

**EKONOMICKÁ UNIVERZITA V
BRATISLAVE
NÁRODOHOSPODÁRSKA FAKULTA**

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**UNIVERZITNÉ PATENTY AKO NÁSTROJ TRANSFERU
POZNATKOV V EÚ**

**UNIVERSITY PATENTS AS A TOOL OF KNOWLEDGE
TRANSFER IN THE EU**

Diplomová práca

Bratislava 2021

Bc. Anikó Barcziová

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Študijný program: Verejná správa a regionálny rozvoj
Študijný odbor: Ekológia a manažment
Školiace pracovisko: Katedra verejnej správy a regionálneho rozvoja
Vedúci záverečnej práce: Valéria Némethová, Ing., PhD.

Bratislava 2021

Bc. Anikó Barcziová

Čestné vyhlásenie

Vyhlasujem, že záverečnú prácu som vypracoval(a) samostatne a že som uviedol (uviedla) všetku použitú literatúru.

Dátum:

.....

podpis študenta

Pod'akovanie

Touto cestou by som sa chcela pod'akovať Ing. Valérii Némethovej, PhD. a Ing. Eve Belvončíkovej, M.A. PhD. za odborné konzultácie, cenné a užitočné rady, ochotu a usmerňovanie pri vypracovaní diplomovej práce. Ďakujem Vám!

ZADANIE ZÁVEREČNEJ PRÁCE

Meno a priezvisko študenta: Bc. Anikó Barcziová
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Názov: Univerzitné patenty ako nástroj transferu poznatkov v EÚ

Anotácia: Podpora transferu technológií je jedným z kľúčových prvkov politik vedy a výskumu podporujúcich inovácie. Jedným z prvkov transferu poznatkov medzi firmami a univerzitami sú aj patenty. Predmetom diplomovej práce bude skúmať univerzitné patenty (university - owned patents) na regionálnej úrovni vo vybraných krajinách EÚ, pričom bude skúmať potenciálne faktory ovplyvňujúce zapojenie univerzít do tohto procesu. Hlavným zdrojom údajov bude European Tertiary Education Register (ETER databáza) OECD, regionálna databáza patentov REGPAT OECD, ako aj doteraz publikované výskumy o vybraných krajinách.

Vedúci: Ing. Valéria Némethová, PhD.

Katedra: KVSaRR NHF - Kat. verej. spravy a regional. rozvoja NHF

Vedúci katedry: doc. Ing. Štefan Rehák, PhD.

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doc. Ing. Štefan Rehák, PhD.
vedúci katedry

Abstrakt

BARCZIOVÁ, Anikó: Univerzitné patenty ako nástroj transferu poznatkov v EU – Ekonomická univerzita v Bratislave. Národohospodárska fakulta; katedra verejnej správy a regionálneho rozvoja. – Vedúci záverečnej práce: Ing. Valéria Némethová, PhD. – Bratislava: NHF VSRR, 2021, počet strán: 87

Hlavným cieľom práce je preskúmať vývoj patentovej aktivity vo vybraných európskych krajinách. Naším zámerom je ukázať a definovať rozdiel medzi dvoma patentovými metódami: Bayh Dole Act a Professor's Privilege. V záverečnej práci s názvom Akademické patenty ako nástroj transferu poznatkov v EU analyzujeme teórie a tendencie akademického patentovania. Ďalej konkrétne pracujeme a analyzujeme štyri krajiny, dve krajiny zo severnej časti EÚ - Švédsko, Dánsko a dve ďalšie krajiny zo stredovýchodnej časti EÚ - Rakúsko a Maďarsko. Vo vybraných štyroch krajinách študujeme mieru registrácie akademických patentov, súčasne aplikovanú politiku a jej účinky na národné akademické patentové registrácie. Analyzujeme tiež účinnosť americkej patentového Bayh Dole Act vo vybraných krajinách Európskej únie.

Naša práca obsahuje 6 kapitol, 12 podkapitol a 11 podkapitol. Použili sme 24 grafov, 6 tabuliek, 3 mapy a 2 obrázky. V prvej kapitole diplomovej práce analyzujeme súčasnú situáciu a súčasné publikácie na trhu akademických patentov. Ďalej analyzujeme rôzne teórie patentov aplikovaných v Európskej únii. Druhá a tretia kapitola sa zameriavajú na stanovený cieľ a použitú metodiku v práci. Štvrtá kapitola obsahuje výsledky diplomovej práce. V tejto časti popíšeme novo získané informácie pomocou použitej metodiky a pokúsime sa nájsť odpovede na naše hypotézy. Piata kapitola je zhrnutím a záverom našej diplomovej práce. Tu zhrnieme a vyhodnotíme prácu a hypotézy. Posledná, šiesta kapitola je slovenské resumé záverečnej práce.

Kľúčové slová:

patent, akademický patent, výdavky na výskum a vývoj, Professor's Privilege, teória Bayh Dole Act, teória patentov

Abstract

BARCZIOVÁ, Anikó: University Patents as a Tool of Knowledge Transfer in the EU. – University of Economics in Bratislava. Faculty of National Economics; Institute of Public Administration and Regional Development – Supervisor of the thesis: Ing. Valéria Némethová, PhD. – Bratislava: NHF VSRR, 2021, pages: 87

The main goal of this thesis is to analyze the development of patent activity in selected European countries. The aim to show and define the difference between two patenting methods: the Bayh Dole Act and the Professor's Privilege. In the master thesis named: University Patents as a Tool of Knowledge Transfer in the EU we analyze academic patent registration theories and tendencies in the European Union. Furthermore, we particularly analyze four countries, two countries from the northern part of the EU- Sweden, Denmark and two more countries from central-eastern part of the EU- Austria and Hungary. In the selected four countries we study academic patent registration rate, the applied patent theory and its effects of the national academic patent registration number. We also study the efficiency of the American Bayh Dole Act patent theory in the selected countries of the European Union.

Our work contains 6 chapters, 12 subchapters and 11 sub-subchapters. Also, we used 24 graphs, 6 tables, 3 maps and 2 figures. In the first chapter of the thesis, we analyze current situation and the empirical publications on the market of academic patenting. Furthermore, we analyze various patent theories implicated in the European Union. The second and the third chapters are focused on the defined goal and the used methodology in the paper. The fourth chapter brings the results of the thesis. In that part we describe the newly received information with the help of the used methodology and we try to find answers for our hypothesis, and prove if they are true or false in the case of our studies. Finally, the fifth chapter is a summary, conclusion. Here we sum up and evaluate the work and the hypotheses. The final, sixth chapter is the Slovak résumé of the master thesis.

Key words:

patent, academic patent, R&D expenditure, Professor's Privilege, Bayh Dole Act

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INTRODUCTION

People or group of people as a result of a planned action can create intellectual property, what is a created knowledge, thought or information. The value of the intellectual property can be different, it depends on the quality, level of uniqueness and usefulness of the knowledge. People, institutions, companies to save their newly created special knowledge can register the information at the Intellectual Property Office (IPO). IPO after a long administrative process gives legacy right to individuals who applied for registration, it can be a person, group of people, or an institution. This given legacy right for the registered intellectual property is called patent. With patent the owner has right to decide who can use the knowledge and about the period, how long the other side can be an active user of it.

Furthermore, the legal patent owner gets financial compensation from the users of the patent. With patent rights the researcher can save his unique knowledge from the users, who would use it without payment for further researches. Also, it can motivate researchers and institutions for further actions in the act of patenting.

In our master thesis, we are going to study and analyze patents, especially academic patents (those patents which were researched and registered by the workers of an academic institution). The action of academic patenting in Europe is not working that efficiently as in the US. Nowadays, in Europe we can define two important patenting systems and policies, the Bayh Dole Act and the Professor's Privilege. The Bayh Dole Act patent policy comes from the United States of America and gives the ownership right to the academic institution, where the knowledge was registered. The new American patent theory says that the academic institutions can provide better service for patent management, marketing and sales than the inventor professors of the patent. The Bayh Dole Act is used since the 2000's in Germany, Austria, Denmark, etc. On the other hand, Professor's Privilege patent theory provides the proprietorship legacy to the person or group of people, who were working on the action of the research and who were registering the newly created intellectual property. This classic European theory defines that the best patent management can be done by those actors, who know the registered intellectual property the best, by those academic professors who were working on its creation. This patent policy is applied in Italy and Sweden.

We will study publications of world widely famous economics and their ideas, scientific researches about the sphere of academic patent registration. After receiving the theoretical knowledge from these masters of this area, we try to applicate it in practical issues, problems. In our work, as we already said before, we concentrate on the European market, and on the academic patent registration on it. Our thesis concentrates on the Bayh Dole Act American patent theory, its application in some countries. Moreover, we analyze, study and try to define if it is an efficient patent policy and if it can be applied for any country of the world with the same level of efficiency.

In the first chapter of the thesis, we analyze current situation and the empirical publications on the market of academic patenting. Furthermore, we analyze various patent theories implicated in the European Union. The second and the third chapters are focused on the defined goal and the used methodology in the paper. The fourth chapter brings results of the thesis. In that part we describe the newly received information with the help of the used methodology and we try to find answers for our hypotheses, and prove if they are true or false in the case of our studies. Finally, the fifth chapter is a summary, conclusion. Here we sum up and evaluate the work and the hypothesizes. The final, sixth chapter is the Slovak resumé of the master thesis.

1.1 The Intellectual Property¹ and its Protection

Intellectual property is knowledge, information, innovation created personally by a person or group of people. To save this property from the public people, companies, universities can use different methods as registering a patent, trademarks, copyrights or trade secrets. Patent is one of these options where the owner can get exclusive right for his intellectual property, and can decide to share it with other companies for financial compensation. Registration of a patent provides exclusive legal right for creation of special, unique intellectual property (IP). The successful IP application is registered in the Patent Office. After this operation the owner of the patent with a document can show and assure its legacy. This document creates strong protection for the newly created information, and is valid for a defined certain time period, during which only its legal owner has right to use it, and decide about its users. In the case of more than one creator of the patent, the owner of the patent in a contract with the parties decides who has right for its application and the period of its use, too. Patent as a way for intellectual property protection is very common action in the world, especially for various technological innovations of knowledge. Patents usually have a time limitation during which the protection for the intellectual property is active and is saved from the public users. This limit can be different according to countries of Europe where the intellectual property was registered from, and of course depending on legal patent owners. (Wipo Patent Office)

In case the when the intellectual property is not protected efficiently enough, the unique and special knowledge will become open for the public and society. The mechanisms of commercialization and publication of IP are complicated questions and issues for the knowledge management. It is very difficult to find the correct amount of researched knowledge that should be shared, and which information should remain in secret. In knowledge management it is possible to find and listen about “free-riders”. “Free-riders” are the people who are enjoying the benefits brought from the knowledge transfer without paying financial compensation for its usage. Without asking for the permission of the inventor, the free-riders use the new technology, they do not put their input or their creativity inside of the new knowledge. The effect of the “free-riders” can

¹ Based on WIPO- World Intellectual Property Organization (2021)

demotivate researchers from further innovation and creation and registration of new knowledge, since their hard work is used by other people without extra financial income for it. Registration of a patent is a good method and opportunity to decrease the percentage of users of the knowledge without permission, but cannot provide 100% security.

1.2 Patents - Pros and Cons²

The registration of a patent in the patent office gives an exclusive right for its owner, with what they can decide about the patent's user, and its conditions. The owner of patent gets protection for his knowledge, ensures the fact that no one will use it or „steal it“ without financial compensation for it.

Patents can bring their owners *profit*, too. After the legal acceptance of the patent, the competition and other actors on the market have to ask for permission to use it, for what obviously they need to pay.

Many times, companies *cannot afford* to registrate a patent, or *do not have the knowledge, qualified labor* to work on research and development. The already registered patents are perfect solution for the subject on the market, they can use and work on an already existing and registered knowledge, with the goal to create and establish a better invention in the future.

Exclusivity is another attribution what goes together with the patent innovation rights. The owner of the patent becomes the exclusive owner and user of it, and can decide who gets exclusive right to use it.

Thanks to the rights what patents provide, the owners can *formulate the competition market*. The holder can decide who gets access for using it, and can limit their number. With this limitation can create a monopol in the market, with what they can have power on price setting actions.

In the era of the Internet, the speed of knowledge transfer has fastened rapidly, in the same time *the protection is more needed*. Nowadays, access to information is available very easily for everyone who has connection for the Internet, that is why researchers have to protect their special knowledge more than ever, this action is possible to be done with applying for a patent.

² Based on Patent Rebel, 2020

Patents can motivate people for further *innovating*, if they see that after creating a unique idea, item, it can be protected, they do not need to be afraid of it getting into other hands, moreover they can even earn money for it. Patents can motivate scientists to create something new and special, and be the best and the first on the market.

Owning a patent can be impressive for *investors*, too. The investors more likely invest into already existing patents, than into only ideas of small companies, start-ups. With investment into an already existing idea, the company is able to do more researches for the future.

On the other hand, patenting can have many negative sides, too. To register a patent is a complicated action, about what companies and universities have to decide carefully. This action can be very *expensive* and takes a lot of time. Companies or institutions have to make a hard decision if their knowledge worth to be saved legally and be patented. Many times, small start-up companies cannot allow to spend a big amount of money for registering the intellectual property, and it has negative effect on the action of registering patents.

As mentioned before, the patent registration is a process, what takes longer *time* period to be legally accepted. Many times, companies can consider it as negativity before making the decision of patenting. Since companies, do not have time to wait many years for the administrative registration.

Moreover, they can be afraid of complicated *administrational, byrocracy* issues. It is a complex operation. Many times, the creator does not have all the needed information to start this process, and it is necessary to ask for help in the act of registration, what is obviously not a free service.

The protection is *limited geographically*, for some countries, it does not provide protection world widely. The idea, the knowledge can be freely used by people from some countries, where the patent legacy is not valid.

The patent rights, and their use has to *be monitored by its owner* actively. If the person, who has the legal property, so the owner realizes that someone is using the knowledge without permission, has to start a law court against this subject.

With publishing the patent owner is *sharing some details* of the innovation, knowledge. In the same time, some special, important information stay in secret. The patent publication has to increase the interest of the investor, competitors and motivate them to buy personal access for it.

1.3 The Role of the University

Intellectual property rights are used to encourage creativity and innovation by granting exclusivity to the right holder for the duration of the legal protection. This means that the object of protection (an invention, a work of art or a design) can only be exploited by the rightsholder or a person with his permission. Anyone who engages in an activity that falls within the scope of intellectual property rights without such permission (i.e., license) commits an infringement.

Academic patent is a knowledge created and registered by universities, with the idea to create something new, unique and special for the future and get ownership rights for it. The criteria for establishing an academic patent is, that the patent was created in higher education institution and research center, what does not want to gain or maintain a market position and can only access the market of research results through industrial partners. “Academic patents may be owned or co-owned by the inventors, their universities, a governmental agency or public research organization (with whom the inventor may have collaborated), or a business company (again as a result of collaboration, but also, possibly, of contract research or consultancy).“ (Lissoni, Montobbio, 2015)

Universities next to the first mission of educating they have also other mission, as creating and discovering new ideas, knowledge, theories, items for the future generation. The legal ownership of patents and knowledge is not enough, universities have to share, promote and sell their knowledge to the public on the market of patents, and work together for further exploration with knowledge transfer. This process is many times mentioned as the third mission of the universities.

According to the theories of Link, Siegel and Bozeman (2006) the third mission of universities, the knowledge transfer between universities and the public sphere can happen with two mechanism, with formal and informal. The formal way of transforming information between institutions happens with the assistance of legal tools, as university spin-offs, licensing contracts or with the help of partnership projects between universities and private institutions. The informal mechanism of knowledge transfer happens in informal way, with communication between parties or publication of professors. Feldman (2003) defined that formal and informal knowledge-transfer tools are not in competition but they are used in parallel, for examples a publication about an academic patent.

European universities in the area of academic patenting are often compared to the universities in the USA. Thanks to the appearance of the Theory of New Public Management in Europe, the third mission of universities got a bigger and more important role, and defines the importance of the connection between public and private sector for the successful and effective work. Moreover, it emphasizes the importance of the existence of active competition between universities, that can motivate them for further progression in development. In Europe as the reaction on New Public Management some countries started apply patent policy Bayh-Dole Act. (Novotný, 2010)

1.3.1 University-owned Patents

In the research paper written by Geuna and Nesta we can read, that “the largest part of (European) patents in which university researchers are involved as inventors, is owned by private firms, rather than universities. This suggests that the firm is involved in the university research as early as the pre-patent phase, and that who owns the patent (the firm, the university, or, in the context of some European countries, the researcher) is the result of a bargaining process. Our data confirm earlier impressions of the empirical relevance, in Europe, of this type of involvement of university researchers in patenting by firms.” (Geuna, Nesta, 2006). When we are talking about university-owned patents, we analyze it from the legal ownership part. As mentioned before, in the US, as well in the European Union most of the university patents are created in a partnership with private companies, that means with the collaboration of the public and private sector. From these theoretical knowledges we can presume that the rate of university-owned patents is very low in the EU.

1.3.2 University-invented Patents

„University-invented patents, defined as those patents that have a member of university faculty among the inventors whether or not the university is the patent assure assignee, should be included in the analysis.“ (Geuna, Nesta, 2006) That means the creator or inventor of patent is working at the university. Thanks to the information about owned patents described before, we can expect, predict that the number of university-

invented patents is on a lower level as the quantity of university-owned patents. Azagra Caro and Llerena in their paper stated that academic patents usually are university-invented patents, although not university-owned patents. (Caro, Llerena, 2003)

Table 1: University - owned and university - invented patents

Country	No. University owned patents	No. University invented patents	Time period	Science areas of highest university activity
Italy	40. EPO	1475. EPO	1978-1999	Biotechnology, Drugs, Organic Chemistry
Finland	36. USPTO	530. USPTO	1986-2000	Telecommunications, Instruments, Biotechnology

Source: Caro A. Llerena (2003), Balconi et al. (2003, 2004), Meyer (2003), OECD (2002), Saragossi and van Pottelsberghe de la Potterie (2003) and Schmoch (2000): EPO data refer to patent applications USPTO data refer to granted patents. The sources use different technological/scientific classifications.

On Table 1, we can see a comparison of university-owned patents with university-invented patent. “Balconi identified that out of 1475 university-invented patents in Italy in the period 1978–1999 only 40 EPO patents had university assignees whereas Italian university inventor patents account for 3.8% of EPO patents by Italian inventors.” (Geuna, Nesta, 2006)

In Finland between the years, 1986 and 2000 only 36 patents were owned by universities, and 530 were invented by them. The situation in the other countries was similar. Most of the researches were allocated and concentrated in Biotechnology, Chemistry and Pharmaceutical industry. These 3 industries are developing very fast, and is very important to patent the knowledge. With patenting the new ideas, we can share

our knowledge with other universities for further development (knowledge spillovers), and we can use the knowledge of other research centers, too.

1.4 History of Patents in Europe

The action of patenting has always been the part the life of the population, even in the 500 BC in the Ancient Greek society, „where chefs in Sybaris had the opportunity to enjoy a year of monopolized profit for a unique dish that they had created “ (History of patent law, USC University of Southern California). At this time patents were not in the form as we know them today, but we can observe some similarities in their usage.

