -.0574765        .4387       -.4961765        .0720046
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       34.88
                Prob>chi2 =      0.0000
                (V_b-V_B is not positive definite)
```

Model 6

Fixed effect regression step 1

```
. xtreg log_firm_entry_density log_foreign_ownership_patents GDP_growth, fe

Fixed-effects (within) regression               Number of obs     =        190
Group variable: Country_no                      Number of groups  =         20

R-sq:                                           Obs per group:
     within  = 0.0312                                         min =          2
     between = 0.3182                                         avg =        9.5
     overall = 0.2271                                         max =         12

                                                F(2,168)          =       2.70
corr(u_i, Xb)  = -0.7765                        Prob > F          =     0.0699

------------------------------------------------------------------------------
log_firm_en~y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
log_foreign~s |    .152388   .0669392     2.28   0.024     .0202375    .2845384
   GDP_growth |    .002515    .005259     0.48   0.633    -.0078672    .0128972
        _cons |    3.35552   .3831686     8.76   0.000     2.599075    4.111966
--------------+---------------------------------------------------------------
      sigma_u |  .61773148
      sigma_e |  .20077176
          rho |  .90445803   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(19, 168) = 32.60                    Prob > F = 0.0000
```

Fixed effect regression step 2

```
.  xtreg log_firm_density log_foreign_ownership_patents log_entrepreneur_cost GD
> P_growth, fe

Fixed-effects (within) regression               Number of obs     =        148
Group variable: Country_no                      Number of groups  =         20

R-sq:                                           Obs per group:
     within  = 0.0720                                         min =          2
     between = 0.3812                                         avg =        7.4
     overall = 0.3093                                         max =          8

                                                F(3,125)          =       3.23
corr(u_i, Xb)  = -0.8105                        Prob > F          =     0.0247

------------------------------------------------------------------------------
log_firm_de~y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
log_foreign~s |   .1537058   .0779662     1.97   0.051     -.000599    .3080107
log_entrepr~t |  -.0602875   .0318625    -1.89   0.061    -.1233473    .0027723
   GDP_growth |   .0072856   .0053184     1.37   0.173    -.0032402    .0178114
        _cons |     3.0221   .4649527     6.50   0.000     2.101901    3.942299
--------------+---------------------------------------------------------------
      sigma_u |  .65624559
      sigma_e |  .17326538
          rho |  .93483341   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(19, 125) = 36.32                    Prob > F = 0.0000
```