Determinants of patent innovation of Central and Eastern Europe knowledge intensive firms: the roles of R&D expenditure and internationalisation

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Abbreviations

R&D –Research and Development

CEE – Central and Eastern Europe

EU – European Union

GDP – Gross Domestic Product

OECD - The Organisation for Economic Co-operation and Development

MNE – Multinational Enterprise

Chapter 1 Introduction

Rapidly changing technologies, global downturns, decreasing transportation cost and merging consumer preferences around the world are just few of the topics, which attract much attention from researchers. All mentioned topics are interrelated and more or less relate to innovation and firms' ability to gain competitive advantage by satisfying special customer needs or even creating new market by satisfying latent needs. Everybody recognises that innovation is essential for each company, however, it is not clear why some companies manage to benefit from innovative efforts and others do not.

In order to understand this phenomenon, the first step is to understand what factors determines larger or smaller innovation output. Therefore, our main research question concentrates on the determinants of patent innovations, which we use as a measure of companies' innovative efforts. We aim to answer the research question by identifying the influence of Research and Development (R&D) expenditure and the degree of internationalisation on innovation output. We concentrate specifically on Central and Eastern Europe (CEE) region firms in order to contribute to innovation literature by expanding its geographical scope.

To answer our research question we analyse existing literature and propose 3 hypotheses. We use quantitative panel data analysis based on the top knowledge intensive firms from CEE region. We employ a regression analysis to test whether our selected determinants, i.e. R&D expenditure and degree of internationalisation, which are supported by other scholars' studies conducted mainly in developed countries, are valid and have similar effect in the case of CEE countries.

We argue that it is important to look at the CEE companies and expect to provide useful business insights, which are specific to the CEE and also encourage further research to be conducted on the region, as we believe it has a growing future potential.

In line with other research, we found that R&D expenditure is one of the most significant determinants of patent innovation. Interestingly, analysing internationalisation role in the relationship we found that it is important variable both in terms of influencing innovation output on its own as well as providing greater benefits by moderating the R&D expenditure and patent innovation relationship. Many studies found mixed results on internationalisation (e.g. Higon et al., 2011; Tsang et al., 2008) therefore we suggest that it might be a country or in our case region specific feature.

In the next, Background, chapter we explain why innovation is an important field of study, provide reasoning why we choose to look at the CEE region and introduce key terms, which will be used throughout the study. The third chapter will review the broad existing literature on innovation by concentrating on determinants of innovation output. We will conclude the chapter by proposing three hypotheses for our study. The fourth chapter will describe the methods, which we employ to test our hypotheses. We will describe sample, variables and analysis employed. In the fifth chapter, we will present the results generated, relate it with existing literature and suggest how our results are unique compared to other studies. In the sixth chapter, we conclude our findings and draw the implications of our research to the innovation literature and more importantly to the CEE firms. We will finalise the chapter by explaining the limitations of the study and suggesting areas for future research.

Chapter 2 Background

In this chapter, we discuss why innovation is important in the current economy both for business and governments, highlight why we are interested in CEE economies and provide some basic explanations on key terms used in our study.

2.1. Importance of Innovation

"Innovation is regarded as the introduction of products and processes that are new to the context of the location but not necessarily new to the world as a whole" (Collinson and Morgan, 2009, p. 46). It is widely acknowledged that innovation plays a vital role not only at companies' level but also at countries' and regional levels (Storey and Salaman, 2005). Therefore, governments are trying to find new or better ways to attract or retain innovation in their countries by creating new policies and calls for action. A good example is 'EUROPE 2020 Strategy', which highlights the importance of smart growth; meaning information, education and innovation fostering (Fontaine, 2010). The overall aim of this strategy, in terms of innovation, is to increase total European Union (EU) R&D expenditure to 3% of the EU's Gross Domestic Product (GDP) (Europe 2020, 2014). However, each country within the European Union is different and unique and, therefore, the R&D intensity as well as the amount each country spends varies greatly. Figure 1 below shows how the percentage of GDP spent on R&D varies across the Europe (pale yellow colour - low expenditure, the expenditure is increasing towards green, where dark green is the highest level of expenditure on R&D). We can clearly see that majority of CEE countries spend less on R&D, as yellow colour dominates on the right (East) side of the map, compared to Western countries, where green colour

dominates. This indicates that there is a gap between CEE and Western Europe economies and therefore the relationship between inputs and outputs of innovation might be different and worthwhile investigating.

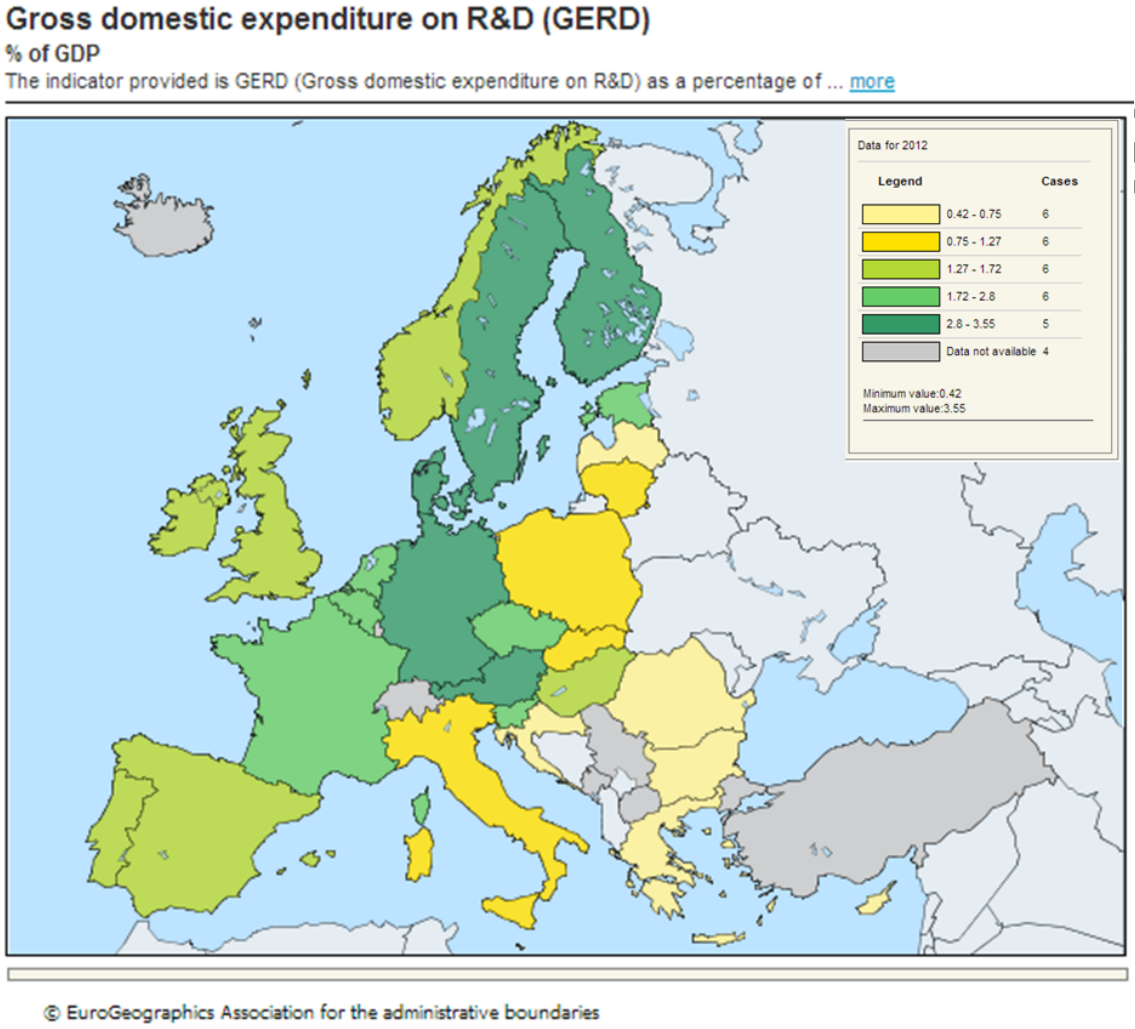

Figure1: Gross Domestic expenditure on R&D (Eurostat, 2014)

2.2. Central and Eastern Europe Economies

It has been 10 years since the majority of CEE economies joined the EU. Many of these countries are very different from the other EUs' member states, not only because its' development level but also unique history, with rapid transition from inefficient state planned economy to competitive market economy (Porter & Ketels, 2013).