In 1474 in Italy, in Venice the Venetian Statute on Industrial Brevets (later mentioned as Venetian Law) was created. They created this law to form a more secure system and environment for scientists to protect their rights and support their workload.

„No matter how strict the punitive guild regulations were to restrict the emigration of workers and dissemination of trade secrets outside Venice, their effectiveness was mitigated by the simultaneous development of the legal incentives (monopolies and patents) designed to lure skilled professionals or the entire industry into other cities and states. In fact, Venice itself was one of the first states to develop and benefit from such a system.”.“ (Mandich, Begbee, 2002) (Kostylo, 2008)

The first patent in Europe was registered in 1421 by Filippo Brunelleschi in Florence. Brunelleschi was a talented architect. „The patent gave him a three-year monopoly on the manufacture of a barge with hoisting gear used to transport marble. It appears that such privileged grants to inventors spread from Italy to other European countries during the next two centuries.“ (Fischer, 2019) The creation of the Venetian Law motivated other countries to follow these steps, and thanks that the number of inventions started to increase all around Europe.

In the 17th century, concretely in 1623 the Parliament in England published the Statute of Monopolies. „The statute prohibited most royal monopolies; it specifically preserved the right to grant “letters patent” for inventions of new manufactures for up to 14 years.“ (Fischer, 2019) The English Crown in that Era preferred to support with patent rights people, businessmen or scientists with who she sympathized, or were able to donate

some money for her best. The Statute of Monopolies was written and created to stop these actions, and give the free place for creating real patents by inventions.

„The history of Slovak Republic is connected with the history of Habsburg Monarchy, Austro-Hungarian Empire and with the separation of Czechoslovakia.“ (Transfer Technológií Bulletin: História priemyselno-právnej ochrany, 2016) These territory changes during the years made the patent administration more complicated in the area of the republic of Czechoslovakia.

1.5 Modern Patent Law

The goal of our society has always been to create a fair system, to protect scientists. As mentioned before patent is a right for the owner accepted nationally and internationally. During the years the leaders of countries all around the world saw the huge patenting law differences between countries all around the world. They decided that in case to create the optimal situation and balance between countries, they need to publish an internationally acceptable patenting law.

1958 is an important year of the history of patents, when in Europe (plus some more countries out of Europe, like: Morocco, Cuba) was created an internationally accepted patenting law and policy named: the Lisbon Agreement for the Protection of Appellations of Origin and their International Registration.

„In this Agreement, “appellation of origin” means the geographical denomination of a country, region, or locality, which serves to designate a product originating therein, the quality or characteristics of which are due exclusively or essentially to the geographical environment, including natural and human factors. “ (Lisbon Agreement for the Protection of Appellations of Origin and their International Registration, Article 2, 1958)

In the Lisbon agreement we can read how the EU supports the R&D academic activities, how they provide support for them. In 2007, they published a document, in what they emphasized the importance of collaboration between universities and private sector. In this document they supported and tried to motivate the subjects for this act. „the importance of improving knowledge transfer between public research institutions and third parties, including industry and civil society organizations was identified by the

Commission as one of ten key areas for action.“ (European Commission: Improving knowledge transfer between research institutions and industry across Europe, 2007) Moreover, they write about „how Member States and the Community can act together, in a mutually reinforcing way, to overcome some of the existing obstacles, in particular in terms of promoting the trans-national dimension of knowledge transfer. It is accompanied by a Commission Staff Working Document on "voluntary guidelines for universities and other research institutions to improve their links with industry across Europe" which are based on good practices identified by a number of national public authorities and the work of various European stakeholder associations.“ (European Commission: Improving knowledge transfer between research institutions and industry across Europe, 2007)

In 2008 the European Union agreed about creating a patenting codex: The IPO Code of Practice. „The Intellectual Property Office (IPO) Code of Practice for Applicants and Agents aims to make the patent application process more efficient by encouraging applicants and their agents, such as patent attorneys, to follow best practice. Although adherence to the Code of Practice is not mandatory, following the points set out in the Code could result in an application being processed more quickly and may in some circumstances also lead to cost savings.“ (Intellectual Property Regulation Board: The IPO Code of Practice)

1.6 American versus European Patent Model

The Bayh-Dole act was first used in the United States of America in the 1980's, in Europe started to be used only in the 90's and at the beginning of this century. The main idea of the Bayh- Dole Act is that the university is the legal owner of the patent not the professor as individual. On the other hand, for this benefit the university has to provide the best service in patent management, in favor of the country, the society and the researcher professor, too. The application of this theory can motivate universities to increase the quality of their research within a given university. In addition, the income from applying patents by other subjects make universities able to invest more money in research in the future and support professors for higher quality work.

Applying this rule world widely gave the right for the creator organization to be the owner of the knowledge property, what highly motivated universities for research and

applying for patent registration. Moreover, patents could create a part of the financial income for academic sphere. “In the late nineteenth century Joseph Lewis Ricardo, founder of the Electric Telegraph Co. argued that since, “nearly all useful invention depends less on any individual than on the progress of society”, there is no need for “reward him who might be lucky enough to be the first on the thing (invention) required”.” (Guellec, Pottelsberghe de la Potterie, 2007)

Between the United States of America and the European countries a difference can be observed. While this act worked perfectly in the case of the USA, the number of academic patents has increased highly, in Europe it did not work so rapidly, we call this “European Paradox” (Lissoni, Llerena, McKelvey, Sanditov, 2008). In theory the Bayh-Dole Act could be applied and transformed for Europe as well, since Europe has quality universities and high-qualified professors. In reality, it did not work smoothly. European researchers and universities were not ready to promote and sell their knowledge to third parties. The second problem was in the managerial and marketing function of European universities. The researchers and universities are concentrated more on the scientific part than on the managerial.

At the end of the previous millennium the Bayh-Dole Act has become more popular and well-known all-around Europe. In Europe, before the appearance of Bayh-Dole Act the theory Professors Privilege patent policy was used. Professors privilege is a legal act, when the official owner of the patent is the person who was working on the research and has applied for patent registration. Professors Privilege is in contrast with Bayh-Dole Act. The person working on the patent research is the only one, who could promote and sell the patent in the best way, with the highest quality, and he should be the only one, who benefits of the patent sales. The goal of this act is to motivate professors, researchers for further quality innovative ideas and to create, establish new knowledge, ideas and objects.

Lissoni, Llerane, MCKelvey and Sanditov (2008) divided countries based on Professors Privilege and on Bayh-Dole Act. Bayh-Dole Act has been applied in Germany, Denmark and Austria at the beginning of 2000, before this the professor privilege theory was used. On the other hand, some countries in Europe did not agree with the new theory coming from the USA. Italy claimed that professors have bigger motivation to register patents and offer them to companies.

Table 2. Changes in IP regimes for university patenting in Europe

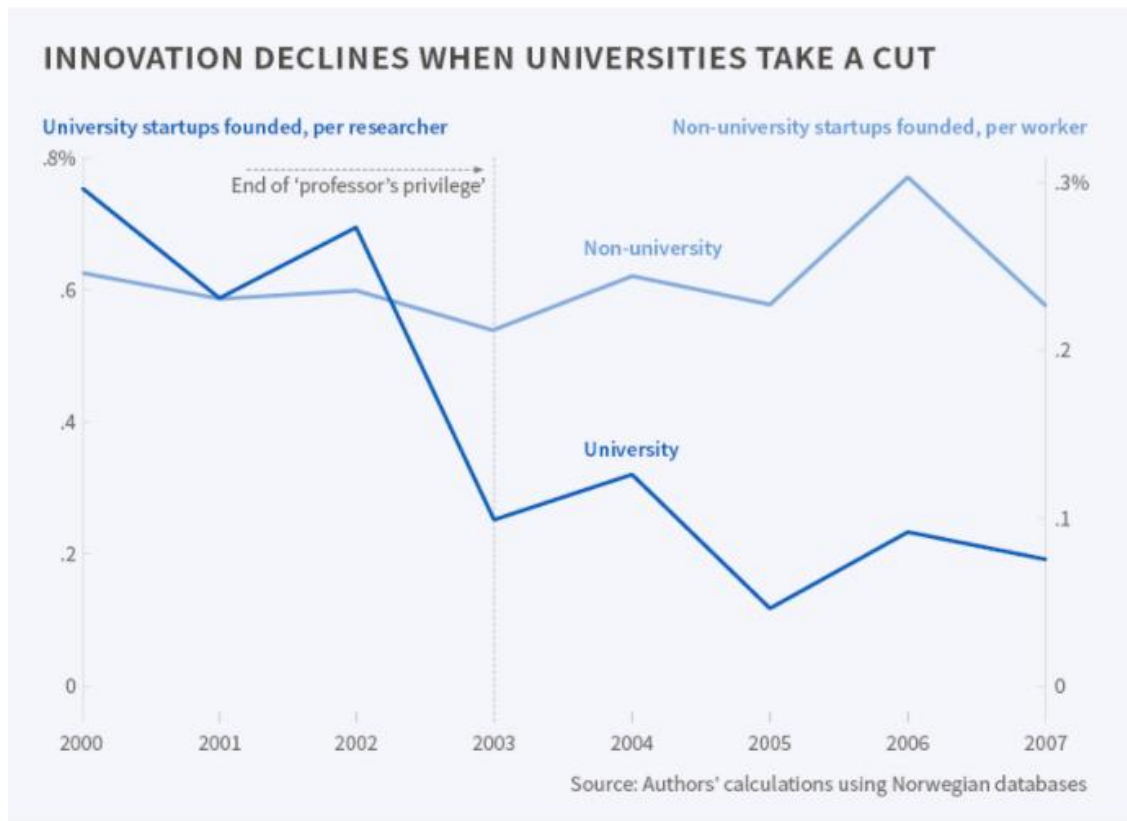
Policy and legal changes	Country	Change	Trend
Abolishment of the Professor's privilege, to increase scientists' incentives to disclose inventions to university managers	Denmark	2000	Universities assign a share of the patent licensing revenue to the inventor and pay all the costs associated with the patent application
	Germany	2002	
	Austria	2002	
	Norway	2003	
	Finland	2007	
Stronger enforcement of institutional owner system already in place	United Kingdom	1977	Harmonization, measures to encourage intellectual property awareness, commercialization and creation of technology transfer offices
	Spain	1986	
	France	1999	
	Switzerland	1991	
Mixed changes: Introduction of Professor's privilege (from institutional ownership to inventor's ownership) + Introduction of managerial and financial autonomy for universities	Italy	2001	Only applies to inventions fully funded by the university employing the inventor since 2005
Continuation of the Professor's privilege	Sweden	1949	Recurrent national debate about IP regimes. The conclusion is always that there is no need for legislative change.

Source: Based on information from Geuna and Rossi (2011) for most countries, Chardonens (2010) for Switzerland, Della Malva, Lissoni, and Llerena (2013) for France, Lissoni et al. (2013) for Italy, Martinez et al. (2013) for Spain, See also Martine and Sterzi (2019)

On table 2 we can see the changes in IP regimes for university patenting in Europe, what means the change of legal administrative theories in some European countries. Countries as Denmark, Germany, Austria, Norway and Finland at the beginning of the 21st century changed their patenting system. Instead of Professor's Privilege they started to apply the theory of Bayh-Dole Act. This abolishment has relocated the legal ownership of the patent to universities, moreover the managerial rights, too with the goal of better promotion, knowledge transfer and the growth of patent sales. Universities offers revenue from the share of the created patent for the inventors, and they accept the obligation of administrative and registration cost for the patent.

In contrast, countries such Italy and Sweden has applied the opposite theory of Professors' Privilege. In 2001 Italy has changed institutional rights to inventors, moreover universities got managerial and financial authority. In Sweden the Professors' Privilege has been used since 1949. We can see well the different effect of these two theories between countries of Sweden and Denmark. Both of the countries are located on the northern part of Europe, have a similar culture, history and mentality influence. "Valentin and Jensen found significant reductions in contributions from Danish researchers, combined with a simultaneous substitutive increase of non-Danish ones and a moderate increase in academic inventions channeled into university-owned patents following the policy change. Valentin and Jensen argue that the reduction in Danish academic patenting can be attributed, at least in part, to the reform. In their own words, 'the larger part of the inventive potential of academia, previously mobilized into company-owned patents, seems to have been rendered inactive as a result of the reform' (Valentin and Jensen 2007). Valentin and Jensen claim that the ex-ante allocation of intellectual property rights to universities required by the reform harmed exploratory collaborative research, for which the results are still uncertain at the time when contracts must be signed and the allocation of potential future outputs must be discussed." (Martínez, Sterzi, 2020)

Graph 1.: Innovation declines when universities take a cut



Source: Norwegian database, 2016

As an example, for the patent theory change we can mention Norway, where since the year 2003 Bayh Dole Act was implicated instead of Professors' Privilege. On the graph n. 1 we can observe two curves. Dark blue color represents founded university startups per researcher, and light blue color are non-university startups- per worker. With the end of Professors' Privilege the University startups show up a deep reduction. On the other hand, non-university startups stayed constant, and from the year 2005 their number is increasing. It means that after 2003, with the application of Bayh Dole Act, both University and Non-University start-ups are stagnating, its number is not increasing or decreasing during this time period.

1.7 The Effect of Bayh Dole Act Theory in Europe on the Patent Registration

The appearance of the American theory and patent policy of Bayh Dole Act in Europe at the beginning of the new millennial (2000's) has caused conflicts of its effectivity and efficiency between the member of the scientific area. With this new patent policy, the ownership of the intellectual property has gone to the institution where the research and the registration of the patent was happening.

The currently available scientific publications about the act and results cause by the active usage of Bayh Dole Act are divided into two groups. The publications of experts from the first group claim that the number of patent registration is in connection with the applied patent theory and policy in a chosen country. Consequently, the American Bayh- Dole Act theory creates perfect and ideal environment for its users. Moreover, motivates researchers for further studies and to register their patents, thanks to what the registered patent number is increasing.

The goal of Bayh Dole Act patent policy is to give the power to the hands of the universities, to promote and sell the academic patents and ensure quality knowledge transfer between universities and third parties. Universities have all the knowledge and human capital to provide and offer quality marketing of the academic patent. Professors, researchers working on the patent have high knowledge in their research area, while their abilities in marketing, business and sales do not have to be on the highest level. To ensure these acts to be done with the best quality, the institution where the patent was created gets the right for the ownership. For its legal property the institution has to create and provide the best environment and services for the patent management on the market of the intellectual properties. The Economist newspaper in 2002 wrote that the Bayh Dole Act is “[p]ossibly the most inspired piece of legislation to be enacted in America over the past half-century.” (Innovation's Golden Goose, 2002).

Also, Perkins and Tierney in their work analyze the results after applying the Bayh Dole Act theory, also its influence on university patent creation and registration. They said “the Bayh–Dole Act caused research universities in the USA to increase their focus on patenting and licensing activities.” (Perkins J. F., Tierney W.G., 2004)

Zeebroeck N, Pottelsberghe B, Guellec D (2008) with their publication are part of the first group of theorists, who think and say that the rising number of patent registration

is the positive result of the implication of the theory of Bayh Dole Act. In their work they defined, that Bayh Dole Act “gave universities greater incentives to commercialize technology” (Zeebroeck N, Pottelsberghe B, Guellec D, 2008).

In contrast with this point of view, the other group of scientists think, that the amount of patent registration is not in correlation with the applied policy and theory in the selected country. What means the rise in the patent application is not caused by the institutional ownership-based Bayh Dole Act theory. They say in their works, this growth is caused by different issues, as establishment and creation of new research sectors, like IT, biotechnology, etc. (Geuna, Rossi, 2011, Sapalis and Pottelsberghe, 2003, Lissoni F, Llerena P, McKelvey M, Sanditov B, 2008, Mowery et al, 2001)

Geuna and Rossi (2011) in their publication say, that the American theory does not fit perfectly for all the countries, cannot be applied in every country with the same level of efficiency. After 2000, the number of registered patents was increasing in most of the countries of the European Union. They defined three reasons and issues, what were the source of this increase. First of all, the number of registered patents was rising because of the new actors- universities- who appeared in the research market. Also, universities, which were already actively registering their intellectual property became more active thanks to their experience and knowledge received through the previous time period. Secondly, they described that in those countries where the system for knowledge transfer was created slower behind schedule the number of patent registration was increasing in the 2000's. The development of the infrastructure for this exchange of intellectual property was happening, but since it was late, the result has also arrived later, and the increase in the number of registered patents was late, too. According to Geuna and Rossi (2011) the third reason “shows that university-invented patents owned by businesses still play an extremely important role in all countries. There are indications also that university-owned patents have increased in some countries, at the expense of individually-owned and business-owned (but university-invented) patents. If academic patenting data are corrected to account for university-invented patents, then for some countries with long traditions of academic patenting (such as Germany) and for some scientific/technological fields where academic patenting has been particularly important (such as biotechnology), we find evidence of a leveling off or decrease in the total number of academic patents applications by mid 2000s “(Geuna, Rossi, 2011).

Also we can read in the work of Sapalis and Pottelsberghe (2003) that “the sharp increase in the patenting activity of Belgian universities is mainly due to a technological revolution, the start of the bio-tech era.” (Sapalis, Pottelsberghe, 2003).

Other authors Lissoni F, Llerena P, McKelvey M, Sanditov B (2008) are from the group with the same point of view of the efficiency of the Bayh Dole Act- the number of registered academic patents is not in correlation with the currently applied patent policy in a selected country- are saying that academic patenting „does not depend upon IPR legislation, but on the institutional profile of the national academic systems, and possibly on the national specificities of the relationship between university and industry. “(Lissoni F, Llerena P, McKelvey M, Sanditov B, 2008).

Mowery et al. (2001) wrote that the rising patent number is caused by the newly established patent offices in Europe, who supported and motivated universities and researchers for further active work. Moreover, they defined that in some sectors (life sciences- biotechnology) the patent registration was remarkably increasing. Furthermore, in the 70's of the previous century, the patent application in the sector of biotechnologies was increasing by 123%, however, in the other sector they could observe only 22% increase. (Mowery et al. 2001).

To sum up, most of the studied research papers state that the American patent theory of Bayh Dole Act is not efficient for the European market. In the researches they showed, that the rise in the academic patents is not caused by the new patent policy, but by other factors. This theory works well in the US, but cannot be fully copied and implemented in all the countries of the European Union or the world. These issues, barriers in the implementation of the American theory can be caused by the different historical, cultural, political backgrounds in the countries of the EU. Shattock (2005) said “breaking down the bureaucratic barriers to entrepreneurialism in universities is probably at least as important as incentivising it through new financial mechanisms.” (Shattock 2005)

2 THE GOAL OF THE THESIS

In the master thesis named: University Patents as a Tool of Knowledge Transfer in the EU, we analyze patents according to theories of various important economists working on this problem. Our work focusses mainly on university patents in the European Union, on their functions and importance for the countries of developing economies. On the following pages, we define what university patents are and what they are used for, we analyze the benefits of patent for universities, for the industrial sector of the country, and their negative aspects. It is very interesting to follow the alterations between different countries, their methods and patenting strategies according to different sectors.

The main goal of this thesis is to analyze the development of patent activity in selected European countries. The aim is to show and define the difference between two patenting methods: the Bayh Dole Act and the Professor's Privilege. We are observing academic institutions, professors in the European Union, and their habits, experiences with the action of patenting. We analyze, define the advantages and disadvantages of both theories and their application in selected countries of the European Union (e.g., the application of the Bayh-Dole Act in Denmark, and its shortcomings). Also, we discuss if the American model, the Bayh-Dole Act is the most appropriate for appliance in the countries of the EU.