CEE economies attracted many foreign investors' attention before and after the accession to the EU. The main reasons for this were cheaper but well educated labour and a good geographical position of the countries (Tondl & Vuksic, 2003). Foreign direct investment (FDI) and other types of investments, like the EU's structural funds, influenced the rapid GDP growth rates of the majority of CEE countries. In the long term the majority of the CEE countries were experiencing considerably higher growth rates than Eurozone countries (see Figure 2). As you can see, few of the CEE economies, i.e. Lithuania, Poland and Slovak Republic were experiencing even higher growth rates than the world overall.

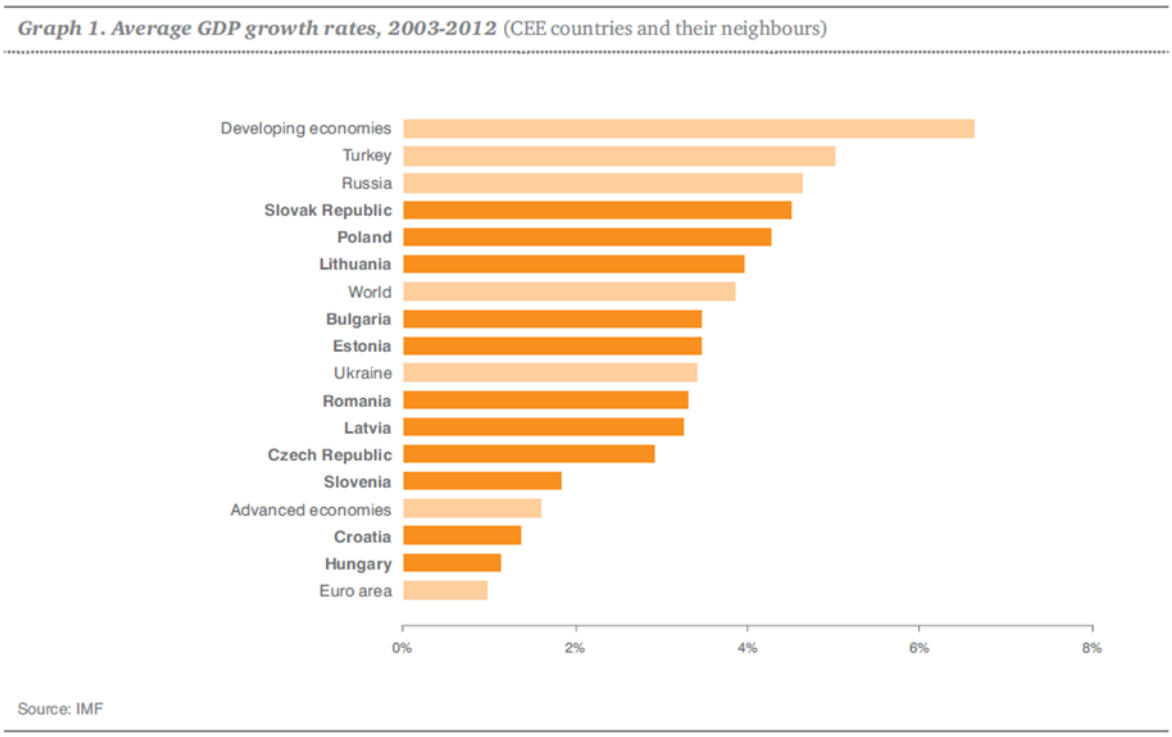

Figure 2: Average GDP growth rates 2003-2012 (Economic Scorecard, 2014)

The increasing GDP growth rate suggest that countries are catching up, however, nobody can deny that the gap between Western and Eastern

countries is still obvious and much more work needs to be done to bridge this gap.

CEE economies are developing or currently more often called transition economies; thus it is not surprising that they are not well known for their R&D activities and the percentage of GDP spent on R&D is well below the one of developed Western Europe countries. However, similarly like overall economic growth, CEE countries on average (long-term) are achieving almost double growth to that of Western Europe (See Figure 3). Figure 3 shows the average R&D expenditure as a percentage of GDP for developed countries, which were members of EU before 2004 expansion (blue colour), and transition economies, which joined EU in 2004 (red colour).

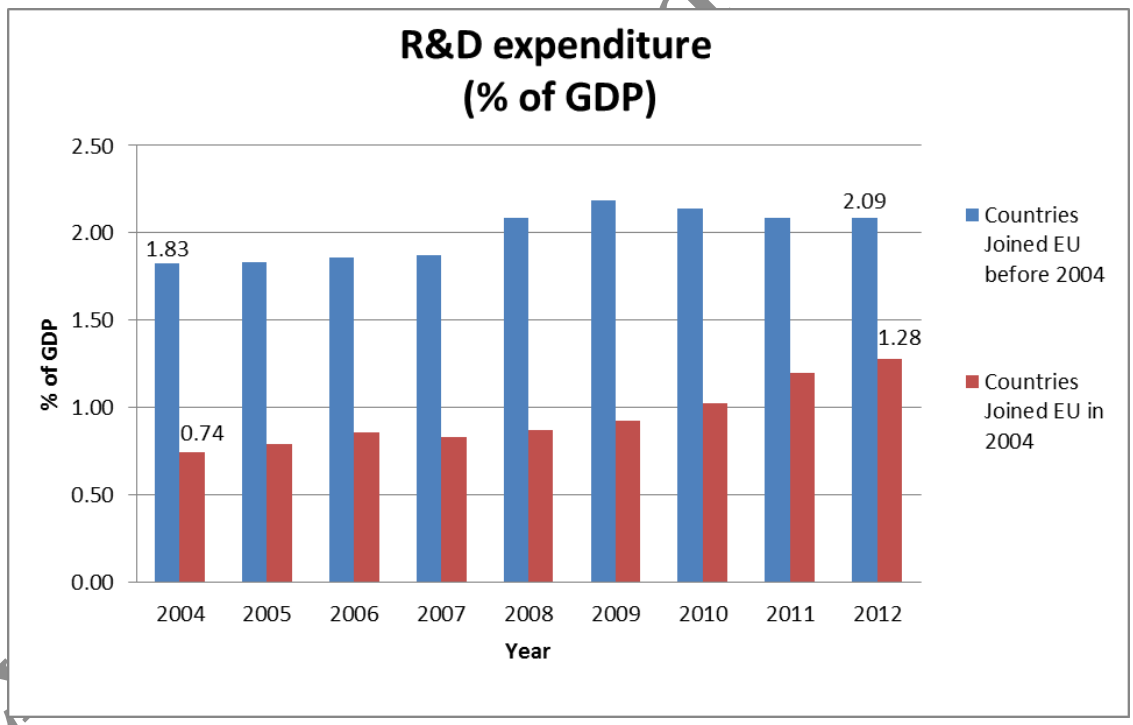

Figure 3: R&D expenditure as a % of GDP (Author, source: Eurostat, 2014)

By indicating these two measures we make our research even more interesting and useful. The GDP and R&D expenditure growth rates indicate that the

regional economic integration with 10 years of institutional convergences positively affected both the CEE economies and the firms within it. In addition to this, the area is also known for strong academic traditions where few of the oldest universities were established, for example, the University of Prague (Czech Republic) or the Jagiellonian University (Poland) (WIPO, 2014). Thus, these countries have a deep pool of well-educated people and the region has strong capacity for producing and expanding knowledge. Therefore, we think that CEE has a high future potential and because there is not much research done on innovation activities in this region, we believe that our study will provide interesting, useful and most importantly specific to the CEE region insights both for business and policy makers.

2.3. General Knowledge

Before we start looking at the literature and the determinants of patent innovation, we believe that it is important to explain key terms and processes associated with our study.

2.3.1 Patents

"A patent is a document, issued by an authorized governmental agency, granting the right to exclude anyone else from the production or use of specific new device, apparatus, or process for a stated number of years" (Griliches, 1990 p.288). In order to obtain patent rights a company, an individual or a public body needs to prove that the invention is novel, involve inventive activities and can be applied in industry (OECD, 2001). Generally the process of gaining patent rights starts with filling the application form, which covers how things work, what they do, how they are made and what they are made from. Later on, the patent office examines the application, i.e. whether it meets all the legal

requirements. Finally, the decision whether patent can be granted or not is being made (OECD, 2001). The original purpose of granting patent rights is to encourage innovation (OECD, 2009). Patent provides an inventor with the exclusive, almost monopoly, rights to the invention, usually for around 20 years. It means that an inventor has 20 years to commercialise the invention, get returns on initial investment and earn profit, which can be seen as an encouragement to innovate more in the future. Also, by making information publicly available the further continuous developments are encouraged, and this way more inventions are created (OECD, 2009). Therefore, patent rights are useful for individuals, companies and overall development of economies.

2.3.2. Internationalisation

According to Daniels et al. (2011), the internationalisation is the process when company decides increasing their commitments to international business. It means that companies operate and perform their commercial transactions in more than one country and, therefore, the internationalisation is the process by which the number of countries is increased. There are many different ways how to serve foreign markets, which are accompanied with different advantages and disadvantages, and all of them are widely discussed in international business literature. However, for our study the key is to understand that, by internationalisation, we mean a company's expansion to different economies.

2.3.3. R&D Expenditure

According to OECD iLibrary (2011) R&D expenditure is one of the most widely used measures of innovation inputs. R&D expenditure as a percentage of the GDP is a country level measure and is referred as R&D intensity (OECD iLibrary, 2011). Even though it is useful to measure R&D at the country level

and various policies, like already mentioned Europe 2020, are created to encourage innovation, a major contributor to the innovation growth remains private business companies, which accounts for about 70% of all R&D performed in OECD area (OECD iLibrary, 2011). It shows that individual companies play a critical role in countries' innovation processes and, therefore, it provide good reasoning to base our study on individual firms data and their yearly R&D expenditure.

In chapter 2, we discussed why innovation is an important topic to explore, why it is important to look at CEE countries and explained key terms, which will be used throughout the study. We begin the next chapter with a review of the literature describing and investigating the innovation field of study and conclude by proposing three hypotheses for our study.

Chapter 3 Literature Review

The purpose of this chapter is to review existing literature related to the study, explain what has been investigated so far and propose the hypotheses. First of all, the innovation and patent relationship is discussed. Next the existing literature on the benefits and drawbacks to the business of using patents is reviewed. In addition to this, we also look at the key determinants, which influence companies' decisions to patent and conclude the chapter by proposing three hypotheses for the study.

3.1. Innovation and Patent Relationship

Globalisation, rapid technological change, growing competition from low-wages economies, reduced transport and communication costs and other factors make new products and processes essential to compete in the current climate (Nieto and Rodriguez, 2011). Therefore, companies are forced to innovate and protect their knowledge in order to survive. It is widely known that firms benefit from R&D efforts. Innovation allows firms to develop and license new products and processes, become more competitive and, consequently, increase their financial performance (Kafouros et al., 2008). However, the extent of benefits varies greatly between the firms (Hall et al., 2009). The majority of the literature splits innovation into two main categories, i.e. product and process innovation (e.g. Fontana et al., 2013, Cohen et al., 2000; Arundel & Kabla, 1998). It is generally argued that a product innovation is about creating new or improving quality of existing products, in order to increase market share, while the process innovation is usually driven by the aim to reduce costs, especially when competition in the market is high (Baldwin et al., 2002). Many people believe that patent rights are the key to protect and explore returns on innovation

(Cohen et al., 2000). According to Oxford Dictionary (2014), a patent is "a government authority or licence conferring a right or title for a set period, especially the sole right to exclude others from making, using, or selling an invention". Therefore, a patent, by its definition, is directly linked to innovation. Many researchers used patents to measure different innovation related theories. For example, to indicate innovation output, measure companies' propensity to patent or research productivity (De Rassenfosse et al., 2009). Most of them also acknowledge that patents, as a measure, have limitations. For example, some of the innovation activities do no lead to a patentable invention. Others say that a propensity to patent depends on the type of innovation and also that some companies might choose alternative ways to protect their inventions (e.g. Griliches, 1990; Levin et al., 1987; Basberg, 1987; Fontana et al., 2013). R&D output comes in various forms as knowledge, academic papers, new processes and products thus it is not possible to capture everything using patents. Despite the controversial views, most of the researchers agree that the availability of the data on patents and difficulty to construct other innovation measures suggest that patents are one of the best tools that could be used for research (De Rassenfosse et al., 2009). In addition to this, many companies carry out R&D activities in order to obtain competitiveness in the market and patents provide them with strength in collaborations, restrict competitors from using or selling the invention, or allow generating returns by selectively licensing the invention (Kondo, 1999). These benefits encourage business to apply for patents rights especially for inventions, which are significant, and are expected to generate high returns, or even lead to significant market changes (Ernst, 1998). Therefore, this study will be focusing

on patents as an innovation output and investigate how different factors, i.e. R&D expenditure and internationalisation will impact the patent innovation of the CEE firms.

3.2. Benefits and Drawbacks of Patenting

Before we try to understand what benefits patents bring for each business, first, we need to understand that each business is, at least to some extent, profit-seeking and, therefore, a key aspect to each firm is to get returns on innovation (Baldwin et al., 2002). There are few different ways how patenting can benefit the company and help to get returns. The original and most obvious motive to patent is to protect one's innovation from imitation and this way secure earnings to cover the expenses (Blind et al., 2009). Patents can also be seen as instruments to secure the future's technological space by preventing imitation. In addition, literature suggests that a good patent portfolio helps in collaborations to generate licencing revenues or financing (Hall and Ziedonis, 2001). Also, some companies use it as initiatives or as a performance indicator to reward researchers (Blind et al., 2006).

On the other hand, there are four main reasons well summarised by Basberg (1987) why companies choose not to patent. First of all, not all inventions can be patented, for example, due to the patent laws on certain industries, which might differ from country to country (Basberg, 1987). Second, the reasons influencing the decision to patent refers to economic expectations, as the cost to apply and get a patent right is usually high, sometimes returns on innovation might not even outweigh the cost (Basberg, 1987). It is especially the case when the inventor is not sure about the success of commercialization of the invention, therefore; it might be preferable to keep it as a secret. Thirdly, the

assumption that competitors can easily “invent around” reduces benefits of having a patent, and fourth, innovation life cycles, i.e. in the case when it is long or extremely short it is preferable to keep it a secret, rather than patent (Basberg, 1987). Later, scholars like Cohen et al. (2000) argued that the lack of novelty and the fact that information needs to be disclosed also impact companies' decision not to patent. Therefore, it is up to each business to decide, which factors are the most important to determine their choice regarding patents.

3.3. Determinants of Patenting

The question, why some companies choose to patent their inventions and others do not, have been investigated for decades, and there is still no clear answer. In the literature there is a clear separation between the process and product innovation (e.g. Fontana et al., 2013; Cohen et al., 2000; Arundel and Kabla, 1998). Peeters et al. (2006) identified that it is more difficult to imitate new processes than products, mainly because processes require specific people related know-how; therefore processes are less likely to be patented. Traditional determinants of patenting include firm size and market power. Schumpeter (1942) was one of the first researchers who hypothesized that larger firms are more innovative. It might be due to the opportunity to exploit economies of scale, synergies and spillovers between different departments as well as because large companies can easier get financing for their projects (Peeters et al., 2006). Van Ophem et al. (2001) found a positive effect between the firm size and the patent portfolio; however, they concluded that the relationship between patent applications and firm size remains controversial. Another factor, which is considered to be influencing patenting behaviour, is

market power, or competition. There are two schools of thoughts where one argues that companies with higher market power invest less in innovation activities, as the gains, which they would get from innovation, would only replace current gains (Arrow, 1962). However, Nielsen (2001) found that the market power positively affects the number of patents the company generates. According to the researcher, the more powerful companies invest more in innovation as they face less or none competition to exploit the inventions. In addition to this, there are evidences that firms in certain, mostly technologically intensive, industries tend to patent more than others (e.g. Mansfield, 1986; Baldvin et al., 2002). Others argue that patenting strategies depend on country specific factors and even more specifically on design of local patent system, science and technology policies or education system (De Rassenfosse et al., 2009). International business literature looks from internationalisation point of view and hypothesises that companies with a higher degree of internationalisation face more competition in different markets and at the same time generate more knowledge, consequently, the internationalisation positively influences innovation performance (e.g. Tsang et al., 2008; Higon et al., 2011 and Kafouros et al., 2008). However, Peeters et al. (2006) found that the relationship between internationalisation and innovation performance is insignificant.

As we can see there are many factors, which influence or might influence companies' patent innovation. Nevertheless, the majority of the reviewed studies are based on developed countries, whereas this paper aims to look at the number of countries, which are neighbouring Western Europe developed economies but are transition economies (i.e. Central and Easter Europe

countries) and identify the relationship between patents and R&D expenditure as well as the role of the internationalisation in this relationship.