Moreover, we compare two opinions of researchers about the increasing number of patent registration. The first group of researchers think and say that the number of patents increases as a reaction for the newly applied patent theory and policy (Bayh Dole Act or Professor's Privilege). On the other hand, scientists of the opposite party claim, that the increase in the number of registered patents is not caused by the change of patent ownership, but it is the result of newly created sectors, spheres where researchers actively work (for examples, IT, biotechnology, nanotechnology, etc.), and it has no connection with the patent policy or theory in the chosen country.

In addition, as a partial goal we emphasize the difference in the action of patenting between the countries of the Eastern (Austria, Hungary) and the Western block (Sweden, Denmark) of the European Union (the impact of the socialism on the patenting process- the post-socialism environment). We analyze, whether the countries of the Eastern block are sufficiently active in the patenting process compared to the Western block? (Novotný Á, 2010)

My thesis is very interesting since this topic, the application of the American theory, of the Bayh-Dole Act is mostly described and applied in European Union as whole, or in the western countries of the EU, but the quantity of research papers written about the eastern part of Europe is significantly lower.

In the master thesis, we are testing the following hypothesis:

1. The number of patent applications was increasing after applying the theory of Bayh Dole Act (Ledebur, Buenstorf, Hummel, 2009)
2. The number of patent registration was not increasing after applying the theory of Bayh Dole Act because of the new theory, but this rise was caused by the creation and development of new sectors. (Sapalis, Pottelsberghe, 2003, Mowery et al. 2001)
3. The patent registration is concentrated in metropolitan areas (OECD, 2013)
4. Most of the academic patents are invented by less or equals to three researchers.

3 METHODOLOGY

To achieve the previously mentioned goals of the thesis, we use different methodologies. First of all, we study 68 research papers, webpages, articles about the theme of university patenting. We mostly examine international research documents written in English; due to that with reading articles in English we can increase the quantity and the quality of the information and the knowledge. We are concentrating on the specific studies written about the difference between two patent application theories, the American theory Bayh- Dole Act and the classical European theory of Professors Privilege, since it is the main element of our thesis. Moreover, we compare two groups of researchers, the first group of scientists claim that the rise in the number of registered academic patents is caused by the implementation and the active usage of a new patent ownership theory Bayh Dole Act, or the Professor Privilege, they say that the new patent politics motivates researchers positively for patent application. On the other hand, the second group of researchers think, this increasement in the number of registered patents does not depend on the actually applied patent theory in the country, but it is caused by the establishment of new sectors (IT, biotechnology, ...). Thanks to these newly created sectors, and because of the higher achieved knowledge, the act of patent creating is fastened, what causes the rise in the number of registered patents. This means, we analyze those sectors, spheres in which the most patent was registered in the selected countries during a defined time period, and we argument these two mentioned point of view of the rising patent registration according to the results of our research and data analysis.

The analyzed countries are: Sweden, Denmark, Hungary and Austria. We choose the previously mentioned countries with the goal to compare countries from the western block with countries from the eastern block (the impact of socialism on the act of patenting). From the western block we chose Denmark and Sweden (Scandinavian countries) and from the eastern block Austria and Hungary (Central Europe). Also, we can compare the act of patent registration of the Scandinavian countries with the countries of Central Europe. Moreover, in the selection of the studied countries different ownership theory is applied (for examples, Denmark- institutional ownership- 2000, Sweden- inventor ownership (1949), Austria (institutional ownership- 2002) and Hungary (institutional ownership- 2006).

Moreover, we collect and analyze patent data OECD between 1997 and 2017, for the reason that 20 years are long enough to show tendencies in the changes of patent registration number. From this database we filter and select data what is necessary for us to answer out hypotheses and research questions. (For examples: Hypothesis n.1: “The number of patent applications was increasing after applying the theory of Bayh Dole Act (Ledebur, Buenstorf, Hummel, 2009).”) Selected analyzed dates are for examples: number of registered academic patents in selected counties in a defined time period, inventor share rate for patents, academic patent registration for NUTS3 regions and academic patent registrations in various sectors. This OECD academic patent dataset, what we were working with has more than 1 316 000 lines. We need to mention, that we concentrate in most of our analysis on the time period 1997-2015, the data from 2016 and 2017 are excluded since the patent registration administration takes longer time period and the dataset is not full and complete, yet. With this strategic movement we would like to avoid and minimalize unreal and incorrect analysis.

Also, we collected data from the World Bank Database, too. Here we found interesting information about national GDP per capita in the selected countries or the R&D expenditure rate of national GDP in Sweden, Denmark, Austria and Hungary. We analyzed the academic patent registration in the selected countries according the regions (NUTS 3) where they were registered from, or the inventor share of the registered patents. In most of the examination we were working with per capita academic patent registration rate, with what we would like to secure the fairest comparison of various countries with the highest quality. Per capita patent registration rate is counted from the patent registration number and the population in a certain country (total academic patent registration number/ population).

Also, we define, if there is a significant change after application of a new patent theory. To achieve the necessary data, we will use research method Difference-in-Differences (DiD) average comparing analyses. Difference-in-Differences method is perfect for observation of a newly applied theory, policy. It clearly shows us the effect of the newly implemented policy (Ejermo, Toivanen, 2008). “If sample average data is available for beneficiaries and non-beneficiaries for at least two time periods, the difference-in-differences (DID) method produces estimates of impacts that are in principle more plausible than those based on a single difference (either over time or between groups).“ (Evalsed Sourcebook: Method and techniques, 2013)

In the Difference-in-Differences analysis we divided countries into two groups, group of countries where Bayh Dole Act patent policy is implicated (Denmark, Austria and Hungary) and countries where Bayh Dole Act theory is not used (Sweden). We analyze the mentioned groups PRE (before) and POST (after) implication of the new policy, and the impact of the theory for patent registration number. For higher quality comparison without eventual mistakes, we use per capita academic patent registration rate. We count and compare average rate in the selected countries between 1997 and 2015. Furthermore, we do DiD analyses for each studied country separately.

Also, we calculate academic patent growth rate in the selected countries between 1998-2015. The academic patent growth rate is calculated as the difference between two years ($n - (n-1)$) and multiplied by hundred. This rate is calculated from per capita academic patent registration rate to ensure and provide analyses and comparison with the lower level of mistakes and uncertainties.

Finally, we study the academic patent registration number in the selected countries according to the sectors. With these analyses we would like to prove hypothesis n.2.: The number of patent registration was not increasing after applying the theory of Bayh Dole Act because of the new theory, but this rise was caused by the creation and development of new sectors. (Sapalis, Pottelsberghe, 2003, Mowery et al. 2001). For these calculations we have used OECD patent database.

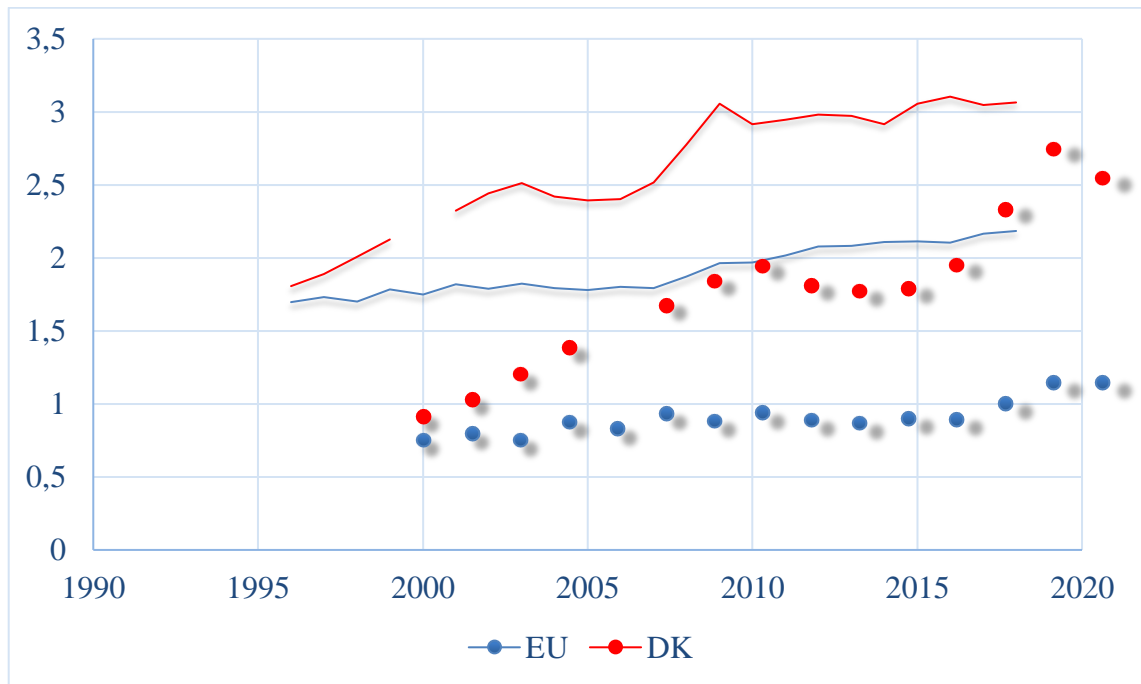
4 RESULTS

In the main and most important part of the master thesis, we analyze academic patent systems in selected European countries. We study patenting in countries as Denmark, Sweden, Austria and Hungary. The following countries are chosen with the logic and goal of comparison of geographical groups, also these groups of countries are not only located close to each other, but they are influenced by similar historical happenings, experiences, mentality and political system. Also, the selection of countries, is combined by different patent policies, in Denmark, Austria and Hungary the American Bayh Dole Act patent theory is used, and in Sweden the classic Professor's Privilege theory is applied actively by local universities. Denmark and Sweden are located in the northern part of Europe and are called as the Scandinavian countries, they are one of the leader countries in the EU, if we think about technology, invention, R&D and of course the quality of tertiary educational institutions. Hungary and Austria are situated in the central/eastern part of Europe. We can make a comparison between eastern and western Europe (the eastern and the western block). On the following pages, we are going to analyze the selected countries (Denmark, Sweden, Austria and Hungary) and their patent policies more into details.

4.1.1 Denmark

In the following part of the thesis, we analyze Denmark as a country, its national economics and theories, policies applied for patent registration in the country. Denmark is located in Northern Europe, and its population is 5,806 million people (Eurostat, 2019). Denmark is member of the European Union since 1973 and the GDP per capita in Denmark in 2019 was on the level of 60,170.34 USD (Eurostat), what means Denmark's was under the GDP per capita level of Germany, but higher than France, Norway or Sweden. In 2019, the unemployment rate in Denmark was 5% (Datacommons, 2019), what means only 5% of the population was registered as person without work. The unemployment rate in 2019 in Norway and Germany was lower than in Denmark, it was only around 4%, on the other hand in France was higher, almost 7 %.

Graph 2.: Research and development expenditure (% of GDP) – Denmark, European Union



Source: *The World Bank Database, own elaboration*

On the graph we can see the gross domestic expenditure rate on research and development of GDP in Denmark during the time period of 1996 and 2018. In the year 1996, the Danish government has invested only about 1,8 % of the GDP (Gross Domestic Product) into research and development. This rate has raised till the year of 2008/2009- till the global economic crisis and the following financial recession. These happenings in 2008/2009 have negatively influenced the amount of money invested into the sector of R&D. Moreover, we can observe a reduction in this investment rate till the year 2014. Later, in 2017 the Danish government has spent even 3,06% of the national GDP on the financial support of R&D activities in the country. If we want to compare it with the European Union, we can say that the Danish government has always invested higher percentage of its GDP to the R&D than the average European Union countries.

Table 3.: Number of positions at universities in Denmark

	Humanities	Social Sciences	Total	% rate of total academic workers
PhD.	700	650	4,940	44,46 %
Adjunkt/Postdoc	262	249	1,483	13,35 %
Lecturer	938	676	3,642	32,78 %
Professor	188	295	1,047	9,422 %
			11 112	0,19 % of the Danish population

Source: Rektorkollegiet 2006

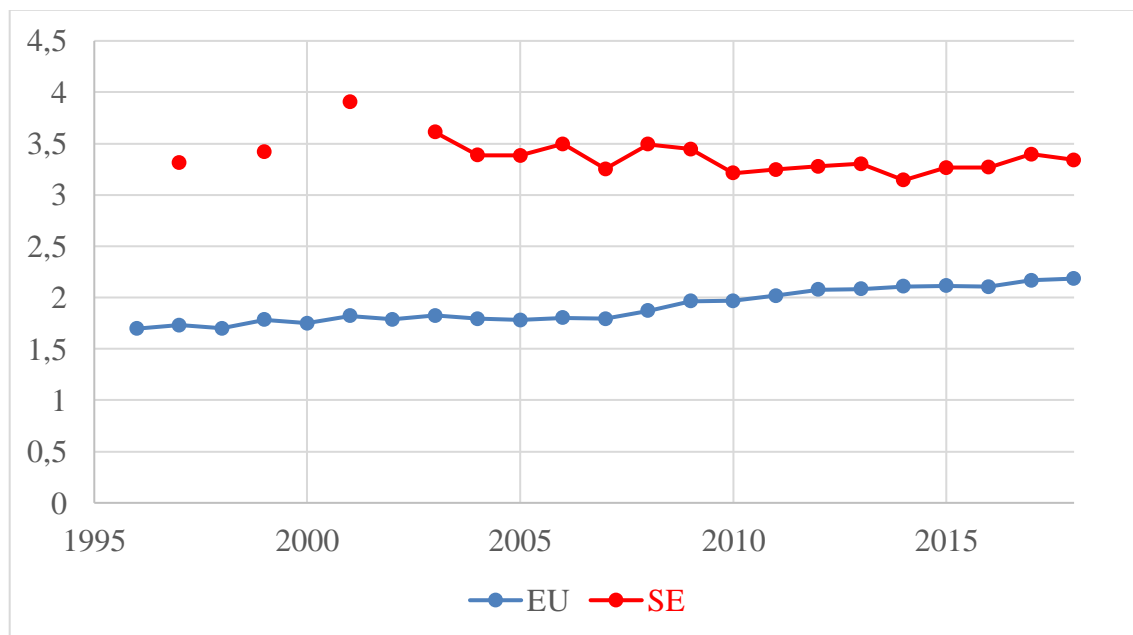
On the table 3 we can see the number of professors, PhD., Adjunkt/Postdocs and lecturers at Danish universities in the year 2006. At universities in Denmark were actively working 11 112 academic labors, the biggest percentage or group of them were PhD. workers, 44,46%. The lecturers formed 32,78% of the total amount of academic employees, and only 9,422% of the academic area were owning the title of professor. In 2006, in Denmark 0,19% of the population has worked in the academic, tertiary educational sphere.

If we want to analyze patent policies in Denmark, we need to mention that in the European Union Denmark was the very first country who applicated the American patent theory, the Bayh Dole Act in 2000. Before the year 2000 the patent registration in Denmark was based on Professor's Privilege theory, what means inventor patent ownership was changed into institutional ownership. On this sample, further European countries started to use Bayh Dole Act patent policies, as Germany (2002), Norway (2003), Finland (2007), Austria (2002).

4.1.2 Sweden

Our second analyzed country is Sweden. Sweden is located in Northern Europe between Norway and Finland. Its population is around 10,23 million people (Eurostat, 2019) and is part of the European Union since 1995. The GDP per capita in Sweden in 2019 was 51 615.02 USD (World Bank, 2019), what means the Swedish GDP per capita in 2019 was higher than in Germany (46 445,25 USD) in the same year but lower than in Switzerland (81 993,73 USD). Furthermore, the unemployment rate in 2019 was more than 9% (Datacommons, 2019), other Scandinavian countries Norway, Finland and Denmark were deeply below this level. In Norway the unemployment rate in 2019 was lower than 5 %, so we can declare that the unemployment rate in Norway is only the half of the unemployment rate in Sweden.

Graph 3.: Research and development expenditure (% of GDP)- Sweden, European Union (1996-2018)



Source: The World Bank database, own elaboration

Graph 3. presents us the R&D expenditure in Sweden and in the European Union in time period 1996-2016. From the graph we see that the Swedish government has always spent higher percentage of his GDP than the countries of the European Union in average.

In the years 2008/2009 the global economic crisis has caused a reduction just as in the case of the Denmark. After this year we can see a slow rise in of R&D expenditure in Sweden. In the European Union this rising trend is more fix, without bigger decreases. In 2017, 3,3% of the Swedish GDP has been invested into R&D. In the European Union countries in average this expenditure was only at level of 2,1%.

If we think about the number of people in tertiary educational institutions in Denmark, we can define a rise between years 2009 and 2019. In 2019, 78 106 employees were registered in the higher educational sphere, what means, 0,76 % of the population is actively working in the academic sector.

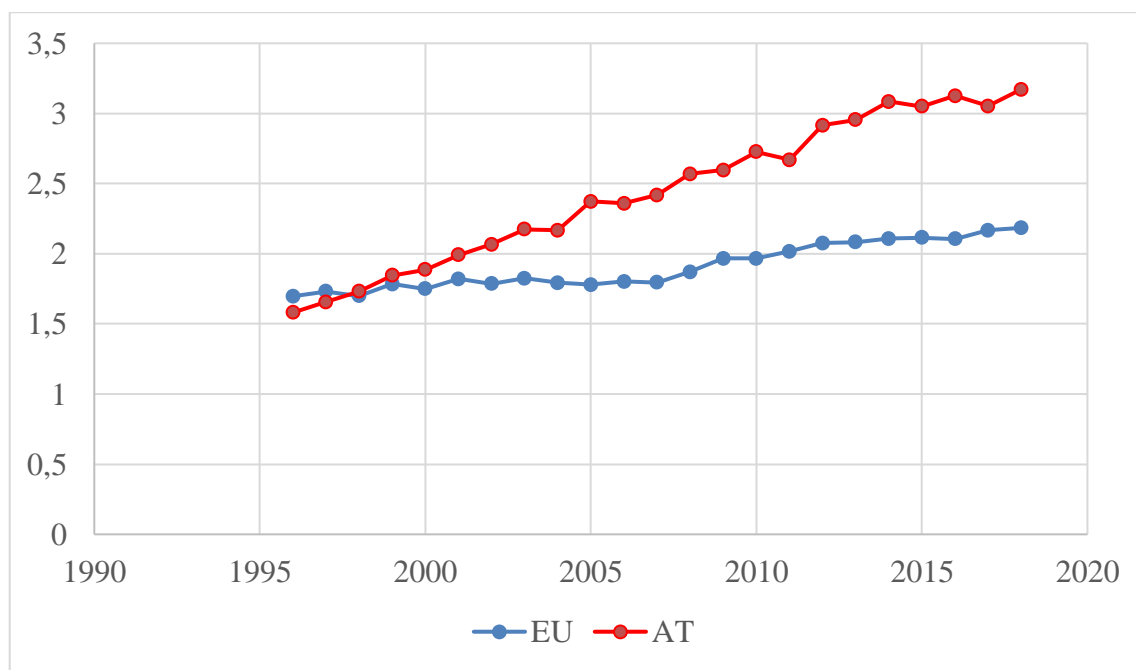
In Sweden, in contrast with the previous Scandinavian country Professor's Privilege patenting policy is applicated since 1949. It means the ownership of the created and registered patent is in the hands of the inventor, who was working on it. In Europe currently only two countries use Professor's Privilege, next to Sweden we can find even Italy, who has changed institutional ownership policy into inventor ownership policy. "The two professor's privilege systems also differ. The scope of professor's privilege in Italy is wider than in Sweden, since it applies to all the employees and potentially all consultants and third parties involved in the university research, while in Sweden it applies only to teachers, postgraduate students and doctoral candidates. "(Geuna, Rossi, 2011).