3.4. Hypotheses

Many researchers have investigated the importance of R&D expenditure. It attracts much attention from scholars as well as from the business mainly because it is usually one of the highest costs innovative companies have to bear. Thus, it is important to understand how investments in R&D activities are related to the R&D output and overall performance of the firm. However, this relationship is not always clear because of the difficulty to define and measure R&D output. The output can take various forms, for example, research articles, know-how, new products, new processes, etc. (Kondo, 1999). One of the common measures for innovation output is patents counts, which will be used for this study. Kondo (1999) suggests that patents are related to R&D expenditure either directly, meaning that the increase in expenditure on R&D leads to the higher number of patents; or indirectly, through increase in technology stock, which consequently expands an invention frontier and finally influences the number of patents generated. The clear positive relationship between R&D expenditure and number of patents generated has been confirmed by many researchers (e.g. Kondo, 1999; Ernst, 1998). Some of the researchers look at this relationship in even greater detail by splitting the amount of research and amount of development expenditure and analysing the relationship with a number of patents and quality of patents generated (Ernst, 1998).

Within this field of study there are publications, which suggest that R&D expenditure is just indirectly linked to the number of patents a company

generates (Fontana et al., 2013). They suggest that there is a clear relationship between R&D expenditure and inventions, which intensity is moderated by productivity effect, and, on the other hand, there is also a relationship between inventions and patents, which is moderated by propensity to patent effect (De Rassenfosse et al., 2009), and, therefore, it is argued that the relationship is not as straightforward as we might expect.

Even though much research has been done on this area, best to our knowledge, there was no research based on CEE R&D intensive companies. It is important to look at these firms, which originated from countries with different background, which went through a fundamental economic and industrial reform accompanied with significant institutional change (Radosevic & Yoruk, 2013). Thus, it is interesting to find out whether institutional convergence of countries with very different levels of development leads to convergence in outcomes in terms of R&D at individual companies' level.

Our study tests whether a direct, clear relationship between R&D expenditure and patents exists. In relation to the majority of research, which suggested that the relationship is strongly positive, we expect to confirm the same approach for the CEE companies.

<u>Hypothesis 1:</u> R&D expenditure positively influences the patent innovation of knowledge intensive Central and Eastern European firm.

It is known that multinational enterprises incur more costs than their domestic counterparts as widely dispersed business units make coordination and management more complex and, therefore, transaction costs increase. Also, depending on the geographical distance, communication between different units

might be negatively affected in terms of frequency, quality and speed (Kafouros et al., 2008), as a result, a greater possibility of information leakages might arise (Fisch, 2003). The increase in costs also depends on the "liability of foreignness", which mainly refers to the level of institutional distance between home and host economy (Sofka & Zimmermann, 2008). Higon et al. (2011) compared domestic multinational enterprises (MNEs) and foreign MNEs and found that R&D returns of domestic ones outperform those of international competitors based in the market. Consequently it provides evidence for "liability of foreignness" effect; which means that foreignness negatively influences R&D returns.

Despite the drawbacks and risks created by internationalisation, empirical research proves that there are many benefits rising from the higher level of internationalisation of a firm. For example, it is argued that knowledge is produced and diffused within particular geographic location and, therefore, just companies, which have a presence in a particular geographic area, where the information is produced, can benefit from that knowledge (Almeida & Kogut, 1999). Thus, firms that engage only into domestic activities have limited or no access to technologies and knowledge generated outside its geographic boundary (Kafouros & Forsans, 2012). In addition, international business literature suggests that MNEs have certain ownership advantages over its domestic counterparts in the markets it serves or intends to serve (Higon et al., 2011) and this helps them to cover the higher cost incurred by having presence in many international markets. Dunning (1993) explains these ownership advantages as MNEs ability to exploit scope economies; others, like Barlett & Ghoshal (2002), add that benefits occur due to superior management and

technological capabilities, where efforts of many units are combined to create synergies. To add, by having multiple units in different locations MNEs are able to exploit country specific resources, enjoy the benefits of worldwide learning (Tsang et al., 2008) and also balance risk by avoiding business cycles and economic fluctuations that are specific to a single market (Kafouros, 2008). It is especially important for our sample companies, which are based in CEE economies. It is well known that development level of these economies is lower than Western Europe countries but due to the regional integration R&D intensive companies are forced to compete, at least to a certain extent, with all companies within European Union. In order to get a competitive advantage or at least be able to compete these companies have to seek knowledge from foreign markets as the home market is just trying to catch up. It is also argued that the higher degree of internationalisation increases the company's innovative capacity because MNEs are able utilise knowledge and ideas from many countries and broader group of clients, suppliers, universities and other research institutions (Kafouros, 2006). According to the indicators presented in Eurostat (2011), the majority of the population in CEE countries are well educated; thus, it is easier for CEE companies to apply knowledge generated abroad. One more benefit of multinationality is flexibility; firms can shift their innovation activities to the places that are most conductive and have best routines for both the development and commercialisation of new technology (Zander, 1998). Therefore, it might be that even though the sample companies are registered and have operational headquarters in CEE countries, the knowledge centres might be based outside the region and this way internationalisation would increase innovation performance of firms. Also, large

MNEs have ability to create competition between different business units and this way increase or at least sustain the level of innovation and its significance in terms of returns (Zander, 1998). Even though we should not forget that the success or failure of the internationalisation and its effect on innovation depends on individual company's strategies and managerial capabilities (Kylaheiko et al., 2011), the findings, mentioned above, suggest that the internationalisation positively influences innovation performance, meaning that companies, which have a presence in many markets innovate more. At the same time internationalisation increases the risk of imitation and more complicated control of inventions, which leads to a need for legal innovation protection (Peeters et al., 2006). Baldwin et al. (2002) found that the use of patents is related to the internationalisation of the firm and that foreign owned firms are more likely to use patents, in order to protect their inventions. Consequently, as more inventions are created, and the need for the invention protection increases it is more likely that the degree of the internationalisation will positively affect the number of patents in the firm's patent portfolio. Therefore, we suggest the following:

Hypothesis 2: The degree of internationalisation positively influences the patent innovation of a knowledge intensive Central and Eastern European firm.

However, not all researchers agree that the degree of internationalisation has an impact or at least a direct impact on innovation output or number of patents companies generate. For example, Peeters et al. (2006) argued that the degree of internationalisation on its own, after accounting for other related variables like size and competition, has no significant effect on patenting behaviour of the

firms. Therefore, the relationship between internationalisation and patenting remains controversial. However, other scholars looked at this phenomenon from the different point of view and argued that the role of innovation and technological capabilities determines firm's internationalisation and performance relationship (Kylaheiko et al., 2011). More interestingly for our purpose Kafouros et al. (2008) found that depending on the level of internationalisation, influence on R&D expenditure is not always the same. It means that even though companies put similar resources in to their innovation activities, the output is different depending on the degree of the internationalisation.

It is especially important to understand this relationship as competition on R&D is constantly increasing, and the length of product life cycles decreases; meaning that it becomes more difficult to obtain the returns on R&D investments (Kafouros et al., 2008). Some authors, therefore, argue that internationalisation is a must for innovative firms in order to be able to exploit fully and capture all possible returns from innovation activities (e.g. Saarenketo, 2004; Kafouros et al., 2008). The opportunities to leverage innovations capabilities and abilities to identify and exploit knowledge spillovers from competitors' innovations in international markets influenced the recent trend towards more globalised and integrated approach to R&D (Cantwell et al., 2004). It is obvious that each company is trying to minimize their R&D expenditure and at the same time maximize the gains from it. Kotabe et al. (2002) found that international firms can charge higher prices for their products. Therefore, by charging higher prices and spreading the cost around many different units in the world as well as by establishing R&D facilities in countries where capital, land and scientific knowledge are cheap (Kafouros et al., 2008) MNEs can reduce innovation

costs, increase speed of returns and consequently increase their competitive advantage over its rivals.

According to neoclassical economics, any produced knowledge becomes a public good and, therefore, spillover effects are highly possible. It diminishes firms' ability to appropriate the benefits from its innovation. Internationalisation increases the risk of knowledge leakages as processes are more difficult to manage and coordinate. Sanna Randaccio & Veugelers (2007) found that depending on a level of knowledge in the local economy it is possible that spillovers from the company might be even higher than those coming to the business. Therefore, it is important to have appropriate mechanisms, like patents, to protect innovations and generate returns. In addition to this, large MNEs with globally dispersed operations, more diversified scope of business and a wider range of products are in a better position to identify future needs and, therefore, it is more likely that the created R&D output will be patented to protect intellectual property rights as the output will reach many markets quickly and this way appropriate more returns from the invention (Tsang et al., 2008). Therefore, we suggest that internationalisation is a significant variable in the innovation process and propose another hypothesis where the level of internationalisation plays a mediating role.

Hypothesis 3: ***The benefits of R&D expenditure on patent innovation are stronger when a central and eastern European firm has a higher degree of internationalisation.***

In chapter 3, we have reviewed the existing literature on patent innovation and proposed hypotheses for our study. The following chapter will describe the methods, which will be used for the hypotheses testing.

Chapter 4 Methods

In this chapter, we describe the data and sample, i.e. how it was collected and what sources were used. We also introduce the empirical methods and provide reasoning behind our choice of dependent, independent and control variables.

4.1. Sample and Data

To test the hypotheses empirically, we used a firm level panel data set. The panel data set, which includes 9 years, is important for our study as it enables identifying changes specific to the company's innovation strategy rather than overall economic, industry, region or period tendencies (Kafouros & Forsans, 2012). Also, as one of our variables is internationalisation, it is important to capture it across the time and see how changes in the level of internationalisation activities affect patent innovation (Kafouros et al., 2008). Finally, the panel data helps to avoid bias created by changes in the business cycle and any business instabilities, which might be caused by recessions or revivals (Kafouros, 2005).

To collect data, the study uses three sources. First of all, in order to identify our sample we used 'The EU Industrial R&D Investment Scoreboard' for years 2004 to 2012. It is a register published by the Department for Innovation, Universities & Skills and the Department for Business, Enterprise and Regulatory Reform on an annual basis and is available for public access. We collected all the reports for years 2004 to 2012 added together and using country description conducted analysis to identify R&D intensive companies from countries, which joined the EU in 2004. We identified 28 companies in 8 countries (See Table 1).

Country	No of companies
Bulgaria	1
Czech Republic	6
Hungary	3
Latvia	1
Malta	2
Poland	9
Slovakia	1
Slovenia	5
Total	**28**

Table 1: R&D intensive companies (EU 2004) - from countries, which joined the EU in 2004 (Author, source: IRI, 2013)

Companies in the scoreboard are allocated to countries according to their registered office (IRI, 2013). Therefore, in some cases it might be different to the country where their headquarters are located. In order to avoid misinterpretation of the data, we used companies' annual reports to make sure that the headquarters of each company is located in the same country where company is registered. This way we make sure that the key activities are happening in one of the CEE countries. In the cases when the location of headquarters was not clear we removed companies from our sample to avoid possible bias. As our study focus is only CEE economies, two R&D intensive companies from Malta were also eliminated from the sample. In addition, we dropped companies, which were acquired by other foreign companies during our selected period.

We are also aware about the limitations of using patents as a measure of innovation output; therefore, we decided that our sample companies should be just those, which have at least one patent during the selected period. This way we acknowledge that patents are not the only way to protect the invention and, therefore, we concluded that companies that invest heavily in R&D but do not

have any patents are either using different appropriability mechanism to generate returns on innovation or they are not producing any significant innovation output, which could be patented. Either way our data would not be able to capture the outcomes and therefore we chose to look at smaller but more accurate sample of companies. After applying all the criteria to the companies our final sample consists of 8 companies, from 6 different industries and 5 CEE countries.

The 'EU Industrial R&D Investment Scoreboard' not only provides information about R&D expenditure and country but also additional information on industry, net sales, total number of employees, capital expenditure, etc. (IRI, 2013). Therefore, it formed a basis for our study. However, in the cases when companies had been dropped from the scoreboard for few years or we needed additional information, for example, degree of internationalisation or company age we have used companies' annual reports. The annual reports were used to conduct the 'EU Industrial R&D Investment Score Board', therefore this way we got a full data set from consistent data sources. In order to identify the number of patents each company holds we used European Patent Office database, which was also used by many other researchers as a reliable source (e.g. Earnst, 1998, Fontana et al., 2013, De Rassenfosse & van Pottelsberghe, 2009). The overall sample covers the period of 2004-2012, as 2004 were a year when CEE countries joined the EU and 2012 are the latest data available on 'EU Industrial R&D Investment Scoreboard'. Therefore, the overall number of observations is 72.

4.2. Measures

In the following section we will describe variables used for our study.

4.2.1. Dependent Variable

The study uses quantitative data analysis. To give meaning to our data we employ a linear regression analysis, which was used in many other research papers in order to understand the determining factors of patent innovation (e.g. Kafouros et al., 2008, Tsang et al., 2008). As we concentrate on finding the determinants of patent innovation our dependent variable of this model is *Number of Patents* generated by the company in a particular year. We count a number of patents by searching for applicant – the company in the European Patent Office database, and restricting publication date to the period of 2004-2012. This way we capture both patents, which are already granted to the companies, as well as patent applications. We are aware of the fact that patent applications need to go through a review and that patent rights might not be eventually granted to the company. Nevertheless, we are analysing a recent data, and because it takes around 4 years for a patent to be granted, we argue that, patent applications are a good proxy of innovation output. Moreover, the high cost of applying for a patent is an important factor, which suggests that companies should apply for patents just when they are confident about the uniqueness and are willing to generate returns on the invention (Fontana et al., 2013). Also, it is important to include patent application as according to Kondo (1999) due to the time gap between actual investment and granted patent rights, it makes more sense to use patent applications, not only patents granted, when analysing relationship between R&D expenditure and patents. Therefore,

by looking at patents based on first publication date we can relate more closely to the companies' activities in that year with their patent innovations.

4.2.2. Independent Variables

Based on our hypotheses we chose two independent variables, which we believe are the key determinants of patent innovation.

4.2.2.1. R&D Expenditure

Our study identifies how much each company spends on its R&D activities each year using the data available from the 'EU Industrial R&D Investment Scoreboard' or applying methodology used by the scoreboard on annual companies' reports for those, which dropped from the scoreboard for few years in the sample period. The methodology used in scoreboard is explained in each scoreboard document appendixes and available online (IRI, 2013). The R&D expenditure included is the cash investment of the business and does not include R&D undertaken under contracts with customers, such as government or other companies (IRI, 2013). Scoreboard uses consolidated companies' annual reports to collect the data. Therefore, it is an ideal measure for our purpose because we are looking at individual companies and the data refers to the overall investment on R&D of a particular company, regardless of where the actual R&D activity was performed. It means that we are not restricting our sample to particular sector or territory, just concentrating on the fact that the company is registered and managed from one of the CEE economies.

4.2.2.2. Degree of Internationalisation

In our study, we investigate whether the degree of internationalisation influences the patent innovation of the firm. Based on internationalisation

theory, which explains the benefits of internationalisation to the company's innovation performance we suggest measuring the degree of internationalisation in terms of breadth i.e. the number of countries the company operates in, which is in line with measures employed by other studies (e.g. Kotabe et al., 2002). We used companies' annual reports, which include a report on either geographical segmentation or if it was too high level, i.e. based on regions rather than countries; we also used reports, which showed all group companies and simply counted the units and the locations of the units in the group.

4.2.3. Control Variables

We employ control variables, which are acknowledged within wide innovation literature as important determinants of innovation output, but which are not the key to answer our research question.

4.2.3.1. Size of the Company

It goes back to the early research of innovation and so called Schumpeterian (1942) hypothesis that large firms innovate more. Also, large firms are more likely to have established capable legal departments for handling patent applications (Baldwin et al., 2002). On the other hand, it is argued that when firms grow large their innovations tend to be less efficient, as the scale and scope economies may be exhausted before a firm becomes large (Levin and Reiss, 1988). Even though the results are mixed on the influence of size on patent innovation we want to ensure that our study are not biased by size variable and, therefore, we use a dummy that is valued 1 when company's annual net sales are above and 0 when below the median sales of the whole sample.

4.2.3.1. Pharmaceuticals Industry

Many researchers found evidence that patent innovation is more dominant in a pharmaceuticals' industry than in other industries (e.g. Tsang et al., 2008; Kondo, 1999; Arundel &Kabla, 1998). Based on the findings in the literature and the fact that our sample includes 3 firms from this industry we introduce a dummy variable that takes value 1 when industry is pharmaceuticals and all the other industries takes value 0. This way we are able to control for the industry with the highest propensity to patent and the highest number of companies in the sample.

4.2.3.1. Age

It has also been claimed that the age of the company can influence the patent innovation. Peeters et al. (2006) argued that, on the one hand, younger companies have no significant market power and, therefore, they have a higher need for patent protection. On the other hand, older companies usually have more innovations, which need to be protected; therefore, they generate more patents. Even though the relationship is not clear, the variable itself is important and thus we will account for it in our study. To measure the variable we used the age of the company for each year in our sample.