4.1.3 Austria

Austria is a country located in Central-Eastern Europe and has the population of 8,859 million people (Eurostat, 2019). Republic of Austria is member of the European Union since 1995, and part of the Eurozone from the year 1999. In Austria in 2019 the rate of GDP per capita was 50 137,66 USD (World Bank, 2019). If we want to compare it with other European countries, we can constate that in 2019 the GDP per capita of Austria was higher than in Germany or France, but lower than in Sweden or Denmark. The unemployment rate in 2019 in Austria was 4,67% (Statista, 2019) what is very low, lower than in Denmark (around 5%), Sweden (around 5%) or France (above 6%), but

higher than in Germany, where the unemployment rate was under 3% (Data Commons, 2019).

Graph 4: Research and development expenditure (% of GDP) – Austria, European Union



Source: The World Bank database, own elaboration

The graph about R&D expenditure in Austria and the European Union is showing us a trend of its rate between 1996 and 2018. The year 2018 was important for the economy and for R&D sectors, in this year Austria started to overload the average government investments of the European Union members. It means before 2018 the Austrian government was investing into R&D from his GDP less than the EU average countries. Both curves show us a rising trend, so both countries, or group of countries are investing year by year more and more percentage of the national GDP into R&D. In the case of Austria, we can observe a faster rising trend.

Table 4.: Number of university positions

	Men	Women	Total
Assistants and other non-tenured	18,805	12,716	31,521
of which Lecturers	2,574	650	3,224
of which Project Assistants	4,902	3,944	8,846
Professors	1,823	369	2,192

Source: European University Institute, 2009

Table number 4. shows us the number of academic workers in 2009. For first sight, we can define that according to the gender of academic workers, women employees are in much lower percentage than men workers in Austria. Only the 16,83% of professors are from female gender, this rate does not even achieve one quarter of the whole amount of the professors.

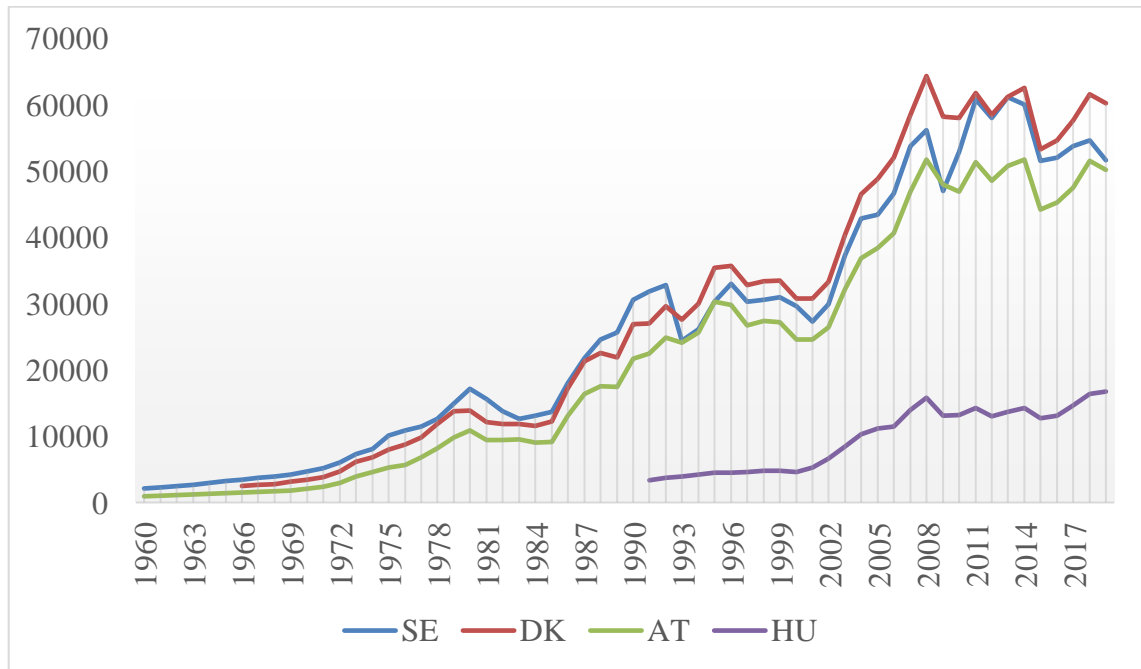
In Austria since 2002 the American Bayh Dole Act patent theory is applied. Before this year legacy of academic patents were in the hands of inventors, after 2002 the ownership went to the academic institution. This new implicated patent policy (Bayh Dole Act) in Austria “has focused on changing employment laws so that university professors are no longer exempted from legislation that gives employers the IP generated by employees” (OECD, 2003), and seek to transfer ownership from individual inventors to universities. “(Mowery D. C., Sampat B. N., 2005)

4.1.4 Hungary

As the fourth country, we analyze Hungary in our master thesis. Hungary is located in Central/Eastern Europe and has population of 9 769 526 people (Hungarian Central Statistical Office, 2020). The unemployment rate in 2019 was 3,4% (Statista, 2019). The history, economy, culture and mentality of the people in Hungary is highly influenced by historical events- being part of the Soviet Union. Nowadays, Hungary is

called many times as a post-socialist country. Hungary is part of the European Union since 2004, but member of the Eurozone. In 2019, the GDP per capita of the country was 16 731,82 USD (World Bank, 2019).

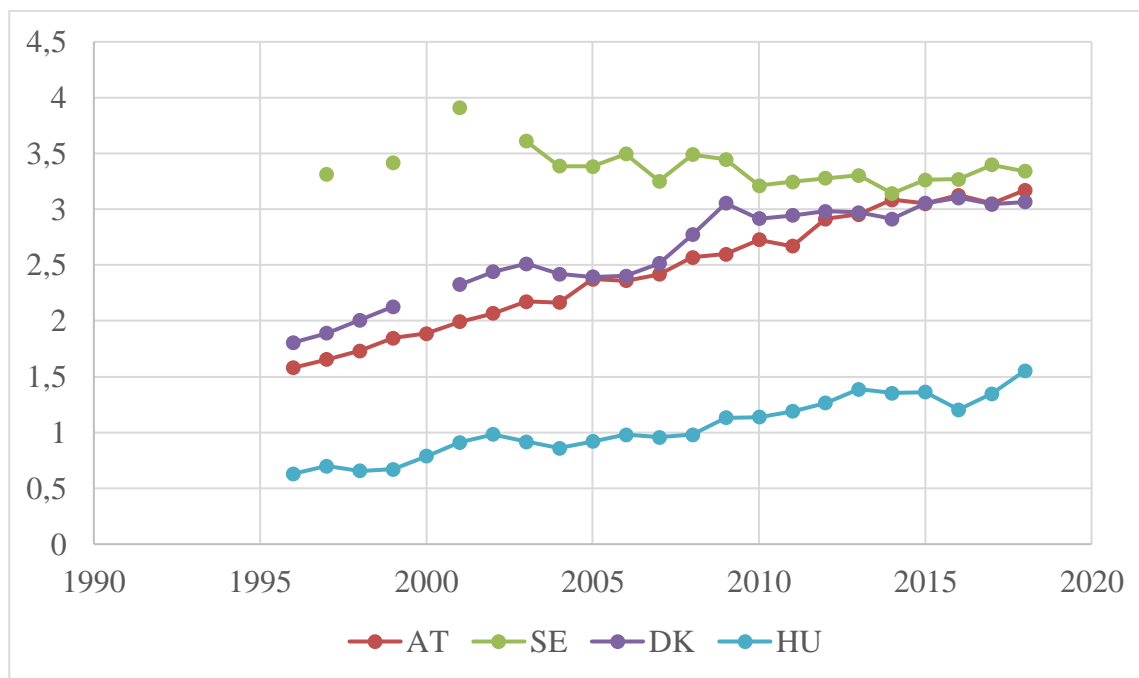
Graph 5.: GDP per capita in selected countries if EU (Denmark, Sweden, Austria and Hungary) between 1960- 2019



Source: World Bank database, own elaboration

Graph 5. shows us the level of GDP per capita in the studied four country, Sweden, Denmark, Austria and Hungary between the years 1960- 2019. Unfortunately, Hungary is lying much lower on the graph compared to the other analyzed countries. According to the data from the World Bank Database in 2019 Denmark had the highest level of GDP per capita, it was followed by Sweden, then Austria and Hungary. The level of GDP per capita can influence even the amount and the quality of public educational institutions and the number of registered academic patents. If a country has higher level of GDP per capita is able afford to spend bigger amount of money for research and development in the country, what can fasten the economic development and increase the quality of life.

Graph 6.: Research and development expenditure (% of GDP) – Denmark, Sweden, Austria and Hungary (1996-2018)



Source: World Bank database, own elaboration

On graph 6, we compare the research and development expenditure (% of GDP) in the analyzed countries (Sweden, Denmark, Austria and Hungary) in the time period of 1996 and 2018. Also, we compare the mentioned countries with the average of the European Union countries. Most of the studied countries invest higher percentage of the national GDP into R&D than the EU average, like Sweden, Austria and Denmark. On the other hand, Hungary is lying below the curve of the EU. As the GDP per capita in Hungary was much lower than at other nations, even the R&D expenditure is on a lower level. While Sweden invests almost 3.5% of the national GDP for R&D, Hungary spends only 1.5% of its GDP. In 2018, Sweden has invested the highest rate of its GDP, it was followed by Austria and then Denmark.

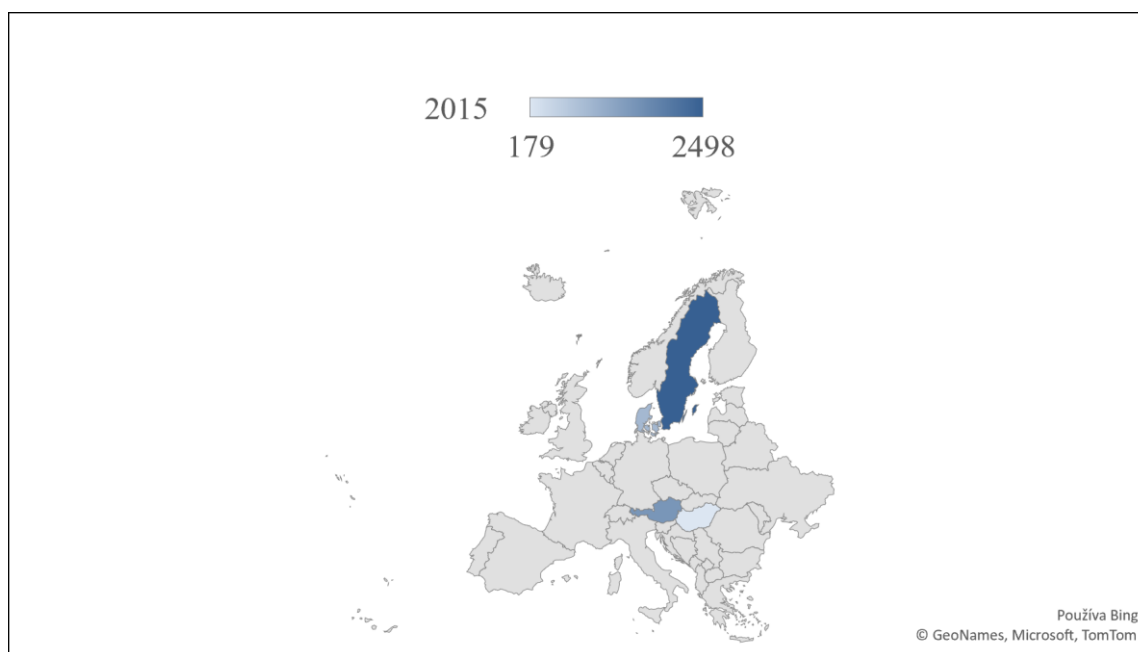
Hungary is often defined as a country with history of strong patent protection. (Zubascu, 2019). In Hungary patents are in institutional ownership since 2006. Post-socialism has highly influenced the patent system in the country. “After WWII, the Hungarian R&D sector was tailored in line with the Soviet model: the autonomy of universities practically disappeared, research institutions were placed outside the academic sphere, and university industry relations weakened.” (Novotný, 2008) These

historical experiences have big impact on the present actions in academic patenting. Furthermore, Geuna and Rossi (2011) defined in their publication that Hungary has hybrid system, because “Hungary make a distinction between “service inventions” which result from the employee’s activity during the term of employment (and which fall under automatic ownership) and “free inventions” (or “dependent inventions” or “employee inventions”) which include all other inventions (rights are assigned to the inventor and the institution can commercialize them under a non-exclusive license). “ (Geuna, Rossi, 2011).

4.2 Comparison of the Act of Patent Registration in the Selected Countries of the European Union

In the following part of my master thesis, we analyze academic patent registrations in selected countries of the European Union- Sweden, Denmark, Austria and Hungary - between 1997 and 2017, so in a 20 years’ time period. All around Europe the popularity of the action of patent registration and the applied patent policy has been different.

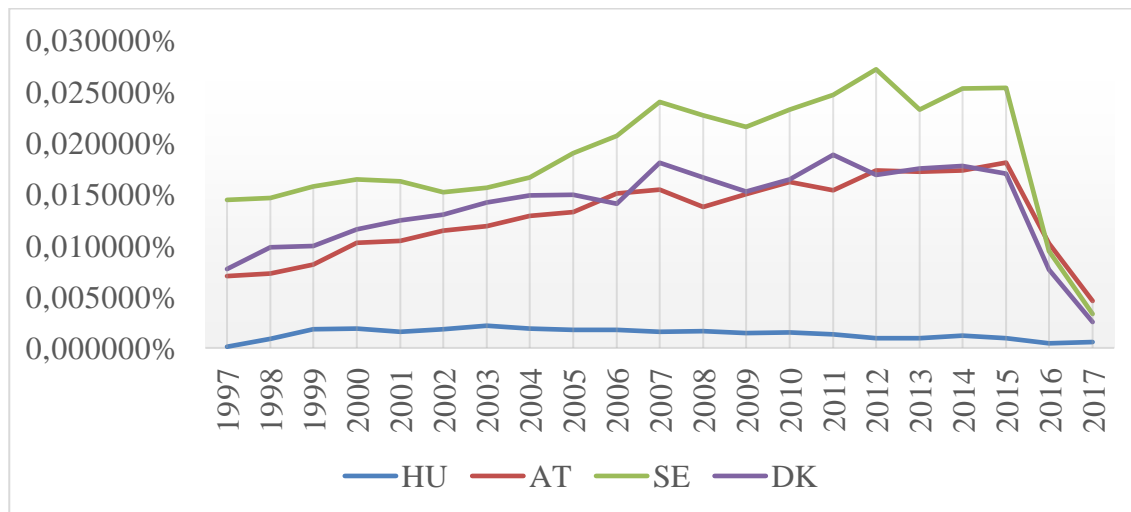
Map 1: Academic Patents- Sweden, Denmark, Austria and Hungary- 2015



Source: Patent database, OECD, own elaboration

Map 1. presents us the academic patent registration in the selected countries of the EU. With blue color are tagged those countries which we analyze in this work (Sweden, Denmark, Austria and Hungary). With light blue color we can see those countries, where patent registration was on low level, this means that country which has the darkest color, had the highest patent registration number, too. In 2015, the amount of academic patent registration in Swede had the highest level of patent registration between these four countries (on the map n. 1. we can see it with the darkest blue color), it was followed by Austria, Denmark and finally by Hungary.

Graph 7.: Per Capita Academic Patent Registration Rate on Population 1997-2017



Source: Patent Database, OECD, 1997-2017, own elaboration

The graph 7.- Per capita academic patent registration rate on population- is perfect for the comparison of academic patents in the selected countries, since on this graph we can see the rate of the academic patent registration on the population in the mentioned countries. This rate provides and offers us a possibility for a fair and efficient evaluation. In Hungary the population is about 10 million people, while in Denmark its level is lower, only its half, 5 million people. If we would not use this rate, and we would compare only the number of registrations between these countries (Sweden, Denmark, Austria and Hungary), and the comparison would not be done on the highest level, and the results would look differently. It is not correct to compare countries who have 10 million inhabitants with countries who have only 5 million.

For the first sight we see, in Hungary the academic patent applications are much below the registration rate in the other countries of the EU. Unfortunately, we cannot see a dominant and impressive rise in this rate during these 20 years.

In the case of Sweden, we can see much more positive results. Sweden has the highest academic patent registration rate on the population from these four selected and studies countries. In Sweden, since 2002- 2003 the patent registration number is increasing, and in 2014 this rate was on its top during this 20 years' time period.

Academic patent application rate in Denmark and Austria between 1997 and 2017 shows a similar trend, both of these countries are on the same level. Until 2006 the patent registration rate in Denmark was a little bit higher than in Austria. However, since 2007 Austria is preceding Denmark.

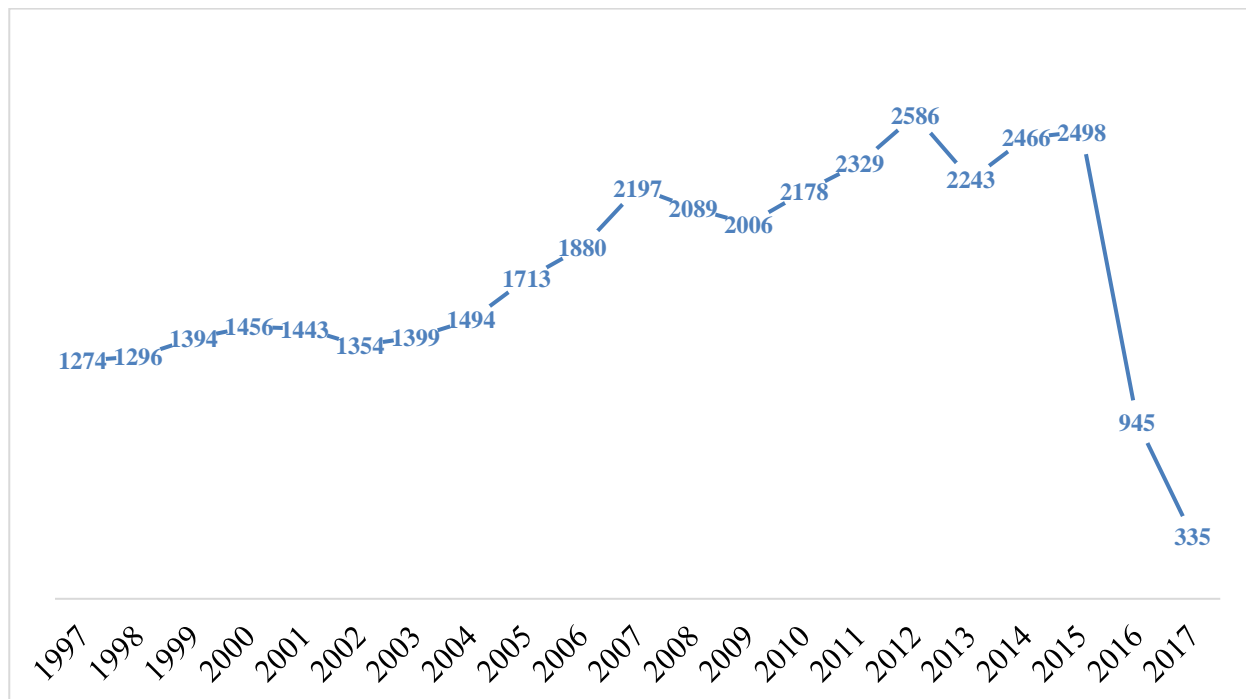
It can be interesting for us, that on Map 1. Austria had the second highest number of academic patent registration after Sweden of the selected four countries. This fact can be explained by the contrast between the quantity of registered academic patents and the academic patent registration rate on the population number of the countries. Maybe, Austrian academic institutions have registered more patents than the ones in Denmark, but if we count the patent number on the population in the mentioned countries the results will be different, this rate will be lower in Austria than in Denmark.

Also, we can speculate, why is the per capita patent registration rate rapidly increasing after 2015. This significant decreasing on the graph can be explained by the long-lasting patent registration process. In our correlation analysis we will not work with these two years (2016,2017), with this act we would like to avoid unreal introduction of the action of the academic patent registration.

4.2.1 Sweden

First of all, from the selected four countries (Sweden, Denmark, Austria and Hungary), we are going to analyze a state where the American patent policy has not been used. In Sweden the Professor's Privilege is applied since the year 1949.

Graph 8.: Sweden- Registered Academic Patents



Source: Patent Database, OECD, 1997-2017, own elaboration

Graph number 8. shows us the trend of the number of the academic patent registrations in Sweden between 1997 and 2017. During these 20 years we can say that the academic patent application is raising. In 1997, the patent registration quantity of the country was only 1274 and in 2012 this number has achieved even the level of 2586 registered academic patents per year.

For better results we have calculated academic patent registration number on the population level, too. This rate has been the highest in 2012, concretely 0,027%, this means for every 100 000 people we can count 27 academic patents in Sweden. The second highest rate was reached in 2015, but in this year only 25 patents were for 100 000 people.

In our work we also analyzed, from where, from which NUTS 3 region were these academic patents registered. During 20 years the biggest quantity of academic patents was registered from SE110 region (Stockholm). This region was followed by SE224 region (Skåne County), where 18,78% of the patents were registered. In this region is Malmö located, the 3rd largest city of Sweden. The third highest patent registration rate was observed in NUTS 3 region SE232 (Västra Götaland County). SE232 region with Gothenburg (2nd largest city) has registered 16,89% of the patents in Sweden. region).

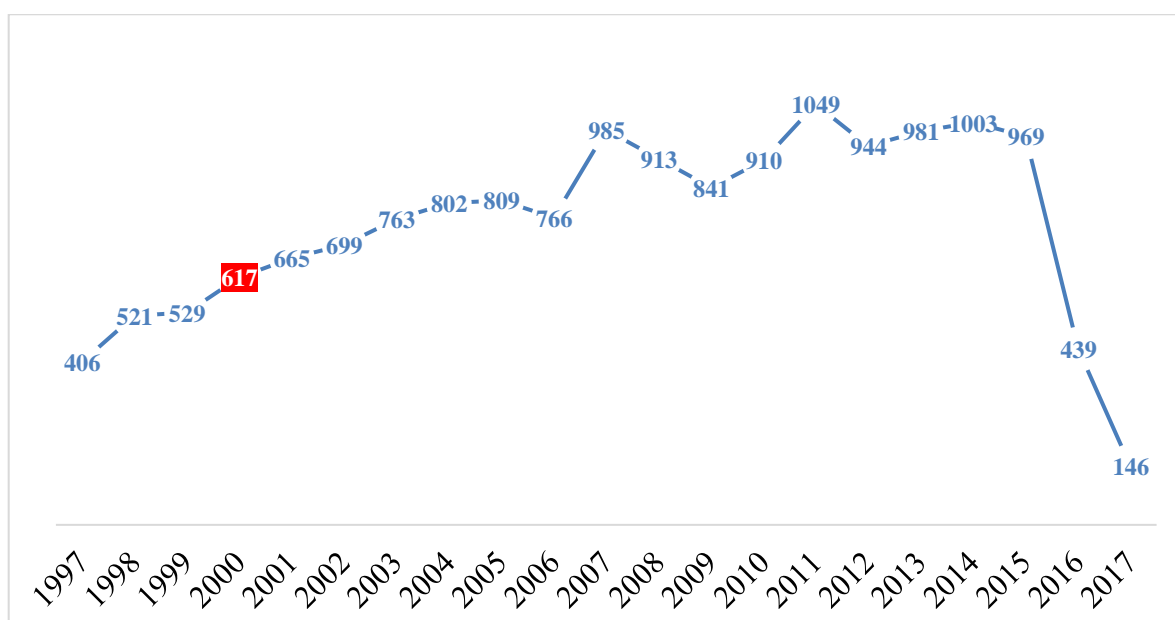
This NUTS 3 region is the capital city of Sweden- Stockholm. Even 35,32% of the total number of academic patents were registered from this region during 20 years.

Furthermore, we studied and analyzed the share of patent inventorship, we were curious if the majority of patents were created by one person or a group of people. In the case of Sweden between 1997 and 2017, 33,88% of the academic patents were invented by one person and 28,43% had 50%-50% inventor share. 17,71% of the academic patents had three creators between 2997-2017. We can see in Sweden 80,02%, more than half of the registered academic patents were invented by less or 3 people, researchers.

4.2.2 Denmark

As the second country we are going to analyze Denmark. Denmark was the very first country in Europe where they started to apply the American patent policy, the Bayh Dole Act. This new patent theory in Denmark is used since 2000.

Graph 9.: Denmark- Registered Academic Patents



Source: Patent Database, OECD, 1997-2017, own elaboration

Graph 9. shows us the number of registered academic patents in Denmark between 1997-2017, so during 20 years' time period. In 1997, the danish academic institutions has registered 406 academic patents. With red color we marked the year when the Bayh Dole Act patent theory started to be applicated. After year 2000, after the application of the new patent theory we can observe a rising trend in the number of registered patents. In 2011 this quantity has reached even 1049 pieces per year in Denmark.

For better and comparable data, we have calculated the academic patent application rate on population in Denmark, too. In Denmark this rate has been the highest in 2011 on the level of 0,01883%. From this rate we can define that in 2011 in Denmark 18,8 patents, almost 19 patents were registered for every 100 000 people. As we saw on graph 8, this rate in Denmark is lower than in Sweden (in Sweden more academic patents were registered than in Sweden). During 20 years the second highest rate was achieved in 2008 when it was 0,01804%, so 18,0 patents were registered for every 100 000 people of the population in Denmark.

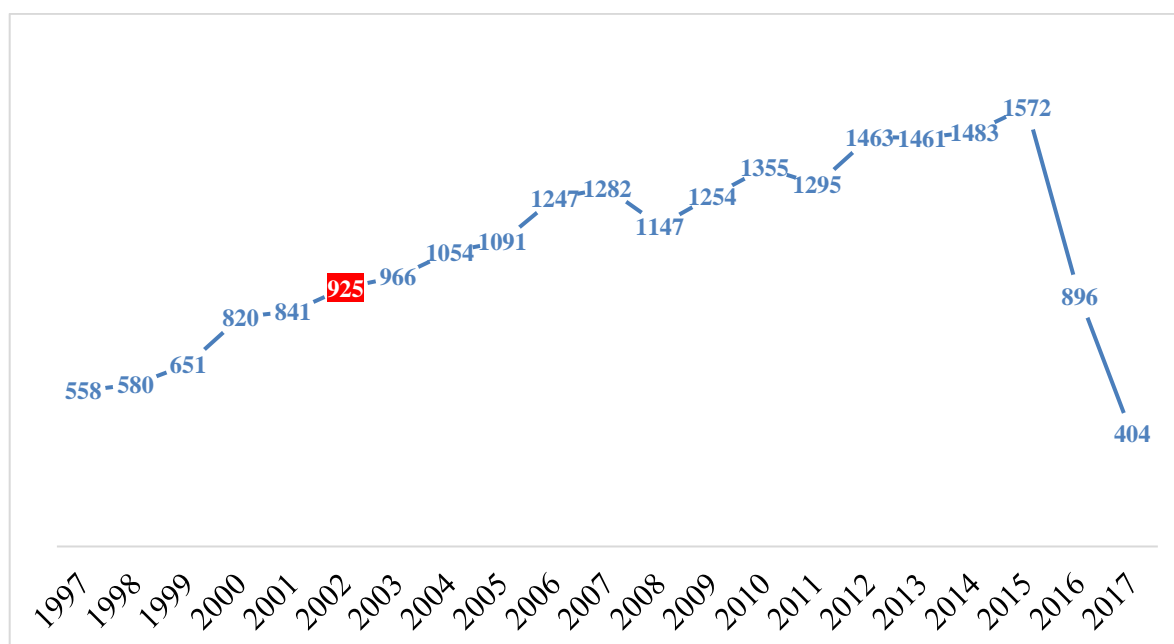
Also, we studied from which region was the highest quantity of academic patents registered in total during 20 years. In Denmark 21,52% of the patents were registered from NUTS 3 region DK012 (Københavns omegn), from Copenhagen surroundings. The academic patent registration in concentrated on the area around the capital city of Denmark. Other 20,57% of the academic patents were registered in DK013 (Nordsjælland) region. In this region are many bigger cities located as, Fredensborg, Frederikssund, Helsingør and Hillerød. It can be interesting for us that from the capital, from Copenhagen (DK011- Byen København) only 14,82% of the academic patents were registered.

In Denmark between 1997-2017 we also analyzed the academic patent inventor share; we were curious if the academic patents are mostly created by one person or a group of researchers. During this 20 years' time period 37,41% of the total number of the patents were invented by only one person, 25,36% of the academic patents were registered by two people and 15,62% by a group of three people. From these data we can define that in Denmark more than half of the academic patent have 1 or 2 inventors (62,77%). Between 1997-2017 only 21,61% of the academic patents had more than 3 creators. The inventors of academic patents in Denmark are mostly only a small group of people or individuals (less or 3).

4.2.3 Austria

Austria is located in Central Europe and from map 1. we know it had the 2nd most patent registrations between 1997-2017 from the selected four countries. In Austria the American Bayh Dole Act patent policy is applied since 2002.

Graph 10: Austria- Registered Academic Patents



Source: Patent Database, OECD, 1997-2017, own elaboration

On graph 10 we see the amount of registered academic patents in Austria between 1997 and 2017. As in the previous country in Denmark even here the red color means the year when Bayh Dole Act was implicated, in the case of Austria it was in 2002. After the year of application of the new American patent policy the number of academic patents were showing a stable rising trend. In 1997 the quantity of registered academic patents in Austria was 558, this amount has become three times bigger in 2015, when it has reached even 1572 pieces/year.

As for other countries, even for Austria we have counted the academic patent registration rate for population. This rate gives us the opportunity to make comparisons with higher quality. In Austria this patent registration on population rate has been the highest in 2015 concretely 0,01807%. This rate means, that on every 100 000 person 18 patents were registered. The second highest result was 0,01728% what was achieved even

in 2 years, in 2012 and 2014. In these two years 17 academic patent applications were registered for every 100 000 people.

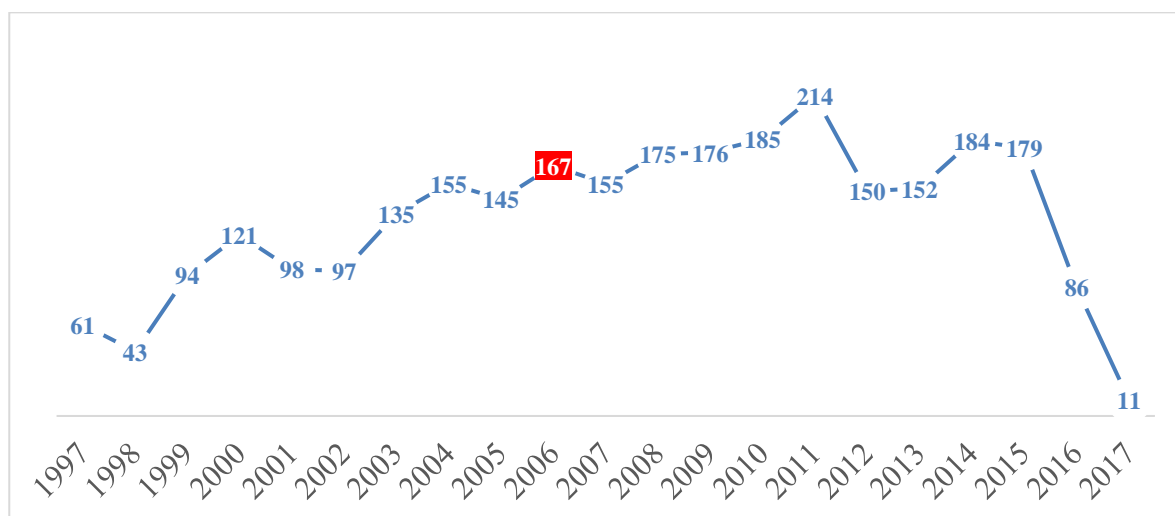
The most patents were registered from region AT130 (Wien), from the capital city, concretely 18,16% of the total patent applications. 11,50% of the academic patent registration has arrived from NUTS region AT342 (Rheintal-Bodenseegebiet), from western Austria and the 11,81% of the patents from AT312 (Linz-Wels) region.

If we talk about patent inventors, we need to mention that 37,83% of the total academic patents between 1997-2017 were created by only one person. 24,92% of the patents had two creators and 16,03% had three. This means, 78,78% of the registered academic patents were invented by 3 or less people, and in Austria only 21,22% of the academic patents had more than three creators.

4.2.4 Hungary

As we saw before, in Hungary the act of academic patent registration has never been and is still not that popular as in other countries of the EU. But this trend can still change. In this Central-European country, in Hungary the American Bayh Dole Act patent policy is used since the year 2006.

Graph 11: Registered Academic Patents in Hungary 1997-2017



Source: Patent Database, OECD, 1997-2017, own elaboration

On this graph we see academic registered patents during 20 years, from 1997 till 2017 in Hungary. During these 20 years we can see a rising trend in the patenting action of academic institution with smaller decreases. In 1997 in Hungary 61 academic patents were registered by academic institutions and in 2011 this quantity has raised to 214 (more than three times rise). With red color we see the year when the new patent policy started to be applied (2006). Since 2006 the American Bayh Dole Act Theory started to be applicated, and after this year we can observe a rising trend in the number or the academic patent registration.

We have studied patent application rate on population in the case of Hungary, too. This rate has been the highest in 2011 (0,00216%). This means, in 2011 in Hungary on 1 000 000 people we can count 21,6 patents. This patent rate was been on the second highest level in 2010 (0,00186%). However, in 2010 only 18,6 patents were registered for 1 000 000 people.

The highest registration number was observed in the capital, in Budapest (1476 patents during 20 years). On the second place is HU321- HU333- Hajdú-Bihar region (with city Debrecen) and on the place, we see Csongrád-Csanád region (with the academic city Szeged). All, in these mentioned regions are nationally and internationally important universities located, what can influence the high patent application number, too. More than half, 67,54% of the academic patents in Hungary were registered from the capital city, from Budapest, 5,76% was from HU321 region and 4,83% from HU333 NUTS-3 region.

Also, we analyzed the share of the patent inventors in Hungary. In Hungary between 1997-2017, 22,95% of the listed patents were invented by only one person, researcher. 20,44% of the academic patents had two inventors (50-50%), and 18,52% of the patent had three creators. We see the majority of the patents have less or 3 inventors. During these 20 years, only 38% of the academic patents had more than 3 authors.

To sum up, in the four selected and analyzed countries (Sweden, Denmark, Austria and Hungary) the academic patent registration has been done differently. Eastern-Central European country, Hungary is situated on the comparison graph deeply below the other analyzed countries. The most academic patent counted on national population was

registered from Sweden, the activity of Austrian and Danish universities was on the same level.

Three of the selected countries, Denmark (since 2000), Austria (since 2002) and Hungary (since 2006) are using the American patent policy, the Bayh Dole Act theory. In the Nordic Sweden the Professor's Privilege is applicated. Our hypothesis number 1 claims: "The number of patent applications was increasing after applying the theory of Bayh Dole Act (Ledebur, Buenstorf, Hummel, 2009)". After our analysis we can define that this hypothesis n.1. is true in situation *ceteris paribus*, we do not consider other influential effects. In all of the three selected and studied countries where Bayh Dole Act started to be used, after the year of the policy application the patent registration was increasing, too.

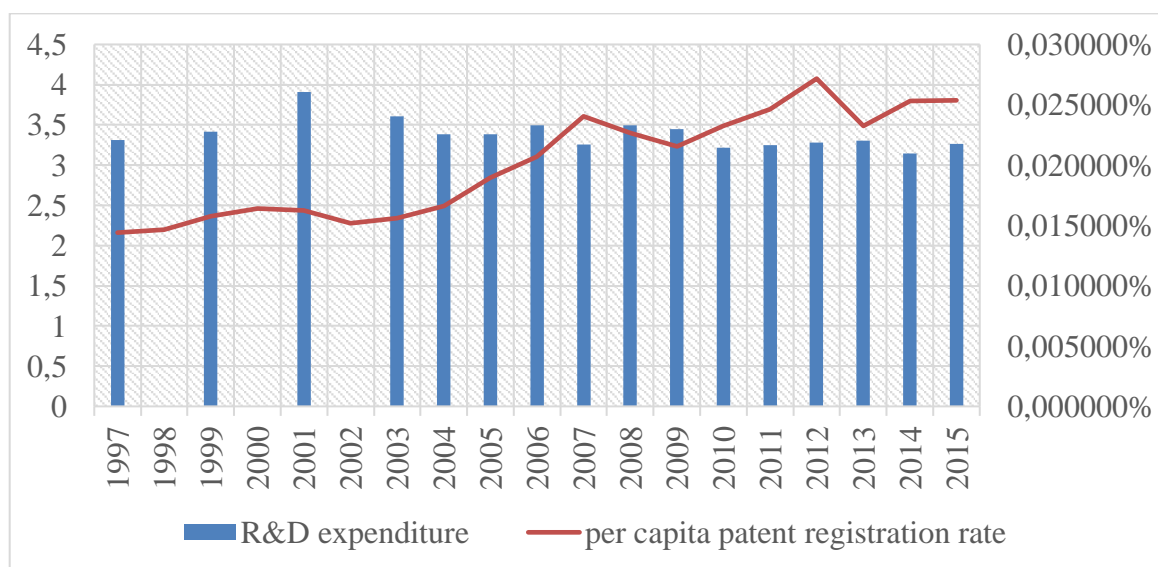
In Sweden, Austria and Hungary the highest number of patent registration has happened in the region of the capital city (Stockholm, Wien and Budapest). The case of Denmark is very interesting, the highest quantity of academic patents was not registered from the capital city of Denmark, but from region DK012- Copenhagen surroundings. It can be explained by the municipal policy and its history in Denmark.