In chapter 4, we explained why we are using panel data, how we came up with our sample of 8 companies and described each of the variables used for the study.

Chapter 5 Results

In this chapter, we present and explain the results of our study as well as discuss how it fits within other research conducted in the innovation field of study.

5.1. Empirical Findings

Descriptive statistics and correlation matrix

		Mean	Std. Dev	1	2	3	4	5
1	*R&D Expenditure*	25.48	31.93					
2	*Internationalisation*	13.10	9.65	0.409**				
3	*Size*	0.50	0.50	-0.177	0.010			
4	*Age*	61.88	45.02	0.145	-0.013	-0.034		
5	*Pharmaceuticals Industry*	0.38	0.49	0.618**	0.037	-0.602**	0.216	
6	*Patents*	8.47	10.81	0.785**	0.471**	-0.354**	0.164	0.559**

Note: Pearson Correlations (2-tailed); ** if p<0.01. The number of observations is 72.

Table 2: Descriptive statistics and correlation matrix (Author, 2014)

Table 2 provides the summary of descriptive statistics and correlation analysis of the variables described in the previous chapter. If we look at the mean column of Table 2 we can see that the 'average' company in our sample spend €25m on R&D each year. It has a presence in 13 countries and is medium size. The average company age is almost 62 years and more than two thirds of our sample is pharmaceutical industry companies. On average each company within the sample generates 8.47 patents a year. Standard Deviation column shows how widely the data is dispersed from its mean. Correlation analysis in Table 2 remaining columns allows identifying a correlation coefficient, which quantifies the strength of the linear relationship between two selected variables (Saunders et al., 2009). The closer correlation coefficient is to 1 or negative 1, the stronger the relationship is. As you can see from the Table 2 patents variable has medium to strong relationship with all variables but age. Patents have a positive correlation with R&D expenditure, internationalisation and pharmaceuticals industry variables. The strongest positive relationship is

between patents and R&D expenditure. Positive relationship suggests that increase or decrease in variables, e.g. R&D expenditure, increase or decrease other variable in the relationship, e.g. number of patents, accordingly. Interestingly, company size is the only variable, which has a negative correlation with patents. It means that the increase in business size decreases the number of patents generated. However, this relationship is not very strong.

Running correlation analysis also helps ensuring that there are no collinearity issues, i.e. absence of correlation between variables, as all correlation coefficients are below 0.90 (Saunders et al., 2009). The correlation matrix provides useful primary insights, but it is just an overall measure of the strength of association and does not reflect the extent to which any particular independent variable is associated with the dependent variable.

We employ a regression analysis in order to test dependency between variables. Table 3 presents the regression analysis results using 4 different models. We used Model 1 to test whether our control variables, i.e. size, age and pharmaceuticals' industry, are important in explaining patent innovations. The results show that, among control variables, the most significant is pharmaceuticals' industry one. Overall, all control variables explain just 0.285 (adjusted R^2) of the relationship. The goodness fit (adjusted R^2) describes how well the relationship is explained by quantifying it 0 – if the model does not explain anything and going towards 1 - fully explained dependency relationship. Therefore, Model 1 serves us as a baseline model.

Regression analysis results (Dependent variable: Patents)

	Model 1	Model 2	Model 3	Model 4
H1: R&D Expenditure		0.270 (8.518)***	0.224 (6.356)***	0.156 (3.316)**
H2: Degree of Internationalisation			0.229 (2.631)*	0.349 (3.416)**
H3: R&D Expenditure x Degree of Internationalisation				0.008 (2.111)*
Size of a company	-0.749 (-0.275)	-6.043 (-3.023)**	-5.373 (-2.780)**	-5.852 (-3.084)**
Pharmaceuticals Industry	11.702 (4.068)***	-2.603 (-0.994)	-0.484 (-0.184)	-0.825 (-0.321)
Age of a company	0.012 (0.468)	0.015 (0.873)	0.016 (0.956)	0.005 (0.289)
Constant	3.738 (1.412)	4.644 (2.508)**	1.650 (-0.783)	10.372 (5.250)***
Adjusted R-squared	0.285	0.652	0.680	0.696
F-statistic	10.431	34.192	31.155	28.068

Notes: N=72; Note: † if p<0.10, * if p<0.05; ** if p<0.01; *** if p<0.001. Figures in parentheses are t-statistics.

Table 3: Regression analysis results (Author, 2014)

We employed Model 2 to test our first hypothesis on the relationship between R&D expenditure and patent innovation. When we look at the goodness fit (adjusted R^2) we notice that significance increases from 0.285 in Model 1 to 0.652 in Model 2. Therefore, R&D expenditure is a very important variable, which explains more than a third of the relationship. In addition, it has the highest significance level (p=0.000) and the relationship is positive, therefore, we are confident to generalise results and say that based on our sample we found that 1% increase in R&D expenditure leads to 27% increase in a number of patents. It confirms our Hypothesis 1, as we argued, that R&D expenditure positively influences the patent innovation of knowledge intensive Central and

Eastern European firm. Many authors who analysed this relationship found that the relationship between R&D expenditure and patents is significant and positive. For example, Kondo (1999) found that 1% increase leads to 1.4% increase in patents. Others, like Peeters et al. (2006) analysed companies probability of having patent portfolios and found that 1% increase in R&D budget leads to 5% increase in the probability that a company will have patent portfolio. When they looked at the direct relationship with patents they found that 1% increase leads just to 0.7% increase in patent (Peeters et al., 2006). Therefore, our results are in line with other authors in terms that the relationship is significant and positive; however, the effect on patents is much higher than other studies. Our findings suggest that CEE companies generate more patents with same 1% increase in R&D expenditure. There might be few reasons why this happened. First of all, our sample is based on CEE region, and we were expecting to generate new insights specific to the region. It is known that the labour cost in the CEE region is lower than in developed economies; however, the labour is well educated (Eurostat, 2014). These are very important facts as according to Hall and Lerner (2010) more than 50% of total expenditure on R&D is spend on researchers' and innovators' salaries. Thus, if we consider these facts together it becomes easier to understand that CEE companies need to spend less on researchers and innovators salaries as labour cost is lower in the region. Also, because the region has well educated specialist the inventors' efficiency is similar despite the country of origin; therefore, CEE companies generate more patents when amount of investment remains constant. In addition to this, our sample is based on the most knowledge intensive companies from the region. We made sure that they use patents as a mean for

the invention protection. It means that we capture the majority of the innovation output and therefore, the strict criteria of our sample might influence the strength of the effect in this relationship.

Overall, we can confirm that R&D expenditure is a very important positive determinant of innovation output for CEE companies, however in order to confirm that CEE companies are more efficient in generating innovation output further research would be needed.

Model 3 allows us to test Hypothesis 2, which suggests that the degree of internationalisation positively influences the patent innovation of a knowledge intensive CEE firm. If we look at the goodness fit (adjusted R^2), there is an increase of 0.028 from Model 2 to Model 3 meaning that internationalisation provides additional explanation on patent innovation. The relationship between innovation and number of patents is positive and significant (p=0.011). This way we confirm our Hypothesis 2 suggesting that the internationalisation, in terms of number of countries the company is present; positively affects the patent innovation, i.e. 1% increase in internationalisation leads to 22.9% increase in a number of patents. There are quite a few studies, which analysed the degree of internationalisation, foreignness of a company or multinationality of a firm, however, the results are mixed. For example, when Peeters et al. (2006) looked at foreign ownership and level of internationalisation they found that these factors do not influence patenting behaviour significantly. Baldwin et al. (2002) argued that foreign owned firms perform more R&D but just because they are larger and more powerful, not because they are international. On the other hand, Higon and Atolin (2012) results are more in line with our results as they found that multinational companies generate higher R&D returns than purely

domestic companies. It is also in line with results of Kafouros et al. (2008) and Tsang et al. (2008). The reasons why we see a clear and strong relationship might be the use of different methods to measure innovation input and output as well as the development level and unique position of CEE countries. In the international business literature, it is known that companies from less developed countries seek knowledge by establishing a presence in more developed economies. CEE companies' market increased significantly after countries joined the EU. The companies had to adapt quickly and learn to compete with other companies from developed world if they wanted to survive. This might be the reason why internationalisation is so important for our sample companies and why the effects are significant and positive unlike in few other studies. Therefore, we can argue that companies from CEE benefit from internationalisation.