Also, we studied and compared inventor share in the selected countries. If we think about share of inventors of academic patents, in all of the selected countries a significant part of the academic patents were invented by only one person. In Sweden between 1997-2017, 33,88% of academic patent were owned by only 1 person, and we can say that only 19,98% of the patents had more than 3 inventors. In Denmark, 37,41% had one owner (more than in Sweden) and 21,61% of the academic patent were invented by more than 3 people. In Austria, 37,83% of the academic patents had only one inventor and 21,22% was invented by a group of more than three people. Finally, in Hungary 22,95% of academic patents had one creator and 38% was invented by more than 3 people. To sum up, we can define that in Austria was the most academic patent invented by only one academic person, concretely 37,83%. On the other hand, Hungary was the country where the highest number of academic patents were invented by more than three people, even 38%.

4.3 R&D Expenditure and Academic Patent Registration

R&D expenditure is the percentual rate of money what countries have invested into research and development from their annual gross domestic product (GDP). In our work we have analyzed R&D expenditure in countries: Sweden, Denmark, Austria and Hungary (Graph 2, Graph 3, Graph 5, Graph 7). In the following part we are going to compare it with the number of patent registration in selected countries. In case this comparison was more efficient we will compare R&D expenditure with per capita patent registration rate, so the population number will not change the results (countries with 5 million inhabitants, and countries with 10 million inhabitants).

Graph 12: The connection between R&D expenditure and per capita patent registration rate in Sweden

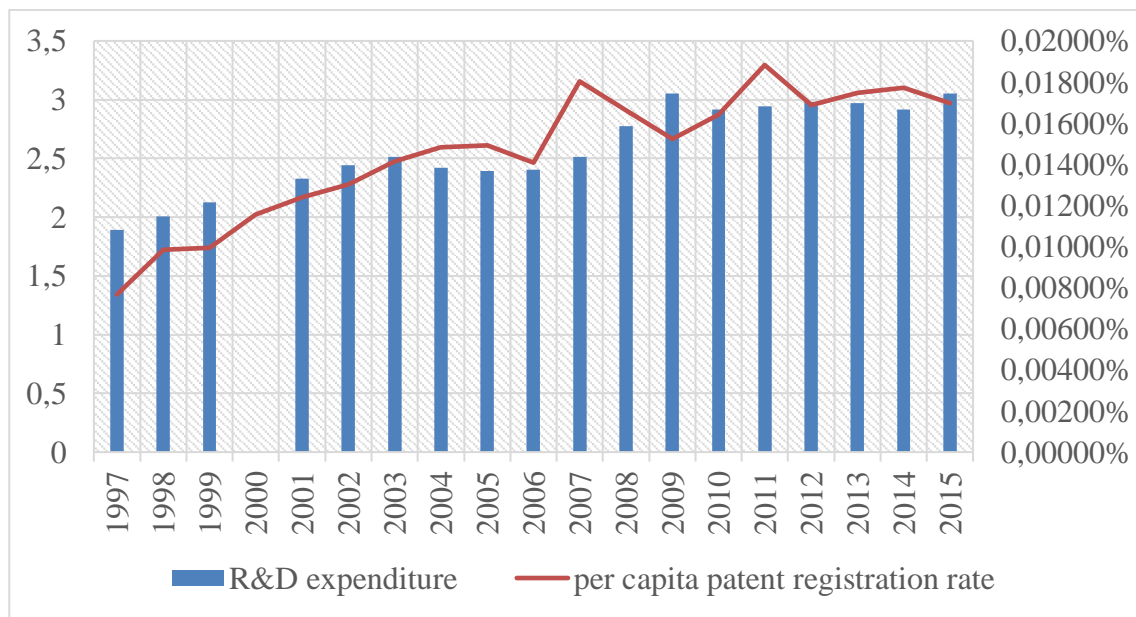


Source: World Bank Database, OECD Patent Database, own elaboration

Graph 12. presents us R&D expenditure rate and per capita patent registration rate in Sweden. With blue color we see the percentual amount what the Swedish government as invested into R&D is various years. Red color presents us the percentual rate of per capita patent registrations. We can see in 2001 the Danish government has invested almost 4% of its GDP into national R&D. It was in important rise compared to the previous years (1997,1999), when less than 3,5% of the Swedish GDP was invested into R&D. After this significant rise in 2001 the number of patent registration started to rise

too (since 2003). This rise has happened in 2 years delay, it can be explained by long lasting the patent administrative process. In 2008, we can observe another rise in the rate of R&D investments. As in the previous even 2 years after 2008, so in 2010 we can observe a rising trend in per capita academic patent registration rate.

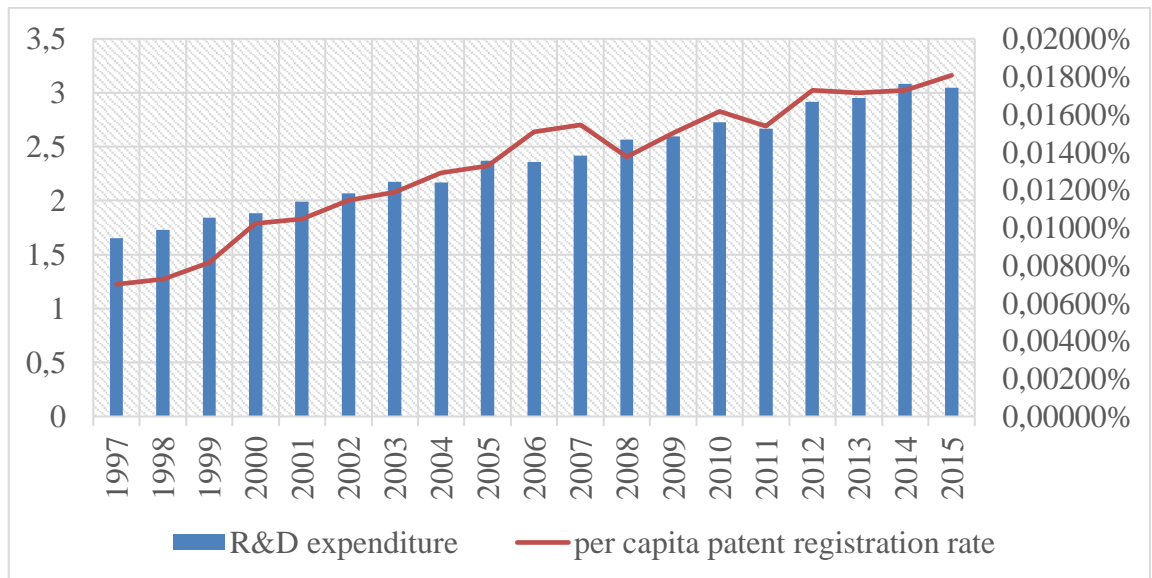
Graph 13: The connection between R&D expenditure and per capita patent registration rate in Denmark



Source: World Bank Database, OECD Patent Database, own elaboration

In the case of Denmark, we analyze the connection between R&D expenditure and per capita academic patent registration rate between 1997 and 2015. The R&D expenditure, so the investment of the Danish government into R&D were increasing year by year, as well as the academic patent registration rate. In year 2009, in Denmark more than 3% of the GDP was invested in R&D, in the following years we can observe a rise in per capita patent registration rate as well.

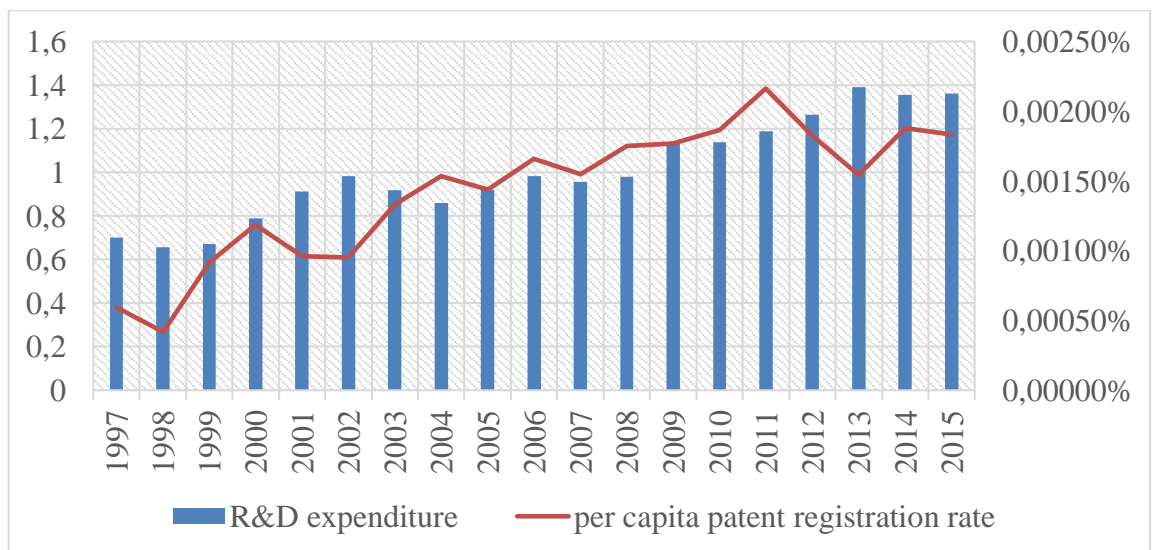
Graph 14: The connection between R&D expenditure and per capita patent registration rate in Austria



Source: World Bank Database, OECD Patent Database, own elaboration

Also, we analyzed central European country Austria, where the R&D expenditure rate from national GDP was increasing during these analyzed 18 years, and the per capita patent registration rate shows a stabile rising trend, too.

Graph 15: The connection between R&D expenditure and per capita patent registration rate in Hungary



Source: World Bank Database, OECD Patent Database, own elaboration

In the case of Hungary, the graph about the connection between R&D expenditure and per capita registration rate shows changing trend. With red color we can see the per capita patent registration rate during time period 1997-2015. This curve is rising since 1997 with smaller decreases. In 2011, per capita patent registration rate has reached its maximum level during 18 years, it has been 0,002%. R&D expenditure of the Hungarian government from its annual GDP has increasing trend during 18 years. In the case of Hungary, we can also observe that with the rise of R&D expenditure (for examples, in 2000, 2001, 2002), the per capita academic patent registration rate rises, too.

To sum up, if we compare the four selected countries, we can have a look at Graph 6 and Graph 7 where we see the comparison of R&D expenditure and per capita patent registration rate in the studied and analyzed countries. In Hungary, per capita patent registration and lying below the curves of other countries, it means here is the less academic patent restarted from the 4 countries, and in Sweden the number of application per capita is the highest. If we think about R&D expenditure from national annual GDP the rank of investment is the same as the rank for per capita patent registrations. It means, in Sweden the R&D expenditure rate is the highest, what is followed by Austria and Denmark (these countries are on the same level), finally they are followed by Hungary. We can mention Sweden as an exception country, where the R&D expenditure rate is not rising as in the other three countries, it is presenting stagnation, a constant trend. Sweden invests the same or less percentual rate of their GDP into R&D every year. With the rise of R&D nation expenditure of GDP the per capita patent registration rate rises, too.

4.4 Analysis for the Application of Bayh Dole Act Patent Policy

Difference-in-Differences analysis is a research method with what we can compare the result and effect of newly applied theory, policy, method etc. With this quantitative research technique, we compare the situation before and after the new policy. In our master thesis we are going to analyze the American patent policy, the Bayh Dole Act theory and its implication results in Denmark, Austria and Hungary. We compare the number of registered patents before the year of application and one year after (we analyze the year after the implication, not from the year when the new theory was applied – for examples: in Denmark the Bayh Dole Act theory is used since 2000, but we study the result of the new policy only from 2001, because the results of the new theory do not happen immediately, and we do not know in which year the theory was implemented in January or December). We compare countries where the Bayh Dole Act theory was implemented (Denmark, Austria and Hungary) with a country where the American patent policy is not used, but the classic Professor's Privilege (Sweden). We analyzed the selected countries during 18 years, since 1997 till 2015.

Table 5: Comparing analysis in Hungary, Austria, Denmark and Sweden

Comparison - Per capita		
HU	Before	0,1036 ‰
	After	0,1797 ‰
	Difference	0,0760 ‰
AT	Before	0,8622 ‰
	After	1,5280 ‰
	Difference	0,6658 ‰
DK	Before	0,9145 ‰
	After	1,5840 ‰
	Difference	0,6695 ‰
SE	Before	1,5483 ‰
	After	2,2239 ‰
	Difference	0,6756 ‰

Source: OECD Patent Database, own elaboration

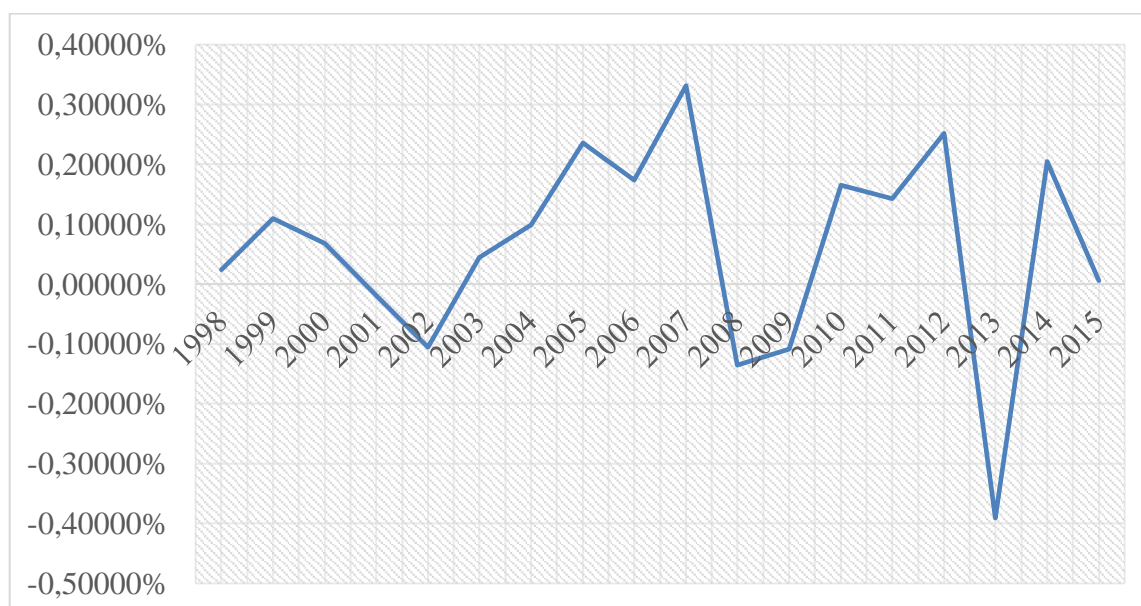
On table 5, we studied the changing situation in all the selected countries individually. To sum up, in all the four countries the per capita patent registration rate was rising during these 18 years. We can state, that after implication of the Bayh Dole Act theory the number of registered academic patents were increasing. However, in Sweden this rate increased, too without implication of the American theory. The biggest percentual difference between pre- and post-data, we could observe in Sweden (without BDA) and Denmark, in the Scandinavian countries.

We need to emphasize, this comparison cannot be taken, considered as a rule, what is always true. Since we have analyzed only four countries, moreover only one country was studied from the group of European countries, where Bayh Dole Act patent theory is not applicated (Sweden). In our work we did not analyze and study enough number of countries to make strong and true statements in academic patent registration sphere.

4.5 Patent Growth Rate and the Bayh Dole Act Policy

We also studied patent growth rate in the selected countries between 1998 and 2015. This rate perfectly shows us the percentual rise or decrease in the patent rise. We need to mention that for the following analysis and calculation per capita academic patent registration rate was used, and was compared. We decided to use this rate for more convenient and real comparison, with this choice we try to avoid unrealistic data created by the differentiation rise in the population in the selected countries. Furthermore, we compared the trend of this rate before and after the application of the Bayh Dole Act patent policy. We will be able to observe on the graph the patent growth rate's trend before and after the implication.

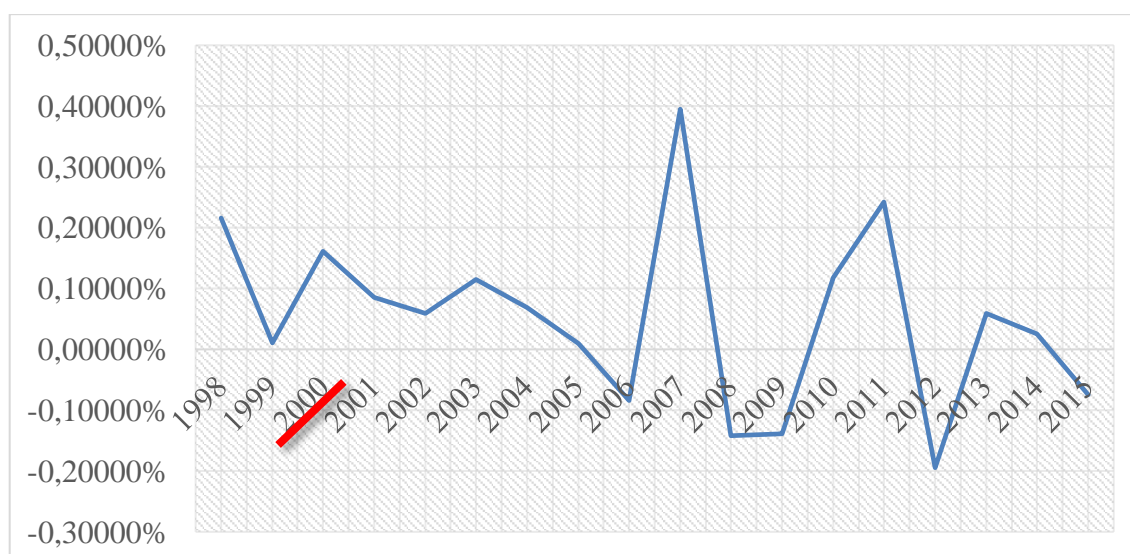
Graph 16: Patent growth rate in Sweden



Source: OECD Patent Database, own elaboration

Patent growth rate studies were done about the situation of the patent market in Sweden. Patent growth rate is a comparison of two years, for examples, 1997-1998. In 1998 the per capita patent registration growth rate was showing a rising trend, compared to 1997, concretely, it has risen by 0,02%. We all know in Sweden Bayh Dole Act patent policy was not applicated, however on the graph a stabile rise can be seen after 2002.

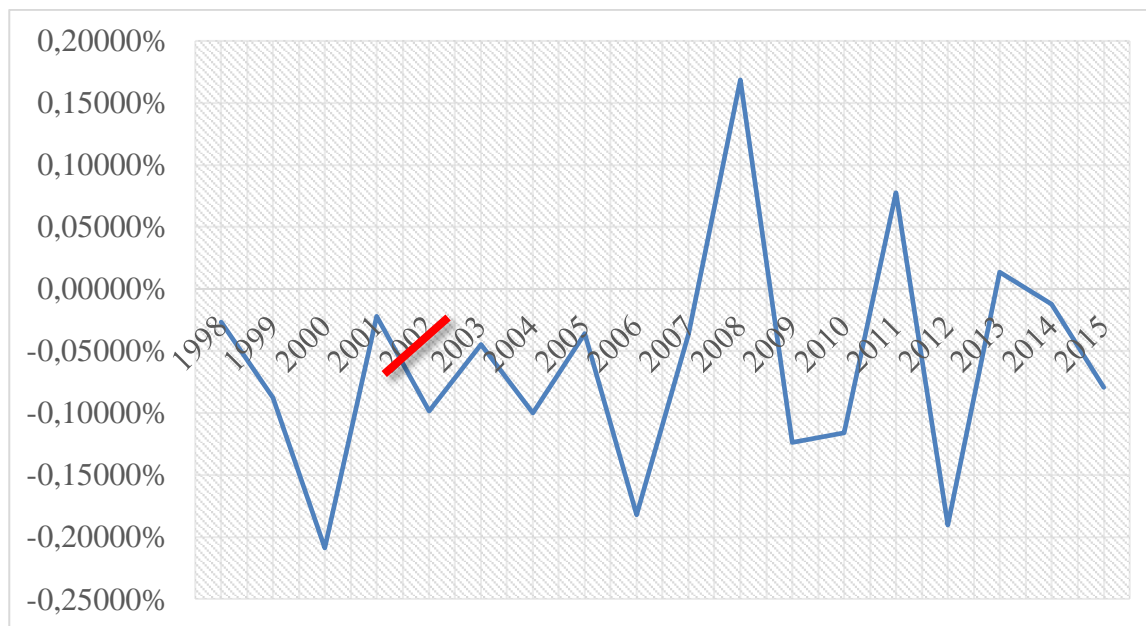
Graph 17: Patent growth rate in Denmark



Source: OECD Patent Database, own elaboration

Graph 17 analyses that patent growth rate in Denmark. In Denmark Bayh Dole Act patent policy is implicated since 2000. Graph 17 shows us that the growth rate for patent registration per capita was showing a stabile decrease. According to our analyses, we can say that the implication of a new theory does not have positive effect on academic patent registration, it did not motivate institutions for rapid rise.

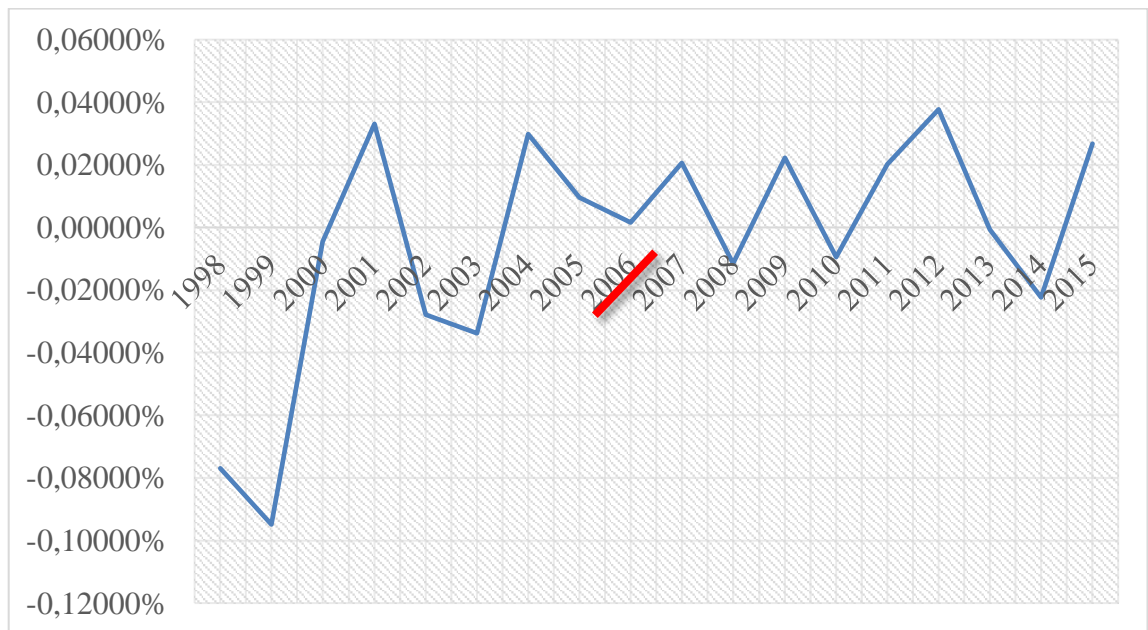
Graph 18: Patent growth rate in Austria



Source: OECD Patent Database, own elaboration

In Austria we can observe similar results as on the graph of Denmark. With red color we tagged the year when Bayh Dole Act patent policy started to be used in the country. After 2000, a negative growth trend can be observed in Austria. In the case of Austria, according to our studies we can say that Bayh Dole Act was not stimulating academic institutions positively enough for rising the rate of patent registration per capita. In 2008 we can observe an important rise. However, unfortunately the big economic crises in 2008/2009 had a negative effect on the patent growth rate.

Graph 19: Patent growth rate in Hungary



Source: OECD Patent Database, own elaboration

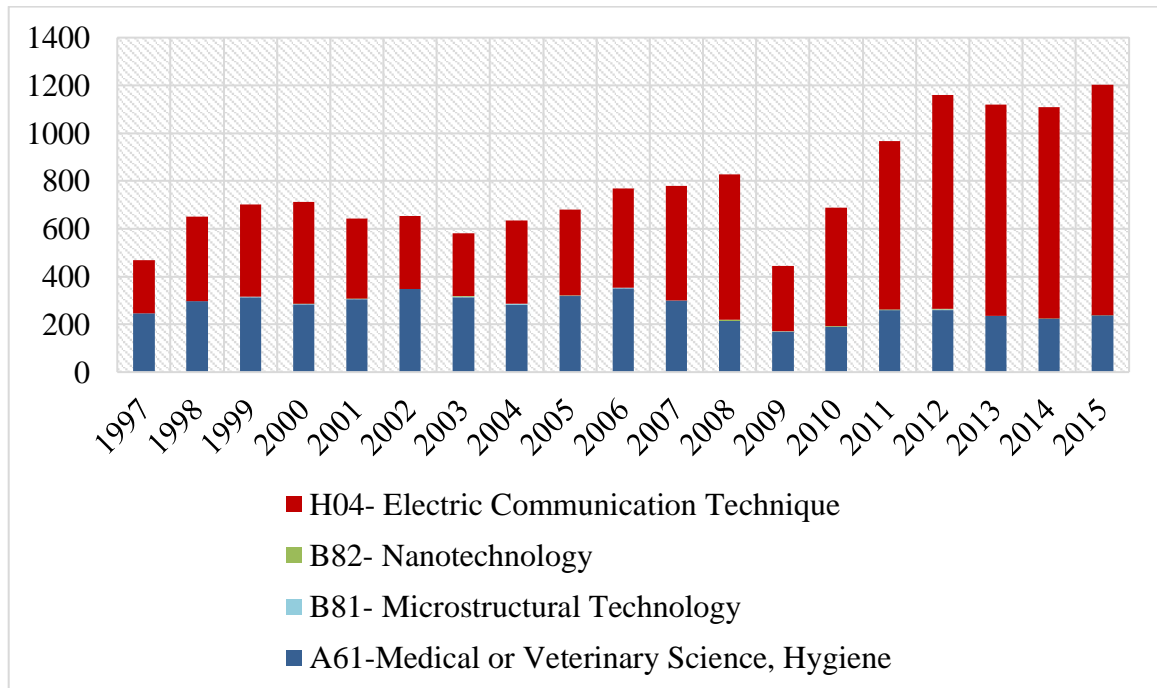
Finally, we analyzed Hungarian patent growth rate between 1998 and 2015. In Hungary Bayh Dole Act was implicated in 2006. After studying the four selected countries, we can say that according to our patent growth rate analyses that the implication of Bayh Dole Act patent policy did not have a significant rising effect on the academic patent registration rate per capita. After the year of the application, we could not observe an outstanding rising trend on patent growth rate.

4.6 Academic Patent Registration in Selected Sectors

In the following part we are going work with academic patent registration in selected sectors. As preciously we wrote, the authors working and analyzing this problematic, the problematic of academic patenting, can be divided into two groups. The first group is contained from specialists who claim the number of academic patent registration has grown with the application of new American patent policy, the Bayh Dole Act theory (Innovation's Golden Goose, 2002, Perkins J. F., Tierney W.G., 2004, Zeebroeck N, Pottelsberghe B, Guellec D, 2008). The scientists from the other group in their publications claim, that the rising number of academic patent registration is not caused by the application of the new American patent policy, but is caused by other indicators, as the establishment of new research sectors and by the rapidly rising development in science and technologies (Geuna, Rossi, 2011, Sapalis and Pottelsberghe, 2003, Lissoni F, Llerena P, McKelvey M, Sanditov B, 2008, Mowery et al, 2001, Sapalis, Pottelsberghe, 2003, Lissoni F, Llerena P, McKelvey M, Sanditov B, 2008, Mowery et al. 2001).

We analyzed four selected sectors (A61-Medical or Veterinary Science, Hygiene, B81- Microstructural Technology, B82- Nanotechnology and H04- Electric Communication Technique). These sectors were chosen from Wipo IP Portal according to the sector analyses of the previously mentioned authors from the second group.

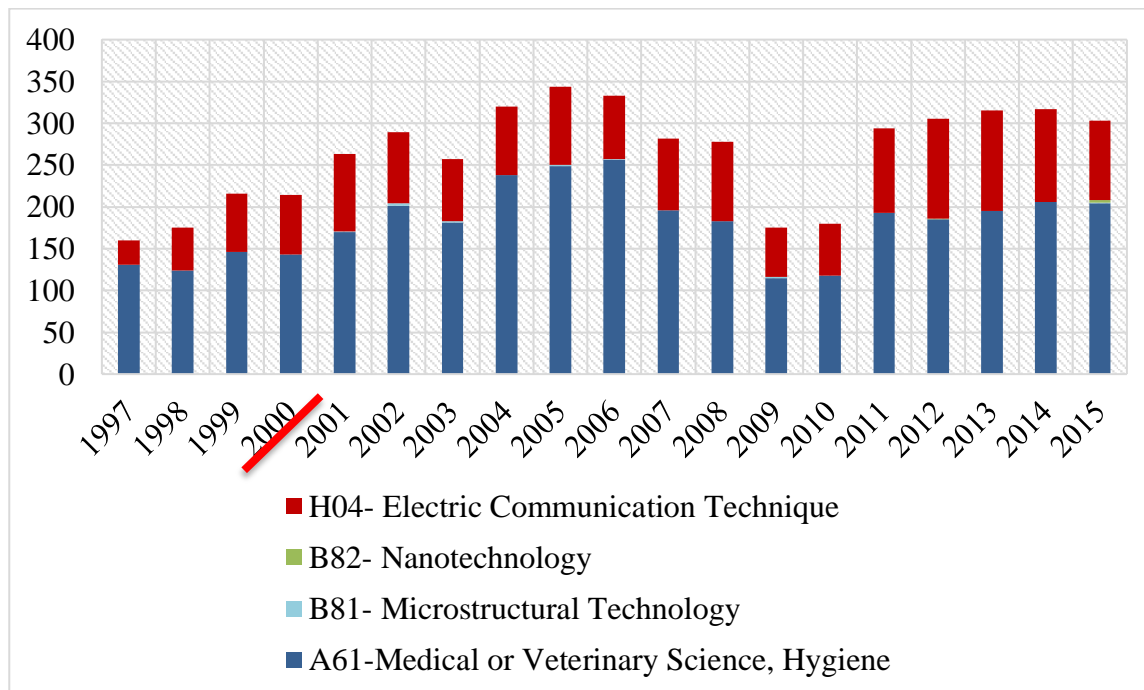
Graph 20: Academic patent registration in selected sectors- Sweden



Source: OECD database, own elaboration

Graph 16. perfectly shows us the rising trend in patent registration number. We need to mention that purple color represents the quality of academic patents registered in the sphere of Electric Communication Technique and the lighter blue color shows the patent registration number in the sector of Medical or Veterinary Science and Hygiene. Year 2009 shows a rapid reduction, what can be explained by the big economic crisis in 2008/2009. In the case of the country Sweden the activity in Electric Communication Technique has increased significantly during these 18 years, while in 1997 only 223 patents were registered in this sector, by 2015 it has reached the level of 966 patent registrations.

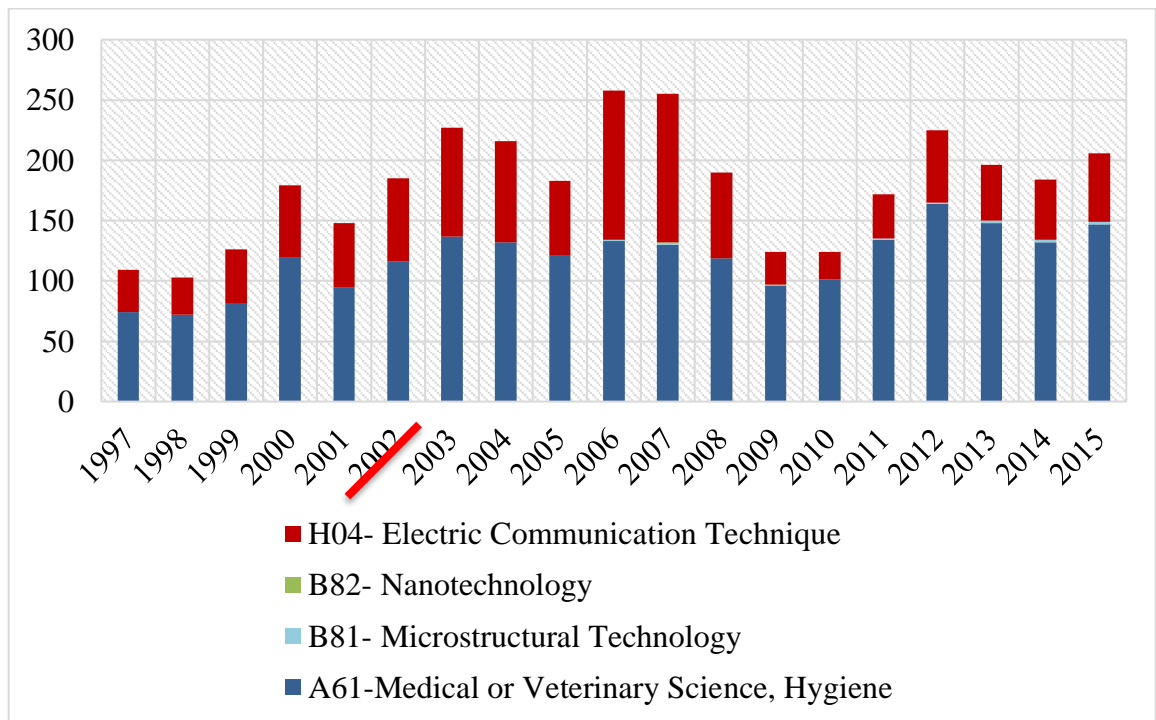
Graph 21: Academic patent registration in selected sectors- Denmark



Source: OECD, own elaboration

Next graph introduces us the academic patent registration number in the selected sectors in Denmark between 1997 and 2015. With red color we have mentioned the year, in the case of Denmark- 2000, when Bayh Dole Act patent policy was applicated. As from the previous part of the thesis we know after the year of the application of the new patent policy the patent registration number in the academic sphere was increasing, however many authors in their publications have described that this rise in not caused by the new theory but by sectoral changes. On the graph 22, we see that these authors were correct, after 2000 in Denmark the academic patent application in Medical or Veterinary Science and Hygiene has increased significantly. As in the case of Sweden, the big economics crisis in 2008 had a negative effect even on the Danish academic patent industry. However, this crisis, and the its following decrease have passed in 2 years, in 2011 the academic patent registration number got to its previous, before crisis level again. In Denmark the sector of Medical or veterinary science and hygiene is more significant for patent registration than in Sweden, where the sector of Electric communication technique has played a bigger role.

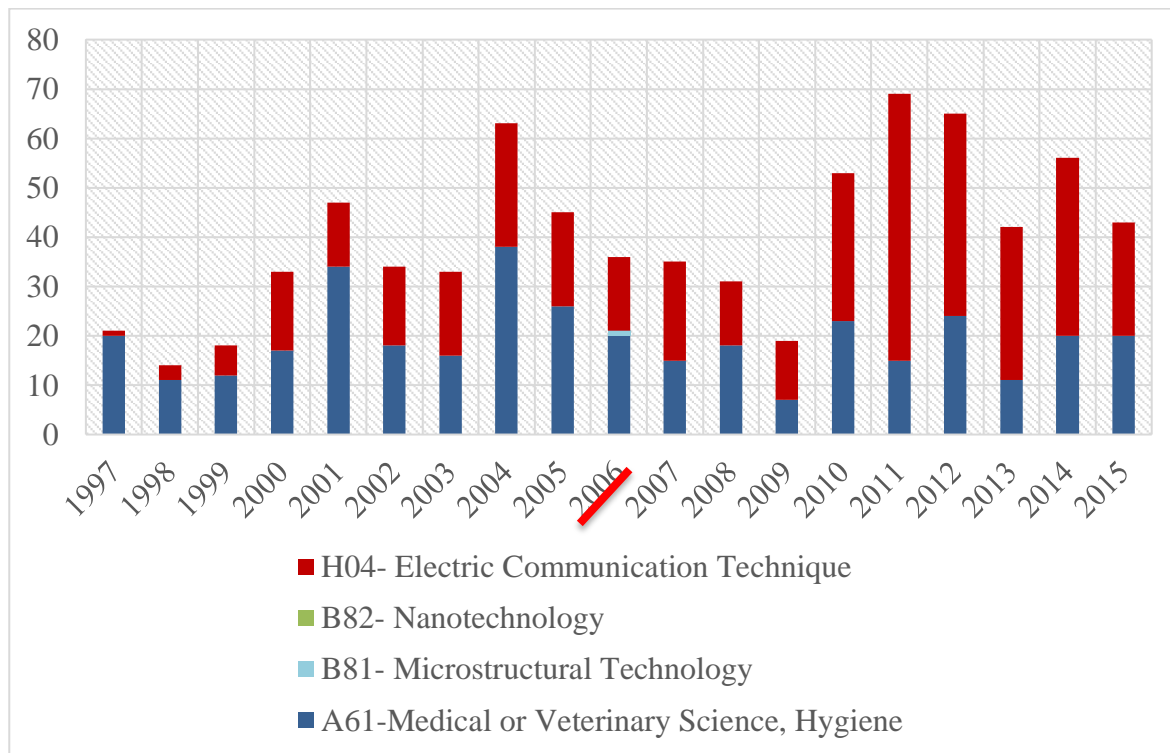
Graph 22: Academic patent registration in selected sectors- Austria



Source: OECD, own elaboration

If we speak about sectoral academic patent registration in Austria, we need to mention the same characteristics, attributes as previously. The patent registration number in the analyzed sectors was increasing. With red color we tagged the year when the American patent policy was applicated, in the case of Austria it has happened in 2002. Since 2002 we can see rising tendency in patent registration numbers. However, the 2008 economic crises had negative effects on the patent registration market of Austria, too.

Graph 23: Academic patent registration in selected sectors- Hungary



Source: OECD, own elaboration

Finally, we analyze academic patent registrations in Hungary between 1997 and 2015. The red color represents the application year of Bayh Dole Act academic patent theory, in Hungary it has happened in 2006. If we look at the graph, we see changing trend, with rises and reduction, but if we compare it with graph 12, where we studied total academic patent registration in Hungary, we can find similarities. The 2008 economic crisis, has negatively influenced the academic patent registration activities.