Model 4 introduce the moderated regression analysis, which is based on interaction model in order to test Hypothesis 3. To use interaction model we mean-centred the independent variables for R&D expenditure and internationalisation, so that interpretability could be increased, and we would avoid potential multicollinearity issues. We ran Model 4 and found that interaction model between R&D expenditure and internationalisation has a positive effect on a number of patents generated by each firm. Therefore, we can confirm that Hypothesis 3 is empirically supported, meaning that the benefits of R&D expenditure on patent innovation are stronger when a CEE firm has a higher degree of internationalisation. As both hypotheses 2 and 3 are confirmed, we can argue that internationalisation plays an important role in patent innovation for CEE firms. Kafouros et al. (2008) found that more

internationalised companies outperform less internationalised competitors when other factors remain constant. This is important as our results also show that the degree of internationalisation not only influence the number of patents generated but also provide a competitive advantage over other firms with very similar characteristics but lower degree of internationalisation. The main reasons are that more international companies generate more and broader knowledge, can spread the R&D cost over many markets and generate more returns quicker by introducing the invention to many markets.

5.2. Further Analysis - Internationalisation

As we mentioned before our sample consists of 8 companies from 5 CEE economies. The degree of internationalisation of these companies varies from 3 to 34 host countries. The countries that are home to the most internationalised companies are Hungary and Slovenia. The graph demonstrates how widely CEE knowledge intensive companies are internationalised and which countries are the most popular host destinations.

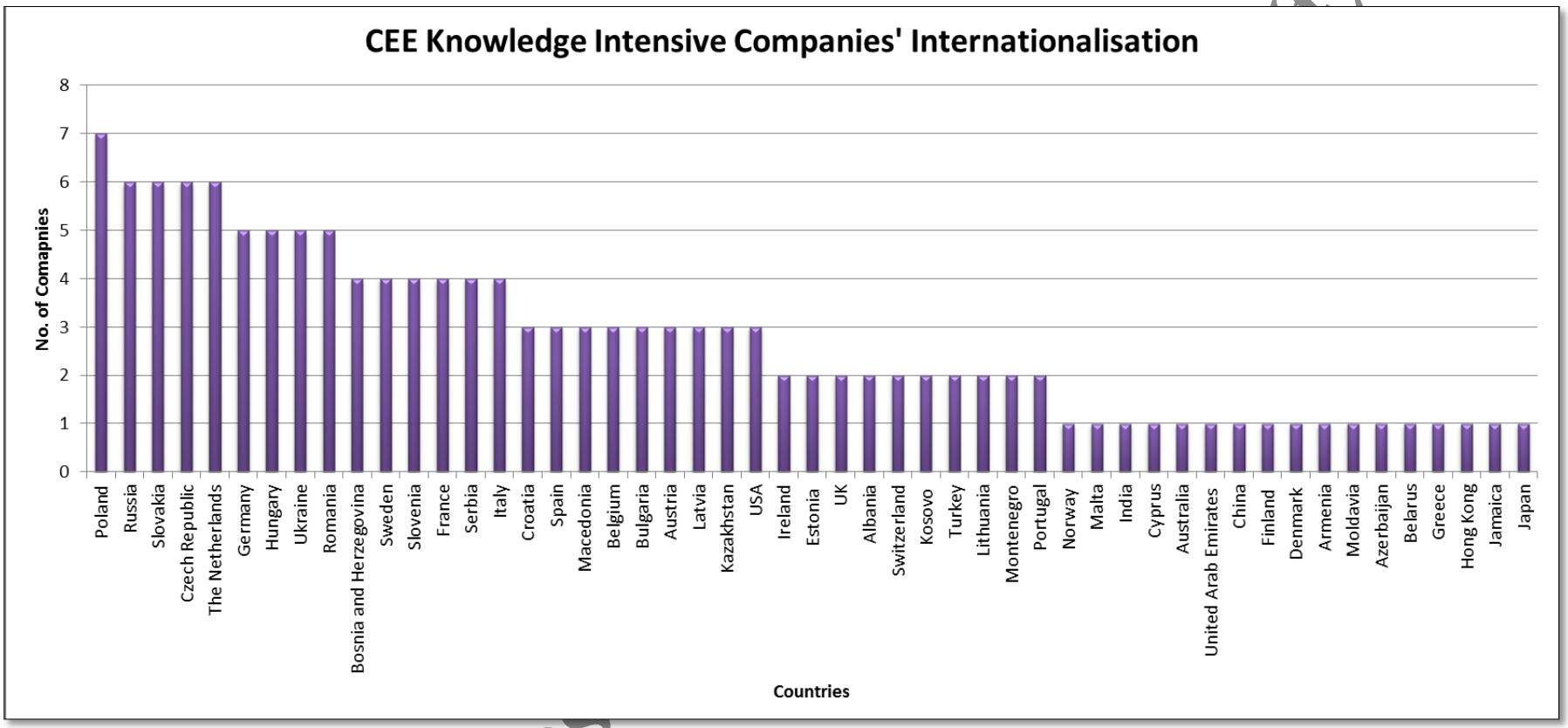

Figure 4: CEE knowledge intensive companies' internationalisation (Source: Author, 2014)

As you can see from the graph there are 51 countries and the leading host locations are Poland (7), Czech Republic (6), Russia (6), Slovakia (6) and The Netherlands (6). It is in line with internationalisation literature, which suggests that the majority of the companies expand to the neighbouring countries first and just in the later stages chose to internationalise to more distant places (Daniels et al., 2011). Also, we can see that the majority of the countries are European countries and that the overall concentration, around 64% of all activities, is based in Europe.

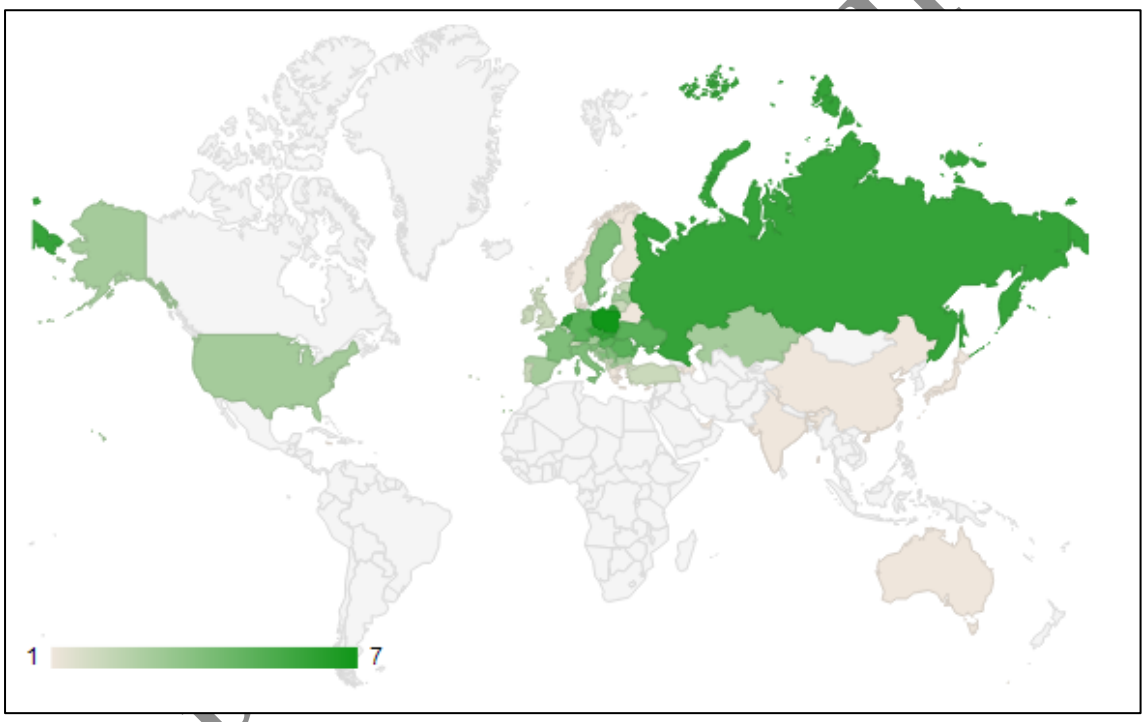

Figure 5: GEO Chart of CEE knowledge intensive firms international spread (Author, 2014). (Interactive GEO Chart available at: http://savedbythegoog.appspot.com/?id=797827c4aba47186ebd4ab04bff5e6c03aa5b8bc)

The geographical chart helps us to visualise how widely the CEE companies are internationalised. We cannot ignore the fact that Russia is an important market for CEE companies. 6 out of 8 companies in our sample have

subsidiaries in Russia. Despite the market size of Russia, we argue that the main reason for an expansion to Russia is close historical relationship. Just one of the companies in our sample was established after the Soviet Union broke down. It implies that some of the important parts of the business might be dependent on specific resources that Russia has to offer, and; therefore, the majority of the CEE companies continued conducting business in Russia.

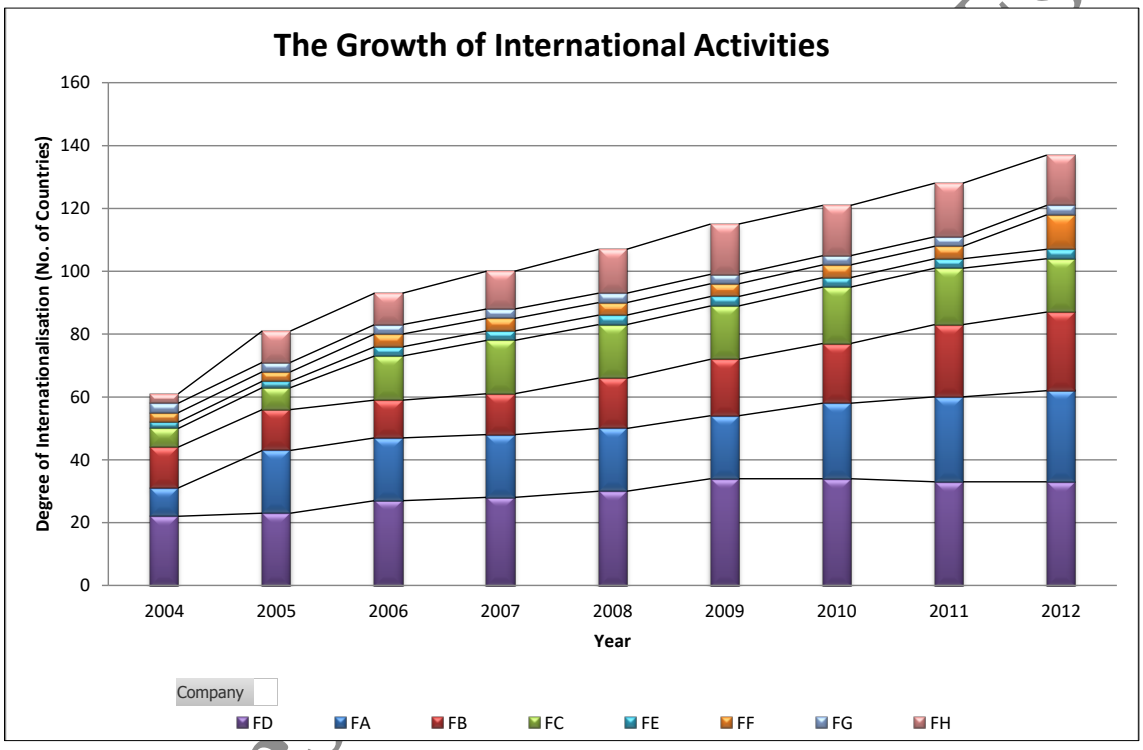

Figure 6: The growth of international activities (Author, 2014)

Another interesting factor about our sample companies is that majority of them increased their international activities significantly after the accession to the EU in 2004. The Figure 6 shows how each company's international activities were growing over the selected period. Probably the steepest overall increase can be seen between 2004 -2005, where the overall breadth of our sample companies increased by 20 countries. We can see that some of the companies were growing internationally more than others; however we cannot deny the overall rapid international expansion. This can be associated to both the opportunities,

which were created by ‘Four Freedoms’ of regional economic integration as it made international expansion within the EU easier, as well as threats, which arose due to increased exposure to the big European market and competitors from developed world. These factors make CEE region interesting and important to analyse as well as confirms our findings that internationalisation plays a very important role in patent innovation of CEE knowledge intensive companies.

In this chapter we have presented and explained the results of our study. We explained how our findings relate to existing innovation literature as well as to the overall conditions of the region.

Chapter 6 Conclusions

The last chapter of our study summarises our key findings and proposes implications to both business managers and policy makers. We also acknowledge the limitations of our research and suggest the areas that would be interesting for future research.

6.1 Conclusions

Our study contributes to the literature by investigating the dependence relationship between patent innovations, R&D expenditure and providing support for the role of the internationalisation based on CEE knowledge intensive companies sample. The patent innovation is measured by a number of patents, both applications and granted, held by the firm. Three main hypotheses were formulated to help us understand how significant R&D expenditure and internationalisation are in determining patent innovations. The first one concerns with R&D expenditure and its impact on patents. The second one suggests looking at the direct relationship between internationalisation, in terms of geographical breadth, and patents. By employing the third hypothesis, we argue that internationalisation also works as a moderator in the R&D expenditure and patent innovation relationship. The companies with the same R&D expenditure, but the higher degree of internationalisation will benefit more, in terms of innovation output.

We found that the most significant determinant for patent innovation is R&D expenditure, which is in line with other authors who analysed this relationship (Kondo, 1999; Ernst, 1998). The internationalisation variable was analysed

using two different models. First of all, we used linear regression analysis to identify whether internationalisation has a direct impact on patent innovation. We found that the relationship is significant and that more international companies are able to generate more patents than others. Many scholars who analysed this relationship found mixed results (e.g. Kafouros et al, 2008; Higon et al., 2011) however, we argue that internationalisation has a greater and clearer impact on our sample knowledge intensive companies as they have to seek for knowledge from developed economies, that is not available in their home transitioning country, in order to be able to compete with other R&D intensive companies. To test Hypothesis 3, we employed moderated regression analysis and found that internationalisation not only influences patent innovation directly, but also acts as a moderator to increase the benefits from innovation effort. This means that companies, which are more internationalised than others generate better results from their innovation effort, when the input efforts are equal. The findings give us useful and specific to CEE companies results, which benefit both businessmen and policy makers.

6.2. Implications

In order to conclude our study, it is important to mention what implications our findings have on managers and policy makers. Like many other authors, we suggest that managers should understand the importance of R&D expenditure on innovation output as cutting down the R&D budgets even during a financial downturn might have a severe impact on company's future competitiveness and overall performance (Earnst, 1998; Kondo, 1999). However, our study focused only on the knowledge intensive firms and, therefore, we do not have any evidence that high investment in R&D activities would benefit low-technology

companies. R&D expenditure is not only influential determinant for innovation output; internationalisation plays a very important role too. Therefore, we suggest that managers need focus equally on both innovation efforts and also look for a potential market expansion options in order to benefit more from the innovation efforts. It is especially important when home countries cannot provide superior knowledge required for the innovation. From a policy perspective, our study suggests that the policy makers need to understand that it is not enough to encourage companies to conduct more R&D activities in their home country; there should also be appropriate systems in place that would allow them to engage in global collaborations, expand internationally and encourage to seek superior knowledge that eventually will raise the national technological capability.

6.3 Limitations and Future Research

Like other studies, our research also suffers from several limitations. First of all, small sample size to some extent limits our ability to generalise the results, therefore, further research could be conducted on a larger sample of the firms from CEE. Also, the existing literature suggest that patent related indicators are not perfect because they are dependent on company's strategy, whether to use patents as a means of innovation protection or not. Therefore, it would be interesting to use other measures of innovation output, like new product sales, to provide more insights for the CEE companies. In terms of R&D expenditure, it would be really useful to get further insights and analyse whether the lower cost of labour, in terms of R&D, can be seen as a competitive advantage of CEE companies. Furthermore, it would be interesting to look at these companies in more detail and find out, for example, what type of innovation most of the

companies are conducting, whether they are really trying to catch up with companies from developed economies or actually by having high levels of international presence they are able to compete on the legal grounds despite their origins. In our study, internationalisation was measured in terms of number of countries despite the development level. However, it would be really interesting to see whether the direction of internationalisation e.g. to more developed countries influence patent innovation differently.

As you can see, there are many interesting topics to be covered on the CEE region therefore we believe that by this study we acknowledged that CEE countries and companies are to some extent different from those in the rest of Europe, identified key variables determining patent innovation output, provided specific insights for managers and policy makers and hopefully encouraged future studies.

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Appendix I

All the data and working files, which confirm the originality of the dissertation, are in the memory stick attached to the hard copy of the dissertation.

There are two folders, one called ‘Internationalisation and Patents’, it contains files with information about each company’s internationalisation and number of patents it generates each year, another is called ‘R&D intensity in EU’, which contains all R&D industrial scoreboard reports, also files where reports are merged together and analysed. There is a separate Excel file called ‘Full data set’. It has few different versions of collected data, which was used in SPSS to run regression analysis and also some sheets where additional analysis was performed and figures were generated. Finally, there is also an electronic version of the dissertation.