Also, we need to mention that we studied and analyzed two more sectors, concretely Nanotechnology and Microstructural Technology. The following sectors are not visible on the graphs, since their activity, patent registration number is very low compared to the other sectors. However, they are important in our studies, since these are one of those sectors, what were newly created after the millennial, at the beginning of the 21st century, and their popularity, attractiveness is just starting to rise nowadays.

5 CONCLUSION AND DISCUSSION

In the final part of the master thesis, we would like to sum up the analyzed information and the newly received facts. We were working with academic patent theories, policies in the EU. We decided to analyze the two most popular theories, the Bayh Dole Act theory and the Bayh Dole Act. The Bayh Dole Act patent policy gives the legal ownership right for the registered intellectual property for the university where the patent was created and researched. They claim that the university is the institution, who could ensure the promotion and the action of the knowledge exchange on the highest level. On the other hand, the act of Professor's Privilege gives the ownership right to the person or group of people, who were participating the creation of a special intellectual property and registering it as a patent.

Also, we analyzed publications of famous and successful economists, publishers, researchers, who were working with this issue. We have divided them into two groups, the first group was created of scientists who claimed that the Bayh Dole Act theory effects and causes rise in the number of academic patents after the year of its implication (Innovation's Golden Goose, 2002, Perkins J. F., Tierney W.G., 2004, Zeebroeck N, Pottelsberghe B, Guellec D, 2008). In the other group of publications, we have included those researchers who said in their publications that the American patent policy (the Bayh Dole Act) has no effect on the rising patent registration number, and this rise is caused by the rising number of newly created sectors (IT, Biotechnology) (Geuna, Rossi, 2011, Sapalis and Pottelsberghe, 2003, Lissoni F, Llerena P, McKelvey M, Sanditov B, 2008, Mowery et al, 2001, Sapalis, Pottelsberghe, 2003, Lissoni F, Llerena P, McKelvey M, Sanditov B, 2008, Mowery et al. 2001).

We have defined in the part "Goals of my master thesis" 4 hypotheses, what we tried to prove in our work.

According to our data the first hypothesis is accepted we can say, it is true, the number of patent applications was increasing after the application of the theory of Bayh Dole Act in the selected four countries (Sweden, Denmark, Austria and Hungary) between 1997 and 2017 in *ceteris paribus* (we do not consider other influencing factors).

The second hypothesis is also true according to our researches. With the help of Difference-in-Differences average comparing analysis, patent growth rate studies and sectorial analyses we got the results, that this rise is not caused by the implication of the

American patent policy, but it is influenced by other effects, as the creation of new sectors or the rising trend of activity in patent registration in some sectors (IT, Biotechnology, etc.)

We cannot claim 100% the inefficiency of the Bayh Dole Act theory according to our Difference-in-Differences average comparing analyses, since we have studied only four countries, and only one country which has implicated the Professor's Privilege. The small number of studied countries does not ensure and provide the possibility to create general statements, what could be considered as always true.

The third hypothesis concentrates on the areas, sectors from where these patents were created or registered from. According to our studies the 3rd hypothesis is also true. In Sweden, Austria and Hungary the highest number of patent registration has happened in the region of the capital city (Stockholm, Wien and Budapest). The case of Denmark is very interesting, the highest quantity of academic patents was not registered from the capital city of Denmark, but from region DK012- Copenhagen surroundings. In all the four studied and analyzed countries the academic patent registration was concentrated in big cities or in their surroundings.

Finally, the fourth hypothesis concentrates on the patent inventor share, by how many people was the patent created. We can say that according to our studies, the last, the fourth hypothesis is correct, too. In Sweden, Austria and Denmark more than 30% of the total number of academic patents were created by only one person, and in these countries less than 22% of academic patents had more than 3 creators. On the other hand, in Hungary this trend was different, only 23% of academic patents had one creator and on more than 38% of academic patents were working more than three people. In all the four studied countries more than 60% of the registered academic patents were made and created by less or equals to three people.

Also, we wanted to compare the Northern and Central-Eastern countries of the European Union, and their patent activities. We cannot make general statements, that in the northern countries of the European Union this activity of patent registration was happening on a higher level in bigger amount, since Austria was on the same level as Denmark. Only in Hungary we could observe academic patent registration happening on a lower level compared to the other selected countries and to the EU average. To sum up, we cannot say generally that in the countries of Central Europe the academic patent registration is happening on a lower level, it is an individual action, changing individually by the countries (the case of Austria and Hungary).

This work can be useful for the creation of policies of countries, regions and universities. According to our analyses we can show, that the implication of a new patent policy was not than effective in the European Union than in the USA, also it does not work equally efficiently in every countries of the EU. Also, according to our studies we cannot say that the R&D expenditure from the national GDP has to rise annually so it will ensure the rising academic patent registration number. We saw in our analyses the case of Sweden, where the R&D expenditure rate was constant, however the academic patent registration number was increasing year by year.

6 RESUMÉ

V záverečnej práci s názvom: Akademické patenty ako nástroj transferu poznatkov v EÚ sme skúmali akademické patenty a ich použitie v EÚ. Práca je zameraná najmä na univerzitné patenty, na ich funkcie a na ich význam pre rozvíjajúce sa hospodárstvo krajiny.

Duševné vlastníctvo sú vedomosti, informácie, inovácie vytvorené jednou osobou alebo skupinou ľudí. Na ochranu tohto majetku pred verejnosťou môžu spoločnosti a univerzity používať rôzne spôsoby registrácie patentov, ochranných známk, autorských práv alebo obchodných tajomstiev. Patent je jednou z týchto možností, keď majiteľ môže získať výlučné právo na svoje duševné vlastníctvo a môže sa rozhodnúť zdieľať ho s inými spoločnosťami za účelom finančnej kompenzácie. Registrácia patentu poskytuje výlučné právo na vytvorenie špeciálneho a jedinečného duševného vlastníctva (IP). Úspešná žiadosť o IP je zaregistrovaná v Patentovom úrade. Po tejto registrácii sa môže vlastník patentu s dokumentom preukázať a zabezpečiť svoje dedičstvo. Tento dokument vytvára silnú ochranu pre novovytvorené informácie a je platný určitý čas, počas ktorého ich má právo používať iba ich zákonný vlastník a rozhodovať o ich používateľoch. V prípade viacerých tvorcov patentu rozhoduje vlastník patentu na základe zmluvy so zmluvnými stranami, kto má právo na jeho aplikáciu a tiež na dobu jeho používania.

Cieľom záverečnej práce je analyzovať vývoj patentovej aktivity vo vybraných krajinách. V záverečnej práci sa predovšetkým zaoberáme s dvoma prístupmi, Bayh-Dole Act a Professor's Privilege.

Bayh-Dole Act bol prvý krát publikovaný a aplikovaný v Spojených štátoch amerických. Podľa danej politiky sa zákonným majiteľom univerzitných patentov stávajú univerzity, kde daný produkt, prípadne nápad bol vymyslený a poslaný na registráciu. Subjektmi benefitov a výhod Bayh Dole Act politiky sú univerzity. Univerzita dostane právo na držanie patentov a musí zabezpečiť najkvalitnejšiu službu vo manažovaní patentu, jeho reklamu, predaj a promóciu patentov, v prospech krajiny, spoločnosti a tiež profesora pracujúceho na výskumnom projekte. Aplikovanie danej politiky môže motivovať univerzity k zvýšeniu počtu výskumov v rámci danej univerzity, navyše aj príjem univerzít za vedu sa zvyšuje, vďaka čomu v budúcnosti bude univerzita schopná investovať viac peňazí do výskumu a podporovať profesorov ku kvalitnej práci.

Patentová politika Bayh Dole sa používa od roku 2000 v Nemecku, Rakúsku, Dánsku atď.

Medzi Spojenými štátmi americkými a európskymi krajinami je rozdiel. Aj keď tento akt v prípade USA fungoval perfektne, počet akademických patentov sa výrazne zvýšil. V Európe nefungoval tak rýchlo, hovoríme tomu „Európsky paradox“ (Lissoni, Llerena, McKelvey, Sanditov, 2008). Teoreticky by sa mohla politika Bayh-Dole uplatniť a transformovať aj pre Európu, pretože má kvalitné univerzity a vysokokvalifikovaných profesorov. V skutočnosti to nefungovalo hladko. Európski vedci a univerzity neboli pripravení propagovať a predávať svoje vedomosti tretím stranám. Druhým problémom boli manažérske a marketingové funkcie európskych univerzít. Vedci a univerzity sa sústreďujú viac na vedeckú časť ako na manažérsku.

Politika Professor's privilege je práve opačná teória, podľa jej zakladateľov a aktivistov má osoba, ktorá pracovala na jej vytvorení právo na držanie práva o patente a jedine tá má najvyšší podiel z predaja patentu. Podľa tejto politiky sú profesori motivovaní ku vytváraniu nových poznatkov, nápadov a objektov. Táto klasická európska politika definuje, že najlepšiu správu patentov môžu urobiť tí aktéri, ktorí najlepšie poznajú registrované duševné vlastníctvo, tí akademickí profesori, ktorí sa podieľali na jeho vzniku. Táto patentová politika sa uplatňuje v Taliansku a Švédsku.

V súčasnosti dostupné vedecké publikácie o akte a výsledkoch spôsobených aktívnym používaním zákona Bayh Dole Act sú rozdelené do dvoch skupín. Publikácie odborníkov z prvej skupiny tvrdia, že počet patentových registrácií súvisí s aplikovanou patentovou teóriou a politikou vo vybranej krajine. V dôsledku toho americký Bayh-Dole Act vytvára pre svojich používateľov dokonalé a ideálne prostredie. Okrem toho motivuje výskumných pracovníkov k ďalším štúdiám a registrácii ich patentov, vďaka čomu sa zvyšuje počet registrovaných patentov. (Innovation's Golden Goose, 2002, Perkins J. F., Tierney W.G., 2004, Zeebroeck N, Pottelsberghe B, Guellec D, 2008).

Denník Economist v roku 2002 napísal, že zákon Bayh Dole je „[nepochybne] najinšpirovanejším legislatívnym predpisom, ktorý bol v Amerike prijatý za posledné polstoročie.“ (Zlatá hus Innovation, 2002).

Perkins a Tierney tiež vo svojej práci analyzujú výsledky po uplatnení Bayh Dole Act a tiež jeho vplyv na tvorbu a registráciu patentov na univerzity: „Zákon Bayh – Dole spôsobil, že sa výskumné univerzity v USA zamerali na činnosti v oblasti patentov a licencií.“ (Perkins J. F., Tierney W.G., 2004)

Zeebroeck N, Pottelsberghe B, Guellec D (2008) sú so svojou publikáciou súčasťou prvej skupiny teoretikov, ktorí si myslia a hovoria, že rastúci počet patentových registrácií je pozitívnym výsledkom implikácie Bayh Dole Act. Vo svojej práci definovali, že zákon Bayh Dole „dal univerzitám väčšie stimuly na komercializáciu technológií“ (Zeebroeck N, Pottelsberghe B, Guellec D, 2008).

Na rozdiel od tohto pohľadu si druhá skupina vedcov si myslí, že rozsah registrácie patentu nie je v korelácii s aplikovanou politikou a teóriou vo vybranej krajine. Čo znamená, že nárast patentovej prihlášky nie je spôsobený Bayh Dole Act založeným na vlastníctve. Vo svojich štúdiách hovoria, že tento rast je spôsobený rôznymi aspektmi, ako je zakladanie a vytváranie nových výskumných sektorov, ako sú IT, biotechnológie atď. (Geuna, Rossi, 2011, Sapalis a Pottelsberghe, 2003, Lissoni F, Llerena P, McKelvey. M, Sanditov B, 2008, Mowery et al, 2001).

Geuna a Rossi (2011) vo svojej publikácii tvrdia, že americký prístup nepasuje úplne pre všetky krajiny, preto ich nemožno aplikovať v každej krajine s rovnakou úrovňou efektívnosti. Po roku 2000 sa počet zaregistrovaných patentov zvyšoval vo väčšine krajín Európskej únie. Definovali tri dôvody a aspekty, ktoré boli zdrojom tohto zvýšenia. V prvom rade stúpala počet registrovaných patentov kvôli novým aktérom - univerzitám - ktoré sa objavili na trhu výskumu. Univerzity, ktoré už aktívne registrovali svoje duševné vlastníctvo, sa stali aktívnejšími vďaka svojim skúsenostiam a znalostiam získaným v predchádzajúcom období. Po druhé, popísali, že v krajinách, kde sa systém prenosu vedomostí vytváral pomalšie sa v priebehu roku 2000 oneskoril nárast registrácie patentov. Dochádzalo k rozvoju infraštruktúry pre túto výmenu duševného vlastníctva, ale keďže bolo neskoro, výsledok sa dostavil aj neskôr a oneskorený bol aj nárast počtu registrovaných patentov. Podľa Geuny a Rossiho (2011) tretím dôvodom je „patenty vyvinuté univerzitami a vlastnené podnikmi stále hrajú vo všetkých krajinách mimoriadne dôležitú úlohu. Existujú náznaky toho, že v niektorých krajinách sa zvýšil počet patentov vlastnených univerzitami, a to na úkor patentov vlastnených jednotlivcami a podnikmi (avšak vynaliezavými univerzitami). Ak sa údaje o akademickom patente opravujú tak, aby zohľadňovali patenty vyvinuté univerzitami, potom pre niektoré krajiny s dlhoročnou tradíciou akademického patentovania (napríklad Nemecko) a pre niektoré vedecké / technologické oblasti, kde je akademický patent obzvlášť dôležitý (napríklad biotechnológia), sme našli dôkazy o vyrovnaní alebo poklese celkového počtu žiadostí o akademické patenty do polovice 21. storočia “(Geuna, Rossi, 2011).

V práci autorov Sapalis a Pottelsberghe (2003) sa tiež dočítame, že „prudký nárast patentovej činnosti belgických univerzít je spôsobený predovšetkým technologickou revolúciou a začiatkom éry biotechnológií.“ (Sapalis, Pottelsberghe, 2003).

V diplomovej práci skúmame nasledujúce hypotézy:

1. Počet patentových prihlášok vzrástol po uplatnení teórie zákona Bayh Dole Act (Ledebur, Buenstorf, Hummel, 2009)
2. Po uplatnení zákona Bayh Dole sa počet patentových registrácií nezvyšoval vďaka tomuto prístupu, ale tento nárast bol spôsobený vytvorením a rozvojom nových sektorov. (Sapalis, Pottelsberghe, 2003, Mowery et al. 2001).
3. Registrácia patentu sa sústreďuje na metropolitné oblasti (OECD, 2013)
4. Väčšinu akademických patentov vymysleli traja vedci.

Prvú hypotézu môžeme prijať, počet patentových prihlášok stúpal po uplatnení teórie zákona Bayh Dole vo vybraných štyroch krajinách (Švédsko, Dánsko, Rakúsko a Maďarsko) v rokoch 1997 až 2017 *ceteris paribus*.

Druhú hypotézu taktiež prijímame. Na základe našej analýzy sme zistili, že tento nárast nie je spôsobený implikáciou americkej patentovej politiky. Nárast mohol byť ovplyvnený ďalšími efektmi, ako je vytváranie nových sektorov alebo stúpajúci trend aktivít v registrácii patentov v niektorých odvetviach (IT, biotechnológie atď.)

Podľa našich analýz Difference-in-Differences nemôžeme tvrdiť, že uplatnenie zákona Bayh Dole Act je 100% neefektívne, pretože sme študovali iba štyri krajiny a iba jednu krajinu, ktorá implikuje Professor's Privilege. Malý počet skúmaných krajín nezabezpečuje a neposkytuje možnosť vytvárať všeobecné vyhlásenia.

Tretia hypotéza sa zameriava na oblasti, z ktorých boli tieto patenty vytvorené alebo v ktorých sa zaregistrovali. Vo Švédsku, Rakúsku a Maďarsku došlo k najväčšiemu počtu patentových registrácií v regióne hlavného mesta (Štokholm, Viedeň a Budapešť). Prípád Dánska je veľmi zaujímavý, najväčšie množstvo akademických patentov nebolo zaregistrovaných z regiónu hlavného mesta Dánska, ale z regiónu DK012 - okolie Kodane.

Nakoniec sa štvrtá hypotéza zameriava na podiel inventára patentov podľa počtu ľudí, ktorí si nechali patent vytvoriť. Vo Švédsku, Rakúsku a Dánsku viac ako 30% z celkového počtu akademických patentov vytvoril iba jeden človek a v týchto krajinách malo menej ako 22% akademických patentov viac ako 3 autorov. Na druhej strane, v

Maďarsku bol tento trend odlišný, iba 23% akademických patentov malo jedného tvorca a na viac ako 38% akademických patentov pracovali viacerí ako traja ľudia.

Taktiež sme porovnali severné a stredovýchodné krajiny Európskej únie a ich patentové aktivity. Nemôžeme všeobecne potvrdiť, že v severných krajinách Európskej únie sa činnosť registrácie patentov diala na vyššej úrovni a vo väčšom množstve, pretože Rakúsko bolo na rovnakej úrovni ako Dánsko. Iba v Maďarsku sme mohli sledovať registráciu akademických patentov na nižšej úrovni v porovnaní s ostatnými vybranými krajinami a priemerom EÚ. Ak to zhrnieme, nemôžeme všeobecne povedať, že v krajinách strednej Európy sa registrácia akademických patentov deje na nižšej úrovni, jedná sa o individuálnu akciu, ktorá sa individuálne mení podľa krajín (prípady Rakúska a Maďarska).

Tiež sme analyzovali a porovnali výdavky na výskum a vývoj, mieru registrácie patentov na jedného obyvateľa v skúmaných a analyzovaných krajinách. V Maďarsku registrácia patentov na obyvateľa leží pod krivkami ostatných krajín, naopak vo Švédsku počet prihlášok na obyvateľa je najvyšší. Ak uvažujeme o výdavkoch na výskum a vývoj z ročného HDP, poradie investícií je rovnaké ako poradie registrácií patentov na obyvateľa. To znamená, že vo Švédsku je najvyššia miera výdavkov na výskum a vývoj. Nasledujú Rakúsko a Dánsko (tieto krajiny sú na rovnakej úrovni), na konci týchto rebríčkov sa umiestnilo Maďarsko. Môžeme spomenúť Švédsko ako výnimočnú krajinu, kde miera výdavkov na výskum a vývoj nerastie, na rozdiel od ostatných troch krajín, predstavuje stagnáciu, neustály trend. Švédsko každý rok investuje do výskumu a vývoja rovnakú alebo menšiu percentuálnu mieru svojho HDP.

Táto práca môže byť užitočná pri tvorbe politík krajín, regiónov a univerzít. Pomocou našich analýz sme mohli ukázať, že implementácia novej patentovej politiky nebola v Európskej únii efektívna a nefunguje rovnako efektívne ani v rámci krajín EÚ. Taktiež vytvára ďalšie administratívne náklady pre krajinu. Tiež nemôžeme povedať, že výdavky na výskum a vývoj z národného HDP musia každoročne rásť, aby zabezpečili stúpajúci počet registrácií akademického patentu. Videli sme prípad Švédska, kde miera výdavkov na výskum a vývoj bola konštantná, avšak počet registrácií akademických patentov sa z roka na rok zvyšoval.

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